The 3rd International Conference on the Physics of Optical Materials and Devices

BOOK OF ABSTRACTS

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FOREWORD

The 3rd International Conference on the Physics of Optical Materials and Devices (ICOM 2012) will be held in Belgrade, Serbia, from 3rd to 6th of September 2012 and is jointly organized by the Vinča Institute of Nuclear Sciences, University of Belgrade (Serbia) and the Laboratoire de Chimie de la Matière Condensée de Paris (France).

ICOM 2012 conference brings together scientists and technology users who are investigating or developing materials for optical applications. The conference will present the state of the art in preparation methods, optical characterization and usage of optical materials and devices in various photonic fields. The conference will stress the value of a fundamental scientific understanding of optical materials and applications in lasers, scintillators, phosphors. The accent will be put on material elaboration and characterization.

The ICOM2012 Conference will be composed of several sessions, which will comprise 21 Invited lectures by the leaders in the field, 72 contributed oral lectures and 183 poster presentations.

We are grateful for sponsorships which have assisted us by providing financial support.

We wish to express our thanks to the members of the International committee for their suggestion of oral speakers and we are also grateful to the members of the local organising committee in Belgrade for their effort and time during preparation of the conference.

Chairpersons

Prof. Dr. Miroslav D. Dramićanin Dr. Bruno Viana

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CHROMOPHORES AND THEIR BIOLOGICAL COMPATIBILITY FOR BIOPHOTONICS

Chantal Andraud

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Following pioneering works of Webb and co-workers, two-photon excited luminescence, and photo-dynamic therapy (PDT), are becoming promising tools for biological applications like imaging, diagnostic or even therapy [1]. In this context, we developed chromophores, with excellent quantum yield of luminescence or exhibiting enhanced efficiency for singlet oxygen generation, and featuring optimized biphotonic cross-section.

Lanthanides complexes for bioimaging

Using the unique luminescence properties of LnIII ions, we designed a new family of ligands-based chromophores inducing lanthanides emission by two-photon antenna effect [2]. Results obtained for ytterbium based bioprobes led to consider these complexes as a new generation of molecular probes for NIR-to-NIR two-photon scanning laser microscopy imaging [3].

Stabilization of triplet state for singlet oxygen generation and photodynamic therapy

An ideal two-photon absorbing chromophore for PDT must present a high a "figure of merit" (σ_{TPA} . ϕ_{1O2}), where σ_{TPA} and . ϕ_{1O2} represent respectively the two-photon absorption cross section at the excitation wavelength, and the quantum yield of singlet oxygen generation.

A new molecular engineering strategy based on systematic variation of the bromine subsitution pattern on a two-photon chromophore is introduced [4].

Finally, we explored the potentialities of these chromophores to be used in cellulo for photodynamic therapy [5].

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- [1] For a review see: G. S. He, L.-S. Tan, Q. Zheng and P.N. Prasad, Chem. Rev. 108 (2008) 1245
- [2] A. Picot, A. D'Aléo, P. L. Baldeck, A. Grichine, A. Duperray, C. Andraud, O. Maury J. Am. Chem. Soc. 130 (2008) 1532.
- [3] A. D'Aléo, A. Bourdolle, S. Brustlein, T. Fauquier, A. Grichine, A. Duperray, P. L. Baldeck, C. Andraud, S. Brasselet, O. Maury Angew.Chem.Int.Ed.51 (2012) 1.
- [4] P.-H. Lanoë, T. Gallavardin, A. Dupin, O. Maury, P.L. Baldeck, M. Lindgren, C. Monnereau, C. Andraud Org. Biomol. Chem. DOI : 10.1039/C2OB25536G.
- [5] T. Gallavardin, M. Maurin, S. Marotte, T. Simon, A.-M. Gabudean, Y. Bretonnière, M. Lindgren, F. Lerouge, P. L. Baldeck, O. Stéphan, Y. Leverrier, J. Marvel, S. Parola, O. Maury, C. Andraud Photochemistry and Photobiology Sciences 10 (2011) 1216.

APPLICATIONS OF OPTICAL NOVELTY FILTERS IN PHOTOTHERMAL SPECTROSCOPY

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Applications of optical novelty filters based on a photorefractive BaTiO3 beam fanning limiter to photothermal spectroscopy and imaging are described. Optical novelty filters reject the average or "mundane" part of the optical signal carried on the laser beam. The mundane is rejected by redirecting that light to a different propagation direction. Novel information, that which has high frequency temporal and/or spatial character, is not rejected and propagates along the normal beam path. A Fourier optics based model for the operation of the beam-fanning limiter are shown and used to illustrate how it can be used for signal contrast enhancement and imaging. In particular, a 4f optical transform model is used to show how continuous probe laser phase shifts caused by the pulsedlaser excited photothermal effect causes large amplitude changes beyond the optical novelty filter. Novelty is imparted to the probe laser beam by inducing a rapid change in refractive index of the medium. The refractive index change produces an imaginary transmission change resulting in real changes in beam profile in the Fourier plane. The real components couple out of the novelty filter and are subsequently detected. Experimental apparatuses are described and results are used to illustrate utility. The resulting signal is not linear but does exhibit an enhanced signal-to-background ratio that is 4 to 6 orders of magnitude better than that of conventional infrared absorption spectrophotometry in the shot-noise limit. This signal enhancement technique also has advantages for rapid signal analysis and for visible imaging of infrared absorption.

TRIVALENT RARE EARTH IONS-DOPED CERAMICS AS OPTICAL MATERIALS: TEM-EDX CHEMICAL ANALYSIS OF THE SPATIAL DISTRIBUTION

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The research activity on advanced optical materials for various applications, such as lasers, scintillators, phosphors, is greatly increasing with the availability of transparent sintered polycrystalline ceramics, which present some advantages compared to single crystals (sizes, mechanical strength, overall production cost). Understanding their optical properties requires a detailed investigation of their microstructure, especially regarding the exact location of the required dopants (e.g. rare earth elements such as Ce^{3+} , Nd^{3+} or Yb^{3+}). The main goal of this lecture is to show how Transmission Electron Microscopy (TEM) useful for characterizing the spatial distribution of rare earth ions in YAG and Y2O3 ceramics from the following new observations:

- Nd³⁺ and Ce³⁺ luminescent ions strongly segregate at grain-boundaries of YAG [1-2-3],

- Yb³⁺ ions do not segregate significantly at grain-boundaries of YAG and Y₂O₃ [4],

- There is a correlation between segregation of rare earth dopants in melt crystal growth and ceramic processing depending on their place in the lanthanide family [5-6],

- High Resolution and chemical spectroscopic nano-analysis results indicate the presence of amorphous and crystalline silicate phases at grains triple junction in some YAG ceramics that could be one of the major scattering sources and the reason of the high optical losses[7],

- Detection of a single luminescent Yb³⁺ ion in the YAG host [8].

- M.O. Ramirez, J. Wisdom, H. Li, Y.L. Aung, J. Stitt, G.L. Messing, V. Dierolf, Z. Liu, A. Ikesue, R.L. Byer, V. Gopalan, Optics Express, 16(2008) 5966.
- [2] W. Zhao, C. Mancini, D. Amans, G. Boulon, T. Epicier, Y.Min, H. Yagi, T. Yanagitani, T. Yanagida, A. Yoshikawa, Jap. J. of App. Phys. 49 (2010) 022602..
- [3] W. Zhao, S. Anghel, D. Amans, G. Boulon, T. Epicier, Y. Shi, X. Q. Feng, Y. B. Pan, V.Chani, A. Yoshikawa, Optical Materials 33 (2011) 684–687.
- [4] T. Epicier, G. Boulon, W. Zhao, M. Guzik, B. Jiang, A. Ikesue, L. Esposito, submitted on June 2012
- [5] V. I. Chani, G. Boulon, W. Zhao, T. Yanagida, A. Yoshikawa, Jpn. J. Appl.Phys. 49 (2010) 075601
- [6] G. Boulon, T. Epicier, W. Zhao, V. I. Chani, T. Yanagida, A.Yoshikawa, Jpn. J. Appl. Phys., 50, 9, Article ID: 090207, published on 2011/09/20 (online).
- [7] L. Esposito, T. Epicier, M. Serantoni, A. Piancastelli, D. Alderighi, A. Pirri, G. Toci, M. Vannini, , S. Anghel, G. Boulon, Journal of the European Ceramic Society, accepted on February 27, 2012.
- [8] T. Epicier, T. Konno, K. Sato, G. Boulon, presented at ICL'11, June 27- July1st, 2011, Ann Arbor (USA), under publication (2012).

CRYSTAL FIELD EFFECTS AND THEIR INFLUENCE ON OPTICAL PROPERTIES OF TRANSITION METAL IONS FROM Sc TO Zn

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Transition metal ions with unfilled 3d electron shell are being widely used for several decades in numerous applications [1, 2]. Their unscreened 3d electrons strongly interact with the crystal lattice vibrations, which leads to a large crystal field splitting of energy levels and broad emission/absorption bands of the spin-allowed transitions.

In the present work the crystal field effects and their influence on the optical properties of all 3d ions from Sc to Zn are reviewed and discussed. The exchange charge model of crystal field [3] and the CASTEP module [4] of Materials Studio package [5] were used as the main tools in the performed calculations. The following topics were selected for presentation:

i) systematic calculations of the transition metal ions energy levels in crystal field and analysis of their absorption spectra [e.g. 6];

ii) modeling of microscopic crystal field effects on the 3d electron states, in particular, by calculating the electronic band structure at the ambient and elevated hydrostatic pressure and extracting from these calculations the distance dependence of the crystal field strength 10Dq and main parameters of the electron-vibrational coupling, such as Huang-Rhys factor and Stokes shift [7, 8]. In addition, peculiar features of the chemical bonding between impurities and crystal lattice ions in pyrochlore crystals have been also revealed and discussed [9, 10];

iii) *ab initio* studies of the structural, electronic, optical and elastic properties of the transition metals mononitrides and monocarbides [11].

Such a combination of the semi-empirical and *ab initio* calculations allows for getting a deeper insight into the properties of studied crystals, by comparing the results of the band structure and crystal field calculations [12], especially if the isostructural crystals or isoelectronic impurities are chosen.

- [1] S. Kück, Appl. Phys. B 72 (2001) 515–562.
- B. Henderson, R.H. Bartram, Crystal-Field Engineering of Solid-State Laser Materials Cambridge University Press, 2000.
- [3] B.Z. Malkin, in: A.A. Kaplyanskii, B.M. Macfarlane (Eds.), Spectroscopy of Solids Containing Rare-Earth Ions, North-Holland, Amsterdam, 1987, pp. 33-50.
- [4] M.D. Segall, P.J.D. Lindan, M.J. Probert, C.J. Pickard, P.J. Hasnip, S.J. Clark, M.C. Payne, J. Phys.: Condens. Matter 14 (2002) 2717.
- [5] http://accelrys.com/products/materials-studio/
- [6] R.M.Krsmanović, Ž.Antić, M.Mitrić, M.D.Dramićanin, M.G.Brik, Appl. Phys. A 104 (2011) 483-492.
- [7] M.G. Brik, I. Sildos, V. Kiisk, J. Lumin. 131 (2011) 396–403.
- [8] M.G. Brik, N.M. Avram, C.-G. Ma, Comput. Mater. Sci. 50 (2011) 2482–2487.
- [9] A.M. Srivastava, M.G. Brik, J. Lumin. 130 (2010) 2368–2376.
- [10] M.G. Brik, A.M. Srivastava, N.M. Avram, J. Lumin. 131 (2011) 54-58.
- [11] M.G.Brik, C.-G.Ma, Comput.Mater.Sci. 51 (2012) 380–388; V.Krasnenko, M.G.Brik (in preparation).
- [12] M.G. Brik, A. Majchrowski, L. Jaroszewicz, A. Wojciechowski, I.V. Kityk, Phil. Mag. 90 (2010) 4569–4578.

QUANTUM DOT LUMINESCENCE NANOTHERMOMETRY: RECENT ADVANCES

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There is currently a great interest in the development of novel systems capable of thermal sensing at the nano-scale. Among the different scenarios in which they could be used, thermal sensing in optically excited biological systems seems to be one of the most challenging ones. The exact knowledge of the local temperature of biological systems (such as living cells) is required in order to understand the dynamical behavior and state of the bio-system. Optical nano-thermometers (NTs) are constituted by luminescent nano-particles whose luminescence features are strongly influenced by small changes induced in their local temperature. When incorporated into biological or bio-photonic systems the analysis of their luminescence properties provides a direct measurement of the intracellular temperature without any interaction with the cell under study. During the last years numerous number of examples of intracellular thermal sensing based on optical NTs can be found.

Among the different optical NTS, semiconductor nano-crystals (Quantum Dots, QDs) have recently emerged as one of the most promising systems due to their good stability, high fluorescence quantum efficiency, high absorption cross sections (via one and two-photon processes) and good bio-compatibility. Thermal sensing from QDs can be achieved through different approaches that will be summarized in this talk and that include spectral thermometry, intensity thermometry and, even, lifetime thermometry.

In this work we summarized the most recent examples that evidence the huge potential of QDs for Luminescence Nanothermometry. We will show how it is possible to use QDs to achieve real time controlled hyperthermia processes carried out at the cellular level. We will also show how QDs can be used for high resolution thermal spectroscopy of laser traps. Finally, we will present some recent results showing how QDs can be also used for thermal imaging of opto-fluidic devices.

EXPLORING NEW RARE EARTH-DOPED TUNGSTATE AND MOLYBDATE MATRICES FOR OPTICAL MATERIALS

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The tungstate and molybdate compounds are well known as an excellent host lattice for rare earth elements, due to their chemical stability and possibility of high doping level of lanthanides ions. Since they could be applied as luminophores, scintillators and laser devices, mainly as single crystals, their interest have grown rapidly. Especially, $KGd(WO_4)_2$ (KGW) and $KY(WO_4)_2$ (KYW) tungstates doped with Nd^{3+} , Er^{3+} and Yb^{3+} rare-earth ions show high potential for light generation or amplification.

In our research group, we have obtained four new tungstate and molybdate matrices doped with rare earth ions (Eu³⁺, Nd³⁺, Yb³⁺) that appeared to be natural candidates for replace the previously used optical materials. A high temperature solid-state reaction, as well as the Czochralski method were used to obtain microcrystalline (1-30 µm) powder samples and single crystals, respectively. The ZnY₄W₃O₁₆:RE³⁺ solid solutions with the wolframite-type structure, crystallizing in the orthorhombic system, could be used for white light emitting diodes (WLEDs) (due to the combination of broad band charge transfer blue emission of tungsten group with red luminescence of the Eu³⁺ ions) [1] or laser materials and temperature sensors (Nd³⁺-doped materials) [2]. Also, in the case of Yb³⁺-doped zinc tungstates the high value of absorption cross-section and intense IR emission made them promising materials for the laser application. It is worth to note, that the nonlinear effect, clearly observed in the undoped and RE³⁺ -doped ZnY₄W₃O₁₆tungstates, can be applied for the second harmonic generation, that is unusualeffect for powdered samples.

All new cadmium tungstates and molybdates, i.e. the $CdRE_2W_2O_{10}$, $Cd_{0.25}RE_{0.50}\square_{0.25}WO_4$ [3] and $Cd_{0.25}RE_{0.50}\square_{0.25}MoO_4$ solid solution as well as their gadolinium or yttrium diluted analogues represent the scheelite-type structure. CdWO₄ usually crystallizes into the wolframite-type structure, however doped with lanthanide ions unexpectedly underwent a transformation to shellite-type one. The substitution of Cd^{2+} by trivalent RE^{3+} cations leads to the formation of cation vacancies in a framework. Both ,,disordered' with regard to their actual cationic distribution cadmium tungstates, as well as the cadmium molybdates with ,,ordered'' cation environments can be used as efficient laser hosts, mainly for Nd³⁺ ions.

The broad spectral emission band of Nd³⁺ ions, caused by structural disorder, allows for both the tuning of laser radiation over 1030-1080 nm range and the generation of ultra-short pulses, which could find applications in pico- or even femtosecond laser [4]. As compared to YAG:Nd, new Nd³⁺ doped tungstates and molybdates have the advantage of larger absorption crosssection $(2.5 \times 10^{-19} \text{ cm}^2 \text{ for the } Cd_{0.25}Gd_{0.50} \square_{0.25}WO_4$:Nd³⁺and $1.3 \times 10^{-19} \text{ cm}^2$ for CdY₂W₂O₁₀:Nd³⁺) and higher values of integrated emission intensities.

- [1] E. Tomaszewicz, et al., Helv. Chim. Acta, 9 (2009) 2274,
- [2] M. Guzik, etal., Opt. Mater., 34 (2011) 487.
- [3] M. Guzik, etal., J. Non-Cryst. Solids, 356 (2010) 1902. [4]M. Guzik, etal., J. Mat. Chem. (2012), DOI:10.1039/C2JM30799E.

TEMPERATURE DEPENDENT LIGAND TO METAL ENERGY TRANSFER RATES IN LANTHANIDE COMPLEXES: THEORETICAL MODELING AND THE FIRST DIRECT EXPERIMENTAL OBSERVATION

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To our knowledge, for the first time the transient curve of the ${}^{5}D_{1}$ level of the Eu³⁺ ion in a model complex, under UV excitation, as a function of temperature has been measured. Comparison with the transient curve of the ${}^{5}D_{0}$ level, in the same temperature interval (10K to 300K), shows unambiguously that the ${}^{5}D_{0}$ is populated by non-radiative decay from the ${}^{5}D_{1}$, while this latter level is populated through intramolecular energy transfer from the lowest tta triplet state. From these results temperature dependent transfer rates could be measured. Good agreement between theoretical predictions, including selection rules, and experiment was obtained [1,2].

- G. F. de Sá, O. L. Malta, C. de Mello Donegá, A. M. Simas, R. L. Longo, P. A. Santa-Cruz and E. F. da Silva Jr., Coord. Chem. Rev. 196, 165 (2000).
- [2] O. L. Malta, J. Non-Cryst. Solids 354, 4770 (2008).

CNPq, INAMI, PRONEX

HYDROTHERMAL SYNTHESIS OF NANOSTRUCTURED RARE EARTH OXIDE – BASED PHOSPHORS

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Synthesis of nanostructured rare earth oxide-based phosphor particles with enhanced optical characteristics leads to the creation of the new photonic devices with diverse applications. Tailoring of the phosphors quality depends on our ability to utilize the best of their intrinsic structure through the control of nucleation and growth process of the desired phase. A large number of works have contributed to the better control of particle shape and crystal growth in soft-chemistry routes. Here, examples from (Y_2O_3 -Gd₂O₃): Eu³⁺ and Y_2O_3 :(Yb³⁺/Er³⁺) will be presented to highlight the controlled synthesis of 1D and 2D nanostructures through simple hydrothermal method. Conversion of the starting nitrates mixture into carbonate hydrate phase is performed with the help of ammonium hydrogen carbonate solution during hydrothermal treatment at 200°C/3h. Morphological architectures of rare earth oxides obtained after subsequent thermal treatment and their correlation with the optical characteristics will be discussed based on X-ray powder diffractometry, particle size analysis, scanning electron microscopy and photoluminescence measurements.
DOWN-CONVERSION AND SOLAR CELL EFFICIENCY

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It is a true challenge to generate a significant fraction of the energy demand with solar cells, which implies to strongly increase the output of these while reducing their production costs. Currently one of the principal limits to the output of solar cells is the inadequacy between the spectrum of the incident radiation and the absorption spectrum of cells. Among the various possibilities suggested to obtain a better coupling between the spectrum of illumination and the absorption of solar cell, an approach, still little developed, consists in modifying the spectrum of illumination rather than to seek to adapt, as well as possible, solar cells to the sun spectrum. Accordingly, wavelength shifter materials are used to convert energy between various spectral ranges. For a direct application on solar cell, it is necessary to develop and optimize new luminescent materials which can be deposited as thin layers. Some of them will down-convert UV-photons into less energetic photons which should fit better to the maximum of solar cell sensitivity.

The challenge is to develop materials simultaneously "down-converter" and "quantum cutter" which strongly absorb light in the UV and blue range. The physical processes which carry out this conversion involve luminescent ions and transfers of energy between these ions. The conversion efficiency of silicon based photovoltaic cells is currently around 20%. Thermalization of electron-hole pairs created by high energy photons is one major loss mechanism in silicon based solar cells. It is responsible for the poor yield in the blue range of the solar spectrum. The deposition of a quantum-cutting material on top of the silicon solar cell is a promising solution to reduce these losses. Using this approach, each blue photon could thus be converted into two near-infrared photons both able to generate an electron-hole pair.

Quantum-cuting has been demonstrated in SrF₂: Pr^{3+} , Yb^{3+} [1]. The absorption of a blue photon leads to the excitation of the ${}^{3}P_{0}$ level of Pr^{3+} ion. Then, a two-step relaxation Pr^{3+} : $\{{}^{3}P_{0} \rightarrow {}^{1}G_{4}, {}^{1}G_{4} \rightarrow {}^{3}H_{4}\} \rightarrow 2 \times Yb^{3+}$: $\{{}^{2}F_{7/2} \rightarrow {}^{2}F_{5/2}\}$ leads to the sensitization of two Yb^{3+} ion. In this study, we show results obtained on CaYAlO₄ co-doped with Pr^{3+} and Yb^{3+} and we discuss the possibility of having efficient quantum-cutting. The upper levels of Pr^{3+} ion show sharp and inefficient absorption bands since those are $4f \rightarrow 4f$ transitions. It is thus necessary to introduce a third ion to strongly absorb energy from the UV-blue region of the solar spectrum and transfer it to the Pr^{3+} ion. The very efficient $4f \rightarrow 5d$ transition of Ce^{3+} ion may satisfy these requirements, but the position and the width of its absorption and emission bands are very sensitive to the crystalline environment. In a CYA (CaYAlO₄) matrix, the position of Ce^{3+} absorption and emission bands appears to make it able to sensitize the upper levels of Pr^{3+} ion. Moreover CYA is transparent in the solar spectrum range. It is thus an interesting host matrix to achieve efficient quantum-cutting. We have measured a maximum quantum cutting rate of 145\% in CYA: 0.5\% Pr^{3+} and 10\% Yb^{3+}.

[1] B. M. van der Ende, L. Aarts, A. Meijerink, Adv. Mater. 21, 3073 (2009).

NANOPHOTONIC SENSORS

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Photonic structures such as photonic crystals, photonic wire cavities and optical metamaterials - all with submicron features can be described as 'nanophotonic'. Many of these devices and structures can be configured as sensors. The usual approach to photonic sensing is to rely on the change the refractive index of a surrounding medium. Here we consider several nanophotonic sensing systems, including photonic wire cavities, polymer Bragg gratings and asymmetric split ring resonators. We compare the relative merits of high Q structures with a small shift in wavelength due the analyte versus low Q structures with a large shift in wavelength.

SUBDIFFRACTIVE IMAGING USING UPCONVERSION IN RARE EARTH DOPED NANOPARTICLES

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During the past two decades, multiphoton microscopy, mainly two-photon excitation microscopy, has become a powerful tool for imaging biological structures, the infrared excitation lying in the range of the therapeutic window, multiphoton microscopy allows imaging living tissues at a higher depth than its counterpart, the Laser Scanning Confocal Microscopy. Nonlinear processes are implemented such as multiphoton absorption mainly two-photon absorption (TPA), multiharmonic generation mainly second harmonic generation SHG and coherent anti-Stokes Raman scattering. All these phenomena occur under high peak power excitation provided by femtosecond lasers. Using infrared excitation, the photostability of commonly used optical probes (organic molecules, proteins...) is enhanced but the high excitation power densities are photoxic providing destruction of the living tissues by hyperthermia. On other hand, there is a need to improve the resolution of the imaging system. This can be achieved by breaking the Abbe's diffraction law as proposed by S. Hell [1] with the STED microscopy. If the axial and lateral resolutions are well beyond that is given by the diffraction barrier, the experimental set up is greatly expensive and the photobleaching of the probes is still a drawback, furthermore no multiplexing of the signal is possible for the moment.

We demonstrate that Rare Earth doped Nanoparticles (RE/NPs) represent interesting alternative to common optical probes for multiphoton microscopy. RE/NPs are recognized since few years as potential optical nanoprobes for biological imaging [2,3] and the biocompatibility has already been demonstrated [4,5]. Due to their high photostability, long time observations can be achieved. The upconversion process by energy transfer (ETU), discovered in the sixties, well before the use of coherent sources [6,7], is particularly efficient and visible emissions are obtained under coherent or non coherent infrared excitation. Furthermore depending on the nature of the dopants or their respective concentration, several colors (red, green, blue) of the dopants are observed that open the way to multiplexing of signals in a way similar to the multiplexing use of quantum dots. Due to the high non linearity of the upconverted emissions, measured lateral and axial resolutions of the images are well beyond the diffraction limit. Developing a low cost imaging system looks possible.

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- [1] T. A. Klar, E. Engel, S. W. Hell, Physical Review E, 64 (2001) 066613.
- [2] A. Doat, M. Fanjul, F. Pellé, E. Hollande, A. Lebugle, Biomaterials, 24 (2003) 3365.
- [3] H.J. Zijlmans, J. Bonnet, J Burton, K. Kardos, T Vail, R.S. Niedbala, H.J. Tanke, Analytical Biochemistry, 267 (1999), 30.
- [4] D. K. Chatterjee; A. J. Rufaihah; Y. Zhang, Biomaterials, 29 (2008) 937.
- [5] Feng Wang, YongZhang, Xianping Fan and MinquanWang, Nanotechnology, 17 (2006) 1527.
- [6] F. Auzel, CR. Acad. Sci. (Paris), 262 (1966) 1016.
- [7] V. V. Ovsyankin; P. P. Feofilov, Sov. Phys. JETP Lett., 4 (1966) 317.

CATHODOLUMINESCENCE OF DOPED NANO- AND MICROWIRES OF SEMICONDUCTOR OXIDES

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Nanostructures of semiconducting oxides and their alloys, have potential applications in optoelectronic devices, gas sensing, field emitters, transparent conductors and other fields. One of the basic problems related to the applications of semiconducting nanostructures, in particular, nanowires, nanobelts and other elongated systems, is the development and control of doping processes. In this work we report on the fabrication and characterization of nano- and micro-wires, belts, rods, needles or plates of ZnO, In₂O₃, SnO₂ and Ga₂O₃ doped with different elements, and of the compound Indium-Zinc-Oxide (IZO) [1-4].

The structures were grown by a catalyst free thermal evaporation-deposition method under gas flow, with compacted powders as precursor. Doping is performed by adding oxide of the dopant element to the starting material or by an after-growth diffusion process . Luminescence of the structures has been investigated by cathodoluminescence (CL) in the scanning electron microscope (SEM). CL has been used to assess the general luminescent behavior of the structures, providing information on the dopant incorporation, the nature of the defects as well as on the formation of ternary compounds.

Energy dispersive X-ray spectroscopy (EDS) and CL measurements on the same samples in SEM enabled to study the dopant concentration and distribution. In particular, dopant incorporation into the structures during the growth has often a marked effect on the resulting morphology leading to the growth of complex branched or hierarchical micro- and nanostructures, as tree-shaped arrays and networks of nanowires. CL measurements show the existence in some of these complex arrangements of wires or rods, of a gradient of dopant concentration along the growth axis. Additional information on the optical properties of the nanowires has been obtained by PL microscopy and spectroscopy.

- I. López, A. D. Utrilla, E. Nogales, B. Méndez, J. Piqueras, J. Phys. Chem. C 116 (2012) 3935-3943.
- [2] A. Urbieta, P. Fernández, J. Piqueras, Mat. Chem. Phys. 132 (2012) 1119-1124.
- [3] B. Alemán, Y. Ortega, J. A. García, P. Fernández, J. Piqueras, J. Appl. Phys. 110 (2011) 014317
- [4] D. Maestre, E. Hernández, A. Cremades, M. Amatti, J. Piqueras, Cryst. Growth Des. in press (2012)

MATERIALS FOR OPTICAL MEMORY: RESOLVED HYPERFINE STRUCTURE IN KYF4:Ho

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Revival of the interest to the investigations of hyperfine interactions in the rare-earth (RE) ions is connected with the promising perspective to build an effective three-level A system on the basis of the RE hyperfine sublevels, for applications in quantum information storage and optical manipulation (see, e.g., [1] and references therein). Because of long optical and hyperfine coherence times and possibility to achieve high optical density, RE containing crystals are considered as the best candidates for development of quantum information systems at low temperature. The knowledge of the precise energies and symmetries of the hyperfine levels of both the ground and optically excited states is crucial in order to create a well-defined Λ system. To analyze the hyperfine structure (HFS) of the ground state, electron paramagnetic resonance (EPR) spectroscopy is a powerful tool [2]. As for the excited state, the spectral line broadening usually prevents from resolving the HFS in optical spectra. In these cases, the parameters of the hyperfine interaction are determined by calculations. On rare occasions, the optically resolved HFS can be used to verify the validity of these computations. On the other hand, the resent successful demonstration of the gradient echo type optical memory [3] where the bandwidth limitations come from the HFS being unresolved has put forward a task to search for crystals with resolved HFS in optical spectra.

In the recent Letter [4], we have reported on the well resolved HFS of some lines in the optical spectra of KY_3F_{10} :Ho³⁺. The earlier published EPR spectra of this compound have revealed the HFS of the magnetic dipole transition between the ground and the first excited singlet crystal-field states [5]. The present work was performed in course of collaboration of the three scientific groups. It combines a detailed high-resolution broad-band optical spectroscopy study of KY_3F_{10} :Ho³⁺ carried out in the Institute of Spectroscopy RAS, a new more complete EPR investigation performed in the Zavoisky Physical -Technical Institute RAS, and a thorough theoretical analysis accomplished in the Kazan Federal University. Precise crystal-field parameters for Ho³⁺ in KY_3F_{10} are derived, the measured HFS in both optical and EPR spectra is simulated, all the peculiarities of the observed HFS are explained. This work is a good example of a combined approach to studying hyperfine interactions in RE containing materials for quantum informatics.

- B. Lauritzen, N. Timoney, N. Gisin, M. Afzelius, H. de Riedmatten, Y. Sun, R.M. Macfarlane, R.L. Cone, Phys. Rev. B 85 (2012) 115111 (10 pages).
- [2] O. Guillot-Noël, Ph. Goldner, Y. Le Du, E. Baldit, P. Monnier, K. Bencheikh, Phys. Rev. B 74 (2006) 214409 (8 pages).
- [3] M. P. Hedges, J. J. Longdell, Y. Li, M. J. Sellars, Nature (London) 465 (2010) 1052–1056.
- [4] E.P. Chukalina, D.S. Pytalev, M.N. Popova, Phys. Lett. A 375 (2011) 3205–3207.
- [5] B.Z. Malkin, V.F. Tarasov, G.S. Shakurov, JETP Lett. 62 (1995) 811.

In vivo IMAGING WITH PERSISTENT LUMINESCENCE NANOPARTICLES

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Optical imaging is a rapidly developing field of research aimed at noninvasively interrogating animals for disease progression, evaluating the effects of a drug, assessing the pharmacokinetic behaviour of a drug, or identifying molecular biomarkers of disease. A prerequisite of molecular imaging is the development of specific, targeted imaging contrast agents to assess these biological processes. In fluorescence imaging, an external light of appropriate wavelength is used to excite a target fluorescent molecule, followed almost immediately by release of longer-wavelength, lower-energy light for imaging. With the recent development of more sensitive optical sensors and new powerful probes optical imaging can now be considered for *in vivo* studies. *In vivo* optical imaging using fluorescent probes is commonly used but still presents numerous disadvantages. The first one is the autofluorescence from tissue organic components due to constant probe illumination during signal acquisition which often results in poor signal-to-noise ratio.

To overcome these difficulties, we have recently developed inorganic persistent luminescence nanoparticles, which are suitable for *in vivo* imaging and can avoid most of inherent problems. Persistent luminescence nanoparticles possess the ability to store the excitation energy and to emit light for a long period of time, from dozen of minutes to hours. This property is of particular interest for *in vivo* bioimaging applications since it allows complete avoidance of the autofluorescence signal. This lecture will focuses on the work undertaken in our laboratory on the synthesis of several persistent luminescence nanoparticles, their characteristics, the modification of their surface with molecules of interest as well as examples of their use for bioimaging.

- [1] le Masne de Chermont Q. et al., Proc. Natl. Acad. Sci. USA 104, 9266-9271 (2007).
- [2] Maldiney T. et al., ACS Nano 5, 854-862 (2011).
- [3] Maldiney T. et al., J. Am. Chem. Soc. 133, 11810-11815 (2011).

CT LUMINESCENCE OR INCANDESCENCE? IR STIMULATED WHITE EMISSION OF RE DOPED NANOCRYSTALS

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Recently the intense anti-Stokes white emission in highly concentrated RE oxides placed in vacuum was observed under infrared multiphoton excitation with focused beam of laser diode [1-4]. It was found that the rise times of this emission very long dependent on incident light power and concentration of active ions. The intensity of white emission increased by two orders of magnitude in vacuum. The temperature of observed white emission was surprisingly low not exceeding 1000 K. Much higher temperature were reported in upconversion experiments for $Yb^{3+},Er^{3+}:LaF_3$ nanopowders [5,6] and was discussed in terms of black body radiation (incandescence). In present work we present the anti-Stokes white emission measured in several RE doped systems. We argue that an origin of white emission may be well understood as $RE^{3+}CT$ cluster emission.

- [1] J. Wang and P. A. Tanner, J. Am. Chem. Soc. 132 (2010) 947-949.
- [2] J. Wang, J. Hua Hao and P. A. Tanner, Opt. Lett. 35 (2010) 3922-3924.
- W. Strek, L. Marciniak, A. Bednarkiewicz, A. Lukowiak, R. Wiglusz, D. Hreniak, Opt. Express 19 (2011) 14083-14092
- [4] W. Strek, L. Marciniak, D. Hreniak, A. Lukowiak, J. Appl. Phys. 111 (2012) 024305.
- [5] S. Redmond, S.C. Rand, X. L. Ruan, M. Kaviany, J. Appl. Phys. 95, 4069, 2004.
- [6] S. Redmond, S. C. rand, S. L. Oliviera, Appl. Phys. Lett. 85, 5517, 2004.

ACTIVE GLASS CERAMICS FOR PHOTONIC APPLICATIONS

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This talk will overview novel glass ceramics we have developed for photonic applications; solid-state lighting, persistent phosphor, optical amplifier and photovoltaic applications.

- S.Tanabe, S.Fujita, A.Sakamoto, S.Yamamoto, "Glass ceramics for solid-state lighting", in "Advances in Glass and Optical Materials", (Eds. S. Jiang, The American Ceramic Society, Westerville, 2006) pp.19-25.
- [2] S.Tanabe, "Active glass and ceramic materials for green photonics", *International Congress on Glass 2010*, (Salvador, Sept. 2010).
- [3] S.Nishiura, S.Tanabe, "Properties of transparent Ce:YAG ceramic phosphors for white LED", Opt. Mater. 33, (2011) 688-691.
- [4] T.Nakanishi, S.Tanabe, "Novel Eu²⁺-activated glass ceramics precipitated with green and red phosphors for high power white LED", *IEEE. J. Select. Top. Quant. Electron.* 15, (2009) 1171-1176.
- [5] J.Ueda, S.Tanabe, "Preparation and Optical Property of Glass Ceramics Containing Ruby Crystals", J. Am. Ceram. Soc. 93[10], (2010) 3084–3087.
- [6] T.Nakanishi, Y.Katayama, J.Ueda, T.Honma, S.Tanabe, T.Komatsu, "Fabrication of Eu: SrAl₂O₄based glass ceramics using frozen sorbet method", *J. Ceram. Soc. Jpn.* 119[7], (2011) 609-615.
- S.Fujita, S.Tanabe, "Fabrication, microstructure and optical properties of Er³⁺:YAG glassceramics", Opt. Mater. 32, (2010) 886-890.
- [8] T. Murakami, S.Tanabe, "Preparation and 1.3μm emission of Pr³⁺ doped transparent nano-glass ceramics containing SrF₂", J. Ceram. Soc. Jpn. 115, (2007) 605-607.
- S.Tanabe, "Transparent glass ceramics doped with Cr⁴⁺ for a broadband amplifier", 4th DGG Symposium on Novel Optical Technologies (Aachen, June 5, 2007)
- [10] Y.Katayama, S.Tanabe, "Near infrared downconversion in Pr³⁺-Yb³⁺ codoped oxyfluoride glass ceramics", *Opt. Mater.* 33[2], (2010) 176-179.

LANTHANIDE-DOPED NANOPARTICLES: FROM THEIR SYNTHESIS TO APPLICATIONS IN BIOLOGY

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Multiphoton excited luminescent nanomaterials such as semiconductor quantum dots (QDs) or gold nanorods (GNRs) are emerging as useful tools in diagnostic medicine and therapeutics. These nanomaterials are excited with near-infrared (NIR) light mitigating some of the drawbacks associated with the use of UV light as the excitation source. NIR light is silent to tissues thus minimizing autofluorescence, possesses greater tissue penetration capabilities and does not incur damage to the sample. However, these nanomaterials require femtosecond (fs) excitation light to induce the multi-photon excited luminescence.

It is in this regard that there has been an ever-increasing interest in lanthanide (Ln^{3+}) doped upconverting nanoparticles (UCNPs) as an alternative to more common multiphoton excited nanomaterials [1]. With UCNPs, it is possible to obtain UV/visible/NIR emissions using a single NIR excitation source (typically 980 nm) via a process known as upconversion [2]. Upconversion is a multiphoton excitation process, however, unlike conventional two-photon excited materials where the absorption is simultaneous, the multitude of long-lived "real" electronic energy states of the Ln^{3+} ions (from the partially filled 4f shell) allow for sequential absorption of multiple NIR photons eliminating the need for complex and expensive optical excitation.

Here, we present the synthesis of upconverting Ln^{3+} -doped fluoride UCNPs, which are known to have the highest upconversion efficiency amongst UCNPs due to their low lattice vibrational energies (phonon energies) and demonstrate how they can be used in biological applications. However, before these biological studies can performed, the surface of the UCNPs must be modified, first to impart water dispersibility and second to attach chemically and/or biologically relevant molecules. Furthermore, we will show how these UCNPs can be used as building blocks towards developing a multi-modal nanoplatform for the biological imaging and nanothermometry of malignant cancer cells.

^[1] N. Bogdan, F. Vetrone, G. A. Ozin, J. A. Capobianco, Nano Letters, 11 (2011) 835-840.

^[2] F. Vetrone, R. Naccache, A. Zamarrón, A. Juarranz de la Fuente, F. Sanz-Rodríguez, L. Martinez Maestro, E. Martín Rodriguez, D. Jaque, J. García Solé, J. A. Capobianco, ACS Nano, 4 (2010) 3254-3258.

ULTRASENSITIVE AND ULTRAHIGH RESOLUTION FLUORESCENCE SPECTROSCOPY AND IMAGING FOR FUNDAMENTAL BIOMOLECULAR STUDIES AND TOWARDS CLINICAL DIAGNOSTICS

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The focus of our research group at KTH is to develop ultrasensitive and ultrahigh resolution fluorescence spectroscopy and imaging techniques for detection, identification and characterization of biomolecules, and to apply these techniques for biomolecular diagnostics, screening, and for fundamental dynamic and conformational studies of biomolecules and their interactions.

In this presentation, a brief overview will be given of how so-called single-molecule multi-parameter fluorescence detection (smMFD) can be used to detect, identify and characterize biomolecules, and how fluorescence fluctuation analyses, so called Fluorescence Correlation Spectroscopy (FCS), can be used to monitor a wide range of molecular dynamic processes down to a single molecule level. Recently developed FCS modalities will be presented, and how the FCS technique can be used to provide new perspectives on proton exchange and biomolecular interactions in biomembranes.

In clinical diagnostics, fluorescence methods may provide a unique combination of sensitivity, specificity and spatial resolution. For cancer patients, an early diagnosis is typically of utmost importance for the prognosis and treatment outcome. Our research group is coordinating a highly inter-disciplinary European research project (FLUODIAMON) comprising 12 partners, and with the aim to improve early subcellular diagnosis of early disease and disease progression in breast and prostate cancer. By combining ultrahigh resolution imaging of cellular protein distribution patterns using Stimulated Emission Depletion (STED) microscopy, multiparameter characterization of multiple protein expression and interaction patterns in cells by smMFD imaging, and by monitoring intracellular environments and metabolic states via long-lived, non-fluorescent, photo-induced transient states of organic fluorophore marker molecules the aim of the project is to provide new diagnostic parameters, representative for early cancer development, and not within reach by conventional methods. In this presentation an overview of the project and the methods developed for the cellular analyses will be presented.

FAST d-f LUMINESCENCE OF Pr³⁺ IN NEW OXIDE MATERIALS

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Luminescent inorganic materials doped with Pr^{3+} are presently being actively investigated, as they can show strong electric dipole allowed 5d-4f transitions located in the UV and visible regions. These transitions find numerous applications in important technological fields, such as the development of scintillators, converting ionizing radiation to UV and visible emission, and useful for applications in medicine and high energy physics [1].

The search for new materials showing efficient 5d-4f luminescence of the Pr^{3+} ion [2, 3] has led us to the synthesis of several complex oxides and fluorides doped with this ion. In this contribution we will present recent results obtained during this search. Our attention will be focused on the host materials: Ca₉Lu(PO₄)₇ as a bulk powder, and Y₂SiO₅ (X1 and X2) and Lu₂SiO₅ as ultrafine powders.

The synthesis and the structural characterization of these doped materials will be described in detail. Luminescence emission and excitation spectra and decay curves measured using synchrotron radiation will be presented and discussed, together with the prospective applications of these luminescent materials.

Despite the observation of strong and fast 5d-4f emission of the Pr^{3+} dopant in Ca₉Lu(PO₄)₇, a host-impurity transfer does not populate the emitting $4f^15d^1$ configuration upon band-toband excitation of this host. On the other hand, efficient energy transfer from the host to the $4f^15d^1$ levels is found in the ultrafine powders of both phases of the oxyorthosilicate hosts.



Figures. Left panel: time integrated emission spectra of X1- and X2-Y₂SiO₅:Pr³⁺ upon excitation at 240 nm. Right panel: decay curves of Pr³⁺ in X1- and X2-Y₂SiO₅ monitoring 5d-4f emission of Pr³⁺.

- C. Ronda, J. Gondek, E. Goirand, T. Jüstel, M. Bettinelli and A. Meijerink, Mater. Res. Soc. Symp. Proc. 1111 (2008) 1111-D08-01 (11 pages).
- [2] K. V. Ivanovskikh, A. Meijerink, F. Piccinelli, A. Speghini, E. I. Zinin, C. Ronda, M. Bettinelli, J. Lumin. 130 (2010) 893-901.
- [3] K. Ivanovskikh, A. Meijerink, C. Ronda, F. Piccinelli, A. Speghini, M. Bettinelli. Opt. Mater. 34 (2011) 419-423.

PERSISTENT LUMINESCENCE: NEW MATERIALS

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After irradiation with electromagnetic radiation or particles - visible light, UV radiation, electron or plasma beam, X-rays, or even γ -rays - a persistent luminescence material can emit continuously for up to 24 hours [1]. The persistent emission presently covers most of the visible range (Figure) whilst the genuine white light and IR emitting materials are lacking from the color palette. Although the remarkable ability of these materials to store and release energy is recognized, the actual species able to achieve the outstanding performance are not known equally well. The development of new, either more versatile or more adept materials is thwarted by the lack of knowledge of the corresponding mechanisms [2]. The progress in the field takes generally place either by hard and tedious work or by accident.



Figure. The emission color of presently available commercial persistent luminescence materials (left) and the mechanism of the Ti^{3+} doped zirconia (right).

This contribution describes how the present knowledge on the mechanisms of persistent luminescence can be used to design new materials. In addition, the solutions to the obvious and compulsory trends in the materials development, e.g. the substitution of the expensive rare earth containing materials, are suggested based on novel innovations. The growing role of persistent luminescence originating from other than the divalent europium – presently overwhelming in the materials [3] - is emphasized.

- [1] J. Hölsä, Electrochem. Soc. Interface 18(4) (2009) 42-45.
- [2] H.F. Brito, J. Hölsä, T. Laamanen, M. Lastusaari, M. Malkamäki, L.C.V. Rodrigues, Opt. Mater. Expr. 2 (2012) 371-381.
- [3] K. Van den Eeckhout, P.F. Smet, D. Poelman, Materials 3 (2010) 2536-2566.

STUDY OF OPTICAL WAVE TURBULENCE IN FIBRE LASERS

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We present numerical study of optical turbulence using the particular example of a recently created [1], ultra-long Raman fibre laser (Fig. 1). We show that the theory of weak wave turbulence [2] is not applicable in this case. We demonstrate and that sign of the cavity dispersion has a critical impact on the spectral and temporal properties of the generated radiation. For normal fibre dispersion (here IDF – inverse dispersion fibre), we observed an intermediate state with an extremely narrow spectrum (condensate), which experiences instability and a sharp transition to a fluctuating regime with a wider spectrum (Fig. 2), whereas in the case of anomalous dispersion (here SMF - single mode dispersion fibre), the generated spectra became steady after only a few round trips time [4]. We show that the number of longitudinal modes in the laser cavity has an impact on the condensate's lifetime. The smaller the number of modes, the more resistant is the condensate to perturbations.



Fig. 1 Fibre laser system setup



Fig.2 Generated spectra for IDF fibre with normal dispersion (green and blue lines) and for SMF fibre with anomalous dispersion (red lines). Inset picture – power evolution versus round trips.

- J. D. Ania-Castañón, J. D., T. J. Ellingham, R. Ibbotson, X. Chen, L. Zhang, S. K. Turitsyn, Phys. Rev. Lett. 96 (2006) 023902.
- [2] V.E.Zakharov, V.S.L'vov, G.Falkovich, G.Kolmogorov Spectra of Turbulence, Springer-Verlag, Berlin, 1992.
- [3] S.A.Babin, D.V.Churkin, A.E.Ismagulov, S.I.Kablukov, E.V.Podivilov, J. Opt. Soc. Am. B 24 (2007) 1729-1738.
- [4] E.G. Turitsyna, G. Falkovich, V.K. Mezentsev, S.K. Turitsyn, Phys. Rev. A 80 (2009), 031804(R).

THICKNESS EFFECT ON THE PROPERTIES OF CHEMICAL BATH DEPOSITED SnS₂ FILMS

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Tin disulphide (SnS_2) is one of the potential candidates for application in the fabrication of opto-electronic devices such as photovoltaic solar cells and thin film transistors. In this work SnS_2 films were deposited using a simple and economic method, chemical bath deposition (CBD). The effect of film thickness on the physical properties of the layers was studied and the results reported.

Thin films of SnS_2 were grown using CBD process on to sodalime glass substrates. The reaction bath used for deposition contains 10 ml of 8 M stannous chloride $SnCl_2.2H_2O$, 8 ml of 0.5M thioacetamide (C_2H_5NS), 12 ml of ammonia (NH_3), 24 ml of triethanolamine ($C_6H_{15}NO_3$) and double distilled water. The temperature of the reaction bath was maintained constant at 60°C. The influence of thickness of the as-grown films on the composition, structural, morphological and optical properties were respectively studied using X-ray photoelectron spectroscopy (XPS), X-ray diffraction (XRD), scanning electron microscopy (SEM) and optical transmittance versus wavelength spectra.

The XPS spectra indicated the presence of Sn, S in addition to O and C in all the asgrown layers. The XRD patterns revealed the (001) direction of SnS_2 as the preferred orientation with hexagonal crystal structure. Small peaks corresponding to SnS and Sn_2S_3 were also noticed in the XRD spectra. The crystal quality of films was improved with the increase of film thickness and the evaluated crystallite size increased continuously from 26 nm to 38 nm. The surface morphology showed smooth surface without any cracks and the grain size increased with film thickness. The optical studies revealed direct optical absorption in the films and the evaluated energy band gap varied in the range of 2.8 - 3.0 eV with the film thickness. The optical parameters such as the refractive index (n) and the extinction coefficient (k) were also calculated from the optical data. The results will be presented and discussed.



Fig. 1: XRD spectra of SnS₂ films. spectra of SnS₂ films.

Fig.2: Transmittance versus wavelength

THE OPTICAL PROPERTIES OF DOPAMINE-TiO₂ SUBMICRONIC SIZED PARTICLES

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It is highly desirable to induce significant red-shift in the optical absorption edges of TiO₂ phases so that this class of low-cost and environmentally friendly materials can be used as effective optical absorbing materials in photovoltaic cells. This work focuses on studying the formation of charge transfer (CT) complex, between TiO₂ surface and dopamine as surface modifier, that induced significant red-shift of optical absorption in comparison to unmodified TiO₂ particles. For that purpose, the submicronic sized TiO₂ particles were synthesized at 150 °C by means of ultrasonic spray pyrolysis route using two different approaches for powder processing differing on how the precursor solution was made. In the first one, the colloidal source solution of unmodified TiO₂ nanoparticles was used as precursor solution and the particles were additionally modified by dopamine after completing the synthesis procedure. In the second approach, the dopamine modification of source colloidal TiO₂ nanoparticles preceded to powder processing. From Transmission Electron Microscopy (TEM) and Scanning Electron Microscopy (SEM) images it can be concluded that both groups of dopamine modified submicronic spheres have diameter of approximately 430 nm and contain small primary building units (Figure 1a and 1b). The surface structure and optical properties of resulting particles were analyzed using Fourier Transform Infrared (FT-IR) and UV-Vis spectroscopy investigations. The FT-IR measurements show that dopamine successfully formed CT complex at TiO₂ surface. Based on the significant red shift on diffusive reflectance spectra (Figure 1c) it was estimated the effective band-gap value for all observed samples as to be ~1.3 eV.



Figure 1. TEM images of: a) TiO_2 particles obtained at 150 ^{0}C , b) marked region at a higher magnification; and c) diffusive reflectance spectra of unmodified (bare) TiO_2 and dopamine modified TiO_2 submicronic sized particles

PERFORMANCE OF HIGH-EFFICIENCY BUFFER LAYER CdS/CIGS AND ZnS/CIGS SOLAR CELLS

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This work aims at studying copper-indium-gallium-diselenide (CIGS) based solar cells Replacements of conventional cadmium sulfide (CdS) with other buffer layers, such as ZnO, ZnS (O,OH), ZnSe, InS and Zn_{1_x}Mg_xO, have been studied in terms of layer thickness effects. While the CdS based buffer layer showed an efficiency of 21.33% (with V_{∞} of 0.636 V, J_{sc} of 45.7 mA/cm² and fill factor of 0.73) as a reference case, an efficiency of 20.61% (with V_{∞} of 0.635 V, J_{sc} of 44.08 mA/cm² and fill factor of 0.73) has been achieved with ZnS(O,OH) based

buffer layer. It is also found that the high efficiency CIGS cells can be achieved with absorber thicknesses between 2 and 3 μ m. A comparative device analysis between this type of solar cells and the slightly more efficient ZnO/CdS/Cu(In,Ga)Se₂/Mo and ZnO/ZnS/Cu(In,Ga)Se₂/Mo solar cell structure is also provided. Such a comparative study allows elucidation of the areas for optimization in the quest for conversion efficiency above 20% in thin-film polycrystalline solar cells. It also quantifies the gains in current generation due to superior collection at short wavelengths, as well as the somewhat lower voltage and infrared response.

Figure 1 indicates that the optimum thickness for CIGS absorber layer is in the range 3000–4000 nm. While the 1000 nm thickness yielded efficiency values of 20.51% for CdS system (and 19.78% for ZnS), the 4000 nm thickness yielded 21.33 %, (and 20.61%) respectively. At 3000 nm thickness, the



efficiency values were 20.97% and 20.24% for CdS and ZnS respectively, showing a 0.5% efficiency lowering with a decrease in 1000 nm of absorber thickness. On the other hand, increasing the absorber thickness by 1000 nm resulted in only 0.82% (and 0.83) increase in efficiency values. The Figure shows that the V_{OC} and J_{SC} values also increased with increased absorber p-type layer thickness.

The effect of absorber layer thickness on efficiency is presumably due to longer wavelengths of the illumination to be collected which in turn contribute to electron–hole pair generation. The V_{OC} and J_{SC} values are thus increased. Conversely, lower absorber thickness may allow more re-combinations at the back contact of the solar cell. This is because the back contact becomes closer to the depletion layer, and electrons are captured easily by the back contact. Therefore, fewer electrons will contribute to the quantum efficiency of the solar cell and the value for VOC and JSC will be low.

THERMAL MANAGEMENT OF Yb:CaGdAlO₄ 1 μM LASER MATERIAL

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A crucial issue in the field of high power lasers is the management of thermal effects. leading to mechanical distortions, thermal lenses and optical losses of the laser crystal. A suitable candidate for such application should combine a weak quantum defect and good thermomechanical properties in order to limit the heat production in the laser material. In this context, Yb^{3+} :CaGdAlO₄ is a promising new laser material with a very high thermal conductivity (> 6.5 W K⁻¹m⁻¹) allowing high-power diode pumping. High gain and broad emission (> 40 nm) due to site occupation disorder allow this matrix to be well suitable for high power and/or ultrafast laser realization and the material is very competitive between other various oxide laser hosts, for example with the generation of 47 fs-pulses in a bulk configuration. However some problems with the crystal quality still remains and should be improved. The optical quality of CaGdAlO₄ is still perfectible as the single crystal presents color centres. Indeed the coloration is related to a parasitic absorption in the UV and visible range with a residual tail extending in the near IR in the wavelengths where trivalent ytterbium ions absorb and emit resulting to a decrease of the performances. Thermal annealing in a reducing atmosphere after the growth process led to an elimination of color centres. Decreasing the thermal load in high power laser materials could also be achieved by developing new laser architectures such as thin disk, slabs or fibers as seen in Figure 1. Those devices were recently tested with some promising results. Hence, samples of Yb³⁺:CaGdAlO₄ as thin-disk and crystalline fibers were elaborated and the demonstration of laser operation with a 350 µm-thick 2% Yb³⁺:CaGdAlO₄ thin-disk laser is realized, in CW and Q-Switch configuration [1].



Figure 1. Different architectures of CALGO:Yb: single crystal of CaGdAlO4:2% Yb3+ (up left), 350um thin-disk of CaGdAlO4:3,5% Yb3+ (down left), crystal fibers of CaGdAlO4:0.2% Yb (right).

 S. Ricaud, A. Jaffres, P. Loiseau, B. Viana, B. Weichelt, M. Abdou-Ahmed, A. Voss, T. Graf, D. Rytz, M. Delaigue, E. Mottay, P. Georges and F. Druon, Optics Letters, 36, 21, 2011

APPLICATION OF LARGE SIZED SAPPHIRE CRYSTAL IN LED: CRYSTAL GROWTH AND CHARACTERIZATION

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Sapphire crystal with high crystalline property and low reactivity is an excellent host in the semiconductor industry for blue light-emitting diodes (LED) and diode lasers, as well as in extreme environments. During past years, LED market has experienced an unprecedented growth which is generating a strong demand for sapphire substrates for the manufacturing of blue and white GaN based LEDs. The extensive demands of sapphire crystal in quantity and large diameter, from 4 inch to 8 inch, has continuously promoted the development of crystal growth technology such as Kyropoulos method (KY), Edge-Defined Film-Fed Growth method (EFG), Czochralski method (Cz) and Heat Exchanger Method (HEM).

Shanghai Institute of Ceramics, CAS has developed the KY technology for sapphire crystal growth since 2008. Traditionally, the operation of KY furnace is manually controlled and strongly depended on experienced technicians, especially at the seeding stage. As a result, the production yield is relatively low by the traditional KY method. In our newly-established KY furnace, the sapphire crystal growth process is automatically controlled even at the seeding stage. After the growth program commission of crystal growth is set, the growth process can be manipulated by any trained technician. With the improved KY furnace, the sapphire production yield has been increased to 90%. The FWHM was measured to be less than 10arcsec. The average dislocation density is 3.98×10^2 atoms/cm².



85KG sapphire crystal



FWHM<10"



Average Dislocation Density: 3.98×10^2 atoms/cm²

WATER CONDENSATION EFFECT ON SNOM CHARACTERIZATION

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The relevance of SNOM, for near field characterization, is often shaded by the appearance of artifacts, specially when geometrical characterization is intended [1]. Artifacts are related to many features like the feedback system [2] or the scanning mode [3]. Also artifact sources maybe related to tip geometry [4] and pollutants either on the tip or on the studied surfaces altering the optical image, mainly in non-vacuum environmental conditions. Here we present a theoretical study of water nanocondesation effects on different samples, carried out with layers above the substrate and meniscus between tip and sample.

Water can be found as a layer or a neck formed between an emitting SNOM tip and a substrate. To analyze water nanocondensation effects, we use, on one hand a lattice gas model, to study the-thermodynamic and chemical character, together with the geometry of the bridge [5]. And, on the other hand, light propagation through the different involved media is carried out solving the Maxwell equation using a finite difference time domain (FDTD) scheme.

Our study revealed that a few water layers can modify the optical signal and this effect may be enhanced when a water neck is formed between tip and substrate, explaining some of the artifacts in the topological signal usually achieved with SNOM.

Inclusion of water layers may be used as an advantage to characterize the sample, not only in topological characterization but also for chemical characterization, identifying polar patches on surfaces [6].

hydrophobic patch		
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Simulation of the final part of a tip scanning a substrate with different chemical character at high humidity rates, where enhancement of optical signal is observed in the presence of water bridge.

- [1] B. Hetch, H. Bielefeldet, Y. Inouye , D.W. Phol and L. Novotny, J. App. Phys. 81 (1997) 2492-2498.
- [2] R.L. Williamson, L.J. Brerenton, M. Antogonozzi, M.J. Miles, Ultramicroscopy. 71 (1998) 165-175.
- [3] P. J. Valle, J. -J. Greffet, R. Carminati, J. Appl. Phys. 86 (1999) 648-656.
- [4] G. Kaupp, A. Herrmann, M. Haak, J. Phys. Org. Chem. 12 (1999) 797-807.
- [5] P.A. Serena, M. Douas, M.I. Marques, C. Carrasco, P.J. de Pablo, R. Miranda, J.L. Carrascosa, M. Castellanos, and M.G. Mateu. Phys. Status Solidi C 6. (2009) 2128 2132.
- [6] L.-T. Lee, T. Ube, H. Aoki, A. Ito, Polymer. 52 (2011) 5897–5903.

NONLINEAR REFRACTIVE INDEX MEASUREMENT OF NEW TELLURITE MULTICOMPONENT GLASSY MATRIX POSSESSING NONLINEAR SUSCEPTIBILITY BY USING Z-SCAN

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New multicomponent Tellurite glassy matrixes (TeO₂–GeO₂–Li₂O and TeO₂–Bi₂O₃–GeO₂) possessing high nonlinear susceptibility were developed. Their optical properties were study. The nonlinear refractive index n_2 and nonlinear absorption β were measured by using own sub picosecond z-scan method. The second harmonic generation was observed in poled glassy samples (Fig. 1).



Fig. 1 Second harmonic generation (SHG) from a TeO2-GeO2-Li2O sample.

OPTICAL STUDIES IN BRAGG REFLECTORS BUILT FROM ZnO/MgO MULTILAYER FILMS

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ZnO/MgO distributed Bragg reflectors (DBRs) with 10 and 15 periods are grown on silicon substrate by sputtering techniques. In this paper, the experimental and simulate reflectivity spectra are carried out to compare and investigate the optical properties of ZnO/MgO multilayer. The reflectivity spectra at normal indicidence of 10 and 15 periods ZnO/MgO multilayer are shown as opened dots in Figs. 1 and 2. The theoretical reflectivity spectrum is given by the transfer matrix method [1]: $\begin{pmatrix} M_{11} & M_{12} \\ M_{21} & M_{22} \end{pmatrix} = D_0^{-1} \begin{bmatrix} D_H \cdot P_H \cdot D_H^{-1} \cdot D_L \cdot P_L \cdot D_L^{-1} \end{bmatrix}^N D_S$, where D_0 , D_H , D_L and D_S are the dynamic matrices for free space, ZnO, MgO and Si substrate, repectively; P_H and P_L are

the propergation matrices for ZnO and MgO, repectively. The refractive index of

materials varied with the wavelength of light $(n_{ZnO} = \sqrt{1 + \frac{2.60 \times \lambda^2}{\lambda^2 - 211.4^2}}$ and

 $n_{MgO} = \sqrt{1 + \frac{1.86 \times \lambda^2}{\lambda^2 - 100.4^2}}$ [2] and a model of distributed random thickness [3] are used in

the transfer matrix method. The red solid lines in Figs. 1 and 2 are the simulate spectra for 10 and 15 periods ZnO/MgO multilayer. From the experimental and simulate reflectivity results, we demonstrate that the shape of the stop band of reflectivity spectrum would depend on the number of layer pairs and the single layer thickness.



Fig. 1 Reflectivity spectrum of 10 periods ZnO/MgO multilayer.



Fig. 2 Reflectivity spectrum of 15 periods ZnO/MgO multilayer.

- [1] J.L. Shen, C.Y. Chang, P.N. Chen, W.C. Chou, Y.F. Chen, M.C. Wu, Optics Comm. 199 (2001) 155–159.
- [2] C. W. Teng, J. F. Muth, Ü. Özgür, M. J. Bergmann, H. O. Everitt, A. K. Sharma, C. Jin, J. Narayan, Appl. Phys. Lett. 76 (2000) 979–981.
- [3] S. S. Murtaza, J. C. Campbell, J. Appl. Phys. 77 (1995) 3641–3644.

INFLUENCE OF Ni-DOPING ON THE PROPERTEIS OF CHEMICALLY SPRAYED Zn_{1-X}Ni_XO FILMS

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Zinc oxide (ZnO) doped with transition metals like Fe, Co, Ni, Mn found to develop ferromagnetism in it and development of such materials demonstrated their use in spintronic devices. In this work, Ni-doped ZnO films were deposited using a simple and economic process, chemical spray pyrolysis. The properties of the layers were investigated using appropriate characterization techniques and the results discussed.

Ni-doped ZnO thin films were deposited on glass at a substrate temperature of 350 $^{\circ}$ C using spray pyrolysis. The concentration of Ni in the layers was varied in the range, 0 - 15%. 0.1 M solutions of zinc acetate and nickel sulphate were used as the precursors. Compressed purified air was used as a carrier gas at a flow rate of 8 l/min and the solution was sprayed at a flow rate of 6 ml/min. The nozzle to substrate distance was fixed at 20 cm.

The grown layers were uniform, pin hole free and well adherent to the substrate surface. The X-ray diffraction studies indicated that all the grown films were polycrystalline with the (002) plane as the preferred orientation without any secondary phases related to the oxides of Ni and the peak position shifted towards higher diffraction angles with the increase of doping concentration in the films. The structural parameters such as crystallite size, lattice strain and dislocation density were also calculated. The scanning electron microscopy (SEM) studies revealed that the films had hexagonal shaped grains (Fig. 1) and the evaluated grain size varied in the range, 20 - 48 nm. The optical studies revealed a decrease of optical transmittance with the increase of Ni-doping concentration in the films with a red shift of the optical absorption edge. The evaluated energy band gap was found to be direct that decreased from 3.32 eV to 3.05 eV with an increase of Ni-doping concentration in the layers. Magnetic properties of the layers (Fig. 2) revealed paramagnetic behavior at room temperature while at 4.2K the films showed ferromagnetic property with the hysteresis loop.



Fig.1: SEM pictures of Ni-doped ZnO layers with Ni-concentrations: (a) 0%, (b) 3%, (c) 5% (d) 10%.

Fig. 2: M - H curve for a typical $Zn_{0.9}Ni_{0.1}O$ film.

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OPTICAL SIZE EFFECTS IN NICKEL FILMS IN VISIBLE SPECTRAL RANGE

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The classical size effects are considered in metal films of nanometer-range thickness by theoretical and experimental methods. Nickel metal films are considered as an example. It is known that optical characteristics of thin films are dependent on the thickness [1]. There are few experimental demonstrations of this phenomenon but explanations of such effects are only qualitative [2,3]. So, in this work the influence of classical size effects on optical constants of thin (d =5-50 nm) nickel films on thermally evaporated onto quartz substrates is considered. The dispersion of refractive index (Fig. 1) and extinction coefficient was modeled over wide spectral range. Experimental determination of nickel optical constants was carried out by laser ellipsometer (LE) at λ = 632.8 and 488.2 nm because of high accuracy of this kind of ellipsometry. The surface parameters of quartz substrate and nickel films were measured by AFM. Film thickness values were found by AFM an LE. The refractive index and extinction coefficient quantitative dependences on the film thickness were established for the first time. There is a satisfactory agreement between experiment and theory in the framework of the Drude-Lorentz model and theories describing the size effects in thin films with thickness above 8 nm (Fig. 2) [4,5].



2.3 theory 2.2 2.1 2.1 2.1 10 20 30 40 50 thickness, nm

Fig. 1. Dependence of refractive index dispersion on the thickness for nickel films.



- Ch.Wang, D.R. Baer, St.M. Bruemmer, M.H. Engelhard, M.E. Bowden, J. A. Sundararajan, Y. Qiang, Nanosci. Nanotechnol. Lett. 11 (10) (2011) 8488-8497.
- [2] A. Lehmuskero, M. Kuittinen, and P. Vahimaa, Opt. Express 15 (17) (2007) 10744-10752.
- [3] Y.Yin, Y. Pan, S. Rubanov, M. M. Bilek, D.R. McKenzie, Nanosci. Nanotechnol. Lett.1 (1) (2009) 32-36
- [4] A.D. Rakić, A.D. Djurišić, J.M. Elazar, M.L. Majewski, Appl. Opt. 37 (22) (1998) 5271-5283.
- [5] Y-Han-Kao, Phys. Rew. 144 (21) (1966) 405-410.

GROWTH AND CHROMIUM SEGREGATION IN GaSe:Cr SINGLE CRYSTALS

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Due to its high birefringence and nonlinear optical susceptibility the layered ε -GaSe crystals are widely used in the nonlinear optics of IR and THz spectral ranges. Doping of nonlinear optical semiconductors with magnetic elements can be interesting for applications in magnetooptics and spintronics. In the present work, the growth conditions and chromium concentrations allowing to get the GaSe:Cr crystals of optical quality have been studied.

GaSe:Cr crystals (Fig. 1.) were grown by the Bridgman method from melts with chromium contents $C_0 = 0.1, 0.5$ and 0.7 mass %. The growth rate was up to 2.5 mm/h and temperature gradient at the crystallization front were within 6-12 C°/cm. The real concentration of chromium in the crystal C_s as a function of solidified melt fraction g was studied by atomic adsorption spectrometry. Assuming constant efficient segregation coefficient K_{eff} during growth process and high diffusion rates in liquid phase, the segregation in the crystal is described by the expression given in Fig. 2. Basing on fitting of the experiential results with this expression the efficient segregation coefficient of Cr in GaSe (Fig. 2.) was found. The analysis of the experimental data on crystal chemical compounds allow to conclude that at Cr content in the liquid phase less than 0.2-0.3 mass % crystallization equilibrium took place. Above this threshold the grown crystals have macroscopic Cr inclusions. The data are confirmed by the measurements of Hall effect and optical transmission as well as by electron microscopy patterns.



(0.1 mass % Cr in melt).



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A SOLVATOCHROMIC FLUORESECENT SENSOR BASED ON NILE RED ADSORBED ON LAPONITE NANOCLAYS

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The inorganic host of the solvatochromic sensor is Laponite. It is a disk-like hectorite nanoclay with the empirical formula of $Na_{0.7}[Si_8Mg_{5.5}Li_{0.3}O_{20}(OH)_4]$. The average dimensions of the primary particles are about 30 nm in diameter and 1 nm in height [1]. The clay consists of one octahedral sheet of magnesium oxide surrounded by two tetrahedral sheets of silicon oxide. Due to the substitution of Mg^{2+} with Li⁺ a negative charged layer is formed, whose charge needs to be compensated. Na⁺ counter cations are thus located in the interlayers between the particles [2]. The very good swelling behavior in water results in glass clear aqueous dispersions. Even without further surface modifications the dispersions are transparent and very stable at comfortably high concentrations (up to 5 %w).



Figure 1: Sketch of Nile red on the Laponite nanoclay. The clay structure was reconstructed from single crystal date of a Cs-Hectorite [2].

The Laponite's surface properties can be modified to a great extent using cationic tensides like Cetyltrimethylammoniumbromid to offer lipophilic properties or ethoxy silanes with specific functional groups to introduce covalent bonding at the Si-OH groups at the edges.

In this investigation, the adsorbed guest molecule Nile Red serves as a solvatochromic dye [3], i.e. a probe for the polarity and thus the chemical environment of the nanoclaydye hybrid. While Nile Red, widely used as a lipohilic stain in biochemistry, is natively insoluble in water, the highly sensitive absorption and emission properties of the dye can be exploited in aqueous solution via mobilization by the nanoclay as well. Furthermore, the clay adsorbtion of the dye brings forth a significant increase in quantum yield in aqueous solution, which proved to be sensitively responsive to codissolved species. In addition to the solution experiments, transparent Laponite - Nile Red films were prepared and characterized. The exposure of such films to various solvent vapours also led to a broad variation of the optical properties, suggesting their utilization as sensors.

^[1] F. Bergay, B.K.G. Theng, G. Lagaly, Handbook of Clay Science, Elsevier, Amsterdam, 2006.

^[2] J. Breu, W. Seidl, A. Stoll, Z. Anorg. Allg. Chem., 629 (2003) 503.

^[3] see e.g. M. Sutter et al., J. Fluoresc., 17 (2007) 181.

IMPROVEMENT OF THE PHOTORESPONSE BY DOPING NANOPARTICLES IN SERIES OF AZOBENZENE POLYMERS

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Azobenzene polymers (azopolymers) have been extensively investigated for the last three decades because of the high photoinduced birefringence in them and its potential use for optical storage and polarization holography. The observed effect is based on the selective *trans-cis* isomerization and the consecutive reorientation of the *trans* azobenzenes [1]. Many approaches have been used in order to increase the value of the photoinduced anisotropy in these materials – specific designs of the polymer architecture, thermally assisted recording, etc – all aimed at improving the mobility of the azobenzene molecules [2]. Recently it has been reported that doping photopolymers with nanoparticles allows to achieve near 100% net diffraction efficiency in case of conventional holographic recording [3].

Based on this rationale, we have synthesized novel organic/inorganic composite materials by incorporating ZnO nanoparticles (NP) in series of side-chain azopolymers. To characterize the properties of the samples we measured their absorption spectra and thickness. The photoresponse was evaluated by classical polarimetric setup with two crossed polarizers, recording laser at 473 nm and probe He-Ne laser.



Figure 1. Kinetics of photoinduced birefringence in doped and non-doped samples based on one of the investigated azopolymers ($I_{recording} = 400 \text{ mW/cm}^2$, $\lambda = 473 \text{ nm}$).

We observed a considerable improvement of the photoresponse in these composite materials in relation to the pure samples – more than 40% increase of the saturated value of the birefringence and also reduction of the recording time with about 30%. For one of the investigated polymers, we also observed an increase of the photoinduced anisotropy after the exposure has been stopped.

- [1] L. Nikolova, P.S. Ramanujam, Polarization Holography, Cambridge University Press, Cambridge, 2009.
- [2] L. Nedelchev, A.S. Matharu, S. Hvilsted, P.S. Ramanujam, Appl. Opt. 42, (2003) 5918–5927.
- [3] N. Suzuki, Y. Tomita, Appl. Opt. 43, (2004) 2125–2129.

SYNTHESIS, OPTICAL PROPERTIES AND PHOTOSTABILITY OF NOVEL FLUORINATED ORGANIC-INORGANIC HYBRID (R-NH₃)₂PbX₄ SEMICONDUCTORS

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We report on the synthesis and the optical properties of several novel semiconductors $(R-NH_3)_2PbX_4$, where R is an organic group, X is Cl, Br and I. These semiconductors are two dimensional organic-inorganic perovskite (2DOIP) materials and have multiple quantum-well energy level structures. Large exciton binding energies as large as 300 meV are found, leading to a strong photoluminescence at room temperature and applications in optoelectronic devices such as strongly coupled perovskite microcavities. [1, 2] However, a lot of effort is still necessary to find new perovskites with improved properties, for instance higher photoluminescence efficiency and stronger photo-stability, in order to meet up with the requirement of scientific researches and advanced technology.

In this work, we start from the most extensively studied phenylethyl based perovskite and vary the organic components ($R-NH_3^+$), introducing fluorine atoms into the organic part, on the phenyl ring of the amine. We discuss its influence on the self-organization ability and long-term photo-stability of the 2DOIPs. The trends of introducing fluorine atoms on the self-organization and long-term photostability of 2DOIPs are obtained by analyzing photoluminescence experiments. We show that the influence of the fluorine position on the benzene ring is quite important. Among the main families investigated here, two photo-stabilized perovskites: 4FPEPI (p-fluorophenethylamine tetraiodoplumbate) and 5FPEPI (pentafluorophenethylamine tetraiodoplumbate) are successfully found.



Figure 1: 3D structure of the molecule 4FPEPX (X = I or Br or Cl) perovskites.

Figure 2: Photoluminescence intensity as a function of time, under an illumination of 7 mW at 325 nm.

G.Lanty, J.S.Lauret, D.Byrne, E.Deleporte, S.Bouchoule, X. Latosse, *Appl. Phys. Lett.* 95, 81101, 2008.
 Y.Wei, J.S.Lauret, L.Galmiche, P.Audebert, and E.Deleporte. Opt. Express, 20(9):10399-10405, 2012.

MEMBRANE-BASED PLASMONIC NANOCOMPOSITES FOR CHEMICAL OR BIOLOGICAL SENSING

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One of the important applications of subwavelength plasmonic optics is sensing of chemical and biological analytes [1]. Plasmonic sensors are based on tuning of either propagating surface waves (surface plasmon polaritons, SPP) or nonpropagating (localized) ones. The adsorption of analyte modifies the surface refractive index, ensuring ultrahigh sensitivities that may exceed 10^{-8} refractive index units, i.e. 1 ng/cm^2 (0.003 monolayer) [2]. For all plasmonic sensors it is of interest to enhance their selectivity, since their operation is based solely on refractive index sensing, i.e. different materials with similar refractive indexes cause similar outputs.



Fig. 1. Plasmonic structures for chemical. a) laminar structure with porous membrane functionalized by ligand over plasmonic part; b) multifunctional structure with plasmonic lattice integrated with porous membrane.

In this work we propose the integration of active plasmonic part with separator (e.g. membrane or nanomembrane with nanopores) and ligand binding the targeted analyte into a single structure. This may be done by membrane nanocompositing [3], e.g. by lamination (Fig. 1a) or volume structuring/pore formation (Fig. 1b). At the same one may use built-in (nano)pores to augment the effective surface for adsorption and thus vastly increase the amount of adsorbate. For our work we chose macroporous crosslinked copolymers (MCP) which are readily formed into membranes and keep a permanent well-developed porous structure. Particularly we used glycidyl methacrylate (GMA)-based MCP. GMA has already been successfully used for heavy and precious metals adsorption and enzyme immobilization [4]. For the formation of membranes comprising GMA we selected a new method combining traditional immersion precipitation with photopolymerization and crosslinking of functional monomers [5]. Our approach may be extended to other types of chemical and bio sensors.

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- [1] W. L. Barnes, A. Dereux, T. W. Ebbesen, Nature, 424 (2003) 824-830.
- [2] L.S.Jung, C.T.Campbell, T.M.Chinowsky, M.N.Mar, S.S.Yee, Langmuir, 14 (1998) 5636-5648.
- [3] Z. Jakšić, J. Matovic, Materials, 1 (2010) 165-200.
- [4] N. Miletić, Z. Vuković, A. Nastasović, K. Loos, Macromol. Biosci., 11 (2011) 1537-1543.
- [5] P. Radovanovic, M. Kellner, J. Matovic, R. Liska, T. Koch, J. Membrane Sci., 401-402 (2012) 254-261.

ORGANIC/INORGANIC PEROVSKITE-TYPE HYBRID MATERIAL BASED ON PbBr₂ FOR REFLECTIVE COMPUTATIONAL FLUORESCENCE GHOST IMAGING

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In ghost imaging (GI), information of an object reconstructed through measuring second-order of correlation between two different beams of light which, one of them never see the object. Since image of desired object retrieved by one of beams that never strike to object, this advanced imaging is called "ghost imaging". Computational version of this amazing phenomenon has proposed by Shapiro [1], which retrieved ghost images more easily than before.

Imaging of fluorescent objects in computational ghost imaging scheme as a novel approach (to the best our knowledge) is investigated experimentally and theoretically. The considered photo-luminescent material is an organic/inorganic complex based on PbBr₂, which is synthesized in our labs and depends on excitation wavelength, has two luminescence emission lines in blue and green regions. Range of excitation is approximately about 350 nm – 450 nm, results in green emission in 530 nm at room temperature. This proposed photo-luminescent material has capability of illuminating in a sharp emission spectrum. Brilliant and monochrome radiation of this material can retrieve ghost image of objects more efficiently by omitting environmental beams of light which are considered as noises in ghost imaging.



Fig 1. Experimental results from fluorescence CGI. (a) Reconstructed image from 4000 realizations in 32×32 pixels. (b) Reconstructed ghost image in the resolution of 65×65 and the same realization. (c) Ghost image of fluorescent material in the resolution of 130×130 pixels. (d) Image of fluorescent object.

As Fig. 1 shows, changing speckle size has resulted in different contrast of final ghost image. We also studied effects of object size on visibility of final ghost images in order to prove our experimental outcomes according to theoretical fundamentals which were proposed for previous proposed ghost imaging techniques [2]. Advantages of computational fluorescence ghost imaging for future usages in biomedical science, and flexibility of shaping light by SLM and computer, brought us to this conclusion that, replacing this method by earlier ones, many of the previous drawbacks in medical diagnosis can be solved.

- [1] J. H. Shapiro, Phys. Rev. A 78, 061802(R) (2008).
- [2] K. W.Clifford Chan, M. N. O'Sullivan, and R. W. Boyd, Opt. Express, Vol. 34, No. 21 (2009).

THE EFFECT OF THE APPLIED POTENTIAL OF ELECTRODE ON PHOTOLUMINESCENCE AND STRUCTURAL'S PROPERTIES OF ZNO NANOPARTICLS ELABORATED BY ELECTROCHEMICAL ROUTE.

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In this paper, ZnO nanoparticls were directly deposited onto titanium and Indium doped tin oxide (ITO) glass substrates via an electrochemical deposition method from an aqueous solution of Zn(NO3)2 at a low temperature of 65°C for the first time. The effects of the applied potential of electrode of deposition and the flow rate of oxygen on optical properties such as a photoluminescence are investigated.

Fig 1 shows the XRD spectra of zinc oxide thin films (ZnO) deposited at different applied potential of electrode (-1, 3, -1, 2, -1, 1, -1, 0, -0, 9) V The first remark that all the patterns showed three peaks (100), (101) and (002) with different intensity[1][2]. This reveals that the Zinc oxide deposited on ITO have a crystallite structure (wurtzite) with no treatment thermique. The sample deposited at -1,2V electrode potential showed all peaks characterized ZnO with equal intensity for three peaks (100), (101) and (002). But the films deposited at -1,0V electrode potential showed strongly orientation along c-axis, peak (002) with very high intensity.



Fig. 1. X-ray diffraction spectra of ZnO thin films deposited at different applied potentials electrode

[1] N. Shakti, P. S. Gupta Applied Physics Research Vol. 2, No. 1, May 2010

[2] Tingting Ren, Holly R. Baker, Kristin M. Poduska, Thin Solid Films 515 (2007) 7976-7983

VUV EMISSION OF TRIVALENT THULIUM IONS

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The spectroscopy of trivalent lanthanides (\mathbb{RE}^{3^+}) has progressed significantly over the last decades due to the development of new experimental facilities and theoretical models for calculation of $4f^{n-1}5d$ energy level structure and $4f^n \leftrightarrow 4f^{n-1}5d$ transition spectra [1-3]. In the majority of cases the $4f^{n-1}5d \rightarrow 4f^n$ emission originates from the lowest energy $4f^{n-1}5d$ states (i.e. states corresponding to Coulomb interaction of 5d electron with the ground state of residual $4f^{n-1}$ core). Observation of radiative transitions from higher energy (upper) $4f^{n-1}5d$ states is quite uncommon due to a high density of states and high probability of non-radiative decay to the lower $4f^{n-1}5d$ states. Potentially suitable compounds for observation of emission from upper $4f^{n-1}5d$ states of \mathbb{RE}^{3+} are those characterized by wide bandgap, cubic symmetry and low energy of lattice vibrations. The desired criteria are met for $\mathbb{CaF}_2:\mathbb{Tm}^{3+}$ which we thoroughly studied by performing time-resolved VUV spectroscopic measurements and modelling of \mathbb{Tm}^{3+} energy level structure and $4f^{11}5d \leftrightarrow 4f^{12}$ transitions.

We report that Tm^{3+} ions doped into CaF_2 demonstrate fast VUV $4f^{11}5d \rightarrow 4f^{12}$ emission originated from upper $4f^{11}5d({}^4I_{13/2})$ mixed spin (MS) state in addition to previously known emission from the lowest energy $4f^{11}5d({}^4I_{15/2})$ high spin (HS) state. At the same time emission from the lowest energy $4f^{11}5d({}^4I_{15/2})$ low spin (LS) state is not observed due to a rapid non-radiative relaxation to the lower lying HS states bridging a gap of ~614 cm⁻¹ (see figure). Our study provides a detailed analysis of spectroscopy and dynamics of $4f^{11}5d \leftrightarrow 4f^{12}$ transitions in wide temperature and excitation energy range. The experimental results are well supported by theoretical modelling of $\text{Tm}^{3+} 4f^{12}$ and $4f^{11}5d$ energy levels and energies and intensities of interconfigurational $4f^{11}5d \leftrightarrow 4f^{12}$ transitions. Relaxation of $4f^{11}5d$ excited states is analyzed using knowledge of $4f^{11}5d$ energy level structure and competition between radiative and non-radiative processes. In conclusion we present our views on possible further extension of research on higher energy $4f^{11}5d$ states of Tm^{3+} and other RE³⁺ ions.



Figure. Emission spectra of CaF₂:Tm³⁺ recorded in time-integrated mode and within slow and fast time windows (TWs) under synchrotron excitation at 142 nm. Energy level diagram.

[1] M.F. Reid, L. van Pieterson, R.T. Wegh, A. Meijerink, Phys. Rev. B 62 (2000) 14744.

[2] L. van Pieterson, M.F. Reid, M.F. Wegh et al. Phys. Rev. B 65 (2002) 045113.

[3] L. van Pieterson, M.F. Reid, G.W. Burdick, A. Meijerink, Phys. Rev. B 65 (2002) 045114.

THE ORIGIN OF SPECTRAL BROADENING OF PL EMISSIONS IN Nd³⁺-DOPED FLUORBRITHOLITES

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Strontium fluorbritholites, with the general formula $Sr_{10-x}Nd_x(PO_4)_{6-x}(SiO_4)_xF_2$ ($0 \le x \le 6$), have been investigated using Raman scattering spectroscopy as well as luminescence, and lifetime measurement techniques. The analysis by Raman spectroscopy confirmed the incorporation of SiO_4 groups within the apatite lattice, and showed that this incorporation induced a disorder in the structure. This disorder, which increases with increasing content of Nd³⁺ and SiO_4^{4-} , results in a wide variation of the local environment of Nd³⁺ ions. In addition, fluorescent emissions from the ${}^4F_{3/2}$ multiplet were observed. Experimental results showed that the increase of neodymium ions leads to a significant spectral broadening of the Nd³⁺ emission bands (*Figure 1*). The time-resolved luminescence of the ${}^4F_{3/2} \rightarrow {}^4I_{9/2}$ emission was observed under pulsed laser excitation in the ${}^2G_{7/2}$ multiplet ($\mathbb{A}_{exce} = 532$ nm). The decays were shown to be approximately exponential for x= 0.02, 0.5, 5.0 and 6.0, with an associated decay time depending on the Nd³⁺ ion concentration. Whereas, for x values between 1.0 and 3.0, the photoluminescence showed a non-exponential decay which was analyzed with a "two-exponential" function relatively to the two crystallographic sites in the apatite lattice [1]. The existence of new spectroscopic sites as well as a radiation trapping mechanism [2] (self-absorption) has been evoked to explain the broadening effect of Nd³⁺ line-shape.



Figure 1: Normalized emission spectra versus the Nd³⁺ concentration ($\lambda_{exc} = 514 \text{ nm}$).

A. Hassine, N. Jaba, G. Panczer, K. Bouzouita, C. R. Chimie 13 (2010) 1460
 X. Feng, S. Tanabe, T. Hanada, J. Am. Ceram. Soc. 84 (2001) 165.

THE EFFECTS OF POLYMER MOLECULAR WEIGHT ON PERFORMANCE OF SINGLE LAYER PLEDs

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After introducing of poly (p-phenylenevinylene) (PPV) as an emissive layer in a single layer polymer light emitting diode (PLED) [1], poly (n-vinyl carbazole) (PVK) has been one of the well known polymers that is used as a hole transporting and an electron blocking layer. There are some investigations about influence of organic salts [2], weight ratio of PBD (that acts as an electron transport material) [3] and thickness of film [4] on the performance of PVK based single layer PLEDs with ITO/PVK:PBD:TBAPF₆/AL structure. But it has never been investigated the effect of molecular weight in such devices.

In this experimental study, three kinds of poly (n-vinyl carbazole) (PVK) based single layer polymer light emitting diodes (PLED) were fabricated. We used two kinds of PVK with 1100000 (PVK(h)) and 50000 (PVK(l)) molecular weights as host polymers and 2-(4biphenyl)-5-phenyl-1,3,4-oxadiazole (PBD) as an electron transporting small molecule and also terabutylammonium hexafluorophosphate ($TBAPF_6$) as organic salt. We kept fix the weight ratio of PBD and TBAPF₆ in all of cases and investigated the effects of PVK's molecular weight on ITO/PVK(1):PBD:TBAPF6/AL (device A). ITO/PVK(h):PBD:TBAPF₆/AL (device B) and ITO/PVK(h):PBD:TBAPF₆ /AL (device c) structures. Photoluminescence (PL) and electroluminescence (EL) spectra were measured and analyzed by Gaussian fitting and compared with together. All of the emission characteristics were explained via Kalinowski model [5]. We found that PVK molecular weight has a considerable effect on the performance of diodes and their electrical and optical properties are completely different. We also observed a tendency for formation of aggregates (in the EL) and excimers (in the PL) in ITO/PVK(1):PVK(h):PBD:TBAPF₆/AL device (device C) and revealed that this diode has a low work voltage in comparison with (A) and (B) devices and it's EL spectrum covers the visible region (figure 1).



Figure 1. PL and EL of device (c)

- J. H. Burroughes, D. D. C. Bradley, A. R. Brown, R. N. Marks, K. Mackay, R. H. Friend, P. L. Burn, A. B. Holmes, Nature 347(1990), 539
- [2] C.C. Yap, M. Yahaya, M.M. Salleh, Current Applied Physics 9 (2009) 722-726.
- [3] Xuezhong Jiang, Richard A. Register, Kelly A. Killen, Mark E. Thompson, Florian Pschenitzka et al, J. Appl. Phys .91(2002)617.
- [4] C.C. Yap, M. Yahaya, M.M. Salleh, Current Applied Physics 8 (2008) 637-644.
- [5] G. Giro, M. Cocchi, J. Kalinowski, P.D. Marco, V. Fattori, Chem. Phys. Lett. 318 (2000) 137.

TRAP FILLING IN Eu²⁺ AND Dy³⁺ CO-DOPED Sr₂MgSi₂O₇

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The three decisive properties of a persistent luminescence material are: 1) emission color, ii) duration of emission and iii) excitation of persistence [1]. The last one is usually neglected in studies due to experimental difficulties; the conventional excitation spectra of persistent luminescence materials are severely smoothed and deformed. Very recently, a new method, thermoluminescence (TL) excitation spectroscopy [2], was introduced to provide detailed information on the mechanism of trap filling preceding persistent luminescence. Although rather complicated and time consuming, the information obtained is crucial to assess the performance of the persistent phosphor. In many applications, the extension of the excitation range into visible is desirable and this information is readily obtained from the thermo-luminescence excitation spectroscopy. In this work, the blue emitting Eu²⁺ and Dy³⁺ co-doped Sr₂MgSi₂O₇ – one of the best performing persistent luminescence excitation spectroscopy.



Figure. The dependence of thermoluminescence on the type of irradiation (left) and the 3D thermoluminescence excitation spectra of the Eu^{2+} and Dy^{3+} co-doped $Sr_2MgSi_2O_7$ (right).

The TL glow curves (Fig.; left) show strong dependence on the energy of irradiation: with hard UV (but not yet VUV) and β irradiation, a deep trap appears corresponding to a TL band at *ca*. 230 °C. This band is absent with irradiation at 400 nm because weakening fast above 250 °C. Instead, two other bands appear at *ca*. 115 and 175 °C. The duration of persistent luminescence is expected to be longer with irradiation at 230 nm since the deep trap can act as an energy reservoir. The TL intensity increases towards long wavelength irradiation revealing also a distinct band structure, due to the excitation of Eu²⁺ via the 4f⁷ \rightarrow 4f⁶5d¹ transitions (Fig.; right). Four distinct bands (out of five) are observed though strongly overlapping as usual. The splitting of the 4f⁶5d¹ configuration – partly due to the fine structure within each band - is quite large and thus TL emission is obtained with irradiation close to 500 nm. This is very promising when considering the daylight operation of this disilicate phosphor.

- H.F. Brito, J. Hölsä, T. Laamanen, M. Lastusaari, M. Malkamäki, L.C.V. Rodrigues, Opt. Mater. Expr. 2 (2012) 371-381.
- [2] A.J.J. Bos, R.M. van Duijvenvoorde, E. van der Kolk, W. Drozdowski, P. Dorenbos, J. Lumin. 131 (2011) 1465–1471.
- [3] H.F. Brito, J. Hassinen, J. Hölsä, H. Jungner, T. Laamanen, M. Lastusaari, M. Malkamäki, J. Niittykoski, P. Novák, L.C.V. Rodrigues, J. Therm. Anal. Calorim. 105 (2011) 657-662.

INVESTIGATION OF IMPURITY-TRAPPED EXCITONS IN TWO SITES OF Yb²⁺ DOPED NaMgF₃ USING FEL AND SYNCHROTRON RADIATION.

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NaMgF3 doped with divalent ytterbium forms impurity-trapped excitons on two different charge compensation sites [1]. An electron excited from a 4f to a 5d orbital becomes partially delocalized to form the impurity-trapped exciton [2]. We have developed a two-colour excitation technique to investigate the structure of these excitonic states by first creating the exciton with a UV pulse and then using IR radiation from the Dutch free electron laser (FELIX) to probe the intra-excitonic transitions [3,4]. Two-colour excitation of NaMgF3:Yb2+ shows that the energy level structure and dynamics of the impurity-trapped excitons vary for the two sites.

To better understand the 4f14-4f135d transitions of the Yb2+ ions at each of the sites, we have recorded VUV excitation and emission spectra at the SUPERLUMI station at HASYLAB (DESY). A semi-empirical crystal-field model is used to analyse the excitation spectra, giving us information about the interaction of the 4f135d states with the surrounding crystal ligands.



Figure 1: The VUV excitation spectrum of NaMgF₃:Yb²⁺ recorded at DESY. The peaks below 60,000cm⁻¹ are 4f^{N-}4f^{N-15}d transitions which can be simulated using semi-empirical crystal field calculations. The peak at 90,000cm⁻¹ is caused by the intrinsic NaMgF₃ exciton and the band edge starts at around 100,000cm⁻¹.

- [1] S. Lizzo, A. Meijerink G. J. Dirksen and G. Blasse, J. Phys. Chem. Solids 56, (1995) 959.
- [2] P. Dorenbos, J. Phys. Condens. Matter 15, (2003) 2645.
- [3] M. F. Reid, P. S. Senanayake, J.-P. R. Wells, G. Berden, A. Meijerink, A. J. Salkeld, C.-K. Duan and Roger J. Reeves, Phys. Rev. B 84, (2011) 113110.
- [4] P. S. Senanayake, J.-P. R. Wells, M. F. Reid, G. Berden, A. Meijerink, and R. J. Reeves, App. Phys. Lett. 100 (2012) 041902.

CATHODOLUMINESCENCE OF Gd₂SiO₅ CRYSTALS

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It is necessary to study the physical processes occurring in the scintillation crystals to improve the parameters of scintillation materials. Knowledge of the relaxation processes allows choose the matrix and impurity with necessary energy states. Cathodoluminescence (CL) of Gd_2SiO_5 , irradiated at 5.4 K (1) and 293 K (2) was measured by us (Fig.1)



Figure 1-Spectrum of CL Gd₂SiO₅: Gd₂SiO₅: at5 ,4 K(1), at 293 K (2)

Figure 2- spectrum of phosphorescence 1-at 5,4 K; 2 - at 413 K

Phosphorescence (PhL) was measured after irradiating with electronic beam at 5.1 K(Fig.2, curve 1), and after heating up to 413 K (curve 2). Thus, there are three emission bands associated with the relaxation of intrinsic electronic excitations in the irradiated crystal Gd₂SiO₅. What is the nature of the luminescence of Gd₂SiO₅? It is known that the band 3.95 eV associated with the emission of ion Gd^{3+} . There are two emission bands with maximums of 2.0 eV and $2.5 \div 2.7$ eV at low temperatures. Emission band $2.5 \div 2.7$ eV must correspond to [1] the emission of the triplet selftrapped anionic excitons. At room temperature, this band is extinguished and is absent in the spectrum of CL. The emission with a maximum of 2.0 eV is partially present in the spectrum at 8K under photoexcitation[1]. We assume that this emission band as well as in other oxygen-containing oxyanion crystals should correspond to the tunnel or recombination radiation occurring in the electronic-hole capture centers in their grid. Both emission bands are present in the PhL of the irradiated Gd₂SiO₅. PhL is present in systems where correlated electronic and hole trapping centers are generated. It is present in the spectrum 1.5-2.5 eV of Gd₂SiO₅ which is annealed to 413 K and irradiated with electrons. This experimental fact confirms the existence of radiation defects in irradiated Gd_2SiO_5 up to these temperatures. On the grounds of above facts, we can assume that the emission arising in the spectral range 2.0-2.2 eV should correspond to electron transitions between the correlated electronic-hole trapping centers.

 V.U. Ivanov, E.S. Shlygin, V.A. Pustovarov, V.V. Mazurenko, B.V. Shulgin, Fizika tverdogo tela, 50, 9 (2008)1628-1634.
EXPLOITATION OF ENERGY TRANSFER CHANNELS IN RARE EARTH DOPED POLYMERS

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Rare earth β -diketonate and carboxylate complexes, especially those containing Eu³⁺ and Tb³⁺, belong to the most extensively investigated ones for optical applications, e.g. in fiber amplification and lasing, safety marking (both, emergency and anti-counterfeit), as downconverters in light emitting diodes (LEDs), and as primary emitters in organic light emitting diodes (OLEDs), thanks to the "antenna effect", which has been well described in the literature. However the poor solubility due to their polymeric nature has prevented their incorporation into nonpolar polymer matrices such as silicones (polydimethylsiloxanes).

In this work, the modification of these complexes by co-coordination with trioctylphosphine oxide (TOPO) as neutral ligands is described. Highly transparent composite materials, obtained by the incorporation of the modified complexes into silicone matrices, are presented. The luminescence properties of the hybrid systems, which even exceeded the pure complexes with regard to efficiency, are reported.



Figure: Left: Photographic images of silicone samples (from left to right: C460, Tb^{3+} , Eu^{3+}) with and without broad UV excitation. Right: Schematic sketch of the possible energy transfer (ET) channels in rare earth complex - Coumarin C460 mixtures.

In lack of an efficiently blue emitting metalloorganic rare earth complex, we have furthermore attempted to introduce the blue emitting dye coumarin (C460) as a third RGB component to increase the accessible colour gamut. Not unexpectedly, fluorescence resonant energy transfer (FRET) complicates the desired color adjustment: addition of C460 enhances the red emission of the Eu³⁺ complexes, while it acts as an effective quencher of the green emission in mixtures with the Tb³⁺ complex. The differenct interactions are attributible to the dissimilarity of the ligand triplet states as well as different energy transfer channels within the systems, which is confirmed by decay time measurements.

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[1] T. H. Tran, M.M. Lezhnina, U. Kynast, J. Mater. Chem., 21(2011) 12819.

ELECTRIC FIELD ENHANCEMENT IN SILICON SEGMENTED MICRORING RESONATORS

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A novel waveguide structure confining light in a very thin low index slot region was proposed recently [1]. These slotted waveguides consist of a nanometer-sized low index region (e.g. air, SiO₂) in between two high index regions (e.g. Si). The optical field in such a structure tends to propagate mainly within the center of that waveguide. A great variety of optical devices has been recently proposed or fabricated by using slot waveguides: label-free biochemical sensors, microring resonators, optical modulators etc. [2]. The system analyzed here is shown in Fig. 1. It consists of a segmented (36 segments) ring and a bus waveguide made of silicon on SiO₂ substrate. The presence of the substrate makes this configuration inherently three-dimensional, since it destroys the vertical symmetry. The parameters of the system are: ring outer radius $R_1 = 2.25 \,\mu$ m, ring inner radius $R_2 = 1.75 \,\mu$ m, ring height $b = 0.405 \,\mu$ m, waveguides width $a = 0.55 \,\mu$ m, while the gaps between the bus waveguide and the ring and between segments are 60 nm.



Figure 1. Horizontaly coupled bus and segmented ring wavegudes



Figure 2. The electric field in the horizontal plane

The result presented here are obtained using fully vectorial 3D finite element calculations. The second-order edge elements are used, and the computational domain is closed using standard perfectly matched layer (PML) method. The calculations are performed in the frequency domain, and modal driven approach is used. The input port is excited by the fundamental mode of the waveguide connected to it. In Fig.2 the magnitude of the electric field in horizontal plane cutting waveguides at the half of the heights is shown, for the frequency of f=186.5 THz corresponding to the absolute minimum of the optical power transmission coefficients through the bus waveguide. The results show that the significant part of the optical field is confined in the gaps between segments, which can be potentially very important for sensing applications.

[1] V. Almeida, Q. Xu, C. A. Barios, and M. Lipson, *Optics Letters* 29 (2004) 1209–1211.

^[2] C.Barrios, Sensors 9 (2009) 4751-4765.

PHOTO-POLYMERIZATION AND PHOTO-GRAFTING VIA MULTI-PHOTON ABSORPTION PROCESS USING ULTRASHORT LASER PULSES

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Utilization of multi-photon absorption employing near infrared ultrashort laser pulses has led to important advances in photo-fabrication. Here, we present the Z-scan [1] results on precise evaluation of multi-photon absorption (MPA) cross section for various synthesized photo-initiators (PIs) used for two-photon induced polymerization (TPIP) and aromatic azide, selected for photo-grafting. We also report on the real 3D micro-structuring by means of TPIP [2] and three-photon grafting [3]. Z-scan measurements revealed the prodominance of two-photon absorption (2PA) in all photohighest cross section of 440 GM initiators with the in 2,7-Bis((4-(dibutylamino)phenyl)ethynyl)-9H-fluoren-9-one (B3FL). The predominant nonlinear in the 2,6-bis(4-azidobenzylidene)-4-methylcyclohexanone (BAC-M), absorption selected for photo-grafting, was determined three-photon absorption (3PA) ensuring finer structural resolution due to the higher dependence on the laser light intensity. In order to estimate the activity of the PIs, many different complex 3D structures were fabricated by means of TPIP exploiting different PIs. Structuring test indicated that B3FL is the most active PI as its 2PA cross section was measured the biggest by the Zscan technique. 3D shapes were also successfully created in polymeric materials via immobilization BAC-M molecules by means of 3PA grafting.



Fig. 1. (A) Shows Z-scans of BAC-M for different pulse energies, (B) exhibits a SEM image of a polymeric micro-lens realized by TPIP and (C) displays a fluorescent image of a woodpile pattern produced via three-photon grafting (showing the lateral resolution of around $4 \,\mu$ m)

- [1] A. Ajami, W. Husinsky, R. Liska, N. Pucher, Journal of the Optical Society of America B: Optical Physics, 27 (2010) 2290-2297.
- [2] S. Maruo, J.T. Fourkas, Laser and Photonics Reviews, 2 (2008) 100-111.
- [3] A.J. Gross, S.S.C. Yu, A.J. Downard, Langmuir, 26 (2010) 7285-7292.

TWO-PHOTON EXCITED FLUORESCENCE LOCAL PROBING IN POLARIZED LIGHT BELOW OPTICS DAMAGE, UNDER TIGHT FOCUSING IN THE LYB:Eu MONOCLINIC CRYSTAL

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Direct laser writing (DLW) has largely developed this last decade [1], which led to localized 3D micro-structuring and innovative photonics applications in glasses as Bragg nano-gratings, optics waveguides, or perennial high density data storage [2] Most of these laser/matter interactions were performed in initially isotropic glasses, and the resulting laser-induced properties sometimes introduce a anisotropic optical response as radial birefringence [3], form birefringence, oriented nano-crack structures, or effective second-order nonlinear properties resulting from space charge separation [4]. Up to now, very little works in DLW were performed on intrinsically anisotropic materials as biaxial crystals.

Here, we report on preliminary observations and specific optics behavior to future DLW in low symmetry crystals. By tightly focusing a near-IR femtosecond laser beam in a monoclinic biaxial crystal LYB doped with Eu³⁺ ions, for propagation direction along the crystallographic c-axis with intensities below material modification thresholds, we performed two-photon excited fluorescence in polarized light, which led to the production of two distinct nonlinear emitting focuses that could selectively be addressed with the pump polarization control. Due to spatial walk-off effects on both the pump beam and the epi-collected fluorescence emission, four distinct polarization schemes were performed, providing four related fluorescence features (figure 1).



Figure 1: CCD images of the two-photon excited epi-fluorescence in polarized light for both the pump laser beam and the collected beam. Polarizations o and e stand for the ordinary and extraordinary modes, respectively, for both the pump and the epifluorescence beams. (a), (b), c and (d): polarization schemes with oo, oe, ee and eo polarization modes for the pump and the epi-fluorescence beams, respectively.

We also report on the fluorescence dependence in polarized light with the pump polarization orientation, partial nonlinear absorption saturation due to the partial depletion of the Eu³⁺ ground population, as well as the related modelling. Fluorescence spectral distributions were also measured, showing significant polarization dependences.

These findings introduce the fact that intensity thresholds for DLW in such crystals are to be highly dependent of crystal orientation and polarization direction, these thresholds needing thus extra-care and optimization. Moreover, the two-photon excited fluorescence opens valuable tool for local 3D micro-probing of luminescent crystals, so as to scan possible alterations due either to undesired material aging or to local DLW modifications, or even to probe inhomogeneities of potential laser crystals for orange laser emission[5].

^[1] R. R. Gattass and E. Mazur, "Femtosecond laser micromachining in transparent materials," Nature Photonics 2, 219-225 (2008).

^[2] A. Royon et al, "Femtosecond Laser Induced Photochemistry in Tailored Materials," Nature Photonics 2, 219-225 (2008).

E. Brasselet et al, "Dense arrays of microscopic optical vortex generators from femtosecond direct laser writing of radial birefringence," Appl. Phys. Lett. 100, 181901 (2012).

 ^[4] J. Choi et al, "Three-dimensional direct femtosecond laser writing of second-order nonlinearities in glass," Opt. Lett. 37(6), 1029-1031 (2012).

 ^[5] I. Manek-Hoenninger et al, "Potential of the Eu:LYB crystal as a laser material for DPSS lasers emitting at 613 nm," Proc. SPIE 8235, 82351A (2012).

MODELING OF THE PERFORMANCE OF III-NITRIDE BASED QUANTUM DOT LASER

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Nitride–based quantum dots (QDs) can be potentially engineered to emit light with range frequency from the infrared to ultraviolet easily by modifying the dot size and composition[1-3]. Although there are many reports about QD lasers, but the discrepancy between theoretical expectations and experimental results still exists, especially in the respond dynamic performance aspects [4].

In this paper we have tried to analyze fully numerically the performance of III-nitride based quantum dot laser with including the effects of QD size inhomogeneous broadening, temperature, the polarization fields, and different carrier scattering mechanisms, using self-consistent calculation of a develop rate-equations and Schrodinger equation.

The calculation results show that with increasing of length cavity, the maximal gain increases and output power decreases, although the optical gain has a weak dependence on length cavity and increases slightly with increasing the length cavity (Fig. 1). Also the results show that, at room temperature, by increasing the magnitude of the homogeneous broadening, lasing spectra will be narrower. Even for high homogeneous broadening, lasing occurs from the top of spontaneous emission, leading to a very narrow line dominated by central mode. The almost single-mode lasing is maintained even at higher currents.



Fig.1. (a) Calculated material gain spectra of QD laser at different temperature,(b) light-emission spectra at homogeneous broadening of 5meV and inhomogeneous broadening of 20 meV.

[1] M. Mexis, S. Sergent, T. Guillet, Opt .Lett 36(2011)2203-2205.

[2] M.Sugawara, K.Mukai, Phys.Rev.B 61(2000) 7595-7603

[3] A.Sakamoto, M.Sugawara, Photonics Technology Letters, IEEE, 12 (2000) 107 - 109.

[4] L.W.Shi, Y.H.Chen, Physica E 39 (2007) 203-208.

THE DARK CURRENT OF THE INFRARED PHOTODETECTOR BASED ON MULTI LAYER ARMCHAIR GRAPHENE NANORIBBONS

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There has been a great deal of recent interest in the optoelectronic device based on planar carbon structures, which have unique electronic and optical properties. Although a 2D graphene is semimetal and hence always electrically conductive, what makes it attractive for electronic application is the fact that its band gap can be opened up by imposing quantum confinement in one direction. The quasi one dimensional strips of graphene, called graphene nanoribbon (GNR), has been intensively explored for potential application of optelectronic devices like IR photodetector, field effect transistor, and solar cell [1-3].

The edge shape of nanoribbons dictates their classification in Armchair (A) and Zigzag (Z) ones. In general, Z-GNRs have metallic behavior, but graphene nanoribbon with armchair edge (A-GNRs) have oscillating behavior between metallic and semiconductor [4].

In this paper we study the dark current of IR- photodetector based on A-GNR, and its dependence on Gate voltage, width of nanoribbon, and temperature. In this calculation the energy gap for different families of A-GNR with considering the edge deformation has been calculated using tight- binding model, then the optical absorption by using the single electron approximation is obtained. Knowing the optical absorption, quantum efficiency and the responsivity, the dark current has been found by calculating the interband tunneling and the thermogeneration rate due to scattering rate in graphene nanoribbon including optical and acoustic phonon and Line Edge Roughness (LER) scattering.



Fig.1. Dark current of single layer A-GNR based IR photodetector as a function of gate voltage (a) and Nanoribbon width (b).

[1] P. Sutter, Nat. Mater., 8, (2009) 171 - 172.

- [2] V. Ryzhii, M. Ryzhii, V. Mitin, M.S. Shur, Appl. Phys. Express, 2, (2009) 034503.
- [3] M. Cheli, G. Fiori, and G. Iannaccone, IEEE Trans. Elec. Dev. 56, (2009) 2979.
- [4] E. Ahmadi, A. Asgari, Procedia Eng. 8 (2011) 25-29.

AB-INITIO CALCULATIONS OF THE STRUCTURAL AND ELECTRONIC PROPERTIES OF NaCrSi₂O₆ AND LiCrSi₂O₆

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Electronic absorption spectroscopy of two Cr^{3+} -bearing systems (NaCrSi₂O₆ and LiCrSi₂O₆) was studied recently in Ref. [1]. The experimental absorption spectra of these two hosts were analyzed and assigned, the Racah parameter *B* was extracted from those spectra; the pressure effects on the optical spectra were also considered. Since the Cr^{3+} ions initially belong to the crystal lattice, the chosen systems give a good opportunity to study the optical properties of Cr^{3+} ions in the octahedral environment, without any need for accounting for relaxation effects, which are unavoidable after doping.

In the present work we studied both NaCrSi₂O₆ and LiCrSi₂O₆ crystals using the CASTEP module [2] of Materials Studio package [3]. After having optimized the crystal lattice structures, we calculated the electronic band structure, density of states (DOS) and optical properties of these materials. In particular, a special attention was paid to the position of the Cr³⁺ 3d states.



Fig. 1. Calculated DOS diagrams for NaCrSi₂O₆ (left) and LiCrSi₂O₆ (right).

As an example of the performed calculations, Fig. 1 shows the DOS diagrams (related to the valence and conduction bands) for both considered crystals. Two well resolved peaks in the chromium 3d states distribution can be unambiguously interpreted as the t_{2g} and e_g states, which are separated by 10Dq (crystal field strength). Estimations of 10Dq from Fig. 1 yield the value of about 15300 cm⁻¹, in good agreement with the experimental data of 15700 cm⁻¹ [1]. In addition, dependence of 10Dq and interionic distances on hydrostatic pressure was also modeled.

- M.N. Taran, H. Ohashi, K. Lamger, A.A. Vishnevskyy, Phys. Chem. Minerals 38 (2011) 345–356.
 M.D. Segall, P.J.D. Lindan, M.J. Probert, C.J. Pickard, P.J. Hasnip, S.J. Clark, M.C. Payne, J. Phys.: Condens. Matter 14 (2002) 2717.
- [3] http://accelrys.com/products/materials-studio/

STRUCTURE AND OPTICAL PROPERTIES OF ONE-DIMENSIONAL ZnS NANOSTRUCTURES SYNTHESIZED USING A SINGLE EVAPORATION PROCESS

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ZnS nanostructures with different morphologies and microstructures were synthesized using a single thermal evaporation process. The microstructure and photoluminescence properties of the ZnS nanowires produced in four different temperature zones were examined. Scanning electron microscopy showed that as the substrate temperature decreased, the morphology of the ZnS nanowires changed from a longer curved morphology to a shorter earth worm-like morphology. Photoluminescence spectroscopy revealed a decrease in emission intensity with decreasing substrate temperature. ZnS nanostructures synthesized in temperature zones 2, 3 and 4 (~900, ~800, and ~700 °C, respectively) showed green emission, whereas those synthesized in temperature zone 5 (~600 °C) showed yellow emission. The origins of the emissions are also discussed.

[1] T. V. Prevenslik, J. Lumin. 1210 (2000) 87-89.

[2] T. Yamamoto, S. Kishimoto and S. Lida, Physica B 308 (2001) 916-919.

GAUSSIAN WAVE PROPAGATION IN ALTERNATING POSITIVE AND NEGATIVE COUPLING WAVEGUIDE ARRAYS WITH SATURABLE NONLINEARITY

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The coupling in waveguide lattices is due to light electric field leakage and is mathematically defined as a specific overlap integral between the linear modes of adjacent waveguides. So far the sign of coupling parameter has been considered positive in most of the works in this area [1], where the portion of electric field penetrate to first adjacent neighbours are in phase with itself. More recently, an alternate positive/negative coupling has also been proposed in Kerr media [2].

In this article, propagation of a Gaussian beam in arrays of waveguides with alternating positive and negative coupling (AC) in presence of saturable nonlinear phenomenon is studied numerically and compared to homogenous positive coupling (DC) case [3].

One-dimensional discrete nonlinear Schrodinger equation for the waveguide with saturable nonlinearity reads as [2,3]:

$$i\frac{dE_{n}}{dz} + \alpha^{n}\kappa(E_{n-1} - E_{n+1}) - \beta\frac{E_{n}}{1 + |E_{n}|^{2}} = 0$$
(1)

Where the field amplitude in nth waveguide is E_n , κ is coupling coefficient between n-1 and nth guide where α is equal to 1 for DC and is -1 for AC coupling respectively. z is the propagation coordinate and β is saturable nonlinearity parameter which is related to electro-optic coefficient. Runge-Kutta method is used in order to solve coupled equations (1) and to simulate propagation of Gaussian beam with complex profile $A(n) = A_0 \exp[-(n - n_0)^2/w^2]e^{iqn}$. Here q is initial phase difference of waveguides which is caused by input beam tilt angle.

Figure-1 shows lateral distribution of outgoing intensity after passing through 6cm long waveguide for continuous increasing Gaussian beam amplitude A_0 .



Fig.1- Numerically calculated dependence of the output beam profile on the input beam amplitude for normal (q = 0) and awry $(q = \pi/2)$ incidence in AC coupling in (a) and (b) and in DC coupling in (c) and (d) respectively. (Parameters: $w = 1, \beta = 36.2, \kappa = 2$).

Plots indicates deep differences in their behavior for different q and A_0 value as well as

required input intensity to provide soliton propagation.

[2] Nikolaos K. E, et. al., Phys. Rev. A 81 (2010) 053817.

[3] Milutin Stepic, et. al. Phys. Rev E 69 (2011) 066618.

^[1] Lederer. F, et. al.; Phys. Rep. 463 (2008) 1–126.

THE EFFECT OF ANGLE FLUCTUATIONS IN MULTI-SHG PROCESS OF TWO-DIMENSIONAL APERIODIC OPTICAL SUPERLATTICE

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Second harmonic generation (SHG) has a particular importance in the generation of new laser sources. Various one and two dimensional periodic, aperiodic optical superlattice (AOS) and non-periodic optical superlattices (NOS) are utilized in the generation of new frequencies in one and multi-frequency (MF) processes in SHG [1-3]. Phase-matching has critical role in the output efficiency of nonlinear interactions. In optical superlattices the phase-matching condition is maintained by the appropriate definition of reciprocal wave vectors with proper arrangement of the orientation of second order nonlinear susceptibility along the nonlinear crystal. Mentioned method is so called quasi-phase-matching (OPM) in the nonlinear optics. In the periodic crystals the arrangement of layers obey periodic pattern whereas, in the AOS the length of blocks is of one or multiple fixed length and in the NOS the domain size restriction is removed such that the domains size is non-equal along the crystal. Recently, AOS is studied in order to generation of MF in SHG in one and two dimensional crystals [1, 5, and 6]. In MF process the multiple OPM is maintained simultaneously and the definition of realizable designing of AOS is necessary. Different optimization methods like Genetic Algorithm (GA) and Simulated Annealing (SA) are utilized in order to finding a suitable AOS in the nonlinear interactions in one and two-dimensional crystals. The reduced effective nonlinear coefficient depends on parameters such as length of domains, temperature, refractive index and angle between interacting waves such that fluctuation of each of these parameters has considerableand critical role in the efficiency of processes. One of the noticeable parameters in this case is the angle between interacting waves in SHG. In this Paper, the presence of fluctuation in the angle between fundamental and SH generated waves in SHG process is studied theoretically in 2dimensional AOS and the role of this fluctuation on the output efficiency is investigated. By considering the effect of fluctuation on the angle between fundamental and generated second harmonic waves in the optimized 2-dimensional structure it is deduced that the value of

 $d_{\rm eff}$ decreases as the amount of fluctuation increases.



Fig. (a). The gray-scale diagram of the 2dimensional nonlinear AOS. The black and white strips show the negative and positive segments respectively. (b). The behavior of the reduced effective nonlinear coefficient in nonlinear 2-dimensional AOS structure for assumed five initial waves with respect to u and v which arecoefficients of the reciprocal lattice vectorsin x and y directions respectively. The assumed length of nonlinear segments in x and

- M. Lu and X. Chen, "Multiple Quasi-phase matching in Engineered Domain-inverted optical superlattice", Journal of Nonlinear optical physics and Materials, 16, No. 2, 185-198 (2007).
- [2] M. Nemati, R. Kheradmand, M. Rezaei, G. Yu. Kryuchkyan, N. Sang Nour Pour and M. Goalipour, Multiple quasi-phase-matching in one dimensional periodically poled optical superlattice, to appear in J. Phys. B: At. Mol. Opt. Phys.
- [3] D. S. Hum and M. M. Fejer, "Quasi-Phasematching", C. R. Physique, 8, 180-198 (2007).
- [4] J. Y. Lai, Y. J. Liu, H. Y. Wu, Y. H. Chen and S. D. Yang, "Engineered Multiwavelength conversion using nonperiodic optical superlattice optimized by genetic algorithm", Optical Society of America, 18, No. 5, 5328 (2010).
- [5] L. Chen, X. Chen, Y. Chen and Y. Xia, Phys. Lett. A. 349, 484-487 (2006).
- [6] B. Y. Gu, Y. Zhang and B. Z. Dong, J. Appl. Phys. 87, 7629 (2000).

FAST GHOST IMAGING AND GHOST ENCRYPTION BASED ON DISCRETE COSINE TRANSFORM

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Computational ghost imaging (CGI) is an advanced imaging technique that obtains image of objects non-locally, through utilizing one single-pixel detector instead of taking advantage of expensive imaging sensors like: couple charge device (CCD) [1]. Imaging and encryption of computational ghost images is investigated experimentally and theoretically. We encrypt/decrypt ghost images thorough conventional algorithm experimentally. Employing discrete cosine transform (DCT) as an advanced compression tool for sparse images, we simulate and encrypt ghost images. Reconstructing ghost images in lesser time consumption and decreased amount of measurements are the main objectives in improved method of CGI. In order to discuss advantages of this technique we compare outcomes from experimental results and simulated ones.



Fig 1.Experimental and simulated outcomes from CGI.

In Fig. 1(a) to (d) decrypted ghost images for 5%, 10%, 15% and 100% of eavesdropping from secret key are shown respectively which is in agreement to previous reported paper [2]. In Fig. 1(e) our experimental speckle pattern on spatial light modulator depicted in size of 65×65 pixels and, Fig. 1(f) is DCT version of original image that is depicted in Fig. 1(h). We retrieved ghost image in DCT algorithm from 1000 measurements [Fig. 1(g)] which has better contrast and retrieval time in comparison to conventional CGI. Enormous amount of measurements should be done in conventional CGI algorithm to reconstruct faithful ghost image of an object that usually is about 5000 measurement. So, we propose a novel optical process which can retrieved ghost images more quickly. Based on novel experimental setup which we proposed recently [3], one can obtain DCT ghost images experimentally. Imaging and encrypting DCT ghost images by pure gray-scale CGI is our next objective.

- [1] J. H. Shapiro, Phys. Rev. A 78, 061802(R) (2008).
- [2] P. Clemente, V. Durán, V. Torres-Company, E. Tajahuerce, J. Lancis, Opt. Lett. Vol. 35, No. 14 (2010).
- [3] M. Tanha, R. Kheradmand, S. Ahmadi-Kandjani, Submitted to Applied Phys. Letters.

GROWTH OF Na₂W₂O₇ SINGLE CRYSTALS AS POSSIBLE OPTICAL HOST MATERIAL

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Tungstates are promising host materials for many activators like transition metal and RE ions. For example, $KGd(WO_4)_2:Nd^{3+}$ has high laser efficiency with both lamp and laser-diode excitations. Many tungstates such as PbWO₄, ZnWO₄ and CdWO₄ are very important scintillation crystals applied in the high energy physics detection and medical imaging. However, most of tungstates have high melting points and require flux using due to incongruent melting or polymorphism. These disadvantages are not topical for sodium ditungstate, Na₂W₂O₇, which melt congruently at 730°C. The compound is orthorhombic and its structure contains both tetrahedral and octahedral groups sharing corners to form infinite chains.

The starting materials were Na₂CO₃ and WO₃ of high purity, which were allowed to react at 650°C for 12 h according to the reaction Na₂CO₃ + 2WO₃ \rightarrow Na₂W₂O₇ + CO₂↑. The product was extra annealed at 750°C for 12 h to yield the charge for growing. Large single crystals of Na₂W₂O₇ with dimensions up to 60×30×25 mm³ were grown by the low temperature gradient Czochralski technique (LTG Cz). Temperature changes in the crystal and the melt were less than 1 K cm⁻¹. Under such thermal conditions of the growth process, the layer-by-layer growth mechanism is dominated.



Fig.1. Na₂W₂O₇ crystal grown by LTG Cz technique.

The Na₂W₂O₇ single crystals are colourless, transparent, and nonhygroscopic and may be attractive as an optical host material for solid state lasers and scintillators. The functional properties of the material may be substantially enhanced using suitable coupled ion substitutions, for instance, Na⁺ + W⁶⁺ \rightarrow RE³⁺ + Ti⁴⁺.

OH⁻ FREE CALCIUM ALUMINOSILICATE GLASS FOR SMART WHITE LIGTHING

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In the last decade many efforts have been done in order to develop new materials for white light (WL) sources, aiming the replacement of both fluorescent and incandescent lamps. It is recognized that WL emission based LEDs presents several advantages over traditional lamps such as low energy consumption and high durability [1]. There are basically two ways to get WL using LEDs [1]: the first is combining colors emitted from different LED chips and the second by using blue or UV LEDs to excite a phosphor material that has a broad emission band in the yellow region. The last one has attracted much interest due to easy fabrication, low cost, and the possibility to obtain higher brightness. In this context, several materials doped with luminescent ions have been studied in order to develop WL generators having LEDs as the primary sources [1]. OH free Low Silica Calcium Aluminosilicate (LSCAS) glass has been shown to be a promising candidate for the development of luminophore hosts due to its superior thermal, optical and mechanical properties [2]. Fig. 1 shows emissions from this glass with $Ce^{3+}[2]$, Eu^{3+} and Eu^{2+} [3] luminescent ions. The Eu^{2+} emission contributed to the spectral shift to yellow, centered at 600 nm, Fig. 1a,b. For excitation between 390 to 410 nm, it is possible to observe emission from the Eu³⁺ ions around 610 nm. Fig. 1c shows the emissions and the photographies of the samples with Eu, Ce and Eu-Ce. The emissions were obtained in different positions of the visible, including in the red region. Combining these luminescence with the use of UV and/or blue LEDS and using the Commission Internationale de l'Éclairage 1931 chromatic diagram, they allow de development of tunable visible light to simulate emission close to the ideal white light. The potentiality of this glass for white lighting will be presented, with attention to the characterization in relationship with their properties like concentration quenching, ions oxidation states and energy transfer processes. The development of a smart white lighting device combining this glass with UV and/or Blue LEDs will be discussed.



Fig. 1. Excitation and emission curves for LSCAS glass sample doped with 2.0 wt.% of CeO₂, doped with 0.5 wt.% of Eu₂O₃ and co-doped with 2.0 wt.% of CeO₂ and 0.5 wt.% of Eu₂O₃.

- [1] H.Yu, Y.Lai, G.Gao, L.Kong, G.Li, S.Gan, and G.Hong, J.Alloy.Comp. 509(23), 6635–6639 (2011).
- [2] L.H. C. Andrade, S.M. Lima, A. Novatski, A. Steimacher, J.H. Rohling, A.N. Medina, A.C. Bento, M.L. Baesso, Y. Guyot, and G. Boulon, Appl. Phys. Lett. 95(8), 081104 (2009).
- [3] A. C. P. Rocha, L. H. C. Andrade, S. M. Lima, A. M. Farias, A. C. Bento, M. L. Baesso, Y. Guyot, and G. Boulon. Optics Express, 20(9), 1034 (2012).

TEMPERATURE DEPENDENCES OF PHOTOLUMINESCENCE PROPERTIES OF Eu³⁺-DOPED GdAIO₃ AND YAIO₃ CERAMICS

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The temperature-dependent photoluminescence of Eu³⁺ doped GdAlO₃ and YAlO₃ samples, synthesized by solid state method, were investigated for high-temperature phosphor thermometry. The photoluminescence spectra were collected under excitation of 399 nm, elevating temperature gradually from room temperature to 800K. The characteristic emission lines of Eu³⁺ were detected for both samples, and the following transitions ${}^{5}D_{1}\rightarrow{}^{7}F_{1}$, ${}^{5}D_{0}\rightarrow{}^{7}F_{1}$ and ${}^{5}D_{0}\rightarrow{}^{7}F_{2}$ chosen for the temperature-dependence study using the fluorescence intensity ratio method (see Fig. 1a) and Boltzmann distribution function for its fitting. Decay curves for the strongest emission peaks, centered at 615 nm and 614 nm for Eu³⁺-doped GdAlO₃ and YAlO₃, respectively, were recorded in the wide temperature range (300 – 850 K). The experimental lifetime measurements data (see Fig. 1b) were fitted using modified charge transfer (CT) model that accounts temperature dependence of CT energy. Our results suggest that Eu³⁺ doped GdAlO₃ and YAlO₃ could be used as high temperature thermographic phosphors.



Figure 1. a) Temperature-dependent intensity ratio for ${}^{5}D_{1} \rightarrow {}^{7}F_{1}$ and ${}^{5}D_{0} \rightarrow {}^{7}F_{2}$ emission transitions for Eu³⁺-doped GdAlO₃ and YAlO₃ samples and b) graph representing ${}^{5}D_{0} \rightarrow {}^{7}F_{2}$ lifetime values dependence of temperature.

ENHANCEMENT OF THERMAL QUENCHING PROPERTIES OF YELLOW-EMITTING SiO₂-COATED Y₃Al₅O₁₂ :Ce³⁺ PHOSPHOR FOR WHITE LED APPLICATIONS

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Up to now, the conventional method for making the white light is to combine InGaN blue chip with yellow-emitting $Y_3A_{15}O_{12}$: Ce^{3+} phosphor(YAG : Ce^{3+}). The white LEDs generated with yellow-emitting YAG : Ce^{3+} phosphor are ecumenically commercialized. However, YAG phosphor hasn't showed the good thermal quenching properties. To improve the phosphor efficiency of the phosphor converted white light emitting diodes, $Y_3Al_5O_{12}$: Ce^{3+} Phosphor were coated with SiO₂. The photoluminescence properties of the SiO₂-coated $Y_3Al_5O_{12}$: Ce^{3+} Phosphor showed the excellent yellow emission intensity under 460 nm. The highest emission peak was observed at a Ce^{3+} doping concentration of 0.2 mol. However, the emission intensity decreased suddenly when the Eu^{2+} concentration was > 20mol%. This can be explained by concentration quenching, due mainly to the increase of intraionic non-radiative relaxation between Ce ions. The temperature dependence of photoluminescence was measured from 20 to 180 °C. The SiO₂-coated phosphors showed improved thermal quenching property compared to pristine phosphors. This result suggests that SiO₂-coated $Y_3Al_5O_{12}$: Ce^{3+} Phosphor could be considered as a good candidate for the white LED applications.



Figure 2. Temperature dependence of the relative photoluminescence properties of SiO₂-coated phosphor and noncoated phosphor.

 Haiyan Song, Young-Min Leem, Byoung-Gyu Kim and Yeon-Tae Yu, Materials Science and Engineering. 143 (2007) 70–75.

COLOUR TUNING PHOSPHOR OF Eu_{0.01}Tb_{0.99}TMA·4H₂O COMPLEX

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(1,3,5-benzenetricarboxylate)terbate(III) doped with 1 mol % trivalent europium ion $(Eu_{0.01}Tb_{0.99}TMA.4H_2O)$ was prepared using an aqueous reflux system. The RECl₃ aqueous solution was slowly added dropwise in the neutralised TMA solution at boiling point at 1:1 molar ratio followed by 2 h reflux [1]. The complex was characterized by elemental analysis (CHN), infrared spectroscopy (FTIR) and powder X-ray diffraction (XRD). The luminescence behaviour was investigated based on the excitation and emission spectra, as well as the phosphorescent decay study.

The CHN shows that the complex is a tetrahydrate, corroborating with the FTIR data, exhibiting a broad band in the spectral range from 3600 to 3200cm⁻¹. The bridge coordination mode between the TMA ligand and the RE³⁺ ions is confirmed by comparing the frequencies of symmetric and asymmetric stretching of the complex and the Na₃TMA salt.

The emission spectrum of the compound, when excited at the maximum absorption band of the ligand (300 nm), shows a highly efficient energy transfer TMA \rightarrow RE³⁺, evidenced by the absence of the emission band of the ligand. When excited in the RE³⁺ ions (345 and 394 nm for Tb³⁺ and Eu³⁺, respectively), low intensity ligand phosphorescence is observed and the Eu³⁺ and Tb³⁺ ions transitions exhibit different intensity ratios. The phosphorescence decay curves shows uncommon long lifetime for the Eu³⁺ ion when excited in the ligand or Tb³⁺, indicating multiple energy transfer pathways in the Eu_{0.01}Tb_{0.99}TMA·4H₂O complex.



Figure 1: Emission spectra at different excitations (left); phosphorescence decay curves (middle) and CIE diagram (right).

 E.R. Souza, I.G.N. Silva, E.E.S. Teotonio, M.C.F.C. Felinto, H.F. Brito, J. Lumin., 130, (2010) 283–291.

COMPARING THE VALENCE CONTROL OF Pr AND Tb IN ZIRCONIA BY CO-DOPING EFFECT

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Despite the large number of reports on rare earth doped zirconia, the knowledge about the valence change of key lanthanides in zirconia is still serendipitously poor. For many applications, the zirconia materials are stabilized with yttria generating the yttria-stabilized-zirconia (YSZ). The luminescence of the Tb and Pr doped YSZ has thus been reported frequently. The enhancement of red luminescence in the Pr^{3+} doped zirconia has been attributed to sensitization by the Y^{3+} co-doping [1].

The valence of Tb and Pr in ZrO₂ changes from four to three with increasing concentration of the R^{3+} (R: Gd or Yb) co-dopant as shown by the XANES measurements (Fig., left and center). Similarly, photoluminescence measurements show an almost linear increase in the intensity of the ${}^{5}D_{4} \rightarrow {}^{7}F_{5}$ transition of Tb³⁺ with increasing Yb³⁺ co-doping (Fig., right). This behavior indicates a very slow and incomplete Tb^{IV} \rightarrow Tb³⁺ conversion. On the other hand, the intensity of the ¹D₂ \rightarrow ³H₄ transition of Pr³⁺ reaches a maximum for the Gd³⁺ co-dopant concentration of 10 %, whilst luminescence is quenched at higher co-doping level. Thus, the valence conversion of Pr and Tb behave differently in zirconia, partly due to different redox potentials [2]. Minor contribution to the R^{IV}/R^{3+} reduction may come from the smaller size of Tb^{3+} though this species is still 25 % bigger than Zr^{IV} . In the first place, however, the effect of charge compensation when R^{3+} occupies the Zr^{IV} site must be considered. For each oxide vacancy, two R^{3+} ions are required. As the concentration of co-dopant increases, the number of defect clusters ($R_{zr} - V_0^{-} - R_{zr}^{-}$) increases and involve not only Gd^{3+}/Yb^{3+} but also Pr/Tb stabilizing the trivalent state. The created oxide vacancies could store the electrons liberated in the reduction of R^{IV}. The formation of defect clusters is supported by the nearly pure red emission of Pr³⁺ (Fig., bottom right) which indicates the formation of $Pr^{3+}-Pr^{3+}$ pairs and active cross-relaxation path(s) quenching the green and feeding the red emission.



Figure. Synchrotron radiation XANES spectra for the $Zr_{0.99-x}Yb_xTb_{0.01}O_2$ (left) and $Zr_{0.99-x}Gd_xPr_{0.01}O_2$ (center) materials. Integrated emission intensity for the Tb,Yb and Pr,Gd co-doped zirconia, as well as the emission spectra for the Pr,Gd co-doped materials (right).

- J.D. Fidelus, S. Yatsunenko, M. Godlewski, W. Paszkowicz, E. Werner-Malento, W. Łojkowski, Scripta Mater. 61 (2009) 415–418.
- [2] L.R. Morss, Chem. Rev. 76 (1976) 827-841.

SERENDIPITOUS ENHANCEMENT OF UP-CONVERSION LUMINESCENCE FROM NaYF₄:Yb³⁺,Tb³⁺

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The Yb³⁺ and Er³⁺ co-doped NaYF₄ is probably the best performing up-conversion phosphor material [1] – at least the most studied one. This is somewhat surprising since the host material, NaYF₄, possesses several polymorphs: low-temperature cubic, hexagonal and high-temperature cubic [2], each with drastically different luminescence efficiency. Further, there is a quite unique structural arrangement with the Na⁺ and R³⁺ cations both occupying the same crystallographic site. Due to the charge mismatch between the cations, there is a serious risk of non-stoichiometry if the Na⁺/R³⁺ ratio deviates from one. The effect of non-stoichiometry to the luminescence efficiency is usually fatal. In this contribution, it will be shown how the up-conversion luminescence efficiency of the NaYF₄:Yb³⁺,Tb³⁺ material can easily be enhanced with a factor of 1-2 orders of magnitude. The reasons for this enhancement are discussed.

The DSC curves of the NaYF₄:Yb³⁺,R³⁺ materials (Fig., left) show inconsistent variation in the 1st irreversible (cubic to hexagonal) phase transition temperature whilst the 2nd, also irreversible (hexagonal to cubic) one is nearly a constant. Since the luminescence from the hexagonal phase is much stronger than from the cubic ones, the nanocrystalline materials should be obtained in this form *and* at temperatures as low as possible to avoid sintering of the product during post-annealing. Both these goals were achieved by reducing the loss of Na⁺ due to successive washing with water. The cubic to hexagonal phase transition of NaYF₄:Yb³⁺,Tb³⁺ occurs at a record low temperature (Fig., left). Further, the up-conversion luminescence is now 1 to 2 orders of magnitude stronger than that of a material washed with water (Fig., right). The Na⁺/R³⁺ ratio is thus more favourable without washing with water and non-stoichiometry is avoided.



Figure. The DSC curves of the phase transitions of NaYF₄:Yb³⁺,R³⁺ (left) and the luminescence spectra of NaYF₄:Yb³⁺,Tb³⁺ (right).

In the future, the removal of the NaF impurity as well as the origin of the DSC signals just before the hexagonal to cubic phase transition temperature will be studied in detail.

- [1] F. Auzel, Chem. Rev. 104 (2004) 139-173.
- [2] E.Harju, I.Hyppänen, J.Hölsä, J.Kankare, M.Lahtinen, M.Lastusaari, L.Pihlgren, T.Soukka, Z.Kristallogr. Proc. 1 (2011) 381-387.

LUMINESCENT PROPERTIES OF Dy³⁺ IONS IN CaTiO₃ NANO-PEROVSKITES

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CaTiO₃ is a well known perovskite used for different applications [1-3]. This titanate was already used as a host for rare earth ions. The efficient luminescence was already observed e.g. for Pr^{3+} ions in CaTiO₃ matrix [4]. Dysprosium is an interesting rare earth element, because it can emit light spread from blue to red, regions. Therefore, a host doped with Dy^{3+} might be used also as a white light phosphor [5].

In this work we present the spectroscopic properties of perovskite nanocrystals CaTiO₃: Dy^{3+} . Samples has been prepared by the sol-gel method and annealed at 700, 800, 900, 1000 and 1100°C. The concentration of Dy^{3+} was from 0,1 to 3,5%. Average grain size of nanocrystals, was obtained from the Scherrer equation [6]. The absorption, emission spectra and time decay profile of the emitting level have been measured. An argon laser with the 458 nm line and third harmonic of a Ti:sapphire laser which emit UV line at the 355 nm were used as excitation sources. The decay time profiles were measured with a Lecroy digital oscilloscope.

The chromatic coordinates of the CaTiO₃: Dy^{3+} , calculated from the emission spectrum are x=0.318 and y=0.393 which on the CIE 1931 chromaticity diagram is a white color with a yellowish green tone.

The energy levels of Dy^{3+} ions have been obtained from the absorption and emission spectra. Emission peaks were assigned to the transition from the ${}^{4}F_{9/2}$ main emitting level of dysprosium, to the ground and other excited levels of Dy^{3+} ions.

The influence of Dy³⁺ concentration on luminescent properties has been analyzed.



Fig. 3. Emission spectrum of LaAlO₃: Dy³⁺ nanocrystals.

- [1] S.H. Cho, J.S. Yoo, J.D. Lee, J. Electrochem. Soc. 143(10) (1996) L231.
- [2] D. Canil, A.J. Bellis, J. Petrology 48(2) (2007) 231.
- [3] X. Wang, C.-N. Xu, H. Yamada, K. Nishikubo, X.-G. Zheng, Adv. Mater. 17(10) (2005) 1254.
- [4] P.J. Dereń, R. Pązik, W. Stręk, Ph. Boutinaud and R. Mahiou, J. Alloys. Compounds 451 (2008) 595.
- [5] Q. Su, H. Liang, C. Li, H. He, Y. Lu, J. Li, Y. Tao, J. Lumin. 122–123 (2007) 927. [6] P. Scherrer, Gottinger Nachr. 2 (1918) 98.

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MELT SYNTHESIS OF LED PHOSPHORS

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Multi-component LED phosphor materials, for example $Y_3Al_5O_{12}$:Ce³⁺, were prepared by novel "melt synthesis technique". As shown in Figure, "combinatorial melt synthesis reactor" heats small-size samples on a water-cooled 24-sample Cu hearth in the sample chamber. Strong light emitted from a 6 kW xenon lamp is collected by an ellipsoidal mirror (collector) and directed to the sample. Raw materials powders can be heated over 2000°C in various atmospheres within a few seconds then rapidly cooled by switching off the light. In this study, each sample were melted within 30 s and 24 homogeneously melted samples can be prepared within 30 min using this equipment.



 $Y_3Al_5O_{12}:Ce^{3^+}$ (YAG:Ce) is a most well-known yellow phosphor for white LEDs. Conventional synthesis technique of LED phosphor is a solid state reaction using the mixture of oxide or carbonate starting materials. The YAG: Ce phosphor synthesized by the high temperature solid state reaction shows agglomerate and irregular shape particles with inhomogeneous distribution of Ce³⁺ ions because of poor reactivity of high melting point raw materials, Al_2O_3 (melting point 2054°C) and Y_2O_3 (2433°C). The synthesis and morphology control of such complex oxide phosphor is not easy by the conventional solid-state reaction with several grinding and firing steps. In the melt synthesis, the mixtures of raw material powders were melted and mixed homogeneously in a short period of time (1 – 60 s) by a strong light radiation in arc imaging furnace. A spherical phosphor ball samples were directly solidified on a Cu hearth and show bright emission by excitation of visible light.

The melt process produces a well-grown YAG:Ce phosphor with useful lens-like morphology. $Y_3AI_5O_{12}$:Ce³⁺ (YAG: Ce) phosphors synthesized by the "melt synthesis technique" show superior luminescence property (10 – 20 % higher emission intensity) because of high crystallinity.

PHOTONICS IN A CAGE : SODALITES

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Uses of sodalites are known to man since at least 2000 years, when the ultramarine blue was first used as a colour pigment, see e.g. *the mask* of Tutankhamun's *mummy*. Although also very popular in middle age and renaissance paintings, it took until 1828 before a synthesis was devised and another 100 years to understand its peculiar structure (L. Pauling, 1930) [1], see Fig.1. Sodalites belong to the feldspathoid class of minerals and are the first and "smallest" representatives of a series of microporous materials known as zeolites. It has a chemical and thermal stability superior to other zeolites; moreover, albeit small in diameter (app. 0.6 nm), it provides hospitable shelter voids for numerous optically active organic and inorganic species. In case of the ultramarine, the optically active species is a S_3^{\bullet} radical anion - non-existent outside the sodalite matrix. Other reactive species that have been stabilized in the sodalite cages include the BH₄⁻ and BF₄⁻ anions [2,3].



Next to modification of the absorption properties, i.e. colour, by guest species, the voids can also be modified to show efficient luminescence. To this end red line emitting Eu^{3+} , sensitized by an extended array of $(MOQ_4)^{2-}$ strands, could be incorporated, while the equally interesting Tb³⁺and Ce³⁺ have so far withstood our attempts to prepare efficient materials. However, on replacing the molybdate by $(WO_4)^{2-}$, even luminescence involving NIR (near infrared) states could be realized. In case of Nd³⁺, fairly efficient emission at 1063 nm was obtained [4], while Yb³⁺/Ho³⁺ and Yb³⁺/Er³⁺ couples led to upconverted emission in the visible on excitation with a 980 nm laser diode. Last but not least, we were also able to incorporate Eu^{2+} , which yielded a peculiar broad band green emission, if additional $[BF_4]^-$ resided inside the cages. Last but not least, making extensive use of stoichiometric degrees of freedom in the sodalite host, intense broad band red emission can be generated from "all alumina sodalites" comprising an $[Al_{12}O_{24}]^{12-}$ framework.

- [1] L. Pauling, Z. Kristallogr., 74 (1930) 213.
- J.-Ch. Buhl, T. M. Gesing, C.H. Rüscher, Microporous Mesoporous Mater., 80 (2005) 57.
 [3] M.M. Lezhnina, E. Jordan, S.A. Klimin, J. Löns, H. Koller, B.N. Mavrin, U. Kynast, Z. Anorg. Allg. Chem., 635 (2009) 450.
- [4] M. Lezhnina, F. Laeri, L. Benmouhadi, U.Kynast, Adv. Mater. 18 (2006) 280

EFFECT OF DEFECT CLUSTERS ON THE PERSISTENT LUMINESCENCE OF CdSiO₃:Pr³⁺

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Despite the recent advances in the field of persistent luminescence, good red emitting materials are still lacking. Phosphors doped with Pr^{3+} frequently show strong red persistent luminescence; the mechanism has previously been related to an "intervalence charge transfer" (IVCT) model [1]. In this work, a new red emitting material, CdSiO₃:Pr³⁺, was studied and an alternative mechanism is now proposed for the Pr^{3+} persistent luminescence. The structure of CdSiO₃ presents an empty space that may accommodate an interstitial oxide ion needed to compensate the charge mismatch between Cd²⁺ and the trivalent rare earth ions (R^{3+}) [2]. The position of this O_i^{\dagger} defect immediately adjacent to the two $\mathbf{R}_{Cd}^{\bullet}$ enables the clustering of these three defects ($\mathbf{R}_{Cd}^{\bullet}$ - \mathbf{O}_{i}^{\bullet} - $\mathbf{R}_{Cd}^{\bullet}$). This infrequent defect cluster is the predominant reason for the nearly pure red emission of CdSiO₃:Pr³⁺ attributed mainly to the ${}^{1}D_{2} \rightarrow {}^{3}H_{4}$ transition, as witnessed by the UV excited and persistent luminescence spectra (Fig., left). The weakness of the blue-green transition $({}^{3}P_{0} \rightarrow {}^{3}H_{4})$ is due to strong cross-relaxation, coupling the ${}^{3}P_{0} \rightarrow {}^{1}D_{2}$ relaxation with the ${}^{3}H_{4} \rightarrow {}^{3}H_{6}$ excitation (Fig., center: process 1). This process is enhanced even at low Pr³⁺ concentration (0.1 %) due to the formation of the Pr³⁺ - Pr³⁺ pairs. The defect clusters influence also the persistent luminescence mechanism. The O_i ions have reduced stability due to the short O_i["]-O(SiO₄) distance (2.1 Å) [3]. O_i["] can thus be replaced by trapped electrons and contribute to the efficient energy storage of the Pr^{3+} doped CdSiO₃. Since in the CdSiO₃ host the reduction/oxidation of Si (or Cd) is not possible, the IVCT mechanism [1] cannot be applied to this system. Instead, a mechanism similar to those for the Eu^{2+} and Tb^{3+} persistent luminescence is proposed (Fig., right).



Figure. UV excited and persistent luminescence spectra of $CdSiO_3:Pr^{3+}$ (left), cross-relaxation processes for Pr^{3+} ion (center) and persistent luminescence mechanism for $CdSiO_3:Pr^{3+}$ (right).

- [1] M. Boutinaud, R. Mahiou, E. Cavalli, M. Bettinelli, J. Lumin. 122-123 (2007) 430-433.
- [2] L.C.V. Rodrigues, H.F. Brito, J. Hölsä, R. Stefani, M.C.F.C. Felinto, M. Lastusaari, T. Laamanen, L.A.O. Nunes, J. Phys. Chem. C, in press (2012).
- [3] H.F. Brito, M.C.F.C. Felinto, J. Hölsä, T. Laamanen, M. Lastusaari, P. Novák, L.A.O. Nunes, L.C.V. Rodrigues, 10th Int. Conf. Solid State Chem. (SSC 2012), June 10–14, 2012, Pardubice, CZ.

LUMINESCENCE CHARACTERISTIC AND THE SECOND HARMONIC GENERATION IN POWDERED Yb³⁺-DOPED ZnY₄W₃O₁₆ TUNGSTATE

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Rare earth-doped $ZnY_4W_3O_{16}$ solid solutions with the wolframite-type structure, crystallizing in the orthorhombic system, could be applied as Eu^{3+} -doped phosphors with white light emitting diodes (WLEDs) [1] and also as Nd³⁺-doped laser materials and temperature sensors [2]. This presentation will be mainly devoted to Yb³⁺ rare earth-doped tungstate compounds of the same group.

The new microcrystalline Yb³⁺-doped ZnY₄W₃O₁₆ with the orthorhombic-type structure synthesized by the high temperature solid-state reaction, crystallized as rectangular particles, shows interesting optical properties. The Yb³⁺ resonant zero-phonon lines are useful probes for the site symmetries occupied in substitution of Y³⁺ ion. The high value of absorption cross-section and intense near IR emission of this material are promising for laser application. The nonlinear effect well observed in the undoped and Yb³⁺ - doped tungstates can be used for the second harmonic generation (see Figure).



Figure: SEM micrographs of representative samples of $ZnY_4W_3O_{16}$ doped with Yb^{3+} and Nd^{3+} ions (a)The emission and calculated absorption cross–sections of Yb^{3+} –doped $ZnY_4W_3O_{16}$ (b)The second harmonic generation (SHG) of $ZnY_4W_3O_{16}$ and Yb-doped $ZnY_4W_3O_{16}$ (c).

- [1] E. Tomaszewicz, M. Guzik, J. Cybinska, J. Legendziewicz, Helv. Chim. Acta, 9 (2009) 2274.
- [2] M. Guzik, J. Cybinska, E. Tomaszewicz, Y. Guyot, J. Legendziewicz, G. Boulon, W. Strek, Opt. Mater., 34 (2011) 487.

SYNTHESIS, CHARACTERIZATION AND SPECTROSCOPIC PROPERTIES OF NANOSIZE Eu₂(M₀O₄)₃ AND Eu³⁺:Y₂(M₀O₄)₃

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The rare earth molybdates are an important family of inorganic materials which have many potential applications, such as phosphors, optical fibers and scintillators, magnet and catalysts. In this study it is showed the synthesis and characterization of $Eu_2(MoO_4)_3$ and $Eu^{3+}:Y_2(MoO_4)_3$ nanoparticles. These materials have potential to be used as biological markers.

The synthesis of $Eu_2(MoO_4)_3$ and Eu^{3+} : $Y_2(MoO_4)_3$ nanoparticles were done by precipitation method controlling the dispersion rate and were successful according to the structural characterization, elementary analysis, infrared absorption spectroscopy, and scanning electronic microscopy (SEM). All the experiments were done under similar conditions.

The X-ray powder diffraction showed that $Eu_2(MoO_4)_3$ and $Eu^{3+}:Y_2(MoO_4)_3$ is crystalline and diffraction patterns correspond to the orthorhombic β - phase. The crystallite sizes were determined below to 25 nm.

The emission spectra show characteristic bands of Eu^{3+} emission belonging to the ${}^{5}D_{0}\rightarrow{}^{7}F_{J}$ (J = 1-4) 4f transitions. The emission spectrum of the $Eu_{2}(MoO_{4})_{3}$ microarchitectures exhibits a single efficient red PL emission peak centered at around 616 nm, corresponding to the forced electric dipole transition (${}^{5}D_{0}\rightarrow{}^{7}F_{2}$), which is allowed in this case because the europium does not occupy a symmetry center in the matrix. The prepared phosphors exhibited pure and intense red emission at 616 nm under the excitation at 394 nm. Additionally, luminescent properties were correlated with the obtained structural and morphological features of the synthesized powders. Intensity parameters and quantum efficiency were calculated for these materials. High quality molybdate nanomaterials were successfully prepared with a simple one-step precipitation synthesis.



Figure Micrographs, X-ray powder diffraction patterns and emission spectra of Eu₂(MoO₄)₃

NANOPARTICLES OF PHB AND PMMA POLYMERS DOPED WITH Eu(TTA)₃(TOPO)₂ AND Gd(TTA)₃(TOPO)₂

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Nanoparticles with luminescent properties have potential application in high-resolution devices such as electroluminescent, field emission displays, cathode ray tubes and biology assays. Markers based on polymer materials has attracted noteworthy attention for the reason that materials are expected to become alternatives to conventional inorganic based materials due to their easier handling, low cost and integration over inorganic counterparts.

The particles are produced by using chloroform solution of the polymer and ethanol solution of the doping materials and frozen in liquid nitrogen and were successful according to the structural characterization, infrared absorption spectroscopy, and scanning electronic microscopy (SEM). All the experiments were done under similar conditions.

Figure. shows the excitation spectra of the PHB and PMMA:10%Eu(tta)₃(TOPO): nanoparticles with emission monitored at ${}^{5}D_{0} \rightarrow {}^{7}F_{2}$ (~616 nm) transitions of the Eu³⁺ ion. It is observed two overlapped absorption bands between 260 and 425 nm, which are assigned to the PMMA, PHB and tta species. It is observed that in the emission spectrum of the particles , under excitation at 394 nm, the ${}^{5}D_{0} \rightarrow {}^{7}F_{2}$ transition (616 nm) originated from the Eu³⁺ ion is the most prominent in the visible range and is responsible for the subsequent red emission of the polymer nanoparticles

The PMMA and PHB polymer matrix acts as co-sensitizer and enhances the overall luminescence intensity of the polymer nanoparticles as compared to the complex.



Figure Excitation and emission spectra of PHB and PMMA polymers nanoparticles micrographies of Gd and Eu materials and bulk materials doped with $Eu(TTA)_3(TOPO)_2$ under 360nm UV- lamp.

 J. Kai, M.C. F. C. Felinto, L.A. O. Nunes, O. L. Malta H. F. Brito Journal of Materials Chemistry, [2011], [211], 3796

STUDY OF XRD AND PL CHARACTERISTICS IN Ca₃Al₁₀O₁₈ USING COMBUSTION SYNTHESIS

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Inorganic materials activated by rare earth ions are important types of luminescent phosphors for optical and light emission applications. The luminescent properties of host alkaline earth metals, which contain rare earth ions as dopants, have attracted much attention. In the system of CaO-Al₂O₃, CaAl₄O₇, CaAl₁₂O₁₉ and CaAl₂O₄ are more commonly studied. However, there is not much information available on the title compound Ca₃Al₁₀O₁₈. Here we report the synthesis and luminescence for this compound. Ca₃Al₁₀O₁₈ phosphors activated with various dopants was prepared by combustion synthesis. X-ray diffraction patterns were recorded on Philips PANalytical X'pert Pro diffractometer. Photoluminescence Characteristics was studied using a Hitachi F-4000 spectrofluorimeter, at room temperature, using 1.5 nm spectral slit width in the range of 200–700 nm. XRD pattern of the prepared compound matched well with the ICDD file 02-392. Characteristic luminescence of Pb²⁺, Ce³⁺, Eu²⁺ and Eu³⁺ was observed in the as prepared phosphors. Luminescence from the Eu³⁺ ion levels gave emission spectra with sharp peak at 611 nm. Energy transfer was observed from the excited state of the host to the Eu³⁺ ion. Weak emission of Eu³⁺ was predominantly in the ⁵D₀ \rightarrow ⁷F₂ transition which is in the red region.



Fig. 1. XRD pattern of Ca₃Al₁₀O₁₈

Fig. 2. PL Spectra of $Ca_3Al_{10}O_{18}$: Ce^{3+} & $Ca_3Al_{10}O_{18}$: Pb^{2+} a) Ce^{3+} emission for 274 nm excitation b) Ce^{3+} excitation for 360nm emission c) Pb^{2+} emission for 263 nm excitation d) Pb^{2+} excitation for 335nm emission

LUMINESCENCE PROPERTIES AND EMISSION QUENCHING PROCESSES IN Eu³⁺-DOPED Ca₉Al(PO₄)₇

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For the first time the citric route was successfully employed in synthesis of the pure phase Ca₉Al(PO₄)₇ (CAlP) doped with Eu³⁺ powders, being in the same time, an attractive alternative to the solid state reaction using commonly available inorganic substrates. Thermal behavior of the Eu³⁺ emission was studied using excitation line well matched with the $^{7}F_{0} \rightarrow ^{5}D_{4}$ absorption band covering broad range of temperature (300 – 700 °C). The temperature dependence of the emission spectrum excited at 360 nm and of the corresponding 0-2 integrated emission area is shown in Fig 1. We note a progressive decrease of the 0-2 emission intensity from 300 to \approx 570 K due to energy losses that take place during internal relaxation to $^{5}D_{0}$ level. Above 570 K a fast quenching occurs by relaxation to cross over with charge transfer state (CTS). The thermal quenching activation energy being in the same time an energy difference between quenched level to its cross over with CTS.



Figure 1. Emission spectra of the CAIP:Eu³⁺ powders measured as function of temperature(a)and thermal dependence of the ${}^{5}D_{0} \rightarrow {}^{7}F_{2}$ relative intensity

Acknowledgements

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[1] H. Yamamoto, Proc. SPIE, , 7598 (2010) 759808-1.

[2] F. DuF., Y. Nakai , T. Tsuboi., Y Huang , H.J. Seo, J. Mater. Chem.21,(2011) 4669.

NEAR UV TO GREEN CONVERTED LED BY COATING EUROPIUM ACTIVATED CALCIUM ZINC CHLOROSILICATE PHOSPHOR

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Solid state lighting based on high-brightness LEDs have emerged as a new potentially revolutionary technology [1]. White LEDs, based on blue LED chips coated with a yellow emitting phosphor (YAG:Ce), were first reported in 1997[2]. The lamps fabricated in this manner, however give a poor colour rendering because the resulting light is typically deficient in the green and red colours. Two approaches are followed to overcome this problem. In the first approach, white LEDs are made by coating blue chip with yellow emitting phosphor like YAG:Ce. In second approach near ultraviolet (n-UV) emitting LED with a mixture of high efficiency red, green and blue emitting phosphors[3], analogous to the fluorescent lamp. This method yields lamps with better colour rendition. It is therefore necessary to develop phosphors with near UV excitation and emission in one of the primary colors.

Synthesis and characterization of green emitting, near UV excitable europium activated calcium zinc chlorosilicate phosphor are described here. Polycrystalline Calcium Zinc Chlorosilicate was prepared by a solid-state reaction, following recipe given by Lu et al[4]. The phosphor in desired quantity was dispersed in a transparent silicone resin (Wells Electronic Materials Company, 5012-2A and 5012-2B), and coated on LED chip (CREE 400 nm). Emission spectra were recorded on USB-2000 fiber optic spectrofluorimeter. Fig.1 shows the EL spectra of near UV LED coated with calcium zinc chlorosilicate phosphor, curve 5 represents total conversion of near UV (400nm) to green (500 nm), which can be useful as a green diode or can serve as one of the components for white LED.



Fig.1 EL spectra of near UV diode coated with calcium zinc chlorosilicate phosphor

- [1] X. Zhang, B. Park, N. Choi, J. Kim, G.C. Kim and J.H.Yoo, Mater. Lett. 63 (2009) 700-702
- [2] S.Nakamura and G.Fasol The Blue Laser Diode: GaN Based Light Emitters and Lasers. Heidelberg: Spring; (1997)
- [3] Y.Xu, L.Chen, Y.Li, G.Song, Y.Wang, W.Zhuang and Z.Long Appl Phys Lett. 92 (2008) 021129
- [4] Wei Lü, Zhendong Hao, Xia Zhang, Yongfu Liu, Yongshi Luo, Xingyuan Liu, Xiaojun Wang and Jiahua Zhang, J.Electrochem.Soc. 158 (2011) H124-H127.

OPTIMIZATION OF SPARK PLASMA SINTERING CONDITIONS TO PRODUCE POLYCRYSTALLINE Y₂O₃:Eu³⁺ CERAMICS OF SUB-MICRON GRAIN SIZE

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Polycrystalline ceramics have several advantages over their single-crystal counterparts, most important being an easier preparation at much lower temperature and shorter manufacturing time, more feasible preparation of different sizes and shapes, better chemical homogeneity and possibility of introducing activators at higher concentrations. Additionally, it is expected that the use of nanopowder as a starting material would provide easier preservation of grains in nanometer range resulting in ceramic of better mechanical strength and greater resistance to thermal shock.

Nanocrystalline Y_2O_3 :Eu³⁺ powder, synthesized via polymer complex solution method, was used for ceramic preparation via rapid spark plasma sintering (SPS) method. Approximately 2g of powder were sintered under vacuum using a graphite mould (d = 15 mm). The sintering was carried out at 1200°C with a heating rate of 50°C/min and uniaxial pressure of 50 or 100 MPa. The pressure was removed just before the cooling step.

Figure 1 shows the displacement of the punch during the sintering of the sample, i.e. its linear shrinkage. With a force of 100 MPa, the sample starts to shrink at around 730°C and the maximum of the displacement rate occurs at 875°C. At 1200°C, the densification seems to be completed. The final densification rate, measured by Archimedes method, was found to be 99.4 % of the theoretical density. Increasing the applied force from 50 to 100 MPa leads to a decrease of around 70°C of the sintering temperature. Samples were further annealed in O₂ for 10 hours at 700°C in order to remove the carbon contamination generated by the SPS process. Morphology and optical characteristics of the starting powder and prepared ceramic samples were monitored and discussed in order to identify the changes induced with different SPS processing conditions and additional sintering in O₂ atmosphere. With low sintering temperature, it was possible to get very small, sub-micron grains, namely the smallest average grain size obtained is ~ 225 nm (see Fig.1). Photoluminescence measurements showed that ceramic samples retain good optical properties of the starting nanocrystalline Y_2O_3 :Eu³⁺ powder.



Figure 3 SPS relative displacement curve for Y_2O_3 sample sintered under 50 MPa (red circles) and 100 MPa (blue squares) uniaxial pressure and SEM image from the fracture of one Y_2O_3 :Eu³⁺ ceramic sample having average grain size of about 225 nm.

CHARACTERIZATION OF ZnIn₂Se₄ FILMS DEPOSITED BY CHEMCIAL BATH DEPOSITION

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ZnIn₂Se₄ (ZIS) is considered to be one of the potential buffer layers to replace the toxic CdS in CuInGaSe₂-based thin film photovoltaic solar cells. In this work, ZIS layers have been grown using a simple and economic process, chemical bath deposition for the first time. The chemical and physical properties of the layers were investigated and discussed.

ZIS films were grown by chemical bath method on glass substrates using 0.05M equimolar solutions of zinc chloride, sodium selenite and indium chloride as precursors. The films were deposited at different bath temperatures (T_b) that vary from 60°C to 100°C for a fixed deposition time of 60 min. The scanning electron microscopy and energy dispersive X-ray analysis were used to study the morphology and composition of the films respectively. The structural properties of the films were evaluated using X-ray diffraction technique (XRD).

ZIS films had needle like grains that were unevenly distributed on the substrate surface. The bath temperature has a significant influence on the composition and structure of the films. Structural studies showed that all the as-deposited films were polycrystalline in nature with the (112) peak as preferred orientation. Figure 1 shows the X-ray diffraction spectra of ZIS films deposited at three different bath temperatures. Layers grown for bath temperatures $\leq 80^{\circ}$ C had In₂Se₃ as the secondary phase that was not observed in the layers formed at T_b=100°C. All the layers had a high optical transmittance, > 75 % (Figure 2) and the energy band gap of the films varied from 2.83 eV to 3.23 eV with the change of T_b. A detailed investigation of the different properties have been made and the results are reported.



Fig. 1: XRD spectra of ZIS films.



Fig. 2: Transmittance vs. wavelength spectra.

SPECTROSCOPIC PROPERTIES OF Ti⁴⁺ DOPED WITH ZnAl₂O₄ SPINEL

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ZnAl₂O₄ crystallizes in cubic system with the space group Fd3m, the lattice parameter *a* is equal 8,0848 Å. In this structure Zn²⁺ ions are located in tetrahedral site and Al³⁺ ions are in octahedral site. However, zinc aluminate similarly to magnesium aluminate, can crystallize in "inverse" spinel structure [1]. Some part of Zn²⁺ cations are in the octahedral sites and Al³⁺ in the tetrahedral coordination. Degree of inversion in the spinel structure becomes smaller with increasing annealing temperature [2].

Zinc aluminate doped with Ti^{4+} was prepared by hydrothermal method. Two types of samples, pure host and $ZnAl_2O_4$ doped with 2% Ti^{4+} were prepared. After synthesis the powders were annealed at 300, 600 and 900°C for 3h. The XRD spectra were measured and compared with calculated $ZnAl_2O_4$ (ICSD 05-0669). All the samples were single phase. The average size of grains was calculated by the Scherer method and is increasing with increasing heat treatment, it is 4,68 and 19,78 nm for the 300 and 900 °C sample, respectively.

Spectroscopic properties of $ZnAl_2O_4$ were investigated. The emission spectra were recoded under the excitation at 245 nm. For the pure spinel two emission bands at 430 nm and 720 nm were observed (See Fig.1). The emission band at 720 nm disappears when the powder contains 2% Ti⁴⁺. It is due to charge compensation. Emission band at 420 nm is shifted to lower energies and this is connected with decreasing energy band gap.



Fig.1 Emission spectra of pure ZnAl₂O₄ and ZnAl₂O₄ doped with 2% Ti⁴⁺ annealed at different temperatures.

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P. Lombard, B. Boizot, N. Ollier, A. Jouini, A. Yoshikawa, J. Cryst. Growth 311 (2009) 899-903
 A.A. Da Silva, A. de Souza Gonçalves, M.R. Davolos, J sol-Gel Sci Technol 49 (2009) 101-105

TIME RESOLVED ANALYSIS OF ALLOPHYCOCYANIN FLUORESCENCE EMISSION

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Aim of this work is time resolved analysis of cyanobacterial pigment allophycocyanin (APC) fluorescence emission. Allophycocyanin is located at the core of the phycobilisome, a light-harvesting apparatus in cyanobacteria. Together with other phycobiliproteins, such as phycocyanin and phycoerythrin, APC is responsible for efficient capturing and funneling electronic excitation to the membrane-bound photosynthetic reaction centers (PS II) where fast electron transfer occurs with high efficiency, converting solar energy to chemical energy [1]. Our time resolved laser induced fluorescence experimental setup is described in [2]. First results regarding cyanobacterial pigment phycoerythrin are presented in [3]. Because APC absorption peak is on longer wavelength than our OPO range (320-475 nm), we also used second harmonic of Nd:Yag laser for sample excitation, Fig 1. Value of 5.3306 ns (upper left corner) is FWHM value of fluorescence centered around 660 nm shown on Fig 1, after deconvolution procedure is 2.5 ns.



Fig 1. Fluorescence streak image of APC (25 μg/mL) in KPi (0.1 M potassium phosphate) buffer pH 7 excited by 532 nm laser component.

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- [1] Liming Ying and X. Sunney Xie, J. Phys. Chem. B 102, (1998) 10399-10409.
- [2] Maja S. Rabasovic, Dragutin Sevic, Mira Terzic and Bratislav P. Marinkovic, Nucl.Instrum. Meth. B. 279 (2012) 16-19.
- [3] M. Terzić, M. S. Rabasović, D. Šević, A. Delneri, M.Franko and B. P. Marinković, Proc. 2nd National Conference on Electronic, Atomic, Molecular and Photonic Physics (CEAMPP2011), 2011, Belgrade, Serbia, p.128.

THE PHOTOLUMINESCENCE PROPERTIES OF Eu²⁺ DOPED Ba₃Si₆O₉N₄ PHOSPHOR SYNTHESIZED BY GAS REDUCTION NITRIDATION METHOD FOR WHITE LEDs

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Recently, the oxynitride phosphors have been attracted due to progressing of white light emitting diodes. Especially, white light emitting diodes are play an important role as solid state lighting source which can replace the previous lamps because it has excellent properties such as energy consumption, high brightness, long life time and low cost as well as environmental friendly device [1].

In this study, a series of Eu^{2+} -activated $Ba_3Si_6N_9O_4$ blue-green phosphors were synthesized using a gas reduction nitridation method with NH₃ gas [2]. The X-ray diffraction pattern of the synthesized phosphor sintered at 1300°C was well matched to the reference peaks. The synthesized $Ba_3Si_6N_9O_4$: Eu^{2+} phosphors absorbed light from the 350 to 470nm region. The emission spectrum (monitored at $\lambda em = 494$ nm) increased with increasing maintenance time using NH₃ gas. The highest emission intensity was observed when the maintenance time was 12hour. These results were explained by the aggregation of particles and crystallinity. The $Ba_3Si_6N_9O_4$ phosphor exhibited strong thermal properties compared to the commercial phosphor. The greenemitting $Ba_3Si_6N_9O_4$: Eu^{2+} phosphors obtained could be applied as white LEDs.



PL spectra of emission (monitored at 465 nm) spectra of the synthesized samples as a function of the maintenance time.

- K. Shioi, Y. Michiue, N. Hirosaki, R. J. Xie, T. Takeda, Y. Matsushita, M. Tanaka, Y. Q. Li, J. Alloy. Compd. 509 (2011) 332–337.
- [2] R. J. Xie, N. Hirosaki, Sci. Technol. Adv. Mat. 8 (2007) 588-600.

UP-CONVERSION LUMINESCENCE OF Tm^{3+} SENSITIZED BY Yb^{3+} IONS IN GdVO_4

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Up-converting materials due thier unique up-conversion luminescence properties have a variety of potential applications, including solid-state lasers, displays, fiber amplifiers, infared quantum counter detectors and biomedical imaging. The best efficiency of upconversion process was observed by using ytterbium Yb^{3+} as a sensitizer ion in addition to the active ion: thulium Tm^{3+} , erbium Er^{3+} or holmium Ho^{3+} in the host. Here we studied up-converssion luminescence intensity in co-doped GdVO₄ samples, synthesized by solid state method, as a function of Tm^{3+} and Yb^{3+} concentrations ratio $(Tm^{3+}:Yb^{3+}=3:3; 3:6; 3:9)$. The Tm^{3+} ion has a relatively low absorption for the transitions in the near-infrared region around 1000 nm, while co-doping with Yb³⁺ has proven to be a successful alternative for enhanced up-conversion as Yb^{3+} ion exhibits a larger absorption in this region. Up-converted emissions were recorded at room temperature under excitation of 980 nm and these emissions are observed in three different regions: blue, red and near infrared (NIR). The strong emissions appear at 475 nm (blue) and 800 nm (NIR) corresponding to ${}^{1}G_{4} \rightarrow {}^{3}H_{6}$ and ${}^{3}H_{4} \rightarrow {}^{3}H_{6}$ transitions, respectively, while emission in red region around 650 nm, due to ${}^{1}G_{4} \rightarrow {}^{3}F_{4}$, is very weak (see Fig. 1).



Figure 4. Up-converted luminescence spectra of Tm^{3+} , Yb^{3+} co-doped GdVO₄ samples under excitation of 980 nm for: a) 3mol%; b) 6mol% and c) 9mol% Yb^{3+} ions.

LUMINESCENCE IN InxGa1-xN EPITAXIAL LAYERS WITH **DIFFERENT INDIUM CONTENT**

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InGaN-based semiconductors have recently attracted much attention for optoelectronic applications due to its variable bandgap from 0.8eV (InN) to 3.4eV (GaN). In this work, the low temperature photoluminescence (PL) are carried out to investigate the optical properties of $In_xGa_{1,x}N$ material as a function of indium mole fraction (x=0.02, 0.04, 0.09, 0.11, 0.15, 0.25, 0.29 and 0.33). The PL peak energy of the In_xGa_{1-x}N material as a function of indium composition are displayed as opened dots in Fig 1. As shown by the red solid curve in Fig. 1, the composition dependence of the low temperature band gap in the entire composition range can be well fitted by the standard equation: $E_{\varrho}(\mathbf{x}) = \mathbf{x}E_{\varrho}(\mathrm{InN}) + (1-\mathbf{x})E_{\varrho}(\mathrm{GaN}) + b\mathbf{x}(1-\mathbf{x})$ with E_{ϱ} $(InN)=0.799 \text{ eV}, E_{\rho}(GaN)=3.478 \text{ eV} \text{ and } b=1.43 \text{ eV} [1].$

In addition, it is a well-known phenomenon that the full width at half maximum (FWHM) of a PL peak measured in a semiconductor alloy is dependent on the alloy content, x. The FWHM of the luminescence peak of In_xGa_{1-x}N material with different indium composition are plotted as opened squares in Fig. 2. Schubert et al. have indicated that the theoretical increase in the FWHM, ΔE_{EXC} , of the PL peaks due to alloy disorder can be obtained from the expression $\Delta E_{\text{EXC}} = 2.36\sigma_{\text{E}}$ and σ_{E} is the standard deviation of the band gap energy given

by $\sigma_E = \left| \frac{\partial E_g(x)}{\partial x} \right| \sqrt{\frac{x(1-x)V_c}{(4\pi/3)R_{\perp x}^3}}$, where $\frac{\partial E_g(x)}{\partial x}$ describes the variation of the band gap with

composition [2]. The theoretical result is described as the red solid curve in Fig. 2. It is observed that the experimental data of $In_xGa_{1-x}N$ material with $x \leq 0.15$ can consist with the theoretical line, but that of In_xGa_{1-x}N material with x≧0.25 would deviate from the theoretical line. The responsible broadening mechanism for the linewidth is alloy broadening which originates from the spatial fluctuations of the band gap energy.



Fig. 1 Evolution of the In_xGa_{1-x}N band gap with the alloy composition



Fig. 2 The variation of the PL FWHM with composition, x, for $In_xGa_{1-x}N$

- M. Moret, B.Gil, S.Ruffenach, O.Briot, Ch.Giesen, M.Heuken, S.Rushworth, T.Leese, M.Succi, J. [1] Cryst. Growth 311 (2009) 2795-2797.
- E. F. Schubert, E. O. Gobel, Y. Horikoshi, K. Ploog, H. J. Queisser, Phys. Rev. B 30 (1984) [2] 813-820.

TEMPERATURE DEPENDENT OPTICAL BANDGAP IN Cu₂GeS₃ BY PHOTOACOUSTIC SPECTROSCOPY

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The ternary semiconducting compound Cu_2GeS_3 has been investigated for optical properties study with photoacoustic spectroscopy [1]. Optical absorption spectra of Cu_2GeS_3 has been obtained in the range of 0.76 - 0.81 eV photon-energy at temperatures between 70 and 300 K (Figure 1). The absorption coefficient with the incident photon energy at different temperatures has been estimated (Figure 2).





Figure 1: Photoacoustic (PA) spectra of Cu_2GeS_3 at different temperatures

Figure 2: Variation of absorption coefficient (α) of Cu₂GeS₃ with incident photon energy.

The thermal variation of band-gap is calculated from the optical-absorption spectra at different temperatures (Figure 3).



Figure 3: Temperature variation of band gap (Eg) of Cu₂GeS₃.

The temperature variation of bandgap is explained on the basis of electron-phonon interaction with Varshni, Vina and Passler model [2-4]. The Debye temperature was calculated as 238K. The acoustic phonons with a characteristic temperature of 157 K corresponding to effective mean frequency, has main role in the band gap shrinkage with effective phonon energy of 22.8 meV and with cut-off phonon energy of 15.1 meV.

- [1] B. K. Sarkar, A. S. Verma, R. C. Gupta, K. Singh, Int. J. Thermophysics 31 (2010) 620-629.
- [2] Y. P. Varshni, Physica. 34 (1967) 149-154.
- [3] L. Viña, S. Logothetidis, M. Cardona, Phys. Rev. B. 30 (1984) 1979-1991.
- [4] R. Pässler, Phys. Status Solidi B. 200 (1997) 155-172.
SINGLET OXYGEN GENERATION BY UV LIGHT EXPOSURE OF RHODAMINE B IN THE PRESENCE OF CHITOSAN STABILIZED GOLD NANOPARTICLES

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The study of singlet molecular oxygen generation and reactivity has emerged as a rich and diverse area with implications in fields ranging from polymer science to cancer therapy. We report on the efficient production of molecular oxygen in the singlet ${}^{1}\Delta_{\sigma}$ state using rhodamine B (Rh) as photosensitizer in the presence of chitosan capped gold nanoparticlest (Au-Ch NP). Au-Ch NP colloids were prepared by green chemical synthesis procedure using D-glucose as the reducing agent and investigated by transmission electron microscopy and UV-vis spectroscopy. The changes in the absorption spectra with the change in the initial ion concentration were analyzed using Mie theory for the absorption of light by spherical particles. Singlet molecular oxygen was generated by UV light exposure of Rh and detected by electron paramagnetic resonance (EPR) and photoluminescence (PL) spectroscopy using 2,2,6,6tetramethylpiperidine (TEMP) and Singlet Oxygen Sensor Green® (SOSG) labels, respectively. The results of both employed techniques indicate that the Rh dye is an efficient photosensitizer, as well as that, in contrast to the biopolymer, the gold nanoparticles promote the generation of singlet oxygen. In addition, we will present the results of the analyses of the influence of particle size and concentration on the singlet oxygen yield.



IMPROVED DSC EFFICIENCY BY INCORPORATING SINGLE WALL CARBON NANOTUBES IN MESOPOROUS TITANIA

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The basic concept for efficiency improvement in Dye-Sensitized Solar Cells (DSC) is limiting the electron-hole recombination. One way to approach the problem is to reduce the resistivity of the mesoporous titania in order to improve the photogenerated electron mean free path and consequently reduce the electron-hole recombination probability. With this aim we placed the mesoporous anatase TiO_2 with single wall carbon nanotubes, forming a SWCNT/TiO₂ composite photoelectrode. Our investigations towards the overall efficiency of the DSC have been focused on fabricating DSC with photoelectrodes containing different loadings of carbon nanotubes. The SWCNT were dispersed by using the aromatic amino acid O-benzyl tyrosine and mixed directly with the TiO_2 paste. The O-benzyl tyrosine is a biocompatible suspending agent for SWCNT which is disabling aggregation and more importantly it is completely removed from the composite film during the sintering process.

We have studied the composite electrode and the influence of the SWCNT concentration on photovoltaic efficiency and characteristics of the cells using several characterisation techniques. Spectroscopic and morphological characterization was obtained by micro-Raman, UV-Vis spectroscopy and AFM microscopy. The electron transport was investigated through conductivity and impedance spectroscopy measurements. We found that cell parameters such as short circuit current, open circuit voltage and the overall efficiency were extremely sensitive on the SWCNT concentration in the composite films. Also, homogeneous suspension of SWCNT is especially important for reproducibility of the results since the properties of the composite photoelectrodes are sensitive even on small changes in concentration of the SWCNT, and the formation of aggregates is introducing inconsistencies in the electrical properties throughout the composite films.

Enhancing the charge separation and electron transport through the mesoporous photoelectrode that results in higher efficiency was obtained for cells with photoelectrodes fabricated with SWCNT loadings lower than 0,1 wt% (SWCNT vs. TiO₂). Indeed increasing the concentration of SWCNT resulted in improvement of conductivity confirming that nanotubes do favour the collection of electrons from the photoelectrode, but never the less the increase in concentration followed different trends regarding the cell efficiency. Increasing the SWCNT concentration in the composite electrode resulted in higher fill factor, contrary to the change in short circuit current, open circuit voltage and efficiency of the cell which had decreasing tendency. This demonstrates that even though there is a higher reactivity resulting in faster electron collection that is enabling electron transport in the photoelectrode, SWCNT in fact act as recombination centres thus suppressing the photocurrent generation.

STRUCTURAL AND OPTICAL PROPERTIES OF AgInSe₂

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Ternary I–III–VI₂ semiconducting materials with their exceptional electrical and optical properties and their potential application in light emitting diodes, nonlinear optics, optoelectronics and photovoltaic devices caused growing interest in material science community. Hence, great majority of studies is directed toward finding a proper method for synthesis of monodispersed nanoparticles (NPs) of these materials. Colloidal chemistry synthesis in organic media is recognized as excellent way to synthesize NPs with highly developed crystal structure. The main problem of this method is to standardize synthetic procedure in such manner that it can be used for synthesis of various two- or three-component semiconductors NPs. Proper adjustment of reaction parameters, choice of suitable precursors, solvents, and ligands are crucial for this type of synthesis.

Here, we present synthesis of AgInSe₂ NPs in organic media, by colloidal chemistry method, and subsequent characterization of obtained materials. AgInSe₂ is chosen as its bang-gap energy is 1.25 eV which makes it ideal material for NIR application as well as for the preparation of Schottky diodes and solar cells. We examined possibility of using 1-octadecene (safer and "greener" organic solvent) as non-coordinating solvent. This solvent enables synthesis of NPs with good crystallinity, but no control of size and crystal phase. We introduced in system trioctyphosphine (TOP) or oleylamine (OLAM), both well-known long chain ligands, and examined their influence on crystal structure, morphology and optical properties of obtained NPs.

DISPERSIVE OPTICAL PARAMETERS OF ZrON/Si THIN FILMS FORMED BY OXIDATION/NITRIDATION OF Zr METAL

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Aggressive miniaturization of Si-based metal-oxide-semiconductor (MOS) devices has attributed more transistors to be packed in a chip. Of several high κ oxides, ZrO₂ possesses advantages such as high enough κ value (22–25), suitably large bandgap (5.8– 7.8 eV), good thermodynamic stability, minimal lattice mismatch with Si(100), and easily stabilized in the form of cubic or tetragonal polymorphs, which may further enhance its effective κ value. In this study, ZrO₂ thin films were formed by simultaneous oxidation and nitridation of sputtered Zr on Si in N₂O ambient. An ultrathin interfacial layer (2.2 nm) has been also revealed by ZrO₂ incorporated with nitrogen to form a non-stoichiometric ZrO₂ (ZrON) film [1]. The nitridation effect in this process is postulated to provide good electrical properties to the MOS device. Bare n-type RCA cleaned (100) Si wafers (1-10 Ω cm) were used as the substrate in this study. Subsequently, the substrate was dipped into diluted HF solution (1 HF : 50 H₂O) to remove native oxide of the wafer. By utilizing a RF sputtering system (Edwards Auto 500), few-nanometer thick Zr film was deposited on the Si substrates. The working pressure, RF power, inert Ar gas flow, and deposition rate were regulated at 1.2×10^{-7} Torr, 170 W, 20 cm³/min, and 0.2 nm/s, respectively. After the deposition, samples were loaded into a horizontal tube furnace and heated up from room temperature to 700°C at a fixed heating rate of 10°C/min in an Ar flow ambient. Once the set temperature was achieved, N₂O gas was introduced with a flow rate of 150 mL/min for a set of durations before allowing the furnace to be cooled down to room temperature in an Ar ambient. Evaluations of structural and chemical properties of the samples were carried out by various characterization techniques such as XPS, XRD, RHEED. Dispersive optical parameters of ZrON/Si system were measured with spectroscopic ellipsometry (SE) using ELLIPS-1771 SA (Russia) spectroscopic ellipsometer. This ellipsometer provides spectral measurements with possible error of 0.05 deg and 0.08 deg for Ψ and Δ respectively. The spectral dependencies of ellipsometric angles Ψ and Δ were measured in the wavelength range $\lambda = 250-1100$ nm with spectral resolution of 2 nm. The four-zone method of measuring with subsequent averaging over all four zones was used in the experiment. For ZrON/Si system the model of air - (homogeneous isotropic film) – (homogeneous isotropic film) – Si substrate was used in calculations. Formation of interface SiO₂-type layer during heat treatment has been detected by SE measurements.

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[1] Yew Hoong Wong, Kuan Yew Cheong, J. Alloys Compd. 509 (2011) 8728-8737.

ELECTRONIC STRUCTURE OF RbTiOPO₄ AND KTiOPO₄ AND EFFECTS OF Rb↔K SUBSTITUTION IN KTP-FAMILY CRYSTALS

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Rubidium titanyl phosphate, $RbTiOPO_4$ (RTP), is a member of wide family of ternary oxide compounds with KTiOPO₄ (KTP)-type crystal structure. RTP is characterized by noncentrosymmetric crystal structure, space group $Pna2_1$, and pronounced ferroelectric, piezoelectric, acoustic, electrooptical parameters, linear and nonlinear optical properties [1]. Because of high optical damage threshold and high resistivity, RTP is used in electrooptical and nonlinear optical devices. In numerous studies a possibility of solid solution formation by cation substitution in RTP crystal lattice was demonstrated with tuning structural and optical characteristics. Optical waveguide formation by ionimplantation and epitaxial techniques can be achieved in RTP that promises for using RTP-based waveguide structures in integrated optics [2]. Previously, the electronic structure of several members of KTP crystal family was evaluated by theoretical and experimental method (e.g. X-ray photoelectron spectroscopy (XPS)). The detailed information on the electronic structure modification from potassium to rubidium in KTP family, however, is absent up to now. Thus, this study is aimed to determine the electronic structure of RTP with the help of XPS and compare the parameters with those earlier obtained for different titanates and phosphates. Then, the electronic properties of KTP and RTP are calculated using first-principles theory [3] and compared with available experimental results.

A sample of RTP was cut from the single crystal part without visible defects and growth sector boundaries. Then, the sample was gently grinded up to formation of fine powder. Observation of photoemission properties of RTP was produced by using surface analysis center SSC (Riber) with XPS method under illumination by nonmonochromatic Al K α radiation (1486.6 eV). Detailed spectra were measured for the valence band and all element core levels detected in photoemission spectra. These specta are confirmed by the plane-wave pseudopential calculations. Moreover, as the rubidium cations are substituted with potassium cations, the electronic peaks for K and Ru orbitals are quite localized, indicating that they do not take part in the bonds with the neighbor atoms. Namely, they do not affect the electronic states on the other kinds of atoms in the KTP family. Constituent core levels parameters recorded in RTP with XPS have been compared with those earlier determined in other titanate and phosphate crystals to see the chemical bonding effects.

- O. Gobert, N. Fedorov, G. Mennerat, D. Lupinski, D. Guillaumet, M. Perdrix, A. Bourgeade, M. Comte, Appl. Opt. 51 (5) (2012) 594-599.
- [2] Liang-Ling Wang, Xiao-Jun Cui, Opt. Mater. 34 (8) (2012) 1455-1458.
- [3] S.J. Clark, M.D. Segall, C.J. Pickard, P.J. Hasnip, M.J. Probert, K. Refson, M.C. Payne, Z. Krystallogr. 220 (2005) 567-570.

EFFECTS OF PROCESS PARAMETERS ON THE OPTICAL CONSTANTS OF HIGHLY TEXTURED V₂O₅ THIN FILMS

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Vanadium pentoxide (V_2O_5) is an important material for many technological applications. The most stable oxide in the V-O system, exhibits a semiconductor-metal transition at $\sim 250^{\circ}$ C. V₂O₅ thin films exhibit multicolored electrochromism, and have high potential for use in electrochromic display devices, color filters, and other optical and optoelectronic devices. V_2O_5 thin films can also be used in variable reflectance mirrors, smart windows, and surfaces with tunable emittance for temperature control of space vehicles. Despite the wide range of technological applications, it is well known that the optical and electrical properties of V_2O_5 films are highly dependent on the microstructure, which in turn is controlled by the film-fabrication technique, growth conditions, and post-deposition processes. In this work, spectroscopic ellipsometry (SE), which is known to be a sensitive and nondestructive method for structure and optical characterization of thin-film materials, has been employed in combination with reflective high energy electron diffraction (RHEED) to study the optical properties of the textured and oriented $V_2O_5/Si(100)$ system in a photon-energy (E) range of 1-5 eV. The most significant feature of the work is that the highly-textured and c-axis oriented V₂O₅ films grown by magnetron-sputter deposition exhibit optical characteristics similar to high-quality optical V₂O₅ single crystals.

V₂O₅ thin films were deposited using reactive DC magnetron-sputtering of a V-metal target in the O₂+Ar atmosphere. The deposition was made onto chemically well-cleaned Si(100) substrates. The deposition chamber was evacuated down to a pressure of 5×10^{-4} Pa prior to film-fabrication. The grown V₂O₅ films were characterized for phase composition and surface-texture using reflection high energy electron diffraction (RHEED) studies made using the EFZ4 device (Carl Zeiss, Germany). An electronbeam of 65 keV is directed at the sample and the images are recorded by the electrons diffracted from surface. To probe the optical properties, SE measurements were made on the V₂O₅ films using an ELLIPS-1771 SA ellipsometer (ISP, Russia) in the spectral range of 250 nm $< \lambda < 1030$ nm. Ellipsometric angles Ψ and Δ were measured as a function of λ at the incidence angles φ_0 of 50, 60 and 70°. We used the four-zone method of measuring with subsequent averaging over all the four zones. Film thickness was obtained from ellipsometric measurements at $\lambda = 632.8$ nm using laser ellipsometer LEF-3M (ISP, Russia). The profiles of the optical constants, namely the refractive index and extinction coefficient, of V₂O₅ films were evaluated in the photon-energy range of 1-5 eV. At photon-energy above 2.5 eV, the dispersion behavior of the dielectric function is explained based on Lorentz-Drude model. The dispersion of the dielectric function fits to a Cauchy's relation at photon-energy below 2.5 eV, where the V₂O₅-film is mostly transparent. The optical transitions across the bandgap occur at energy ~2.5-3.2 eV depending on the V_2O_5 growth conditions and film-microstructure.

THE STUDY OF ELECTRON TRANSPORT THROUGH A MULTIPLE QUANTUM WELL STRUCTURE IN THE PRESENCE OF THE ELECTRIC FIELD, USING THE RELATIVISTIC TRANSFER MATRIX

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We propose a computational model for obtaining the transmission coefficient of a relativistic electron transported through a semiconductor–based multiple quantum well structure, in the presence of an external, constant electric field. For this purpose, a relativistic version of the transfer matrix formalism based on the Dirac equation in external, piecewise constant potentials is used. Effects of the electric field and geometry upon the relativistic transmission coefficient are investigated. The obtained results in the relativistic framework are compared with the non–relativistic ones. This model could be used in problems with polarisation and point-dependent effective mass, with possible applications in the field of the opto-electronic devices.

- [1] B. R. Nag, Physics of Quantum Well Devices, Kluwer Academic Publisher, Netherlands, 2000.
- [2] J. D. Bjorken and S. Drell, Relativistic Quantum Mechanics, McGraw-Hill, New York, 1964.
- [3] B. Thaller, The Dirac Equation, Springer-Verlang, 1992.
- [4] R. Renan, M. H. Pacheco, C. A. S. Almeida, J. Phys. A: Math. Gen. 33 (2000) L509.
- [5] I. Cotaescu, P. Gravila and M. Paulescu, Phys. Lett. A 366 (2007) 363
- [6] J. M. Luttinger, Philips Res. Rep. 6 (1951) 303.
- [7] R. E. Borland, Proc. R. Soc. London, Ser. A 84 (1961) 926.
- [8] P. Pereyra P, E. Castillo, Phys. Rev. B 65 (2002) 205120.
- [9] J. H. Davies, The Physics of Low-dimensional Semiconductors: An Introduction, Cambridge University Press, Cambridge, 1998.

DOWNSHIFTING AND DOWNCONVERSION OF SOLAR SPECTRUM IN Tb³⁺, Yb³⁺ ACTIVATED OXIDE HOSTS FOR PHOTOVOLTAICS

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The mismatch between spectrum of solar irradiation reaching PV cells and shape of their spectra response is fundamental factor limiting efficiency of solar cells. Among many approaches to minimize effect of the spectral mismatch changing shape of incident light's spectrum has a distinct advantage of increasing the efficiency of solar devices without need for structural redevelopment of the already existing PV cells [1].

In this work we demonstrate the downconversion and downshifting within the Tb^{3+} - Yb^{3+} ion couples embedded in the $(Y_2Al_4O_9)$ YAM nanocrystals. We analyze mechanisms of excitation of the 5D_4 level, critical in both downconversion and downshifting pathways. Possibility of downshifting with participation of single Yb^{3+} ion, as indicated in [2] for other host, is considered. Effects of Yb^{3+} concentration on energy transfer efficiency (ETE) were investigated. Mechanisms influencing shape of visible light emissions from Tb^{3+} were studied [3]. We conclude with evaluation of applicability of the $Tb^{3+}-Yb^{3+}$ system in PV devices.

- [1] B. S. Richards, Solar Energy Materials & Solar Cells 90 (2006) 2329 2337
- [2] I.A.A. Terra et. al., Journal of Luminescence 132 (2012) 1678–1682
- [3] Z. Boruc, B. Fetlinski, M. Kaczkan, S. Turczynski, D. Pawlak, M. Malinowski, Journal of Alloys and Compounds 532 (2012) 92–97

THE ENHANCED TWO MICRON EMISSION IN THULIUM DOPED TELLURITE GLASSES

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In this work we demonstrated enhanced infrared thulium emission in the novel fluorotellurite glasses in comparison with the traditional TZN host. The OH concentration reduction in the novel host material established fast - diffusion regime for the ${}^{3}F_{4} \rightarrow {}^{3}H_{6}$ emission while the same emission in TZN host was in the frame of the diffusion – limited regime. The spectroscopic and thermo-mechanical properties of tellurite glasses showed promising features and possibility for fiber drawing.

ATOMIC AND ELECTRONIC STRUCTURE OF GRAIN BOUNDARIES IN CRYSTALLINE ORGANIC SEMICONDUCTORS

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Organic crystalline semiconductors are very promising materials for electronic and optoelectronics devices, such as transistors, LEDs and solar cells [1]. Real organic semiconductors are polycrystals and therefore contain many contact interfaces (grain boundaries) between monocrystals with different crystalline orientations. Grain boundaries are believed to be bottlenecks to charge carrier transport in these materials [2].

We have developed a methodology for the investigation of the role of grain boundaries in polycrystalline organic semiconductors. The molecular structure is obtained using the united-atom description according to Transferable Potential for Phase Equilibria (TraPPE) methodology for the inter-molecular interaction [3]. A Monte Carlo algorithm is used for the minimization of the system energy and finding the equilibrium system structure [4]. The atomic structure of the material near the contact between two grains is calculated as a result of the energy minimization.

Electronic states near the grain boundaries are calculated using the charge patching method (CPM) [5]. Motifs for the CPM are generated from density functional theory (DFT) calculations [5]. CPM provides a similar accuracy as DFT but with a much smaller computational cost that allows us to calculate electronic states for systems composed of several thousand atoms, which is not feasible using DFT.

The methodology was applied to study the nature of electronic states introduced by grain boundaries in naphthalene crystals. The results obtained for the energies and the degree of localization of the wavefunctions will be presented and the consequences of the results for the device applications will be discussed.

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- [1] S. Verlaak, P. Heremans, Phys. Rev. B 75 (2007) 115127
- [2] A.B. Chwang, C.D. Frisbie, J. Appl. Phys. 90 (2001) 1342-1349
- [3] M.G.Martin, J. I. Siepmann, J. Phys. Chem. B 102 (1998) 2569-2577
- [4] M.P. Allen, D. J. Tildesley, Computer Simulation of Liquids, Oxford University Press, London, 1999.
- [5] N. Vukmirovic, L.W.Wang, J. Chem. Phys. 128 (2008) 121102

SENSITIZED GELATIN AS A VERSATILE BIOMATERIAL WITH TUNABLE MECHANICAL AND OPTICAL PROPERTIES

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Gelatin, as a biocompatible and biodegradable polymer, is widely used in food, pharmaceutical, and biomedical [1-3]. It's poor mechanical properties limit potential applications of gelatin as a biomaterial. Crosslinking of gelatin with various chemical agents such as formaldehyde, glutaraldehyde (GTA), genipin mainly overcome the brittleness of gelatin films, improves its flexibility, reduce the degree of swelling, and enhances the thermal stability [4-6]. It was not reported that any of them possess optical sensitivity and favorable optical properties.

Previously we have shown that gelatin doped with tot'hema and eosin, (tot'hema-eosin sensitized gelatin – TESG for short) becomes excellent optical material [7–9]. High quality, transparent microlenses were produced by direct laser irradiation of TESG film. We have found that TESG becomes elastic, while retaining good optical properties. The mechanical properties of tot'hema-eosin sensitized gelatin films have been investigated for various concentrations of tot'hema (ranging from 5 % to 30 % v/v). TESG specimens were prepared according to the ASTM standards for elastic materials. Tensile strength, strain at break and Young's modulus were measured. The results show that extensibility of TESG film increases with increasing tot'hema concentration, while the Young's modulus and stress at break exponentially decrease. Mechanical properties can be tailored to suit various biomedical applications like blood vessels and biosensors based on microlenses. Tunable (strain responsive) TESG microlenses were produced and mechanical model of blood vessel was prepared.

- [1] S. Sakai, K. Hirose, K. Taguchi, Y. Ogushi, K. Kawakami, Biomaterials 30 (2009) 3371–3377.
- [2] Y. Kimura, M. Ozeki, T. Inamoto, Y. Tabata, Biomaterials 24 (2003) 2513–2521.
- [3] M. Madaghiele, A. Piccinno, M. Saponaro, A. Maffezzoli, A. Sannino, Jour. of Mater. Sci.: Materials in Medicine 20 (2009) 1979–1989.
- [4] T. Salsa, M.E. Pina, J.J.C. Teixeira-Dias, Appl. Spectrosc. 50 (1996) 1314–1318.
- [5] A. Bigi, B. Bracci, G. Cojazzi, S. Panzavolta, N. Roveri, Biomaterials 19 (1998) 2335–2340.
- [6] A.Bigi, G. Cojazzi, S. Panzavolta, N. Roveri, K. Rubini, Biomaterials 23 (2002) 4827–4832.
- [7] B. Murić, D. Pantelić, D. Vasiljević, B. Panić, Appl. Opt. 46 (2007) 8527–8532.
- [8] B. Murić, D. Pantelić, D. Vasiljević, B. Panić, Opt. Mater. 30 (2008)1217-1220.
- [9] B. Murić, D. Pantelić, D. Vasiljević, B. Panić, B. Jelenković, Appl. Opt. 48 (2009) 3854–3859.

SYNTHESIS, STRUCTURAL AND VIBRATIONAL PROPERTIES OF MICROCRYSTALLINE RbSm(MoO₄)₂

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Double molybdates display a variety of crystal structures and they possess useful electro-physical, optical and catalytic properties. Complex molybdates containing Ln^{3+} ions in low-symmetry positions are promising for creation new effective laser mediums. Present study is aimed to synthesize the RbSm(MoO₄)₂ microcrystals and evaluate the morphological, structural and vibrational properties of the compound. Formation of binary molybdate RbSm(MoO₄)₂ was previously found in quasi-binary system Rb₂MoO₄-Sm₂(MoO₄)₃.

Middle-temperature solid state synthesis was applied to create the $RbSm(MoO_4)_2$ crystals. As starting materials, MoO₃ (99.9%), Rb₂CO₃ (99.99%) and Sm₂O₃ (>99.9%) were used. Initially rubidium molybdate and samarium molybdates were prepared by solid state reactions. To avoid a loss of molybdenum oxide due to its high volatility, heat treatment of stoichiometric mixtures was started at T=450°C and followed by stepwise temperature increasing up to $T = 600^{\circ}$ C (Rb₂MoO₄) and 800°C (Sm₂(MoO₄)₃), respectively. Then, these molybdates were mixed and annealed at $T = 550-600^{\circ}$ C by 90h to yield RbSm(MoO₄)₂. Phase composition of the products was produced with Xray analysis by Advance D8 Bruker AXS instrument. Micromorphology was observed by SEM with LEO 1430 device. Final product was formed by slightly agglomerated plate-like microcrystals. The diffraction data for Rietveld analysis were collected at room temperature (298 K) with a Bruker D8 ADVANCE powder diffractometer in the Bragg-Brentano geometry and linear Vantec detector ($CuK\alpha$ radiation, step size 0.016° , counting time 2s per step). The data were collected over the range 20: 5-100°. The atomic coordinates in isotructural molybdate TlPr(MoO₄)₂ were used to refine the structure of $RbSm(MoO_4)_2$. The refinement of structure with *Pbcn* space group was stable and led to minimal *R*-factor. Unpolarized Raman scattering spectra were recorded from powder sample by using a triple grating spectrometer TriVista 777 and a line of 532 nm of solid state laser (200 mW) at room temperature. Spectral resolution was ~1 cm⁻¹ (FWHM). About 20 narrow Raman lines were observed in the experimental spectrum. The most narrow and intense line is at 948 cm⁻¹, which can be compared with Mo=O stretch line of α -MoO₃ crystals (995 cm⁻¹).

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GROWTH AND MICROSTRUCTURE OF CENTAUR CRYSTAL GaSe:InS

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Nonlinear optical crystal GaSe is capable to incorporate different doping elements at high content with noticeable modification of physical properties. Besides the doping by single element, such complex additions as $AgGaSe_2$ and $AgGaS_2$ were proposed and the GaSe: $AgGaSe_2$ crystals were characterized by increased nonlinear coefficient of 75 pm/V yielding a figure of merit six times larger than that of $AgGaSe_2$ [1,2]. Present study is devoted to crystal growth of $(Ga_2Se_2)_{1-x}(InS_2)_x$, and the observation of structural and optical properties of the modified crystals with XRD, TEM and spectroscopic ellipsometry (SE).

The starting materials were Ga (6N) and Se, In, S (5N). Presynthesized charges of stoichiometric GaSe and InS were mixed in the molar fractions 0.95:0.05 and used for crystal growth. Doped GaSe:InS crystals were grown by conventional Bridgman technique in evacuated to 10^{-3} tor quartz ampoule coated with pyrolitic carbon. The samples for measurements were cleaved from the grown ingot parallel to the c-plane and were used without additional surface treatment. Composition determination was provided with electron probe microanalysis (EPMA) and, for selected samples, with atomic-absorption spectrometry and inductively coupled plasma optical emission spectrometry. Structural properties of doped crystals were observed with TEM and XRD. Cleaved sample surface was found to be formed by wide flat terraces with sharp edges that is typical for GaSe crystal surface. The presence of pure *ε*-GaSe-type crystal phase was verified by TEM and XRD analysis. EPMA indicates the inhomogeneous distribution of In and homogeneous distribution of S along the crystal growth direction with higher In content at the boule end. So, pronounced segregation of In can be stated with noticeable effect on phase-matching conditions in GaSe:InS crystals. Dispersive optical parameters of GaSe:InS were measured with SE using ELLIPS-1771 SA (Russia) spectroscopic ellipsometer. The spectral dependencies of refractive index and extinction coefficient were obtained over the wavelength range $\lambda = 250-1100$ nm.

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- N.B. Singh, D.R. Suhre, W. Rosch, R. Meyer, M. Marable, N.C. Fernelius, F.K. Hopkins, D.E. Zelmon, R.J. Narayanan, J. Cryst. Growth 198/199 (1999) 588-592.
- [2] Y.-F. Zhang, R. Wang, Z.-H. Kang, L.-L. Qu, Y. Jiang, J.-Y. Gao, Yu.M. Andreev, G.V. Lanskii, K.A. Kokh, A.N. Morozov, A.V. Shaiduko, V.V. Zuev, Opt. Commun. 284 (6) (2011) 1677-1681.

MICROMORPHOLOGY AND OPTICAL CONSTANTS OF AMORPHOUS CHROMIUM METAL FILMS FORMED BY SUBLIMATION

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Chromium metal films are widely used in microelectronics, modern catalysis, solar energetics and nanotechnologies. In developed device structures the precise control of Cr film thicnkess is required. Optical ellipsometry is a suitable method for noncontact and nondestructive determination of thickness of semitransparent metal films, if optical constants of the metal are known. Thus, present study is aimed at the development of vacuum technology of thin chromium film fabrication to provide the film thickness control and the determination of optical constants of the metal films by spectrosopic ellipsometry.

Chromium films were prepared by thermal metal sublimation in vacuum ~ 10^{5} Torr and substrate temperature over the range $T = 60-250^{\circ}$ C. Sublimation of Cr (99.98%) was produced at $T = 1725\pm25^{\circ}$ C using thermostatic evaporator of special construction providing stable chromium vapor flow. In a result, the amorphous metal films were prepared. Surface micromorphology of the fuzed quartz substrates and Cr films was studied by AFM with Solver P-47H device in noncontact mode. As it was shown by AFM observation, the rms parameter of Cr films was as low as ~0.6 nm for an area of 5×5 μ m². Formation of nanograins with diameter of ~50 nm has been detected by detailed AFM measurements.

Spectral dependencies of refractive index $n(\lambda)$ and extinction coefficient $k(\lambda)$ were determined by means of spectroscopic ellipsometry (SE). Ellipsometric angles Ψ and Δ were measured as a function of λ in the spectral range ~250–1030 nm using an ELLIPS-1771 SA ellipsometer. The instrumental spectral resolution was 2 nm, the recording time of a spectrum did not exceed 20 s and the angle of incidence of light beam on the sample was 70°. We used the four-zone method of measuring with subsequent averaging over all the four zones. Continuous growing of *n* and *k* parameters with wavelength λ icrease were found for evaporated Cr films. The functions $n(\lambda)$ and $k(\lambda)$ are determined over the spectral range 250–1030 nm and compared with earlier experimental results.

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OPTICAL PROPERTIES OF CUBIC OXYFLUORIDE Rb₂KTiOF₅

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Complex metal oxyfluorides are interesting materials because the strong distortion of metal-(O,F) polyhedra in crystal lattice is achievable due to different ionicity of metal-O and metal-F bonds. Effects of mixed anion sublattice, however, are considered for a long time for a suite of transition metals compounds with $[MO_{6x}F_x]$ (M = W, Mo, Nb, Ti) groups. Present study is aimed to synthesize the Rb₂KTiOF₅ crystals and evaluate for the first time the optical parameters of this oxyfluoride. At room temperature the crystals of Rb₂KTiOF₅ are cubic, space group *Fm*-3*m*, because of complete anion disorder [1].

Synthesis of Rb₂KTiOF₅ was carried out basing on the following reaction: $K_2TiF_6 + TiO_2 + 4RbF =$ 2Rb₂KTiOF₅. High purity initial reagents K₂CO₃, Rb₂CO₃, TiO₂, NH₄F and aqueous hydrofluoric acid (HF) (48%) were used. Titanium oxide was fired during 4 h in a platinum crucible at 800C. Waterless RbF was obtained from Rb₂CO₃ by neutralization of HF and solution evaporating at the excess of etching acid. Synthesis of K2TiF6 was carried out in two stages. On the first one we alloyed K₂CO₃ and TiO₂, taken in stoichiometric proportion, at 1000 C with a potassium titanite formation. The obtained alloy was then grinded in a ceramic vessel and placed into a Teflon glass. Afterwards concentrated etchng acid was added by small portions and a relatively violent exothermic reaction: $K_2TiO_3 + 6HF = K_2TiF_6 + 3H_2O^{\uparrow}$. After the reaction one added an excess of etching acid and the glass was heated to melting. At the same time potassium fluoride titanite passed to the solution and at its cooling the $K_{2}TiF_{6}$ crystals precipitated. They were washed in cold water and recrystallized once again. The obtained chemicals were mixed in a stoichiometric ratio and placed in a platinum crucible into a growth furnace, covered by a platinum glass which was blown through continuously with dry nitrogen. Furnace was heated at a rate of 100degrees/h up to 1000 C, kept at this temperature during 6h, afterwards temperature was lowered at a rate of 5 degrees/h during a day and then at a rate of 100 degrees/h to room temperature. X-ray single crystal data from Rb₂KTiOF₅ was measured on SMART APEXII diffractometer (MoK_g, $\lambda = 0.7106$ Å) at room temperature. Structure of Rb₂KTiOF₅ was solved in space group Fm-3m, a = 8.880(1) Å, Z = 4, V = 700.16(2) Å³, by direct methods in program SHELXL97. Coordinates of all atoms were determined and atoms of O and F were refined with the same coordinates and equal thermal parameters. Transparency range for the RbKTiOF₅ plate 0.85 mm thick covers the 0.31-9.0 μ m range on the 50% level at 300 K. The shortwave absorption edge is determined by the band gap whereas second and third harmonics from lattice vibrations are responsible for the longwave limit. An intense absorption peak is observed at 5.58 µm. Fundamental absorption at $\lambda < 0.343$ µm gives a direct line in coordinates ($\alpha * hv$)² = f(hv), which corresponds to the case of direct allowed electronic transition between the valence and conduction bands. Band gap was estimated to be $E_g = 3.87$ eV at T = 300 K. We observed at 300 K photoluminescence (PL) which is most effectively excited at band-to-band transitions. Broad bands in the PL spectra indicate an intense electron-phonon interaction. Shortwave band at 3.3 eV is related to bound excitons whereas the 2.33 eV band is likely due to recombination of self-trapped excitons. The other bands are supposed to be associated with native F-type defects and their complexes.

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[1] A.A. Udovenko, N.M. Laptash, Acta Cryst. B 67 (2011) 447-454.

IMPROVING SCINTILLATING MATERIALS FOR MEDICAL IMAGING APPLICATIONS

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Lu_{2(1-x)}Y_{2x}SiO₅:Ce (10%at Y) single crystals co-doped with Ca²⁺ and Mg²⁺ were prepared by the Czochralski technique. Co-doping allows significant improvement of the scintillation with a reduction of the afterglow and a large improve of the light yield value. For instance LYSO:Ce codoped with Ca²⁺ and Mg²⁺ led to significantly improved light yield, e.g. 34000 Ph/MeV for LYSO:Ce,Ca instead of 28000 Ph/MeV for standard LYSO:Ce under ¹³⁷Cs – 662 keV excitation.

Afterglow can be as low as 200ppm at 20ms when Ca^{2+} is used as a co-dopant, which is comparable to commercial Gd₂O₂S:Pr,Ce ceramics performances.

Afterglow reduction with Ca^{2+} co-doping in LSO:Ce was also already reported [1] but to a lower extent : about 700 ppm remain 1s after X-rays are stopped. This new feature could open an interesting area of use of oxy-orthosilicates in the medical imaging field where very low afterglow is required.

In addition, co-doped single crystals were carefully investigated. Using X-ray Absorption Near Edge Spectrometry (XANES) we were able to evidence that a significant part of the Ce ions are stabilized in the Ce^{4+} oxidation state in co-doped LYSO:Ce.

In order to make the correlation between improved scintillation performances and significant Ce⁴⁺ content in co-doped LYSO:Ce, a new mechanism is presented.

Kan Yang, Charles L. Melcher, Philip D. Rack, and Lars A. Eriksson, *IEEE Transactions On Nuclear Science* 56, 2960-2965 (2009).

SYNTHESIS AND OPTICAL BEHAVIOR OF COPPER NANOPARTICLES IN DIFFERENT MEDIA

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In this report, we describe a simple and rapid chemical reduction method with inert gas protection, for preparing stable copper nanoparticle with average particle size of 9.4 nm. In our synthesis route, ascorbic acid is used as antioxidant to effectively prevent the general oxidation process during copper nuclei formation. As-prepared copper nanoparticles were transferred from water phase to different organic solvents (hexane, octane, cyclohexane, and toluene) using oleylamine as a phase transfer agent. This should allow dispersion of the particles in both polar and nonpolar solvents and avoid particle aggregation during the solvent exchange process. Transmission electron microscopy and UV–Vis spectroscopy contributed to the analysis of size and optical properties of the copper nanoparticles in different media, respectively. The advantages of such solvent exchange process can be found in the applications of metal particles as catalysts for organic reactions in nonpolar solvents and in the study of the changes in surface chemistry depending on the surrounding medium and on the adsorption of different moieties.

OPTICAL AND STRUCTURAL CHARACTERIZATION OF POLYANILINE-GOLD NANOCOMPOSITE

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Nanocomposites based on conducting polymer and metal nanoparticles are very advantageous nanostructures due to their unique optical and conductive properties, offering the opportunity for many nanotechnological applications. In the present work, we report polyaniline – gold nanocomposite (PANI/Au) obtained by "in situ" chemical synthesis route. The chloroaurate ions (AuCl₄) are used as an oxidant for the oxidative polymerization of aniline leading to the formation of gold nanoparticles together with polyaniline. Furthermore, the gold nanoparticles act as nucleation sites for the oxidative formation of PANI, encapsulating the metal in the form of a polymer/metal composite. Characterization of the samples, performed with UV-Vis and FTIR spectroscopy and XRD technique are used for description of the optical and structural properties of PANI/Au nanocomposite. Results from the FTIR spectra of the composite material are consistent with PANI produced using only ammonium persulfate as the oxidant. On the other hand, UV-Vis results indicate that the optical properties can be tailored from PANI.

HYDROTHERMAL SYNTHESIS AND OPTICAL CHARACTERIZATION OF Ni-DOPED CuCrO₂ NANOCRYSTALS

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Ni–doped CuCrO₂ nanocrystals were successfully synthesized by a simple hydrothermal technique using Cu₂O, Cr(OH)₃ and H₂NiO₂ as precursors. NaOH were used to control metal oxide solubility and oxidation state of Cu, respectively. The crystal structure of CuCr_{1-x}Ni_xO₂, where (x=0,01-0,05), was investigated by X-ray diffraction. The asprepared CuCr_{1-x}Ni_xO₂ nanocrystals crystalline in an a rhombohedral 3R type with a <u>space group</u> of R3m and respect the ABO₂ delafossite structure, which consist of a sheet of linearly coordinated A cations stacked between edge-shared octahedral layers (BO₆) [1].

The XRD patterns have shown a slight shift of peaks which is caused by the distortion of lattice determined by increasing of B ionic radius, in according with the difference between Ni²⁺ radii ($\mathbf{r} = 0.69$ Å) and Cr³⁺ radii ($\mathbf{r} = 0.63$ Å) [2]. Particles size was estimated using Scherrer formula and is around 20 nm.

Optical characterization reveals that the band gap energy of the Ni²⁺ doped samples decreases with increasing Ni²⁺concentration from 2.95eV (x=0) to 2.75eV (x=0,05). Such band gap narrowing is also observed in case of Ni doped SnO₂ where decrease in the band gap energy may be due to the accumulation of donor energy levels of TM ions in the actual band gap of SnO₂[3].

Acknowledgements

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[1] Meagen A. Marquardt, Nathan A. Ashmore, David P. Cann, Thin Solid Films 496 (2006) 146 - 156

[2] MR. D. Shannon: Acta Crystallogr., Sect. A 32 (1976) 751.

[3] A. Sharma, M. Varshney, S. Kumar, K.D.Verma, Nanomater. nanotechnol., 2011, Vol. 1, No. 1, 24-28

PROTON CONDUCTING POLYMER ELECTROLYTE BASED ON PLASTICIZED CHITOSAN-PEO BLEND AND APPLICATION IN ELECTROCHEMICAL DEVICES

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Ionic conductivity is an important criterion of a polymer electrolyte. Polymer blending is a useful method to increase ionic conductivity since the properties of the polymer blend could be better than that of single polymer and improve the structural stability. The effect of ethylene carbonate (EC) contents on the conductivity and dielectric properties of solid polymer electrolytes based on chitosan and polyethylene oxide (PEO) blend doped with ammonium nitrate (NH₄NO₃) were analyzed. The electrolyte films were prepared by the solution cast technique. The sample with 11 wt.% chitosan + 7 wt.% PEO + 12 wt.% NH₄NO₃ + 70 wt.% $\overline{\text{EC}}$ exhibited the highest conductivity of $(2.06 \pm 0.90) \times 10^{-3}$ S cm⁻¹ at room temperature. Fourier transform infrared (FTIR) spectra of all electrolytes were analyzed to study the interaction among the polymers, polymer-salt and polymer-salt-plasticizer. Hydroxyl band of pure chitosan film shifted from 3354 cm⁻¹ to 3425 cm⁻¹ when blended with PEO. On addition of 40 wt.% NH₄NO₃, the hydroxyl band in the spectrum of pure chitosan-PEO film shifted to 3227 cm⁻¹, proving that complexation occurred between the polymer blend and salt. The carboxamide band was observed to shift to as low as 1639 cm⁻¹, while the amine band to as low as 1535 cm⁻¹. The interaction between EC and chitosan-PEO-NH₄NO₃ can be observed by the appearance of the doublet C=O stretching band of EC. Proton battery with configuration of Zn + ZnSO₄·7H₂O/11 wt.% chitosan + 7 wt.% PEO + 12 wt.% $NH_4NO_3 + 70$ wt.% EC/MnO₂ were fabricated and showed an open circuit potential (OCP) of (1.63 ± 0.02) V and average discharge capacity at (48.1 ± 8.0) mAh. The maximum power density of the fabricated cells was (9.73 ± 0.75) mW cm⁻². The highest conducting electrolyte was also employed as separator in the application of electrochemical double layer capacitor (EDLC) and the EDLC can performed for 100 cycles at 0.021 mA cm⁻². The capacitance of the EDLC was obtained to be 1.81 mF g^{-1} .

^[1] M.F.Z. Kadir, A.K. Arof, R. Yahya, Z. Aspanut, Mater. Res. Innov. 15 (2011) S164–S167.

^[2] M.F.Z. Kadir, S.R. Majid, A.K. Arof, Electrochim. Acta 55 (2010) 1475-1482.

^[3] S. Rajendran, O. Mahendran, Ionics 7 (2001) 463-468.

INVESTIGATION OF THE OPTICAL PROPERTIES OF NANOCOMPOSITE ZnO-MnO₂ THIN FILMS PREPARED BY SOL-GEL METHOD

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The ZnO-MnO₂ thin films were prepared by sol-gel method. The sol was prepared from zinc and manganese acetate, 2-Methoxyethanol, and MEA as the precursor, solvent and stabilizer, respectively. The sols were prepared with $Zn(ac)_2/Mn(ac)_2$ molar ratios of 8%, 16% and 25%, respectively. After aging the solution for 24 h, the sol was passed through a filter before deposition. Then, the thin films was deposited on glass substrates using dip-coating technique and annealed in ambient condition at 300°C. X-ray diffraction patterns of films show the orthorhombic crystal structure of MnO₂ phases for molar ratio 8% with grain sizes about 34 and 21nm. The XRD patterns for other thin films with Zn(ac)₂/Mn(ac)₂ molar ratios of 16% and 25% indicate an amorphous structure. The SEM images confirm the presence of the granule surface morphology for molar ratio 8%. Increasing *molar ratio* (>8%) leads to *decreasing* nanoparticle size and exhibit a smooth and homogeneous surface morphology that is in agreement with the result of XRD pattern. The transmission spectra of the nanocomposite ZnO-MnO₂ thin films were measured by a UV-VIS Spectrophotometer in the wavelength range 200-900 nm. The transmission spectra show that the transmittance is decreased as the Zn^{2+} concentration is increased. The optical constants, thickness and optical band gap are retrieved by simulating the transmission spectra based on Tauc-Lorentz model [1]. The optimization process is performed using a nonlinear least squares fitting procedure [2]. According to the results of optimization procedure, the values of indirect optical band gap of ZnO-MnO₂ thin films for three different concentrations 8%, 16% and 25% of Zn^{2+} are obtained 1.98, 1.62 and 1.71eV. The results of FTIR measurements for the nanocomposite ZnO-MnO₂ thin film show that the absorption peaks around 501 and 617 cm⁻¹ are due to the Mn-O vibrations in MnO₆ octahedral [3]. Several small absorption peaks at higher wave number correspond to the bending or stretching vibration organic bonds.

- [1] WG.E. Jellison, Jr., F.A. Modine, P. Doshi, A. Rohatgi, Thin Solid Films. 313-314 (1998) 193-197.
- W. Sun, Y. X. Yuan (Eds.), Optimization Theory and Metods: Nonlinear Programming, Springer Science. New York, 2006, pp. 362-366.
- [3] T. Yousefi, A. Nozad Golikand, M. Mashhadizadeh, M. Aghazadeh, Curr. Appl Phys. 12 (2012)193-198.

RAMAN SPECTROSCOPY OF BISMUT SLILICON OXIDE SINGLE CRYSTALS GROWTH BY CZOCHRALSKI TECHNIQUE

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In this work single crystals of bismuth silicon oxide $(Bi_{12}SiO_{20})$ have been grown by the Czochralski method. Growth conditions were studied. The critical diameter and the critical rate of rotation were calculated. Suitable polishing and etching solutions were determined. The structure of the $Bi_{12}SiO_{20}$ has been investigated by X-ray diffraction, Raman and FTIR spectroscopy. The obtained results are discussed and compared with published date. The Raman and FTIR spectroscopy results suggest that way synthesis leads to formation of BSO, as seen by X-ray diffraction analysis. We observed 20 Raman and 5 IR modes.

INFLUENCE OF HOLE SIZE AND SHAPE ON ANGULAR DEPENDENCE OF THE FISHNET STRUCTURE'S OPTICAL RESPONSE

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Fishnet metamaterials consist of alternately arranged metal and dielectric layers with periodically drilled nanosized holes. They attracted considerable attention due to their negative index of refraction at infrared [1,2] and visible frequencies [3]. Negative values of magnetic permeability are related to the excitation of internal surface plasmon polariton (SPP) modes, while negative values of permittivity are associated to the cutoff frequency of the waveguide mode supported by the holes [4]. The resonant frequencies of the modes in fishnet structures can be observed in transmittance and reflectance spectra.

In this work, we calculated the angular dependence of polarized transmission and reflection spectra for different fishnet structure designs. They were composed of twodimensional array of holes perforated in Au/SiO₂/Au film stack on a silica glass substrate. Periods of the structure in both lateral directions were fixed at 500 nm, while the shape and size of holes were varied. Dispersions of the internal SPPs, the cutoff frequency of the waveguide mode and Rayleigh's anomalies [5] were extracted from the transmission and reflection maps. Dispersions of the internal SPPs of different designs were compared to each other and to dispersion obtained from analytical model. The analytical model assumes the same layers as the fishnet structure, but without holes [6]. We showed that the size and shape of holes in fishnet structures significantly affect dispersion of the internal SPPs and the analytical model can be used only as the approximation for evaluation of the resonant position of internal SPPs.

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- [1] G. Dolling, M. Wegener, A. Schädle, S. Burger, S. Linden, Appl. Phys. Lett. 89 (2006) 231118.
- [2] G. Dolling, C. Enkrich, M. Wegener, C. M. Soukoulis, S. Linden, Science 312 (2006) 892.
- [3] C. M. Soukoulis, S. Linden, M. Wegener, Science 315 (2007) 47.
- [4] A. Mary, Sergio G. Rodrigo, F. J. Garcia-Vidal, L. Martin-Moreno, Phys. Rev. Lett. 101 (2008) 103902.
- [5] A. Hessel, A.Oliner, Appl. Opt. 4 (1965) 1275.
- [6] R. Ortuño, C. García-Meca, F. J. Rodríguez-Fortuño, J. Martí, A. Martínez, Phys. Rev. B 79 (2009) 075425.

THERMAL AND NON LINEAR OPTICAL PROPERTIES OF ALLYLTHIOUREA MERCURY CHLORIDE (ATMC) SINGLE CRYSTALS

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Second order nonlinear optical (SONLO) materials, capable of efficient frequency conversion of infrared laser radiation to visible or ultraviolet (UV) wavelengths, are of considerable interest for many applications such as high-density optical data storage. medical diagnosis, photolithography, underwater communication and laser displays. Materials with large second order optical nonlinearities, transparency at required wavelengths and stable physicochemical performance are needed to realize many of these applications, Allylthiourea Mercury Chloride (ATMC) is an excellent second order non linear optical material having the above mentioned properties. A comparatively high optical nonlinearity in this complexe comes from the distortion of the tetrahedron, which is composed of three allylthiourea (AT) and one Cl combining with Hg. Allylthiourea Mercury Chloride (ATMC) crystal has been synthesized and grown by slow evaporation method at ambient temperature. The cell parameters of ATMC crystals are studied using Single Crystal XRD and it belongs to trigonal structure with space group R_{3c} . The chemical composition of the synthesized material is confirmed by ElementarVario EL111 Elemental analyzer. The dielectric characteristics and ac conductivity of grown crystals are studied using multi frequency LCR meter (Agillent E4980) for a frequency range from 1kHz to 2MHz starting from room temperature to 150° C. Piezoelectric properties of the grown samples are studied using a Piezometer system in the frequency range 50-500Hz and applying a tapping force of 0.25N at 25^oC. The piezoelectric charge coefficient(d_{33} pC/N) of ATMC is found to be 6pC/N. The thermal parameters such as Thermal effusivity (e), Thermal diffusivity (a), Thermal conductivity (k) and the Heat capacity (Cp) of the ATMC crystasl are investigated using an improved photopyroelectric technique at 40 Hz and its values are found to be $3167 \pm 70 \text{Ws}^{\frac{1}{2}}/\text{m}^2\text{K}$, $6.36 \pm 0.39 \times 10^{-6} \text{m}^2/\text{s}$, $7.97 \pm 0.37 \text{W/mK}$ and $577 \pm 0.37 \text{W/mK}$ 15J/kgK respectively. Third order non linear optical studies of the ATMC crystals are carried out using open aperture z-scan employing a nanosecond laser at 532 nm, and the numerically calculated effective three photon absorption coefficient (γ_{eff}) is found to be 9 x 10^{-25} m³/W².

RAMAN SPECTROSCOPY OF CARBON DOPED RECORCINOL FORMALDEHYDE THIN FILMS

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In this work we investigated the properties of carbon resorcinol formaldehyde (RF) cryogel thin films. RF cryogels were doped by single wall carbon nanotubes, graphene and graphene quantum dots. The structure of the deposited films was investigated by Raman spectroscopy, optical, transmission electron and atomic force microscopy. Raman spectroscopy was performed using three excitation laser energies in the visible range. The penetration depths of exciting Raman laser lines were determined as well as the effect of glass substrate on Raman features of investigated carbon cryogel thin films. The crystallite size L_a of the carbon doped RF cryogels was determined by Raman spectroscopy using excitation laser energy in the visible range.

SURFACE MODIFICATION OF SINGLE WALL CARBON NANOTUBE THIN FILMS BY MICROWAVES: A RAMAN SPECTROSCOPY STUDY

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In this work we present the results of Raman spectroscopy study of single wall carbon nanotube thin films treated by microwave irradiation. Single wall carbon nanotube thin films were deposited by vacuum filtration method and transferred onto alumina substrate. These thin films were exposed to microwave irradiation of 25 and 250 W at 2.45 GHz. All samples were characterized by Raman spectroscopy study and atomic force microscopy. Raman spectroscopy analysis showed that there were neither selective destruction of metallic nor semiconducting nanotubes. It was noticed that samples were heated only during microwave irradiation at 250 W. Major effect of microwave irradiation on single wall carbon nanotubes was their debundlation.

OPTICAL ANISOTROPY OF THE DOPED SBN CRYSTALS

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Rare-earth and transition metals doping can strongly modify ferroelectric properties of Sr_xBa_{1-x} Nb₂O₆ (SBN:x) and sensitize the crystals to photorefraction. In this paper we consider influence of Ce, Cr, Co, Ni photorefractive impurities on optical anisotropy of strontium barium niobate solid solution of SBN:61. Linear dichroism (LD) and light-induced dichroism (LID) were investigated in visible spectral range for the crystals, grown from the melt by modified Stepanov technique. The SBN:61 single crystals doped with Ce, Co, Cr and Ni reveal the presence of some well resolved bands in the VIS and IR part of the absorption spectrum due to: Ce ³⁺ absorption (522 nm), Co ²⁺ and Co ³⁺ absorption (570 nm, 1400–2000 nm band and 1280 nm, respectively), Cr ³⁺ absorption (667 nm), Ni ²⁺ and Ni ³⁺ absorption (717 and 801nm double band and 1239 nm). The fundamental absorption edge changes from 374 nm for pure, Ce, and Co doped, 378 nm for Cr, Ni (0.01 mol%) doped, up to 419 nm for Ni (0.5 mol%) doped SBN single crystals. The band gap energy changed from 3.28 eV (pure, Ce and Co doped), through 3.24 eV (Ni – 0.01 mol% doped) and 3.17 eV (Cr doped) up to 2.83 eV for Ni (0.5 mol%) doped crystals.

The dependences of linear absorption coefficients on impurity concentration at 476.5, 488 and 514.5 nm wavelengths were studied for the laser radiation polarized parallel (αe) and perpendicular (αo) to the tetragonal C-axis of the crystal. The linear dichroism (LD) was defined as the difference ($\alpha e - \alpha o$). It was estimated that $\alpha e > \alpha o$ for all crystals and absolute value ($\alpha e - \alpha o$) increases with the dopant concentration. Such behavior is associated with the compositional/structural disorder of SBN. SBN crystals doped with Co and Ni are characterized with a high dichroism of absorption coefficient. For SBN:61(0.05wt.%Co₃O₄) ($\alpha e - \alpha o$) is 2cm⁻¹(λ =488HM); for SBN:61(1.0Bec.%Ni₂O₃) ($\alpha e - \alpha o$) α o) =3.5cm⁻¹ (λ =476.5HM). Note, the Co and Ni doping ions can presence in the matrix in different valence state. The Co²⁺ (0.65 Å), Co³⁺ (0.53 Å), Ni²⁺ (0.7 Å) and Ni³⁺(0.56 Å) may enter at two octahedrally coordinated the Nb⁵⁺ sites (0.7 Å). However the Ni²⁺ (0.7 Å) ions may also occupy $Sr^{2+}(1.12 \text{ Å})$ and $Ba^{2+}(1.34 \text{ Å})$ sites. It results in some microdistortions in the SBN:61 lattice. For SBN crystals doped with Ce³⁺ the LD doesn't increase 0.02 cm⁻¹. The small dichroism indicates a weak anisotropy of absorbing centers in this crystal. Since Ce $^{3+}(1.01 \text{ Å})$ generally occupies Sr²⁺(1.12 Å) lattice sites and thus creates nearby oxygen vacancies. Absorption is probably due to Ce³⁺ -V 0 centers. Virtually isotropic absorption spectra were obtained for Cr^{3+} doped SBN:61. Due to the substitution of $Cr^{3+}(0.62 \text{ Å})$ for Nb⁵⁺(0.7Å) and the creation of oxygen vacancies the weakening of Nb–O bonds takes place. Absorption is probably due to orientationally equivalent Cr³⁺-V 0 centers.

Light-induced dichroism (LID) was also investigated in the doped SBN crystals. The samples were illuminated by linearly polarized light (λ =532 HM, I=0.3W/cm²) for several minutes. The absorption α of a probe beam being linearly polarized at angle of \pm 45° with respect to the tetragonal C-axis of the crystal was measured. The LID defined as the difference α (+45°)- α (-45°) was estimated for SBN crystals depending on type and concentration of doping ion. Strong optical anisotropy of SBN:61 (Ce+La) crystals may be attributed to orientationally non-equivalent centers which become anisotropic to the absorption of light after illumination. The light –induced dichroism is reversible.

THE EFFECT OF PLASTICIZATION ON THE CONDUCTIVITY AND DIELECTRIC PROPERTIES OF STARCH-CHITOSAN BLEND BIOPOLYMER ELECTROLYTES INFUSED WITH NH4Br

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Compared to other techniques such as changing the polymer structure and changing the salt anions, the plasticization method has been found to be much more effective at improving the conductivity performance of polymer electrolytes, due to plasticizers having a high dielectric constant value that weakens the columbic force between a salt's anion and cation. This research examines the effect of plasticization on the conductivity and dielectric properties of starch-chitosan blend biopolymer electrolytes. Initial Fourier transform infrared (FTIR) spectroscopy readings of the hydroxyl band were 3280 cm⁻¹ (corn starch) and 3354 cm⁻¹ (chitosan). When 80 wt.% of corn starch and 20 wt.% of chitosan were blended together using 1% acetic acid to create a polymer host, the starch-chitosan blend film FTIR reading shows the hydroxyl band shifting to 3288 cm⁻¹. This indicates that there is an interaction between pure starch and chitosan. Different concentrations of ammonium bromide (NH4Br) were then added to the mixture and stirred until complete dissolution. The homogeneous solutions were then placed onto different plastic Petri dishes, where they were left to dry. It was discovered that the addition of 35 wt.% of NH₄Br increased the conductivity of pure starch-chitosan electrolyte from $(2.64 \pm 1.53) \times 10^{-10}$ S cm⁻¹ to $(9.72 \pm 1.09) \times 10^{-5}$ S cm⁻¹. When 30 wt.% of ethylene carbonate (EC) was added to the 52 wt.% starch-13 wt.% chitosan-35 wt.% of NH₄Br electrolyte, a conductivity reading of (1.44 \pm 0.51) \times 10 3 S cm $^{-1}$ was obtained. The variation of the dielectric constant, ε_r against the frequency for plasticized and unplasticized systems indicates that electrolytes conform the non-Debye behaviour. The temperature dependence of the power law exponent for the highest conducting sample in unplasticized system follows the correlated barrier hopping (CBH) model while conduction mechanism of the highest conducting sample in plasticized system can be represented by the quantum mechanical tunneling (OMT) model.

^[1] E. Salleh, I.I. Muhamad, N. Khairuddin, World Academy Sci. Eng. Tech. 55 (2009) 432-440.

^[2] S. Ramesh, C.W. Liew, A.K. Arof, J. Non-Crystalline Solids 357 (2011) 3654-3660.

^[3] O. Mahendran, S.Y. Chen, Y.W. Chen-Yang, J.Y. Lee, S. Rajendran, Ionics 11 (2005) 251-258.

CONDUCTIVITY STUDIES OF BIOPOLYMER ELECTROLYTES BASED ON CHITOSAN INCORPORATED WITH NH₄Br

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Polymer electrolytes have been extensively studied for application in solid state devices. Problems involving solvent vaporization, leakage and corrosion can be avoided by the use of polymer electrolytes, as well as improving the mechanical stability and flexibility for packaging design. A polymer electrolyte system based on chitosan complexed with different amounts of ammonium bromide (NH₄Br) salt was prepared by solution cast technique. The room temperature conductivity of pure chitosan film was found to be $(2.86 \pm 0.82) \times 10^{-10}$ S cm⁻¹. The incorporation of 30 wt.% NH₄Br increased the conductivity to $(4.38 \pm 1.27) \times 10^{-7}$ S cm⁻¹, and further increased to $(1.97 \pm 0.46) \times 10^{-4}$ S cm⁻¹ with addition of 40 wt.% glycerol. The dependency of the electrolytes on temperature proves that both chitosan-NH₄Br and chitosan-NH₄Br-glycerol systems are Arrhenian. The activation energy (E_a) for 70 wt.% chitosan-30 wt.% NH₄Br film is 0.33 eV, and the E_a value for 42 wt.% chitosan-18 wt.% NH₄Br-40 wt.% glycerol is 0.15 eV. The FTIR spectrum of the chitosan-NH₄Br films suggested the occurrence of the interaction between polymer and salt. The carboxamide band at 1639 cm⁻¹ and the amine band at 1550 cm^{-1} in the spectrum of pure chitosan film shifted to 1621 cm⁻¹ and 1523 cm⁻¹, respectively, in the spectrum of 70 wt.% chitosan-30 wt.% NH₄Br film. The band at 1024 cm⁻¹ in the pure chitosan film spectrum, which corresponds to C-O stretching vibration, shift to the lower wavenumbers on addition of salt. A new band appears at 997 cm⁻¹ on addition of 40 wt.% glycerol.



Figure 1. Conductivity at various temperatures.

[1] M.F.Z. Kadir, Z. Aspanut, S.R. Majid, A.K. Arof, Spectrochim. Acta 78 (2011) 1068-1074.

COMPOSITE PISTON PHOTOACOUSTIC MODEL OF TWO – LAYERED SAMPLES

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A general solution for elastic deformation and rear-surface temperature variations of two-layered materials, due to photothermal effect, is derived. Surface absorption is assumed. The applicability of effective medium approximation is disscused for both phenomena. After that, the composite piston model is presented. The contributions of mechanical piston, produced by thermo-elastic deformation, and thermal piston, proportional to rear-surface temperature variations of the sample, to photoacoustic response, are disscused separatelly. Their contributions to photoacoustic response are compared. The boundary frequency between the regimes of thermal piston and mechanical piston is calculated.

ZOOM SYSTEM FOR MEASUREMENT OF COHERENT BACKSCATTERING OF LIGHT IN MICRO AND NANOMATERIALS

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Coherent backscattering is a process observed in physical systems with certain amount of disorder. Systems can be either completely random (like clouds or milk) or regular with slight randomness. This is an interference phenomenon inherent for any type of waves – from electrons and sound to light. It is characterized by increased intensity in exact backscattering direction. Coherent backscattering was observed in many optical materials (artificial or natural) and gives important information about mean free path of light, density of scatterers and their dimensions.

Devices for measurement of backscattering are simple in principle, but rather demanding from the experimental point of view [1]. The main problem is that the width of backscattering cone is inversely proportional to mean free path length of light. For materials with path-length of the order of several micrometers (like in biological tissues) the cone is very narrow (of the order of microradian), while for nanostructured materials backscattering cone can be quite wide (several hundreds of milliradians). In that respect present systems are either constructed for observation of wide [2] or narrow backscattering cones [3].

Here we report on the universal system which can be used both for low and high backscattering angles. The system is based on imaging the scattering surface using an additional lens system. Image is directly projected into entrance pupil of a zoom lens (Canon 17 - 85 mm) which is focused at infinity and functions as a Fourier lens. In this way angular spectrum of scattered light is focused on the detection surface, making observation of backscattering cone possible. In this configuration, variable magnification of a zoom lens changes the angular field of view, depending on whether the backscattering cone is large or small. Light is detected on a 15.1 Mega pixel CMOS chip of a Canon EOS 50D camera.

Helium-neon laser (633 nm) was used as a light source in a polarization preserving configuration. The laser beam was expanded, its polarization changed to circular, before entering the non-polarizing beam-splitter. Scattered radiation was collected by previously described optical system, and detected by the camera. All ghost reflections from optical components were blocked and we were able to observe clear backscattering pattern. The sample was mounted on the motorized stage, which was used to slightly move the sample during exposure in order to average the speckle.

We observed and measured backscattering cones (both wide and narrow) of a range of samples: milk, skin, Teflon, barium-sulphate, artificial photonic structures, etc.

[3] Y. L. Kim, Y. Liu, R. K. Wali, H. K. Roy, V. Backman, Appl. Opt. 44 (2005) 366 – 377.

^[1] D. S. Wiersma, M. P. van Albada, A. Lagendijk, Rev. Sci. Instrum. 66 (1995) 5473 – 5476.

^[2] P. Gross, M. Störzer, S. Fiebig, M. Clausen, G. Maret, C. M. Aegerter, Rev. Sci. Instrum. 78 (2007) 033105.

A STUDY ON STRUCTURAL AND OPTICAL PROPERTIES OF THIN TIO₂ FILMS UPON THERMAL ANEALLING

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TiO₂ thin films were deposited by RF magnetron sputtering of very pure TiO₂ target, on Si (100) and glass substrates. Films were annealed for 2 hours on 673 K in Ar atmosphere after deposition. The influence of the sputtering parameters and annealing on the morphology and on optical properties of layers is reported. Thicknesses of layers varied between 80nm - 195 nm. Crystallographic structure was analyzed by means of X-ray diffraction (XRD) at grazing incidence; chemical composition and its depth profile were determined by Glow Discharge Optical Emission Spectroscopy (GDOS), optical properties by UV/VIS measurements and microstructure by TEM analysis. Analysis showed that thermaly annealed thin films in comparation with as deposited have increased crystal grain sizes and significant changes in microstructure. By increasing the ratio of O₂ in mass flow of Ar/O₂, change of TiO₂ phase in thin layers, from anathase (101) to ruthil (110), occures. Optical measurements showed that there is no significant change in energy gap between as deposited and thermally annealed samples. It varies between 3.38 eV – 4.41 eV, and it is dependent on mass flow of Ar/O₂.

COUPLING OF HIGH QUALITY FACTOR OPTICAL RESONATORS

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Optical resonators with high quality factor (Q-factor) present a great interest for several applications in optoelectronic [1], metrology or fundamental physics. They can, for instance, be used in optical filtering, all optical switching, low threshold non-linear optics, etc. Main results have been obtained since 1996 [2]. Recently results have been obtained with mono-crystalline such as MgF₂, Quartz or CaF₂ whispering gallery mode (WGM) resonators [3-7]. Rare-earth doped micro spheres are tiny lasers which intrinsically offer narrow line width emission [8]. To characterize the resonators, there is the need to realize a good coupling. Although we improve theoretically and experimentally the problem of the coupling between a high Q-factor resonator and its external coupler. They are characterized by different methods such as slow and fast frequency sweeping [9]. Resonators can be coupled to tapered fibres or prisms. We focus here on characterizations techniques of passive optical resonators or active (Erbium doped ZBLALiP [10, 11]) WGM resonators in terms of Q-factor determination.

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- K. Volyanskiy, P. Salzenstein, H. Tavernier, M. Pogurmirskiy, Y. K. Chembo, L. Larger, Optics Express, 18 (2010) 22358-22363.
- [2] X.S.Yao, L. Maleki, Optics Letters, 21 (1996) 483-485.
- [3] V.S. Ilchenko, A.A. Savchenkov, J. Byrd, I. Solomatine, A.B. Matsko, D. Seidel, L. Maleki, Optics Letters, 33(14) (2008) 1569-1571.
- [4] I.S. Grudinin, N. Yu, L. Maleki, Optics Letters, 34 (2009) 878-880.
- [5] H. Tavernier, P. Salzenstein, K. Volyanskiy, Y. K. Chembo, L. Larger, IEEE Photonics Tech. Lett., 22 (2010) 1629-1631.
- [6] D.K. Armani, T.J. Kippenberg, S.M. Spillane and K.J. Vahala, Nature 421 (2003) 925.
- [7] P. Del'Haye, A. Schließer, O. Arcizet, T. Wilken, R. Holzwarth, and T.J. Kippenberg, Nature 450 (2007) 1214-1217.
- [8] F. Lissillour, D. Messager, G. Stéphan, P. Féron, Opt. Lett. 26 (2001) 1051-1053.
- [9] Y. Dumeige, S. Trebaol, L. Ghisa, Thi Kim Ngan Nguyen, H. Tavernier, P. Féron, J. Opt. Soc. Am. B, 25(12) (2008) 2073-2080.
- [10] M. Mortier, P. Goldner, P. Féron, G. M. Stéphan, H. Xu, Z. P. Cai, J. Non-Cryst. Sol. 326 & 327 (2003) 505-509.
- [11] Z. P. Cai, H. Y Xu, G. Stéphan, P. Féron, M. Mortier, Opt. Comm 229 (2004) 311-315.

STUDIES OF (90-x)P₂O₅-xB₂O₃-10Fe₂O₃ GLASSES USING THE MOSSBAUER EFFECT AND IR SPECTROSCOPY

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Glass systems of composition 90% [x B_2O_3 (1 -x) P_2O_5] 10% Fe₂O₃ (x = 0 mol. %, 5 mol. %, 10 mol. %, 15 mol. %, 20 mol.) was prepared by the twin roller quenching technique and characterized by measuring their density (ρ), chemical durability (DR). The Mossbauer effect has been used intensively to help investigate the structure and bonding of oxide glasses, the properties of amorphous iron compounds and alloys have also been examined. IR studies have been performed in these glasses to examine the distribution of different borate and phosphate structural groups.

BIAS FIELD EFFECT ON THE DIELECTRIC AND PYROELECTRIC PROPERTIES OF (Pb,La)(Zr,Ti)O₃ TRANSPARENT FERROELECTRIC CERAMICS

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Temperature and bias field dependences of the dielectric permittivity ε and pyroelectric coefficient γ for transparent ferroelectric (Pb,La)(Zr,Ti)O₃ ceramics have been studied. Ceramic samples were obtained by hot pressing. Pyroelectric coefficient γ was determined by a dynamic technique in the field-cooling and field-heating modes.

At zero field, the maximum of $\gamma(T)$ dependence is observed in the vicinity of the Fogel-Vulcher temperature but, at even small but finite bias fields, this maximum shifts to the position of the supposed critical point (which is in the vicinity of the permittivity maximum temperature T_m) and grows in magnitude. The latter increases up to the field corresponding to the critical point in the E-T phase diagram (it can be roughly estimated from the minimum in the $T_m(E)$ dependence [1]) and decreases at higher fields. Thus application of the biasing fields driving the system towards the critical point crucially enhances the pyroelectric response. These data support a quasicritical behavior of pyroelectric coefficient in relaxors at the critical point, revealed earlier for Pb(Mg_{1/3}Nb_{2/3})O₃ – PbTiO₃ single crystals [2].

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- [1] S. I. Raevskaya, A. S. Emelyanov, F. I. Savenko, M. S. Panchelyuga, I. P. Raevski, S. A. Prosandeev, Eugene V. Colla, Haydn Chen, S. G. Lu, R. Blinc, Z. Kutnjak, P. Gemeiner, B. Dkhil and L. S. Kamzina, Phys.Rev. B76 (2007) 11580R.
- [2] S. I. Raevskaya, Yu. N. Zakharov, A. G. Lutokhin, A. S. Emelyanov, I. P. Raevski, M. S. Panchelyuga, V. V. Titov, and S. A. Prosandeev, Appl. Phys. Lett. 93 (2008) 042903.

ELABORATION AND CHARACTERIZATION OF NEW ERBIUM DOPED ANTIMONY GLASSES FOR 1.5µM AMPLIFICATION

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Sb₂O₃ glasses emerges as one major family of Heavy metal oxide glasses and appear promising for potential applications in non linear devices like ultra-fast optical switches and power limiters, broad band optical amplifiers operating around 1.5 μ m using antimony–silicate glass fiber. In this paper we investigate new glasses in ternary systems: (90-x)Sb₂O₃-10Na₂O-xZnO-0.25Er₂O₃ in witch antimony oxide is the mean glass former and to measure their physical properties and to investigate their spectroscopic and radiative properties especially in the mid-infrared region.

- D. Lezal, J. Pedlikova, P. Kostka, J. Bludska, M. Poulain and J. Zavadil, J. Non-Cryst. Solids 284 (2001), 288-295.
- [2] M. T. Soltani, A. Boutarfaia, R. Makhloufi, M. Poulain, J. Phys. Chem. Solids 64, (2003), 2307-3012.
- [3] W. J. Miniscalco, J. Lightwave Technol. 9, (1991), 234-250.
THERMAL AND ELASTICS CHARACTERIZATION OF Sb₂O₃-Na₂O- ZnO GLASSES

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By using classical routes (melting – casting), new glasses synthesized in silica crucibles were obtained in the combination of Sb₂O₃, Na₂CO₃ and ZnO precursors. The limits for glass formation have been investigated in the ternary system Sb₂O₃-Na₂O-ZnO. Characteristic temperatures such as glass transition Tg, onset of the crystallization Tx, and maximum of crystallization Tp have been measured using differential scanning calorimeter (DSC). Glass transition temperature, Tg, ranges from 278 to 304°C and the thermal stability range (Tx-Tg) lies between 109 and 155°C for these studied glasses. Ultrasonic's velocities were measured by using pulse echo method to determine the elastics parameters, such as elastic modules (E, G, K, L) and other related parameters (Poisson's ration, acoustic impedance, Debye temperature). Other physical properties were measured, such as density, micro hardness and optical transmission window in the UV-Visible-IR range. Influence of composition on these physico-chemical properties is discussed. A quantitative analysis of thermal, mechanical measurements has been made to obtain more information about the structure of alkali antimonite glasses and the role of Na₂O and ZnO in these no-conventional glasses. These measurements have been made for the first time on these new antimony glasses.

[1] A.Winter, J. Am. Ceram. Soc. 40 (1957) 54.

[2] M. T. Soltani, A. Boutarfaia, R. Makhloufi, M. Poulain, J. Phys. Chem. Solids 64, (2003), 2307-3012.

[3] T. Som and B. Karmakar, Opt. Mater. Vol.31 (4) (2009), p. 609-618.

GENETIC ALGORITHM APPROACH FOR EVALUATION OF OPTICAL FUNCTIONS OF VERY THIN TANTALUM PENTOXIDE FILMS ON SI SUBSTRATE

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We study the optical characteristics of tantalum pentoxide films, deposited on Si (100) substrate by reactive sputtering. These films are investigated as high-kappa materials for the needs of nano-electronics, i.e. design of dynamic random access memories, etc. One problem for their implementation is that metal oxides are thermodynamically unstable with Si and an interfacial layer is formed between the oxide film and the silicon substrate during the deposition process. Herein, we focus on the optical properties of that interfacial layer studied by spectral photometric measurements. The evaluation of the optical parameters of the structure is fulfilled with the genetic algorithm approach. The spectral range of evaluation covers deep UV to NIR. The effective physical thickness and the effective complex refractive index of the interfacial layer are estimated from 236 to 750 nm as well as the thickness of tantalum pentoxide film ~10 nm.

CONDUCTIVITY AND TRANSPORT OF STUDIES PLASTICIZED CHITOSAN BASED PROTON CONDUCTING BIOPOLYMER ELECTROLYTES

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Because natural biopolymers are not associated with problems that plague their nonbiodegradable polymer counterparts (e.g. synthetic polymers), natural biopolymers are better candidates as electrolyte hosts for long term use. Among others, natural biopolymers have minimal impact on the environment, they induce a relatively low cost. they produce a relatively high solubility, and they are able to form a mechanically stable film. This paper focus on the conductivity and transport properties of chitosan based solid biopolymer electrolyte. To address the aims of this paper, chitosan based solid biopolymer electrolytes containing ammonium thiocyanate (NH₄SCN) (dissolved in 1% of acetic acid) were prepared using solution casting. The conductivity was optimized with an additional 40 wt.% NH₄SCN, with a conductivity value of $(1.81 \pm 0.50) \times 10^{-4}$ S cm⁻¹ at room temperature. Glycerol was added to enhance the conductivity to the order of ~ 10^{-3} S cm⁻¹. Due to the fact that both chitosan-NH₄SCN and chitosan-NH₄SCNglycerol systems conform to the Arrhenius rule, the activation energy (E_a) values for all electrolytes were obtained from the conductivity-temperature plots. Rice and Roth model are used to explain the transport properties of the plasticized and unplasticized systems. Sample with the highest conductivity value in unplasticized system obtained an E_a value of 0.16 eV while for the highest conducting sample in plasticized system obtained a value of E_a at 0.10 eV. When salt was added, the FTIR spectrum of undoped chitosan film revealed that the carboxamide (peaking from 1639 cm⁻¹) and amine (peaking from 1550 cm⁻¹), shifted to lower wave numbers. This discovery indicates a polymer-salt interaction. No shift was observed in the peaks of the chitosan-NH₄SCNglycerol spectrum, since glycerol only acts as a plasticizer. However, as more glycerol was added, there is a decrement of band intensity at 1067 cm⁻¹. We attribute this finding to the C-O stretching vibration.

H.J. Woo, S.R. Majid, A.K. Arof, Solid State Ionics 199-200 (2011) 14-20.
N.A. Aziz, S.R. Majid, R. Yahya, A.K. Arof, Polym. Adv. Technol. 163 (2010) 51–59.

CONTACT QUALITY ANALYSIS AND NOISE SOURCES DETERMINATION OF CdTe BASED DETECTORS

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Cadmium-Telluride (CdTe) is a very promising material for sensitive detectors of high energy radiation. Apart from the scintilactic layer, which is used as X-ray detector in conventional radiodiagnostic devices, the CdTe based detectors convert X-ray radiation directly into electric signal, without the necessity to focus the light in optic layer and following conversion to electrical signal. The resulting images are sharper with higher resolution. Also, the CdTe detectors can be used in safety systems in the nuclear power industry. CdTe alloyed with mercury (HgCdTe) is the most widely used material for infrared detectors.

This study includes the experimental results acquired on Au/CdTe/Au planar detectors, made of a (111) oriented semi-insulating single crystal. Golden contacts were manufactured on the opposite surfaces of the sample by prepared by deposition of gold from aqueous solution of AuCl₃. The sides of the sample were optically polished with final 0.05 mm grit and chemically etched in 1 % Br-methanol solution for 1 min. To isolate the influence surface current on overall detector electric parameters, an extra guard ring electrode was added.

Experimental studies of transport and noise characteristics of CdTe sensors have been carried out. The results transport characteristics measurement showed surface as dominant source of leakage current of the detector system. The noise analysis showed different 1/f noise sources; bulk and surface 1/f noise type which is proportional to the square of current and contact 1/f noise with current noise spectral density proportional to higher than the second power of current. Hand-in-hand with the *IV* characteristics symmetry assessment, the contact preparation quality was evaluated by means of calculation of additional noise in the detector system that originated in the contact area. The mobility fluctuation in the semiconductor bulk was found as a main source of 1/f noise type. The noise spectral density magnitude of the samples' bulk $S_i \propto I^n$ is proportional to the square of the sample current, whereas the contact noise and the surface is proportional to the sample current with n > 2.

^[1] A. Andreev, L. Grmela, P. Moravexm P.G. Bosman, J. Sikula. Semicond. Sci. Technol. 25 (2010) 1-7.

^[2] P. Schauer, J. Sikula, P. Moravec. Microelectron Reliab 41 (2001) 431-436.

^[3] F.N. Hooge, IEEE Trans. Elecron. Devic. 41 (1994) 1926-1935.

ANALYSIS OF THERMAL PROCESSES IN THE GLASSES OF THE SYSTEM Cu_x(AsTe)_{100-x}

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Unique properties of chalcogenides based on S, Se and Te cause significant and longterm interest in science and industry, providing their wide application. Chalcogenide glasses are promising materials for fiber optics and all-optical switching devices at the telecommunication wavelengths due to their high transparency in the infrared region and nonlinear refractive index.

In this report we present and discuss the results of analysis of the processes that occur during the thermal treatment of the chalcogenide glasses of the system $Cu_x(AsTe)_{100-x}$, x=5, 10 i 20 at.%. Analysis is based on DCS curves, recorded in non-isothermal measurement conditions in temperature interval 300-770 K, at heating rate β =10 K/min. Sample with x=20 at.% is additionally thermally treated at four heating rates in order to implement kinetic analysis of the processes. Activation energies of the crystallization E_c and glass transition E_g are determined by the methods of Kisinger and Mahadevan. Characteristics parameters of crystallization are determined according to method of Matusita and co-workers. It has been concluded that nucleation occurs in three dimensions and within the volume.

Amorphous character of investigated glasses is verified by X-ray method. X-ray pattern of the glass sample with x=20 at.%, annealed at temperature close to crystallization temperature established by DSC analysis, has showed that in amorphous matrix structural units of copper and arsenic with telluride are formed.

RAMAN SPECTROSCOPY OF GRAPHENE: DOPING AND MAPPING

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We have examined graphene samples prepared by mechanical exfoliation on top of oxidized Si wafers. The Au electrical contacts, fabricated using photolithography, allowed the application of a gate voltage between graphene and the Si substrate. The Dirac point of the samples has been found using transport measurements [1]. In the Raman spectra of the sample we observed shifts of position, changes of intensity and variations of the width of the G and 2D peaks with the change of the gate voltage. Considering the ratio between the peaks intensity, I(2D)/I(G), it decreases for increasing Fermi energy [2,3].

Spatial Raman mapping of the samples has been performed showing variations in intensities of the Raman peaks in different flake regions [4]. The investigated samples are inhomogeneous containing monolayer, as well as few-layer, graphene regions. The differences in peak intensities obtained within the flake can be due to different number of graphene layers, defects, edges, unintentional doping, or flake-substrate interaction [5,6,7].

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- K. S. Novoselov, A. K. Geim, S. V. Morozov, D. Jiang, Y. Zhang, S. V. Dubonos, I. V. Grigorieva, A. A. Firsov, Science 306, (2004) 666-669
- [2] A. Das, S. Pisana, B. Chakraborty, S. Piscanec, S. K. Saha, U. V. Waghmare, K. S. Novoselov, H. R. Krishnamurthy, A. K. Geim, A. C. Ferrari, A. K. Sood, Nat. Nanotechnol. 3, (2008) 210-215
- [3] C. Casirashi, Phys. Status Solidi B 248, (2011) 2593-2597
- [4] Q. Yu et al, Nat. Mater. 10, (2011) 443-449
- [5] J. M. Caridad, F. Rossella, V. Bellani, M. Maicas, M. Patrini, E. Díez, J. Appl. Phys. 108, (2010) 0843211-5
- [6] M. Kalbac, A. Reina-Cecco, H. Farhat, J. Kong, L. Kavan, M. Dresselhaus, AcsNano 4, (2010) 6055–6063
- [7] C. Casiraghi, A. Hartschuh, H. Qian, S. Piscanec, C. Georgi, A. Fasoli, K. S. Novoselov, D. M. Basko, A. C. Ferrari, Nano Lett. 9, (2009) 1433-1441

COMPARISON OF ALPHA AND SULPHUROUS QUARTZ SAMPLES BY SPECTROSCOPIC TECHNIQUES

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Quartz, a mineral widely found in the earth's crust, has applications in industry, geology and archeology. This mineral, formed by the SiO4 tetrahedron, contains channels along the c-axis, which, by allowing the entry of dopants, can induce effects that alter the hardness and color of the material, among other characteristics. The aim of this paper was to study the two varieties of natural quartz (alpha and sulfurous quartz) through spectroscopic techniques (ICP-MS, XRF and FT-IR). Although the chemical analyses did not reveal the existence of a sulfur dopant, we can deduce that it is contained in the channels along the c-axis, through characteristic odors detected during the pulverization of the sulfurous quartz sample and analyses of its FT-IR spectra.

STRAIGHT 1D WAVEGUIDE ARRAY CHARACTERIZATION BY TILTED WIDE BEAMS

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Optical waveguide arrays (WGA) imprinted with femtosecond laser or UV lithography attract considerable interest due to possibility of applications in optical beam control. Wide beams tilted at an angle such that phase difference between waveguides is integer multiply of π (staggered waves) exhibit remarkable property of weak diffraction [1]. This system has been previously studied in the framework of discrete model predicting diffraction arrest, and more generally, with Floquet-Bloch analysis describing band-gap structure of wave propagation.

Our analysis consists of numerically solving paraxial wave equation where WGA is modeled with periodic potential of height Δn , for various initial data [2].

We predict that higher band modes are always excited when anomalous diffraction conditions are satisfied, finding dependences of their effective indices of refraction and diffraction coefficients on Δn , result not obtained by other methods.

These findings can be used for characterization of WGA by determining Δn , or as a method for isolating pure band mode waves.

- F. Lederer, G.I. Stegeman, D.N. Christodoulides, G. Assanto, M. Segev, Y. Silberberg, Physics Reports 463 (2008) 1-126.
- [2] D. Jovic, D. Timotijevic, A. Piper, N. Aleksic, Y.S. Kivshar, M. Belic, Opt. Lett. 35 (2010) 2355-2357.

TWO-PHASE BOUNDARY SYNTHESIS AND OPTICAL PROPERTIES OF SILVER/POLYANILINE NANOCOMPOSITES

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Nanocomposites containing metal nanoparticles, dispersed in electrically conducting polymers such as polyaniline, show enhanced sensing, electrical and catalytic properties as compared with those of neat polymer. These composites have generated increasing interest as advanced technological materials due to synergistic effects of both components. Here, we report silver/polyaniline (Ag/PANI) nanocomposites obtained through a two-phase water/toluene interfacial reaction. As prepared silver nanoparticles in toluene with oleylamine as a reducing and stabilizing agent, were used as nucleation centers for the polymerization of aniline. Once the polymerization occurs at the interface of the organic (containing the aniline and the silver nanoparticles) and aqueous (containing the oxidizing ammonium persulfate agent) phase, the polymer grows around the silver nanoparticles and forming the nanocomposite structure. The formation of Ag/PANI nanocomposite was characterized by UV–Vis and FTIR spectroscopy, and transmission electron microscopy. In contrast to pure PANI, the absorption spectrum of Ag/PANI nanocomposite showed additional strong band assigned to surface plasmon resonance absorption of the electrons in the conducting silver bands.

BROADBAND DISPERSION COMPENSATING USING RECTANGULAR-LATTICE PHOTONIC CRYSTAL FIBER

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One of the major problems in optical telecommunication systems is the fiber dispersion. The main effect of dispersion on the performance of a fiber optic system is known as inter symbol interference (ISI). ISI occurs when the pulse spreading causes the output pulses of a telecommunication system to overlap, and rendering them undetectable. Optical fibers are now used in telecommunication links, at the window of greatest interest, near $\lambda = 1.55 \mu m$ wavelength, show the dispersion of about 17ps/nm/km. Different methods are used to eliminate dispersion effects in optical fibers. For example, the dispersion can be compensated using a short length of a special optical fiber known as dispersion compensating fibers (DCF) with negative dispersion and combine it with the previous single mode fiber (SMF). Conventional DCFs have approximately a negative dispersion value between -100ps/nm/km and -130ps/nm/km at λ =1.55 μ m wavelength. In this research, we present a novel dispersion compensating photonic crystal fiber (DC-PCF) with ultra high negative dispersion. Finite Difference Time Domain (FDTD) method with transparent boundary conditions (TBC) is used to analyze the dispersion property in the rectangular-lattice DC-PCF.

The general design parameters of PCFs are holes diameter (*d*), holes pitch (*A*), and relative holes size (*d*/*A*). As shown on figure 1, with $d1=1.5\mu$ m, $d2=0.4\mu$ m, $d3=1\mu$ m, $d4=0.75\mu$ m and $A=2.2\mu$ m, we produced negative dispersion between -670ps/nm/km and -1590ps/nm/km in C-band (1.53~1.565 μ m) and particularly -1105ps/nm/km in $\lambda=1.55\mu$ m wavelength. With this method, we can compensate dispersion in 65km-long span of a SMF by 1km-long of the DC-PCF at $\lambda=1.55\mu$ m wavelength.



Fig. 1. Cross section of the rectangular-lattice DC-PCF

DESIGN OF PURE SILICA HEXAGONAL-LATTICE MICROSTRUCTURED FIBER WITH ULTRA-LOW AND FLATTENED CHROMATIC DISPERSION USING ELLIPTICAL AIR-HOLES IN THE CORE REGION

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In recent years, Microstructured fibers (also called photonic crystal fibers) have been played a key role in fiber-optic communication systems, fiber lasers, nonlinear devices and so on. One of the most important aspects of optical fibers is to achieve nearly-zero flattened dispersion curve over a wide range of wavelengths. Flattened near zero dispersion can be achieved in PCFs, with periodic cladding composed of micrometer sized air-holes.

As shown on figure 1, we proposed a new method to design pure silica photonic crystal fiber with flattened dispersion characteristics by replacing four circular air-holes of the first ring with elliptic air-holes and add one more elliptical air-hole to the center of the core region. Finite Difference Time Domain (FDTD) method is used to analyze the dispersion property in a hexagonal-lattice PCF. As shown on figure 2, this method produced ultra low and flattened dispersion characteristics over 600nm wavelength range that has better performance than conventional photonic crystal fibers.



Fig. 1. Cross section of the hexagonal PCF with hole diameter $d=0.5\mu$ m, pitch $\Lambda=2.3\mu$ m, the width $a=0.6\mu$ m of ellipse and height $b=0.2\mu$ m of ellipse.



Fig. 2. Chromatic dispersion of the PCF as a function of wavelength.

VISIBLE LUMINESCENCE OF POLYMER COMPOSITES DOPED WITH Pr³⁺ AND Yb³⁺ ACTIVATED NANOCRYSTALLITES

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In recent years the significant progress has been observed in the technology of polymer materials, being presently the most popular material for applications in practically every field of daily life, science, technique, medicine etc. The optoelectronics is among the less explored, but still exciting fields of potential polymer's applications, specifically when the low-cost and compact light emitting devices are of concern. One of the most impressive examples are OLEDs and intensively investigated polymer lasers (typically doped with organic dyes). The RE³⁺ doped polymer lasers may seem to be an interesting alternative, however direct doping by rare-earth ions results in significant quenching of the optical transitions, due to the interactions with highly energetic phonons, inherent for the polymer matrices, typically containing a huge number of light hydrogen atoms. The solution of this problem may lay in doping of polymer material with optically active nanocrystals, which would isolate active centers from the influence of matrix's phonons.

In this work we report the recent results of our investigation on visible emission and upconversion properties of the polymer nanocomposites doped with oxide and fluoride nanopowders activated with praseodymium and ytterbium ions. The set of both type of powders differing in active ions concentration and the PMMA-based nanocomposites doped with these nanocrystallites was manufactured and carefully characterized with respect of their luminescent properties in the visible spectral range. In particular - the concentration dependent emission spectra were measured under direct (single photon) and up-converted excitation and fluorescence kinetics was carefully studied, enabling comparison of luminescent properties of developed nano-composites and original nanopowders, optimization of praseodymium and ytterbium dopant concentrations as well as discussion of excitation mechanisms and analysis of the efficiency of depopulation processes.

INFLUENCE OF DOPANT ON MICROSTRUCTURE AND OPTOELECTRONIC PROPERTIES OF SOL-GEL DERIVED SnO₂:Sb THIN FILMS

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Transparent conducting oxides (TCOs) have a wide range of applications in several optoelectronic devices [1, 2]. Antimony-doped tin oxide (SnO₂:Sb) thin films were prepared by the sol-gel process using dip coating technique on glass substrates. The colloidal sols were prepared by reflux of the SnCl₂.2H₂O and SbCl₃ ethanolic solution. As-deposited films were annealed in ambient atmosphere at 500°C. The nominal molar ratio of Sb/Sn was 0, 2, 5, 7 and 10%. The effect of Sb doping on the optical, electrical, structural and morphological properties were examined by UV-Vis spectrophotometry, Van der Pauw Hall effect measurement, Thermogravimetric and Differential Thermal Analysis (TG/DTA), X-ray diffraction (XRD), and Atomic Force Microscopy (AFM) measurement. The average optical transmittance values of all films are over 80% in the visible region and gradually decrease with Sb doping. This trend can assigned to the enhancement of grain boundaries scattering and increase in structural disorder and surface roughness. Several optical parameters such as refractive index, extinction coefficient, real and imaginary dielectric constants, optical conductivities, and optical band gaps of the films have been determined. The decrease of refractive index with the increase of the Sb concentration can be mainly attributed to an increase of the carrier concentration, reduction of grain size and increase in the porosity of the ATO films. The low value of extinction coefficient indicated the slight scattering of light due to low surface roughness of the prepared films. The dispersion of the refractive index is discussed in terms of the Wemple-DiDomenico single oscillator model. The calculated optical band gap ($E_{\rm s}$) increases from about 3.91 to 4.02 eV with doping concentration and this blue shift is associated with Burstein-Moss effect. Hall measurements results show that conductivity and carrier density increase as the Sb concentration increases from 0 to 10%. The increase in carrier concentration may be attributed to the replacement of Sn⁺⁴ lattice sites by Sb⁺⁵ in thin films. The decrease in Hall mobility of ATO is the combined effect of reduction in grain size, increment in grain boundary potential and structural distortion. Two weight losses were observed at 70-100°C and 110-150°C in TG curve and the most of weight loss happened below 200°C. The weight loss may be from the evaporation of water and alcohol and combustion of resultant organics, respectively. XRD patterns showed that the films have tetragonal rutile structure and grain size reduced after Sb doping. EDAX analysis confirmed the presence of antimony in SnO₂ lattice. Atomic force microscopy images of these films indicated that their RMS roughness of films increase by Sb incorporation.

[1] B. Zhang, Y. Tian, J. X. Zhang, W. Cai, Mater. Lett. 65 (2011) 1204–1206.

[2] B. Benrabah, A. Bouaza, A. Kadari, M.A. Maaref, Superlattices Microstruct. 50 (2011) 591-600.

NONLINEAR AND PYROELECTRIC PROPERTIES OF TETRAAMINODIPHENYL NANOCRYSTALLINE FILMS FOR POLYFUNCTIONAL DEVICES

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The polycrystalline organic films with non-centrosymmetry structure combine important practical properties- piezo- and pyroelectricity, optical nonlinearity, etc, and have wide application in energy converters and devices for data processing. The main advantages of such films are relatively simple technology of preparation and low cost. In [1,2] piezo- and pyroelectrical properties of polar ordered polycrystalline films of tetraaminodiphenyl (TADPH) were investigated and some fields for possible applications were shown. In this work optical nonlinearity (lowest order) of TADPH films was discovered and studied. The intensity of second harmonic generation was measured as a function of angle of pumping beam direction for p- and s-polarization at different temperatures. YAG:Nd³⁺ laser with wavelength 1064 nm, pulse duration 30 ns, and pulse energy 0.2 mJ was used as the pumping source. It was found from angle measurements that investigated polycrystalline films have ∞m point grope of symmetry with polar axis of texture perpendicular to the film plane. The intensity of the second harmonic decreases to zero value when the temperature of the film increases from room temperature to 70°C. It was suggested that there is transition at this temperature to another polymorphic modification or there is a second - order phase transition.

Investigated TADPH films were used for development and manufacturing of electron – optical – convertor (EOC) where pyroelectrical properties of TADPH films are used for electron beam modulation inside the electron beam tube. This convertor we called as PiroEOC. The design and characterics of PiroEOC and thermal vision system based on it are presented and discussed. The correlation between nonlinear optical properties and pyroelectrical properties of TADPH films are also discussed.

- L.M.Dorozhkin, V.V.Lazarev, G.M.Pleshakov, B.A.Chayuanov, Sh.Sh.Nabiev, S.M.Nikiforov, E.M.Hohlov, V.A.Chikov, V.D.Shigorin, G.P.Shipulo. Kvantovayu Electronica. V.10, №6 (1983) 1107–1113.
- [2] L.M.Dorozhkin, M.A.Kulakov, A.I. Morozov, G.M.Pleshakov, B.A.Chayuanov, Akusticheskyi Zhurnal. V.31, №5, (1985), 680-684.

BUTTERFLY SCALES AS BIONIC TEMPLATES FOR COMPLEX ORDERED NANOPHOTONIC MATERIALS

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Biological structures can be extremely intricate [1], exceeding man-made nanostructures in complexity, form and function. Up to now researchers were mostly investigating physical (optical, acoustical, mechanical) properties of insect exoskeletons – the question is how to utilize them. One research direction is to mimick nature by artificially generating biomimetic structures [2]. Another possibility is to utilize biological material itself, where new properties are achieved by additional functionalization [3].

Recently we have analyzed photonic properties of the nanostructured scales on the wings of Apatura ilia and A. iris butterflies [4, 5]. Their intricate nanometer-sized features produce remarkable UV-blue iridescence, spectrally and directionally narrow. An extremely wide variability of butterfly scale forms, shapes and sizes is observed [6]. In this paper we propose a possible use of butterfly scales as templates for ordered 2D or 3D nanophotonic materials, with complexity not easily reproducible by conventional micro/nanofabrication methods. Nanocompositing is utilized to impart novel properties [7]. We show that one is thus able to achieve functionalities seldom if ever met in nature, like a combination of plasmonic behavior with bionic functions, but also other functions like enhanced light localization, light- and plasmon waveguiding and general metamaterial behavior. We present our theoretical analysis including preliminary calculations, as well as initial experimental verification. As an example, we consider a possibility to produce structures with extraordinary optical transmission [8] in a simple manner and at a fraction of the cost and necessary engineering efforts compared to the conventional methods. We conclude that bionic approach offers potentials for vast expansion of the nanophotonic and nanoplasmonic material toolbox.

[1] P. Vukusic, J. R. Sambles, Nature, 424, 6950 (2003) 852-855.

- [2] M. Kolle, P. M. Salgard-Cunha, M. R. J. Scherer, F. Huang, P. Vukusic, S. Mahajan, J. J. Baumberg, U. Steiner, Nature Nanotechnology, 5, (2010) 511–515.
- [3] N. L. Garrrett, P. Vukusic, F. Ogrin, E. Sirotkin, C. P. Winlove, J. Moger, J. Biophotonics, 2 (2009) 157-166.
- [4] D. Pantelić, S. Ćurčić, S. Savić-Šević, A. Korać, A. Kovačević, B. Ćurčić, B. Bokić, Opt. Express 19 (2011) 5817-5826.
- [5] S. Ćurčić, D. Pantelić, B. Ćurčić, S. Savić-Šević, S. Makarov, V. Lačković, M. Labudović-Borović, N. Ćurčić, D. Stojanović, Microsc. Res. Tech. (2012) doi: 10.1002/jemt.22021
- [6] A. L. Ingram, A. R. Parker, Phil. Trans. Royal Soc. B. 363 (2008) 2465-2480.
- [7] Z. Jakšić, J. Matovic, Materials, 3 (2010) 165-200.
- [8] T. W. Ebbesen, H. J. Lezec, H. F. Ghaemi, T. Thio, P. A. Wolff, Nature, 391, 6668 (1998) 667-669.

EFFECT OF THE PHENANTHROLINE AS CO-LIGAND IN THE OPTICAL PROPERTIES OF TWO NEW RARE-EARTH BASED MOFS FAMILIES WITH THE 3,5-DISULFOBENZOATE LIGAND

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Lanthanide containing Metal-Organic Framework (MOF) materials are of increasing interest due to their many possible applications as luminescent and electro-luminescent materials for telecommunications and light emitting diodes as well as materials for catalysis, magnetic devices and contrast agents¹⁻³. Many of these properties depend on the nature and structural arrangement of the active centers (lanthanide), and on that of the organic component.

Two new families of isostructural compounds formed by trivalent lanthanide cations and organic ligands have been synthesized and studied. The RPF-17 series with formula $[Ln_7(3,5-DSB)_4(OH)_9(H_2O)_{15}]$ ·4H₂O contains the 3,5 disulfobenzoate (3,5-DSB) ligand forming a singular hepta-nuclear metallic cluster in a bidimensional network. The seven Ln polyhedra are inter-connected via oxygen ions among which six are octa-coordinated and one hepta-coordinated to oxygen atoms of the carboxylate, sulfonate, hydroxylate and water groups. The RPF-20 series of formula $[Ln_2(3,5-DSB)_2(Phen)_2(H_2O)_2]$ ·2H₂O includes also the 1,10-phenanthroline (Phen) as secondary ligand in order to avoid the formation of multi-Lanthanide clusters. The resulting structure simplification shows that the lanthanide cations are in a unique environment and octa-coordinated to six oxygen and two nitrogen atoms.

A comparison between the optical properties of these two isostructural series obtained for the same trivalent lanthanide cations: Y, Sm, Eu, Gd, Tb, Dy, Ho, Er, and Yb is presented. Micro-Raman and Photoluminescence experiments of individual crystals were carried out at room temperature and time resolved experiments in pellets under UV pulsed-laser excitation were obtained at different temperatures.

The Raman and IR spectra of the 3, 5-DSB ligand and of the Ln^{3+} -MOFs series are reported for the first time. The main vibration modes associated to the different groups of the DSB ligand and of those corresponding to the Phen ligand are identified and their dependence on the structural arrangement and on the lanthanide are analyzed.

The emission spectra reveal broad bands associated to the ligands as well as narrow bands related to f-f transitions of the different Ln^{3+} ions. The lifetimes of several emission bands were also obtained. A competition between the emission processes of the ligands and the Ln^{3+} ions is detected. The results are discussed in view to clarify the mechanism of activation of the ligand and lanthanide luminescence

- [1] J.-C. G. Bünzli, S. Comby, A.-S. Chauvin, C.D.B. Vandevyver, Journal of Rare Earths 25 (2007) 257-274.
- [2] F. Gándara, A. de Andrés, B. Gómez-Lor, E. Gutiérrez-Puebla, M. Iglesias, M.A. Monge, D.M. Proserpio, N. Snejko, Crystal Growth & Design 8 (2008) 378-380.
- [3] R. F. D'Vries, M. Iglesias, N. Snejko, S. Alvarez-Garcia, E. Gutierrez-Puebla, M. A. Monge, J. Mater. Chem. 22 (2012) 1191-1198.

BaTiO₃/POLYVINYLIDENE FLUORIDE NANOCOMPOSITES: THE EFFECTS OF MECHANICAL ACTIVATION OF THE FILLER ON THE STRUCTURAL PROPERTIES OF THE HOST MATRIX

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Fabrication of polymer nanocomposites evolved into one of the most prolific research areas in nanoscience and nanotechnology. By combining favourable features of the matrix polymer and nanostructured filler the materials with completely new functionalities can be obtained. Recent investigations on nanocomposites of electroactive ceramics and ferroelectric polymers exploit this approach in order to produce new functional materials for pressure and IR sensors. The properties of the obtained nanocomposites depend on different parameters such as preparation method, grain size of ceramic particles and their dispersion within the matrix. Taking into account that mechanical activation is one of the methods for modification of physicochemical properties of the filler, in this study we investigate the influence of mechanical activation of BaTiO₃ particles on the structural properties of BaTiO₃/polyvinylidene fluoride nanocomposites. The nanocomposite films were prepared by solution casting method and investigated by X-ray diffraction (XRD), Fourier transform infrared (FTIR) and Raman spectroscopies.

INVESTIGATION OF THE OPTICAL PROPERTIES OF NANOCOMPOSITE ZnO-MnO₂ THIN FILMS PREPARED BY SOL-GEL METHOD

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The ZnO-MnO₂ thin films were prepared by sol-gel method. The sol was prepared from zinc and manganese acetate, 2-Methoxyethanol, and MEA as the precursor, solvent and stabilizer, respectively. The sols were prepared with $Zn(ac)_2/Mn(ac)_2$ molar ratios of 8%, 16% and 25%, respectively. After aging the solution for 24 h, the sol was passed through a filter before deposition. Then, the thin films was deposited on glass substrates using dip-coating technique and annealed in ambient condition at 300°C. X-ray diffraction patterns of films show the orthorhombic crystal structure of MnO₂ phases for molar ratio 8% with grain sizes about 34 and 21nm. The XRD patterns for other thin films with Zn(ac)₂/Mn(ac)₂ molar ratios of 16% and 25% indicate an amorphous structure. The SEM images confirm the presence of the granule surface morphology for molar ratio 8%. Increasing *molar ratio* (>8%) leads to *decreasing* nanoparticle size and exhibit a smooth and homogeneous surface morphology that is in agreement with the result of XRD pattern. The transmission spectra of the nanocomposite ZnO-MnO₂ thin films were measured by a UV-VIS Spectrophotometer in the wavelength range 200-900 nm. The transmission spectra show that the transmittance is decreased as the Zn^{2+} concentration is increased. The optical constants, thickness and optical band gap are retrieved by simulating the transmission spectra based on Tauc-Lorentz model [1]. The optimization process is performed using a nonlinear least squares fitting procedure [2]. According to the results of optimization procedure, the values of indirect optical band gap of ZnO-MnO₂ thin films for three different concentrations 8%, 16% and 25% of Zn^{2+} are obtained 1.98, 1.62 and 1.71eV. The results of FTIR measurements for the nanocomposite ZnO-MnO₂ thin film show that the absorption peaks around 501 and 617 cm⁻¹ are due to the Mn-O vibrations in MnO₆ octahedral [3]. Several small absorption peaks at higher wave number correspond to the bending or stretching vibration organic bonds.

- W G. E. Jellison, Jr., F.A. Modine, P. Doshi, A. Rohatgi, Thin Solid Films. 313-314 (1998) 193-197.
- [2] W. Sun, Y. X. Yuan (Eds.), Optimization Theory and Metods: Nonlinear Programming, Springer Science. New York, 2006, pp. 362-366.
- [3] T. Yousefi, A. Nozad Golikand, M. Mashhadizadeh, M. Aghazadeh, Curr. Appl Phys. 12 (2012)193-198.

TIME-OF-FLIGHT STUDY OF PHOTOINDUCED DYNAMICS OF COPPER PHTHALOCYANINE THIN FILM ON Si(111)

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Organic metal phthalocyanines (MePc) are particularly relevant to such technological areas as optoelectronics, photovoltaic and photochemical device production. The latter motivates understanding of detail mechanisms of interaction of the photon with MePc. Despite of the extensive research of such materials undertaken for recent years, the effect of the photon on the MePc molecule is still unexplored. In relation to this the aim of the present study is to investigate controlled interaction of the photons, generated by Nd-YAG nanosecond pulsed low-fluence (2 mJ/cm^2) laser with one of the most widely utilized metal phthalocyanine – CuPc. The measurements have been carried in ultra high vacuum chamber (base pressure: ca. 10^{-9} Torr) with the aid of time-of-flight (TOF) mass spectrometer equipped with a flight tube of ca. 1 meter long as shown in Fig. 1.



Fig. 1 Schematic view of experimental setup for photoinduced time-of-flight measurements. 1 - specimen, 2, 3 - first and second drifting spaces where the desorbed specie move, 4 - ion source, where the desorbed specie are ionized by electron impact, 5 - detector, 6 -laser beam. Fig. 2. The mass-spectra of the specie desorbed from the CuPc surface. The spectra were registered when 120 (1) and 430 μ s (2) elapsed after the laser shot.

The advantage of the TOF technique used is that it allows distinguishing between the fragments produced on the sample and the artificial fragments produced by electron impact in an ion source (4). The TOF technique used allows obtaining the evolution of the photodesorption process as a function of time delay between the laser shot and the spectrum registration. Corresponding spectra are shown in Fig. 2. Two main features, unreported so far in the literature, are obvious: 1) The effect of the photon results in quite efficient desorption of entire CuPc molecule (m/z=576); 2) The CuPc molecular desorption peak is accompanied by a set of additional prominent peaks, which are likely attributed to CuPc fragments. In this regard the most striking feature is that at the initial stage of desorption (t=11 μ s) there is a Cu atom photoextraction from the CuPc molecule of which evidence is the dominant mass peak at 63 m/z. This allows to expect that photostimulated extraction of Cu atom from isoindole ring causes destruction of the molecule and desorption of fragments formed as a result of photoinduced electronic transitions. Another striking feature is desorption of SiPc specie which are presumably formed by underlying Si support diffusion into the film. Therefore, the metal, as well as Si atom, bound to molecular ligands can be viewed as a key factor determining the photoexcitation energy flow pathways leading to specific fragmentation and desorption of the fragments as well as the entire molecule, thus offering a new fundamental basics for optoelectronic photodevice fabrication based on organometalic compounds.

ELECTROMAGNETICALLY INDUCED TRANSPARENCY DUE TO ZEEMAN COHERENCE IN BUFFER-GAS CELL – EFFECTS OF LASER BEAM RADIAL PROFILE AND INTENSITY

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Electromagnetically induced transparency (EIT) [1], a narrow resonance in a laser transmission through coherent media, is essential for phenomena like slow and stored light, generation of correlated photon pairs, frequency mixing and Kerr nonlinearities. For many applications, EIT line shapes, amplitudes and linewidths are essential. In buffer gas cells, optimum operating laser intensity and cell temperature for maximum EIT contrast and minimum linewidth may vary from cell to cell, depending on the cell geometry, type of buffer gas and its pressure.

We have investigated effects of laser intensity and cell temperature on Zeeman EIT for Rb cell with diameter of 25 mm and 8 cm of length, filled with 30 Torr of Ne buffer gas, at temperatures from 60 to 82 °C. We observed narrow (sub kHz) EIT resonances due to Zeeman coherence in $F_g = 2$ hyperfine level of ⁸⁷Rb ground state using beams of different m dial intensity and definition and of different m diag

different radial intensity distribution and of different radius.

For Gaussian laser beam radial profile, variation of laser radius affects primarily the EIT contrast. Amplitudes for 6.7 mm and 1.3 mm beam diameter, peak at laser intensity around 1.1 mW/cm² and 3.2 mW/cm² respectively and EIT contrast increased 2.2 folds for narrower laser beam. EIT line shapes for 1.3 mm laser beam radius also have non Lorentzian profile. The line narrowing at very center of the resonance is due to Ramsey effect occurring because coherently prepared atoms diffusing out and then back to the laser beam spend comparable time in and out of the interaction region [2].

At larger beam radius, for which the average diffusion time of an atom through the laser beam is much longer then the coherence lifetime (estimated at about several ms), EIT linewidth increases linearly with the laser intensity, throughout entire range covered in the experiment, from 0.5 mW/cm^2 to 12 mW/cm^2 . The slope of linear dependence of EIT linewidth is independent on cell temperature for wider laser beam diameter. For higher intensities (over 2 mW/cm^2) line contrast for the 6.7 mm laser beam increases several times when we block the central part of the laser beam cross section (diameter of blocked beam is also 6.7 mm) in front of the detector. Since the laser beam is well collimated, this eliminated contribution to observed EIT from the most intensed laser region, and thus we detected EIT due to photons in the weak intensity large area laser wings.

^[1] M. Fleischhauer, A. Imamoglu, J. P. Marangos, Rev. Mod. Phys. 77, (2005) 633-673.

^[2] Y. Xiao, I. Novikova, D. Phillips, R. L. Walsworth, Opt. Express 65, (2008) 14128-14141.

^[3] A. J. Krmpot et al., Opt. Express 17, (2009) 22491-22498.

FTIR CHARACTERIZATION OF A GELATIN FROM CHICKEN FEET

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Fourier transform infrared FTIR) spectroscopy has increasingly been adopted as an analytical tool in various fields, such as the petrochemical, pharmaceutical, environmental, clinical, agricultural, food and biomedical sectors during the past 15 years. In food technology, this technique is widely to measure various qualities attributes [1]. There are reports in the literature of analyzes the qualities of various fruits, vegetables, seeds, gelatins and others [1-3]. Gelatin is a denatured fibrous protein derived from collagen by partial thermal hydrolysis. It is an important functional biopolymer that has a very broad application for food, material, pharmacy and photography industries [4, 5]. The objective of this study was characterizing the gelatin from the chicken feet by FTIR spectroscopy. Three gelatin samples were prepared for the experiment they were extracted of 200 g of chicken feet by a thermal bath of 4% acetyl acid solution at 60°C. All of these feet are popular in Brazilian markets. A commercial gelatin was used to compare the results. FTIR spectra of gelatin samples were recorded using a horizontal ATR. Trough a Nicolet iS5 FTIR spectrometer equipped with an ATR/iD3 with argon horizontal cell (Thermo Scientific®, EUA) at room temperature. The spectra in the range of 400-4000 cm¹ were ratioed and automatic signals gained were collected in 32 scans at a resolution of 4 cm¹ against a background spectrum recorded from the clean empty cell at 16°C [2-3]. Results showed that collagen composition of the chicken feet gelatins was greater than 70% while for the beef gelatin (commercial) was only 35% and the vibration bands to beef gelatin has been different than chicken feet gelatins. FTIR spectra of gelatin extracted from the chicken feet showed the major peaks in amide region. Chicken gelatins showed the vibration peak at the wavenumbers of 1652.01 cm⁻¹ to the amide I, of 1539.87 cm⁻¹ to the amide II, of 1241.29 cm⁻¹ to the amide III, of 3399.56 cm⁻¹ to the amide A, of 1652.01 cm⁻¹ to the amide B. Conclusions on the vibration curves are follows: the amide I vibration mode is primarily a C=O stretching vibration coupled to contributions from the CN stretch, CCN deformation and inplane NH bending modes. The amide II vibration modes are attributed to an out-of-phase combination of CN stretch and in-plane NH deformation modes of the peptide group (glycine backbone and proline side-chains). The amide III represented the combination peaks between C-N stretching vibrations and N-H deformation from amide linkages as well as absorptions arising from wagging vibrations from CH₂ groups from the glycine backbone and proline side-chains. Moreover, the amide A band, arising from the stretching vibrations of N-H group. The amide A also tends to join with the CH₂ stretch peak when carboxylic acid groups exist in a dimeric inter-molecular interaction. The amide B peak, suggesting the interaction of -NH₃ group between peptide chains. Thus, it can be concluded that the secondary structure of gelatins obtained from the chicken feet was affected by acid pretreatment and extraction time. The low molecular weight peptides formed during the extraction for long time were more likely able to form covalent cross-links during freeze-drying process [2, 3].

- B. M. Nicola, K. Beullens, E. Bobelyn, A. Peirs, W. Saeys, K. I. Theron, J. Lammertyn, Postharvest Biology and Technology 46 (2007) 99–118.
- [2] M. Ahmad, S. Benjakul, Food Hydrocolloids 25 (2011) 381-388.
- [3] J. H. Muyonga, C. G. B. Cole, K. G. Duodu, Food Chemistry 86 (2004), 325-333.

LUMINESCENT PROPERTIES OF [Eu(tta)₃(adppo)₂] COMPLEX ISOLATED AND COVALENTLY BONDED TO POLYDIMETHYLSILOXANE

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Lanthanide-containing compounds are extensively studied mainly due to their interesting optical properties. The lanthanide complexes are a class of compounds that exhibits intense luminescent properties when certain organic ligands are used, so the search for new ligands and synthetic methods to achieve new coordination compounds are important. The ligand may avoids the luminescence quenching and they may transfer energy to the lanthanide ion in a process called antenna effect¹. These complexes are used in organic-inorganic hybrids in order to stabilize and improve their optical properties. Several works reports the incorporation of lanthanide complexes in silica matrix prepared by sol-gel technique but few are devoted to the incorporation and the anchor of such complexes in silicones. So, this work presents a new approach to obtain organic-inorganic hybrid materials that consists in the functionalization of poly(dimethylsiloxane)-hydride terminated (pdms-H) by allyldiphenylphosphine oxide (adppo) through hydrosilylation reaction and the synthesis of the isolated $[Eu(tta)_3(adppo)_2]$ complex. bis(aqua)tris(2-thenovltrifluoroacetonate)europium(III) The complex ([Eu(tta)₃(H₂O)₂]) was anchored to the previously functionalized silicone with allyldiphenylphosphine oxide (pdms-adppo-eutta) and also dispersed into the nonfunctionalized silicone (pdms-eutta). The isolated complex was obtained through the [Eu(tta)₃(H₂O)₂] water substitution to addpo molecule. The cross-linking was achieved by tetravinylsilane through hydrosilylation reaction. Characterizations were carried out by elemental analysis, thermogravimetric analysis, complexiometric analysis, attenuated total reflection infrared spectroscopy, Raman spectroscopy, UV-Vis spectroscopy and luminescence spectroscopy. The coordination of the adppo molecule wich results in the [Eu(tta)₃(adppo)₂] complex was observed by infrared spectroscopy, and the elemental, complexiometric and thermogravimetric analysis confirmed the proposed stoichiometric. The total cross-linking is confirmed by the absence of the Si-H vibration band around 2130 cm⁻¹ at the infrared spectroscopy spectra of all samples. In the Raman spectra collected before the cross-linking, it is possible to observe the decrease of the band intensities around 2130 cm^{-1} and 1640 cm⁻¹ assigned to Si-H (pdms) and C=C (adppo) stretchings, respectively, indicating the polymer functionalization. The samples show good optical transmittance as indicated by UV-Vis spectroscopy. The absorption edge of the pdms-adppo-eutta sample shifts to higher energy compared to the pdms-eutta, indicating that the aqua ligands of the $[Eu(tta)_3(H_2O)_2]$ complex are substituted by the adppo ligand, which in its turn is covalently bonded to pdms. This is also observed by comparing the excitation spectra of the adppo-eutta-pdms and euttapdms samples and the [Eu(tta)₃(adppo)₂] complex, corroborating to the P=O coordination. The emission spectra of these samples and the [Eu(tta)₃(adppo)₂] complex show different emission profile and the change of the ${}^{5}D_{0} \rightarrow {}^{7}F_{2}$ transition behavior indicates a chemical environmental variation, probably due to the coordination of the Eu³⁺ by P=O. The emission lifetime value of the ${}^{5}D_{0}$ state is higher for the adppo-eutta-pdms sample and [Eu(tta)₃(adppo)₂] complex than the eutta-pdms, indicating once more the substitution of water molecules by the phosphine oxide group.

[1] Armelao, L, Quici, S, Barigelleti, F, Accorsi, G, Bottaro, G, Cavazzini, E, Tondello, E, Coord. Chem. Rev. 254 (2010) 487.

MICROSTRUCTURED LIGHT ABSORBING COATINGS BASED ON Ni-P ALLOY

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The problem of creating new high effective light absorbing coatings is one of the most topical problems for modern opto-electronic instrumentation and solar power engineering.

Such coatings should have low reflectivity in the near UV, visible and near IR wavelengths.

The work describe the method of production of microstructured light absorbing coatings based on Ni-P alloy.

This method includes the following basic operations: preparation of the sample surface by chemical degreasing, etching and activation, subsequent electroless nickel plating from solution, containing nickel sulphate, sodium hypophosphite and sodium acetate, and final etching in an aqueous solution of inorganic acids.

The obtained samples of coatings were studied using scanning electron microscopy, optical microscopy, X-ray diffraction analysis, and X-ray phase analysis.

Spectral dependence of the optical reflectance were measured under normal incidence of the primary beam on the integrating sphere LabSphere ISPREF and in the geometry of specular reflection on a spectrophotometer Shimadzu UV-1700 equipped with a prefix of specular reflection.

It was found that morphology of surfaces depends on operation parameters of chemical etching and on the concentration of microelements in the coatings before etching.

In turn, the optical properties of the surface depend on the produced micro-relief.

The minimum integrated reflectance was obtained for the coating with the concentration of phosphorus of 5,8 %.

The integral reflection coefficient of this coating varies within limits of 0.1-0.25%, reaching minimum in the range of 450-500 nm.

Therewith, reflection coefficient of the specularly reflected components is less than 0.005% in the range 300-670 nm and increases to 0.1% in the near-IR.

Pr³⁺-Yb³⁺ AND Tb³⁺-Yb³⁺ CLUSTERS IN CaF₂ FOR VISIBLE TO IR QUANTUM CUTTING

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The codoping of CaF_2 with $Pr^{3+}-Yb^{3+}$ ions on the one hand, and $Tb^{3+}-Yb^{3+}$ ions on the other hand is investigated for visible to infrared quantum cutting. As displayed in Figure 1, the emission of two photons by Yb^{3+} ions after absorption of a visible photon is possible through two consecutive energy transfers form Pr^{3+} ions [1], and a single cooperative energy transfer from Tb^{3+} ions [2]. It is well known that the doping of CaF_2 with rare-earth ions gives rise to the formation of rare-earth aggregates or clusters. The rare-earth clustering is particularly interesting for applications involving energy transfers since the short distance between the ions in the clusters leads to remarkably high energy transfer efficiencies.



Figure 1 QC mechanism with (a) $Pr^{3+}-Yb^{3+}$ (b) $Tb^{3+}-Yb^{3+}$

Detailed spectroscopic investigations in CaF₂:Pr³⁺-Yb³⁺ revealed the existence of three different Pr³⁺ centers as well as their respective proportions. These centers were identified as single Pr³⁺ ions, Pr³⁺ clusters and Pr³⁺-Yb³⁺ clusters within which extremely efficient energy transfers from Pr³⁺ to Yb³⁺ take place. While Pr³⁺ clusters dominate in singly doped Pr³⁺: CaF₂, the codoping with Yb³⁺ ions (> 4%) is shown to create Pr³⁺-Yb³⁺ clusters replacing all the other centers. Energy transfer rates up to 10⁷s⁻¹ are observed in some Pr³⁺-Yb³⁺ clusters. This transfer rate can hardly be explained by a dipole-dipole interaction, and is most likely due to a super-exchange mechanism. In a similar way, the codoping of CaF₂ with Tb³⁺-Yb³⁺ leads to the formation of Tb³⁺-Yb³⁺ clusters. In this case, the cooperative energy transfer rate is lower than the energy transfer rate observed between Pr³⁺ and Yb³⁺ ions. This is expected since the cooperative mechanism involves a three body interaction which is several orders of magnitude less efficient than a fist order resonant energy transfer. Nevertheless, the short distance between the Tb³⁺ and Yb³⁺ ions within the clusters strongly improves the efficiency of the cooperative mechanism in comparison with other host materials and offers thus promising results.

- [1] B. M. van der Ende, L. Aarts, et A. Meijerink, «Near-Infrared Quantum Cutting for Photovoltaics », *Adv. Mat.*, p. 3073, 2009.
- [2] P. Vergeer, T. J. H. Vlugt, M. H. F. Kox, M. I. den Hertog, J. P. J. M. van der E., A. Meijerink, M. I. den Hertog, J.P.J.M. van der Eerden, et A. Meijerink, « Quantum cutting by cooperative energy transfer in YbxY1-xPO4:Tb3+ », *Phys. Rev. B*, vol. 71, n^o. 014119, 2005.

CHARGE PROPAGATION DYNAMICS FOR ENERGY TRANSFER IN Er DOPED nc-Si OBSERVED WITH ELECTRIC MEASUREMENTS

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Indirect excitation of rare-earth dopants using Si nano-crystals (nc-Si) provides intense and narrow bandwidth luminescence suitable for electro-optical devices. Charge confinement in the nano-structures minimizes charge dissipation, and rapid recombination of the confined charges realizes effective energy transfer to the dopants. In fact, Er-doped nc-Si (nc-Si:Er) in SiO₂ shows intense infrared luminescence at room temperature. However, we still have unknown factors to be considered for improvement of the luminescence intensity, e.g., size distribution of nc-Si and charge compensation for Er^{3+} in the host elements of Si⁴⁺ and O²⁻.

In this study, we investigated the charge confinement and recombination in nc-Si:Er with an electric measurement technique, namely complex impedance spectroscopy (CIS) [1]. We identified charge dynamics corresponding to the luminescence intensity, and evaluated effects of the size distribution of nc-Si and the charge compensation on the dynamics.

The nc-Si were fabricated in SiO₂ 700 nm thick on a p⁺Si substrate. Si (10 at%) and Er (0.5 at%) ions are implanted into the SiO₂ layer at 80 keV and 300 keV, respectively. Thermal annealing at 1100 °C in N₂ forms nc-Si in SiO₂. CIS spectra were obtained with an impedance analyzer (Hewlett Packard, 4192A). To analyze the Er excitation process, the sample was excited with He-Cd laser ($\lambda = 442$ nm) [2].

Figure 1 shows typical CIS spectra indicating effects of Er doping. The CIS spectra (Real part of the complex impedance Z' versus probing frequency) indicate frequency response of charges in AC electric field. From comparison between CIS spectra of (a) nc-Si without Er and (b) nc-Si:Er, a new spectral feature at 780 Hz can be found for nc-Si:Er. The frequency indicates relaxation of the confined charges to a trapping level. The relaxation can be analyzed with an equilibrium circuit as shown by the inset of Fig. 1(b). Interestingly, the value of R_p with respect to sample temperature corresponded to temperature quenching of photoluminescence at $\lambda = 1.54 \,\mu$ m. A possible model of the quenching is as follows: The Er dopants make shallow levels and supply additional charges in nc-Si. The stationarily filled nc-Si leak the charges into the bulk with increasing temperature.



Fig. 1 CIS spectra at 75 K of (a) nc-Si without Er and (b) nc-Si:Er.

[1] M. Ishii, S. Harako, X. Zhao, S. Komuro, and B. Hamilton, Appl. Phys. Lett. 99 (2011) 101909.

^[2] M. Ishii et al., J. Appl. Phys. 111 (2012) 053514.

LUMINESCENCE IN ITRIA STABILIZED ZrO₂ CERAMICS OBSERVED BY RAMAN SPECTROSCOPY

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Stabilized or partially stabilized ZrO_2 represent materials of great technological importance applied in the preparation of ceramics with high resistance to strain, stress, tiring and thermal shocks. Due to these properties it has application as mechanical parts of the motors, but also, due to the good bio-compatibility as bone implants.

ZrO₂ ceramics having different porosity were prepared by sintering the amorphous powder precursor. The precursor is synthesized by sol-gel procedure, ball-milled for 2 h for homogenization and calcinated at 300 °C. The amorphous powder were pressed in pallets and sintered at different temperatures (900, 1000, 1100, 1200, 1300 and 1400 °C). The structure of ceramics was investigated by X-ray powder diffraction (XRD) and Raman spectroscopy (RS), while scanning electron microscopy (SEM). Luminescence was observed using Raman spectrometer with 532 nm excitation.

XRD measurements indicated cubic or tetragonal ZrO_2 ceramics. Tetragonal and cubic zirconia structures have similar lattice parameters and there is aproblem in assigning the structures accurately only by XRD, while RS was proven to be a very successful method for distinguishing the cubic and tetragonal phase in zirconia. Raman measurements indicated tetragonal structure of all investigated ceramics.

With the aim to check luminescence properties of prepared ceramics, broad spectral region was observed by Raman spectrometer using 532 nm for excitation. The strong luminescence parts of spectra was observed in the region between 650 and 700 nm in all sintered ceramics, while the intensity of the luminescence increase with the increase of sintering temperature (Fig. 1).

The observed luminescence properties of ceramics will be discussed considering doping by itria, crystal structure and the morphology of the ceramics.



Figure 1: The luminescence in ZrO_2 ceramics observed by Raman spectrometer. Sintering temperatures are denoted above spectra.

CHARACTERIZATION OF Dy³⁺:Y₄Al₂O₉ CRYSTALS FOR HIGH TEMPERATURE MEASUREMENTS

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Temperature dependent emission spectra of trivalent dysprosium (Dy^{3+}) activated $Y_4Al_2O_9$ (abbreviated YAM) crystals have been studied. The ratio of emission lines intensity can be used in temperature measurements, as it is not dependent on the variability of absolute intensity [1]. Dy^{3+} :YAM phosphor spectroscopic properties have been widely investigated previously [2] together with possible cross-relaxation processes.

The Boltzmann model was applied for modelling the temperature variation of ${}^{4}I_{15/2}$ and ${}^{4}F_{9/2}$ states emissions relative intensities (455 and 481 nm respectively). The experimental line follows precisely theoretical model in mid temperature range (400 -800 K) giving almost the same value of energy gap ΔE between considered levels. The comparison is presented on Arrhenius plot visualizing the changes in ΔE value. For lower temperatures (< 400 K) the slope corresponding to ΔE is less steep, what can be attributed to small ${}^{4}I_{15/2}$ emission quenching caused by strictly resonant cross-relaxation pathway. For higher temperatures (> 800 K) the slope becomes steeper indicating appearance of some additional processes responsible for ${}^{4}F_{9/2}$ emission quenching. From Dy^{3+} energy level diagram it can be seen that ${}^{4}F_{9/2}$ level has many possible crossrelaxation pathways with little energy gap between both included transitions. Such little mismatch can readily be filled by thermal activation energy. The decay time of ${}^{4}F_{9/2}$ state was measured as a function of temperature. The resulting quenching rates plotted as a function of temperature in double logarithmic representation confirm the influence of cross-relaxation process on ${}^4F_{9/2}$ emissions. Considering both ${}^4I_{15/2}$ and ${}^4F_{9/2}$ emissions quenching the agreement between theory and measurements in 400 - 800 K range is most probably the result of the balanced influence of ${}^{4}I_{15/2}$ and ${}^{4}F_{9/2}$ crossrelaxation processes.

Moreover, the temperature dependence of ${}^{4}I_{15/2}/{}^{4}F_{9/2}$ intensity ratio can be precisely approximated by two exponential functions when dividing the measurements range into two parts: 300-600 and 600-1000 K. It seems quite reasonable, when assuming the thermal activation energy delivered to the system with growing temperature. The calculated approximation gives highest sensor sensitivity of about 3×10^{-3} K⁻¹ for 800-1000 K range, what allows to expect usefulness of Dy³⁺:YAM in high temperature luminescence thermometry.

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- [1] S.A. Allison, G.T. Gillies, Rev. Sci. Instrum. 68 (1997) 2615-2650.
- [2] Z. Boruc, B. Fetlinski, M. Malinowski, S. Turczynski, D. Pawlak, Optical transitions intensities of Dy³⁺:Y₄Al₂O₉ crystals, Opt. Mater. (2012), in press, doi:10.1016/j.optmat.2012.01.006.

ELECTRONIC STRUCTURE AND ENERGY TRANSFER PROCESSES OF Sm³⁺ IN SESQUIOXIDES

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Recent interest in Sm³⁺ spectroscopy is connected to development of visible light sources by using direct pumping with new efficient violet laser diodes. The aim of this paper is to elucidate several fundamental aspects concerning the spectral features of Sm^{3+} in sesquioxides (Y₂O₃ and Sc₂O₃), previous studies refer only to Y₂O₃ [1, 2]. Despite of the large amount of the inversion C_{3i} sites (~ 1/4), no spectral data on Sm³⁺ in C_{3i} sites and their role in the emission processes have been reported. Polycrystalline translucent ceramics were prepared by solid state synthesis; after sintering at 1600°C, only cubic C-phase was detected. The spectral features of Sm³⁺ C_{3i} centers, obtained by time resolved selective excitation and emission (energy levels, lifetimes, emission quenching processes, etc) are analyzed comparatively to those of major C₂ centers. The features associated to C_{3i} centers were observed, by time resolved spectroscopy (at delays of 5-10 ms), only in the transitions ($|\Delta J|=0,1$) with significant magnetic dipole intensities: ${}^{6}H_{5/2} \rightarrow {}^{4}G_{5/2}$ in absorption or ${}^{6}H_{5/2} \rightarrow {}^{4}F_{5/2}$ in excitation and ${}^{4}G_{5/2} \rightarrow {}^{6}H_{5/2,7/2}$ in emission spectra (Fig. 1). The lifetimes at 300 K (1.48 ms for C_2 and 8.4 ms for C_{3i} at 0.06at. % Sm in Y_2O_3) and emission quenching processes are quite distinct for the two centers (Fig. 2). The quenching processes for Sm^{3+} in both centers are analyzed; unlike C2 centers, C3i centers participate only in transfer processes involving the Stark levels of ${}^{6}H_{5/2}$ and ${}^{4}G_{5/2}$ manifolds. The larger crystal field splittings for Sm³⁺ in Sc₂O₃ and stronger luminescence quenching than in Y₂O₃ are connected to structural differences.



An attempt to elucidate the spectral features of Sm^{3+} in C₂ and C_{3i} symmetry sites (both sites have a sixfold O²⁻ coordination) in sesquioxides is presented. Qualitatively, one could explain the dissimilarity of C₂ and C_{3i} Sm^{3+} spectra in terms of crystal field differences, by comparing their energy levels schemes with the assignments of Sm^{3+} Stark levels in several local symmetries: O_h in elpasolite [3], D₃ in borates [4], etc.

- [1] N. C. Chang, J. B. Gruber, R. P. Leavitt, C. A. Morrison, J. Chem. Phys. 76, (1982) 3877.
- [2] J.F. Martel, S. Jandl, B. Viana, D. Vivien, J. Phys. Chem. Sol. 61, (2000) 1455
- [3] M. D. Faucher and P A Tanner, J. Phys. Condens. Matter 18, (2006) 8503.
- [4] I. Kabaily, M. Dammak, J. Luminescence, 132 (2012), 2092.

INFRARED-EXCITED RED, GREEN, VIOLET AND UV LUMINESCENCE FROM LANGASITE CRYSTAL DOPED WITH **ERBIUM AND YTTERBIUM**

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In this paper, we investigate the upconversion luminescence in a $La_3Ga_5SiO_{14}$ (langasite, LGS) single crystal doped with erbium and ytterbium. The langasite single crystal was grown by the Czochralski technique, along c-axis, in an iridium crucible (30 mm - diameter, 30 mm - height) in N_2 atmosphere using a pure LGS seed. The luminescence of LGS:Er:Yb was excited in IR, at 973 nm, using the laser diode DioMod980/30/400. The experimental set-up for luminescence measurements contains a Horiba Jobin-Yvon monochromator (model 1000MP), an S-20 photomultiplier and the SR 830 lockin amplifier on line with a computer. All the measurements were performed at room temperature.

The upconversion luminescence spectra for pumping at 973 nm are given in Figs. 1 and 2. In Fig. 1, are shown the green $({}^{2}H_{11/2} \rightarrow {}^{4}I_{15/2}$ and ${}^{4}S_{3/2} \rightarrow {}^{4}I_{15/2})$ and red $({}^{4}F_{9/2} \rightarrow {}^{4}I_{15/2})$ $^{4}I_{15/2}$ luminescence bands. In Fig. 2, the luminescence bands corresponding to $^{4}G_{11/2} \rightarrow ^{4}I_{15/2}$ (at ~ 380 nm, in near UV) and $^{2}H_{9/2} \rightarrow ^{4}I_{15/2}$ (at ~ 410 nm, violet) transitions are observed.



Fig. 1 - Upconversion green Fig. 2 – Upconversion near and red luminescence excited UV and violet luminescence at 973 nm in LGS:Er:Yb excited at 973 nm single crystal.

LGS:Er:Yb single crystal.

Fig. 3. Energy levels diagram of Yb³⁺ and Er³⁺ and the proposed energy transfer mechanisms.

Five $Yb^{3+} \rightarrow Er^{3+}$ energy transfer processes (Fig. 3) were proposed in order to explain the observed upconversion luminescence. We found that the Er^{3+} level $^{2}\text{H}_{9/2}$, responsible for the violet luminescence, is fed, mainly, from the ${}^{4}F_{9/2}$ level while the ${}^{4}G_{11/2}$ level is fed mainly, from ${}^{4}S_{3/2}$ (thermalized with ${}^{2}H_{11/2}$).

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INVESTIGATION OF PHOTOCHEMICAL TRANSFORMATIONS IN SOLUTIONS OF INORGANIC COMPOUNDS WITH SILVER COMPLEXES

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Investigation of photochemical transformations in solutions activated with silver promotes elucidation of various physical processes that occur in such systems. In present work, the photochemical transformations in concentrated aqueous solutions of oxygen-containing and haloid salts with admixture of silver are studied taking into account the photoactivity of the Ag^+ ion.

While investigating the photochemical transformations in above-mentioned solutions activated by silver ions $(10^{-5}-10^{-1} \text{ mol/l})$, the absorption, photoluminescence (PL) and PL excitation spectra of the solutions were measured. The solutions involved do not luminesce at room temperature but at 150-180 K they strongly emit under UV irradiation. The spectra under observation are conditioned by electron transition between energy levels of the Ag⁺ ion which are deformed due to the interaction with the environment.

At 290 K, in given solutions under irradiation by the light with the spectral distribution that meets the absorption region of the Ag^+ ion, the photochemical transformations occur, resulting in the transformations of Ag^+ ions in an insoluble Ag^0 association. The rate of photochemical transformations from the Ag^+ ions to the Ag^0 satisfactorily correlates with the energy values of electron detachment from solvent anions and with the maximum peak positions of absorption bands for given anions in the aqueous solutions. Under irradiation with the visible light, the photochemical transformations in such systems ran rather slowly, during several months. Under storing in the dark over a long period of time, the solutions under observation did not lose their own luminescent properties. During measuring of the absorption spectra in the solutions, the photochemical transformations ran very slowly and therefore those did not influence the experiment.

The study of photochemical processes that occur in the solutions with silver complexes allowed us to elucidate the influence of media on the impurity Ag^+ ion and to determine a number of medium parameters that describe their properties.

ZnAl₂O₄: Cr³⁺ NANOPOWDERS AS NEW STORAGE PHOSPHOR

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Discovery of X – ray has given fantastic possibility to investigate human internal body structures. Today, in spite of ample experience in taking advantage of this method two issues are still addressed; first how to minimize the X-ray dose obtained by the patient and second how to develop an easy, versatile and chemical treatment free method of recording of X ray images. These two problems may find solutions by applying storage phosphors; they require lower X-ray intensity and replace traditional X-ray films.

After irradiation, the storage phosphor converts X-ray ionizing radiation into stable electron-hole pairs, which numbers is proportional to the X-ray density. The generated defects are stable at room temperature and the image information is stored until it is read out. Photon emission is released by heat or by laser beam which scan phosphor plate pixel by pixel.

X-ray create defects/traps at various depths, while shallow traps are not suitable for storage phosphors deep traps should be well adapted to the read out system. In addition large number of the traps will be necessary to obtain high sensitivity materials.

Storage phosphors are commercially the most successful detectors for replacing filmscreen systems. However better results may be obtained by employing ceramic storage phosphor. It is well known that transparent ceramic may be obtained when the host has cubic structure and such structure is offered by $ZnAl_2O_4$ spinel. Therefore, we have focused our investigations on the preparation and the optical features of chromium doped $ZnAl_2O_4$ nanopowders particularly on the thermoluminescence results.

 $ZnAl_2O_4$ doped with 0.1 % Cr^{3+} samples were prepared by microwave-assisted hydrothermal method. As precursors, we used powdered hydrated zinc acetate and aluminum isopropoxide, and chromium nitride, which were dissolved in distilled water. The microwave reaction was carried out 30 minutes in 200°C, under 40 bars. The samples were dried at 120°C and annealed at 300, 600 and 900°C, thermal treatment increases the sample diameter from 2 to 16 nm.

 Cr^{3+} :ZnAl₂O₄ nanopowders exhibit good emission properties in the red/near infrared range at about 700 nm. Traps depths of about 1 eV, corresponding to a TSL curve at about 525 K were obtained after X-rays irradiation. These traps are therefore stable at room temperature and could be emptied by thermal or near infrared source. We believe that ZnAl₂O₄ nano-ceramic may offer very small pixel's size thus increasing considerably the image resolution.

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BIOMECHANICAL MODELS PRODUCED FROM LIGHT-ACTIVATED DENTAL COMPOSITE: A HOLOGRAPHIC ANALYSIS

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Light-activated dental composites, commonly applied in dentistry, can be used as an excellent material for producing the biomechanical models. This can be particularly important in fields where collecting of biological samples is time consuming and raises ethical questions. In addition, there is a great variability between biological specimens, making difficult to perform the same measurement under the same conditions. Lightactivated dental composites can be cast in almost any shape in an appropriate silicone mould, and quickly solidified by irradiation with light in the blue part of the spectrum (centered at 474 nm). In that way, it is possible to obtain any number of nearly identical casts. Dimensional variations were less than 1%. The models can be used to study behaviour of arbitrary structure under mechanical loads. To test the technique, the simple mechanical model of the tooth with MOD (mesio-occluso-distal) cavity was manufactured. Resin composite restoration was placed inside the cavity and light cured. A real-time holographic interferometry was used to analyze the contraction of the resin composite, and its effect on the surrounding material. After measurement of the deformation the finite element method was used for calculation of internal stress. The digital geometric model of the object under investigation was constructed. The model is meshed, direction of forces and pressures were defined and boundary conditions were given in accordance with experiment. The results obtained in the holographic experiment were in a good agreement with those obtained using the finite element method. The described method is particularly suited to study various dental procedures, such as: resin composite polymerization techniques and strategies, loading of teeth and dental implants. The findings obtained could help dental practitioners to choose therapeutic procedures most favourable for patients.

LUMINESCENCE OF MANGANESE-DOPED ZINC THIOINDATE

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Meeting the advanced requirements of modern micro- and optoelectronics involves stringent conditions with respect to the materials used. Severe requirements are put forward for new technologies for producing multicomponent materials and studying their physical properties. Therefore, there is a considerable scientific interest in ternary semiconductor compounds. This family includes zinc thioindates $Zn_xIn_2S_{3+x}$, which exhibit high photosensitivity and intense photoluminescence over a broad spectral range. An unordinary behavior of the manganese impurity in $A^{II}B^V$ and $A^{II}B^{VI}$ compounds has been observed. More detailed information about the behavior of this impurity in $ZnIn_2S_4$ is not available in the specialized literature.

In this study, we analyze the mechanisms of recombination of charged particles in the manganese-doped $ZnIn_2S_4$ compound and their changes induced by temperature and different concentrations of impurities. The technique for producing manganese-doped zinc thioindate is described in [1, 2].

The emission spectra of single-crystal wafers with an area of 0.3 cm² and a thickness of 200-300 μ m were recorded at temperatures of 80 and 300 K. Previously, for the samples under study, from the absorption spectra, using known techniques, we determined the band gap for the ZnIn₂S₄ compound E_g = (2.95 ± 0.05) eV at a temperature of 80 K and E_g = (2.86 ± 0.05) eV at 300 K. For excitation, we used a laser with the parameters $\lambda_{exc} = 337$ nm and E = 3.67 eV.



Fig. 1. Region of the luminescence (emission) spectrum of $ZnIn_2S_4$:Mn single crystals at a Mn concentration of 6.2 • 10^{19} cm⁻³; T = 300 K.

The spectra recorded at the above temperatures have a fairly complex structure. In this study, we analyze a region of the luminescence spectrum with a fixed emission center at an energy of 1.91 eV. For the decomposition of complex spectra, the Fox-Aletz method was used. The technique made it possible to detect a spectrum with characteristic features for these samples, which are absent in undoped ZnIn₂S₄. Figure 1 depicts the emission (luminescence) spectrum of ZnIn₂S₄. Mn single crystals with the impurity concentration of $6.2 \cdot 10^{19}$ cm⁻³ at a temperature of 300 K. The revealed features are shown in Fig. 1 as follows: A(2.25 ± 0.02) eV; B(2.17 ± 0.02) eV; C(2.14 ± 0.02) eV; D(2.07 ± 0.02) eV; E(1.91 ± 0.02) eV; K(1.62 ± 0.02) eV.

The energy position of the identified features for the given spectrum region no. 4 shifts upon a change in temperature in the range of 80–300 K and increases in proportion to increasing Mn concentration in the sample. For example, as the impurity concentration increased threefold $(1.9 \cdot 10^{20} \text{ cm}^3)$, the intensity of recombination of all the experimentally found features also increased threefold. An increase in the impurity concentration heads to an increase in the half-width of the recombination band.

In our opinion, all the revealed optical transitions are intercenter transitions. It is only natural to assume that the recombination processes depend on the crystal-lattice symmetry, which was not calculated in this study.

E.D. Arama, S.I. Radautsan, I.M. Tiginyanu et al. Phys Stat Solidi (a) 1988, V. 109, nr.1 P. k55-57.
E.D. Arama, V.F. Jitari, A.I. Maciuga, M.V.Ciukicev.Jurnal pricladnoi Spectroscopii V.50, p.503-506.

THERMO LUMINESCENCE PROPERTIES OF Eu³⁺ DOPED GD₂O₃ PHOSPHOR

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Rare earth oxides are important hosts for the luminescence of rare earth activators with considerable practical applications in the artificial production of light. In this work we investigated the possibility for $Gd_2O_3:Eu^{3+}$ usage in phosphor thermometry by observing the temperature changes of trivalent europium ion transitions from ⁷D₀ and ⁷D₁ energy levels to the ground state levels. A set of three samples of Eu^{3+} doped Gd_2O_3 : (1, 5 and 10 at.% Eu^{3+} in respect to Gd^{3+} ions) was produced via combustion synthesis. The sample crystalline structure is confirmed from XRD measurements. Photoluminescence measurements were recorded in the temperature range 298-800 K. Fluorescence Intensity Ratio (FIR) of the paired emissions bands was studied as a function of temperature in temperature range 300-800K, and the life time measurement in interval 10-800K. All three $Gd_2O_3:Eu^{3+}$ samples proved to have a good potential for the development of thermographic phosphors.

RARE EARTH (Sm⁺³ AND Dy⁺³) DOPED GADOLINIUM OXIDE NANOMATERIALS FOR LUMINESCENCE THERMOMETRY

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Possibility of using Sm³⁺ and Dy³⁺ doped Gd₂O₃ nanopowders as thermographic phosphors TGPs materials was studied. Both samples were synthesized by combustion method. Crystalline structure of synthesized samples was confirmed by XRD measurements. Photoluminescence measurements were recorded in the temperature range from 298 K to 773 K. The photoluminescence spectrum of Sm³⁺ showed four peaks that originate from ${}^{4}G_{5/2} \rightarrow {}^{6}H_{j}$ transitions, while in the case of Dy³⁺, the ${}^{4}F_{7/2} \rightarrow {}^{6}H_{j}$ transitions were observed. The fluorescence intensity ratio (FIR) of prepared nanomaterials was studied as a function of temperature using the ${}^{4}G_{5/2} \rightarrow {}^{6}H_{5/2}$ transition of Sm³⁺ (emission line at 575 nm) and the ${}^{4}F_{9/2} \rightarrow {}^{6}H_{13/2}$ transition of Dy³⁺ (emission line at 455 nm) as an internal reference. Both doped Gd₂O₃ samples proved to have a good potential for the development of thermographic phosphors. The maximum sensitivity was approximately 2.48x10⁻⁴ K⁻¹ for the sample with 1% mol Dy³⁺ at 773 K and 1.744x10⁻⁴ K⁻¹ for the sample with 1% mol Sm³⁺ at 701 K. The lifetime measurements were recorded in the same temperature region for 606 nm and 572 nm peaks of samarium and dysprosium, respectively. The lifetime at room temperature was found to be about 0.795 ms for (Sm³⁺) and 0.193 ms (Dy³⁺) and it decreased as temperature increased.

ARTIFICIAL NEURAL NETWORK FOR PROCESSING FLUORESCENCE SPECTROSCOPY DATA IN SKIN CANCER DIAGNOSTICS

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Over the years various optical spectroscopic techniques have been widely used as diagnostic tools in discrimination of many types of malignant diseases. Recently, synchronous fluorescent spectroscopy (SFS) coupled with chemometrics, has been applied in cancer diagnostics [1,2]. SFS method involves simultaneous scanning of both emission and excitation wavelengths while keeping the interval of wavelengths (constant wavelength mode) or frequencies (constant energy mode) between them constant. This method is fast, relatively low cost, sensitive and non-invasive. Total synchronous fluorescence spectra of normal skin, nevus and melanoma samples were used as input for training of artificial neural networks. Two different types of artificial neural networks were trained, self-organizing map (SOM) and feedforward neural network. SOM was trained in unsupervised way in order to convert high-dimensional. nonlinear statistical relationships into simple geometric relationships [3]. Unlike SOM, feedforward neural network was trained in supervised way and used for classification of unknown data. Histology findings were used as gold standard for network output. Based on obtained classification success rate of neural networks we concluded that both networks provided high sensitivity with classification errors between 2 and 4 %.

[1] T. Dramićanin, L. Lenhardt, I. Zeković, M. D. Dramićanin, J Fluoresc (2012) In Press

[2] T. Dramićanin, B. Dimitrijević, M. D. Dramićanin, Appl. Spectrosc. 65 (2011) 293-297

[3] T. Kohonen, Computer. 21 (1988) 11.
LOW TEMPERATURE EFFECTS ON UP-CONVERSION EMISSION OF Er³⁺/Yb³⁺ CO-DOPED Y₂O₃

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Over the past years, Rare Earth (RE³⁺) ions doped materials have been attracted a great deal of interest due to the potential application for optical temperature sensors. Luminescence properties of these materials are sensitive and changeable with temperature. Here, we have investigated yttrium oxide doped with Yb³⁺ and Er³⁺ that was synthesized through spray pyrolysis method at 900 °C and afterwards additionally thermally treated at 1100 °C for either 12, 24 or 48h. Structural and morphological characterizations were done through X-ray powder diffraction (XRPD) and scanning electron microscopy (SEM). The obtained particles were spherical in shape and crystallized in cubic bixbyte structure with space group *Ia-3*. Photoluminescent measurements (PL) were recorded using the 978 nm exciting wavelength as a function of temperature in the range from 10 K to 300 K. Emission spectra are assigned to the following trivalent erbium f-f electronic transitions: ²H_{9/2}→⁴I_{15/2} (red: 640-720 nm), (²H_{11/2}, ⁴S_{3/2}) → ⁴I_{15/2} (green: 510-590 nm), and ⁴F_{9/2}→⁴I_{15/2} (red: 640-720 nm). The fluorescent intensity ratio of the blue, green and red areas under emission bands was also examined and showed significant temperature sensitivity, with the largest value of 2.7 K⁻¹.

AEROSOL ASSISTED MOCVD DEPOSITION OF ANTIREFLECTIVE ZnO:Er³⁺ THIN FILMS

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Erbium-doped ZnO oxide films based nanostructured materials have drawn much interest for their high potential of becoming a new class of luminescent materials, antireflective films and enhancement of solar cell spectra. Recent progresses in scientific technologies on structured materials by CVD process at low cost have received great attention.

In this paper we present the growth of Er:ZnO thin films prepared on Si (111) substrate by aerosol assisted metal-organic chemical vapor deposition (MOCVD). By using Zinc and Erbium acetylacetonates precursors dissolved in butanol, the films were grown between 400 and 500°C with different Er atomic concentration in the solution.

Under these deposition conditions thicknesses films was found to be 220 and 320 nm. The affect of thermal annealed films on their structural and optical properties were investigated using the electron probe microanalysis measurements (EPMA), X-ray diffraction and the ellipsometrie measurements.

It was found that the crystallinity was promoted by increasing the annealing temperature, the Er:ZnO film crystallize in the hexagonal wurtzite structure at 900°C and the refractive index value increases.

Reflectance spectrum of the films shows that the oscillation of the reflectance curves is more pronounced for the thin films grown at higher substrate temperature and the optical reflectance is lower than that of bare silicon substrates in the UV and visible region indicating that the ZnO films can be used as antireflection coatings for silicon based solar cells.

NANOPARTICLE SYNTHESIS BY PULSED LASER ABLATION IN LIQUID

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Pulsed Nd:YAG laser with 355nm output at 10 Hz was used to ablate copper (Cu), nickel (Ni), molybdenum (Mo) and silicon (Si) in water. Inert gas is often introduced in laser ablation in order to obtain nano-sized particles as compared to high vacuum deposition; because of collisional cooling and also plasma confinement. Thus, liquid medium can be utilized for stronger effect [1]. In our experiment, the ablated materials in the water were transferred to the silicon substrates and characterized by a scanning electron microscope. Laser-induced heating of suspended Ni materials in water assisted the agglomeration into larger lumps. For the case of Cu, nanoparticles of 100-200 nm were produced but could coalesce into flakes. For the case of Si, the sub-surface melting created an unstable layer which broke up into flakes. For Mo, the laser irradiation induced cracks in the top layer and chemical reactions occurred such as the top surface was turned into ceramic-like sub-micron structures and the presence of some nanocrystals (Fig. 1). The formation and their possible reaction in water were compared and discussed.



Fig. 1 Laser-ablated Mo debris on Si

[1] G.W. Yang. Prog. Mater. Sci. 52 648 (2007).

MORPHOLOGICAL AND PHOTO-PHYSICAL PROPERTIES OF SPIN-COATED POLY {2,5-DIYL PYRROLE) [4-NITROBEZYLIDENE]} (PPNB) THIN FILMS : TOWARDS PHOTOVOLTAIQUE APPLICATIONS

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A new material, the poly {(2,5-diyl pyrrole) [4-Nitrobenzylidène]}, that we called (PPNB), has been synthesized, characterized and probed for application in organic solar cells. The energy levels corresponding to the highest occupied molecular orbital (HOMO) and the lowest unoccupied molecular orbital (LUMO) of the PTB have been determined from the first oxidation and reduction potential respectively, using cyclic voltametric (CV) measurements. From CV curves, PPNB in dichloromethane showed a one electron reversible reduction and oxidation waves. The values of its HOMO and LUMO have been estimated to be 6.16 eV and 3.89 eV respectively. Such values and compared at Fullerene C₆₀ one, show that PPNB could be probed for photovoltaique applications. Thin films of poly poly {(2,5-diyl pyrrole) [4-Nitrobenzylidène]} polymer, have been synthesized by spin-coating technique from Dichloromethane with different polymer concentrations, and a spin speed of 3000 rpm.

For morphological characterization of the films scanning electron microscopy (SEM) was carried out. The samples, when observed by Scanning Electron Microscopy (SEM), reveals that the films deposited are less dense, uniform. Cross-sectional SEM micrographs PPNB films show that thickness of the layers is 55 to 55 nm. Optical characteristics of the polymer thin films were studied using UV-vis spectroscopy; the analysis of absorption spectra shows the direct nature of band-to-band transitions. The optical band gap energy of PPNB polymer ranges between 1.9 eV and 1.94 eV.

- [1] F. Brovelli, M.A. Del Valle, F.R. D'1az, J.C. Bernède, Bol. Soc. Chil. Quim. 46, 319 (2001);
- [2] M.A. Del Valle, G.M. Soto, L.I. Canales, F.R. D´ıaz, J.C. Bernède, e-Polymers 60, 1 (2008).
- [3] R. Rella, J. Spadavecchia, G. Ciccarella, P. Siciliano, G. Vasapollo, L. Valli, (2003) Sensors Actuators B 89,2003, 86.
- [4] S.N. Alamri, A.A. Joraid, S.Y. Al-Raqa, (2006) Thin Solid Films 510, 265, 2006.

CORROLE-BASED OXYGEN OPTICAL SENSOR

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In this work we describe an appplication of corroles, synthetic, aromatic macrocycles of tetrapyrrolic family, as extremely sensitive sensors of oxygen. Corroles were synthesized for the first time in 1965 [1], but the research in these field has grown recently due to efficient methods of synthesis [2].

Majority of fluorophores feature moderate to strong photobleaching under illumination, what manifests itself as a drop in the fluorescence intensity. This process is mainly the result of dye photooxidation. While corroles are not an exception in this regard, they at the same time exhibit an effect that can be applied for oxygen sensing using optically induced process of photomodification. Namely, we find that after initial decrease of the fluorescence intensity due to classical photobleaching effect, the emission intensity of corroles under continuous illumination starts to dramatically increase, frequently overcoming its initial value. This increase is accompanied with strong modifications of the fluorescence spectrum. Importantly, this effect occurs only for corroles directly in contact with atmosphere. Surrounding the molecules with polymer coating dminishes the photomodification, although the final result depends upon particular corrole molecule.

We observe that sensitivity and response time of such a corrole-based oxygen sensor is related to the number of pentafluorophenyl groups comprising the molecule, the smaller the number, the more sensitive device can be fabricated. These results point toward novel application route of corrole molecules in optical sensors, that are highly desirable for using them in harsh environmental conditions and as non-contact, relatively cheap, sensitive devices.

A. W. Johnson et.al., J. Chem. Soc., 1620 (1965).
 B. Ventura et.al., New J. Chem., 29, 1559 (2005).

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EVALUATION OF OPTICAL NOISE EFFECT IN PD MONITORING OF HV CABLE SYSTEMS VIA EO MODULATORS

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Today Partial Discharge (PD) on-line monitoring of High Voltage (HV) Cable systems via optical systems and especially Electro-Optical (EO) Modulators is known as the most immune method against electromagnetic interferences with very little attenuation, high sensitivity, compactness and convenience to use; however not much years have been passed since the first theoretical introduction of the method and thus technical analysis are still demanded to prepare the method as practicable as the most reliable one.

In this study PD discharge monitoring of HV cable systems via EO Modulators is briefly explained as the first step; then the probable consequences of utilizing EO modulation method is investigated via computational simulation; finally as the conclusion, some points are described to enhance the facility of method practicability.

Our simulation configuration is based on utilizing a CW laser instead of a laser diode as the light source in order to increase the output beam stability with the frequency 474 THz, power of 17 mW, line width of 10 MHz; Mach Zehnder EO modulator is selected with extinction ratio of 30 dB; an optical receiver is considered with responsivity 1 A/W, dark current of 10 nA, cutoff frequency of $0.75 \times Bit$ rate and center frequency on 474 THz. Three different cases are considered which in each case a different pulse generator simulates the electrical signal detected by CC: 1- NRZ pulse generator, 3-

Noise source

As the result, the utilization of optical filter can be effective to remove the noise. Also, utilization of a proper CC to transmit appropriate PD signal in comparison with optical components noise is considered as the alternative solution.

- Y. Tian, P.L.Lewin et.al, "Partial Discharge On-line Monitoring for HV Cable Systems Using Electrooptic Modulators", IEEE Transactions on Dielectric and Electrical Insulation, Vol.11, No. 5, October 2004.
- [2] C. Macia-Sanahuja, et.al., "Fiber Optic Interferometric Sensor for Acoustic Detection of Partial Discharge", J. Opt. Technol. 74(2), February 2007.
- [3] Bing Yu, et.al., "Fiber Fabry-Perot Sensors for Detection of Partial Discharge in Power Transformers", Applied Optics, 1 June 2003, Vol. 42, No. 16
- [4] H.L SAADON, N. TH'EOFANOUS, M. AILLERIE, M.D. FONTANA, "Thermo-optic effects in electro-optic crystals used in intensity modulation system-application in LiTaO3", J. Applied Physics ,2006 B83, 609-617.
- [5] M. JAZBINSEK, M. ZGONIK, "Material tensor parameters of LiNbO3 relevant for electro and elasto-optics", J. Applied physics B, Lasers & Optics, 2002 B74, 407-414
- [6] Bahaaa E.Saleh, Malvin Carl Teich, Fundamental of Photonics, John Wiley, 1991, p.209
- [7] Kolimbris, Fiber Optics communications, Pearson Education, 2004, p346

SPARK SENSORS ON BASE OF SILICA AND OXYFLUORIDE FIBERS WITH CADMIUM CHALCOGENIDE NANOPARTICLES

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Electrical spark fiber optic sensors are based on capture of spark radiation through the fiber lateral surface and the transmission of optical signals over fiber to the photodiode. When used in a sensor ordinary glass or polymer fibers the sensitivity of such sensors is low for the following reasons. Capture efficiency of the radiation through the fiber lateral surface is extremely small. The light scattering losses in the fiber are proportional to λ^4 . Therefore, shortwave spark radiation can't pass through the fiber over long distances. The spark emission spectrum is far from the maximum of silicon photodiode sensitivity. In [1] the possibility of spark light spectral conversion at the longer wavelengths is shown by using a fiber with the coating containing an organic dye. In this study, we investigated the possibility of using in spark sensors spectral conversion of radiation in fluorescent fibers with nanocrystals of CdS, CdSe, CdSSe. Luminescent properties of oxyfluoride and silica glasses and multimode fibers with a crystalline phase of various sizes and concentrations were studied. The luminescence excitation was carried out by radiation with $\lambda = 365$, 405, 475 and 532 nm.



Fig. The spectral sensitivity of silicon photodiodes (1); the luminescence spectrum of fibers with nanocrystals of CdS (2) and CdSSe (3). $\lambda_{ex} = 405$ nm.

Studies have shown that fibers with nanocrystals of CdS, CdSe, CdSSe can efficiently convert radiation from the spectral range 365-530 nm at the region of 600-900 nm (Fig.). The using of a cylindrical lens reduces the sensor spatial sensitivity pattern down to 15 deg.

[1] D.S. Agafonova, A.I. Sidorov, J. Opt. Technol. 78 (2011) 735-738.

VISIBLE UP CONVERSION IN Ho³⁺ DOPED Y₄Al₂O₉ NANOPHOSPHORS SENSITIZED BY Yb³⁺ IONS AS TEMPARTURE SENSOR

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Rare earth doped materials have been widely investigated in terms of temperature dependence of their fluorescence [1]. The up-converted emissions are preferable in the area of FIR (Fluorescence Intensity Ratio) method, as they are well separated from the excitation wavelength.

In this work, we report the infra-red (980 nm) to visible up-conversion in trivalent holmium (Ho³⁺) activated Y₄Al₂O₉ (abbreviated YAM) nanocrystals sensitized by Yb³⁺ ions. The spectroscopic properties together with up-conversion process in Ho³⁺ doped materials from Y_2O_3 -Al₂O₃ system have been already studied in [2] and [3]. The presence of Yb³⁺ ions enhances significantly the ⁵S₂ visible emission. There were three up-converted emissions considered: ⁵S₂ \rightarrow ⁵I₈ at about 540 nm, ⁵F₅ \rightarrow ⁵I₈ at 650 nm and ${}^{5}F_{3,2,1} \rightarrow {}^{5}I_{8}$ at 460 nm. Other emissions starting from ${}^{5}S_{2}$ level could not be used, as they lie in NIR region dominated by blackbody radiation at these temperatures. According to predictions, none of these emissions followed strictly the Boltzmann distribution where upper level population is related to the lower one by expression $exp(-\Delta E/kT)$. This is because holmium ion has highly developed energy level structure and many energy transfer processes can appear. Only for mid temperatures range (300-600 K) the intensity ratio of 460 and 540 nm emission lines changes exponentially as follows: $R = 0.78 \times exp(-2386.9/T)$, where R is the intensity ratio and T is the temperature expressed in Kelvins. Such dependence gives low sensor sensitivity. However, other temperature dependencies have to be investigated, as they can turn out to be useful in temperature measurements. For example, intensity ratio of 650 to 460 nm lines specifies with linear dependence on temperature. Although this is only empirical expression, it seems to be great possibility for temperature sensor, as linear dependency gives constant sensor sensitivity what is always desirable. Another example is the intensity ratio of 540 to 650 nm lines, which is decreasing with growing temperature. This could be a result of cross-relaxation process quenching the emission of ${}^{5}S_{2}$ level as the energy delivered to system with temperature can compensate energy mismatches in many possible cross-relaxation channels.

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- [1] S.A. Allison, G.T. Gillies, Rev. Sci. Instrum. 68 (1997) 2615-2650.
- M Malinowski, R Piramidowicz, Z Frukacz, G Chadeyron, R Mahiou, M.F Joubert, Opt. Mater. 12 (1999) 409-423.
- [3] A. Wnuk, M. Kaczkan, Z. Frukacz, I. Pracka, G. Chadeyron, M.-F. Joubert, M. Malinowski, J. Alloy. Compd. 341 (2002) 353-357.

APPLICATION OF DMA FOR SIMULTANEOUS MECHANICAL AND OPTICAL INVESTIGATIONS OF PLASTIC OPTICAL FIBERS

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Dynamic Mechanical Analysis (DMA) is one of the most powerful tools to study the behavior of plastic and polymer composite materials and is potentially very useful to simulate behavior of plastic optical fibers (POF) in real applications. In this work, single and dual cantilever dynamic temperature scan DMA tests of POF done simultaneously with measuring of the transmitted optical signal intensity are described. The dynamic temperature scan test were performed from 40-130 °C, at temperature ramping rate of 3 °C/min, mechanical oscillation frequency of 1 Hz and amplitude of 30 µm for single and 20 um for dual cantilever mode. The investigated POF (ESKATM K-40 was threaded through the movable and stationary fixtures and enclosed in the DMA thermal chamber. The ends of a POF were carefully brought out from DMA chamber through a hole on its top. Those two POF ends were connected to the light source (LED, wavelength 840 nm) and to the photodetector (PD). Used DMA instrument was TA Instruments Q800. During tests the change of storage modulus (E'), loss modulus (E'') and $\tan \delta$ of the POF material were determined simultaneously with intensity of transmitted optical signal. In order to differentiate influence of temperature from mechanical influences, optical signal intensity versus temperature of POF heated in the temperature controlled chamber was measured too. Some of the measurement results are presented in Fig. 1.



Fig.1. a) Normalized optical signal intensity for heated, single and dual DMA tested POF, b) Storage modulus and normalized optical signal changes during dual cantilever DMA test

Different kinds of applied mechanical stress, together with increasing temperature, change the optical signal intensity in POF each in characteristic way. The maximum in optical signal intensity is connected with the beginning of phase transition process in the core material for both DMA modes. In the dual cantilever mode the starting increase of optical signal is connected with the phase transition in the cladding material. A simultaneous measurement of optical properties and DMA testing simulates real processes in POF. That helps prediction of change in its optical properties and on other hand enables development of optical methods for the detection of changes in mechanical and structural properties of materials used for POF.

FUNCTIONAL SILICA OPTICAL FIBERS WITH SILVER MOLECULAR CLUSTERS AND NANOCRYSTALS

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Functional optical fibers that allow performing certain operations with optical signals are of interest in telecommunication and sensor applications. Ag nanocrystals have plasmon resonance, pronounced nonlinear properties and also significantly change the refractive index of glass, which makes glasses containing Ag nanoparticles a promising material for functional fiber fabrication.

The work was dedicated to studying multimode silica fibers with Ag molecular clusters and nanocrystals in entire volume, in the core, in the cladding, and also long-period fiber gratings (LPG). In the first case the Ag ions were doped into glass during the glass synthesis. In the second case, ion exchange (Na-Ag) was performed in a fiber containing Ag ions. In the third case the Ag ions were doped into the cladding by the means of thermal diffusion or ion exchange [1]. Ag nanocrystals formation was performed using photo-thermo-induced crystallization [2]. LPGs were recorded by UV radiation passing through an amplitude mask with a period of 300 microns.

The research has shown that broadband luminescence in the spectral interval of 500-650 nm occurs after UV irradiation of the fibers, which denotes neutral silver molecular clusters Ag_n formation. After 1-3 hours of thermal treatment (t = 500 $^{\rm O}$ C) an intensive plasmon band in the 400-430 nm spectral range appears on the fiber absorption spectrum, which indicates the formation of 5-10 nm diameter Ag nanocrystals.

It has been found that neutral silver molecular cluster and silver nanocrystals formation causes the fiber refractive index change. In case of LPGs this leads to resonance transmission bands emergence in the spectral range of 1-1.8 microns.

[1] A. Tervonen, B. R. West, S. Honkanen, Optical Engineering 50 (2011) 71-107.

^[2] Silver nanoparticles, ed. by D.P. Perez., In-Tech, Vukovar, 2010

APPLICABILITY OF RE-DOPED TiO₂ POWDER AS OPTICAL OXYGEN SENSOR AT ROOM TEMPERATURE

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The main driver for on-going research in the field of oxygen sensing is the lack of good room temperature sensor materials capable of comparable performance of high temperature (>700 $^{\circ}$ C) zirconia based sensors.

Current work aims to investigate the applicability of a highly porous TiO_2 powders doped with RE ions as RT oxygen sensors based on luminescence signal intensity monitoring. The PL output of the dopants (Sm and Eu) is found to be modulated via the ambient oxygen gas partial pressure, optical excitation intensity and residual water vapour on powder grains. The PL decay the RE ions reveals differentiation between emitting ion ensembles depending on oxygen presence.

The mechanism of oxygen sensitivity is attributed to the well know phenomenon of oxygen absorption to TiO_2 surface and subsequent capture of electron from the bulk, forming a Schottky barrier near nanocrystallite surface[1]. The former is believed to act as efficient hole trap region promoting near-surface recombination of holes and captured electrons.



Figure 1: Dependence of Sm^{3+} photoluminescence intensity on partial pressure of ambient oxygen gas in Sm-doped TiO₂ nano-cystalline powder.

[1] G. Lu, A. Linsebigler and J. T. Yates, J. Chem. Phys. 102 (1995), 4657.

FIBRE-GRATING SENSORS FOR THE MEASUREMENT OF PHYSIOLOGICAL PULSATIONS

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Mechanical physiological pulsations are movements of a body surface incited by the movements of muscles in the organs inside the body. These pulsations are usually determined by a counting device or manually (e.g. heart pulsation) and are not analysed as a signal. Since the pulsation time signals can contain information useful for diagnostics of the heart, muscle and respiratory functions, more advanced tools for their monitoring are needed [1]. Here we demonstrate the use of fibre-grating sensors in detection of the cardio-vascular pulsations (CVP).

The investigated sensors are based on long period fibre gratings (LPGs). An LPG is a perturbation of the refractive index of a fibre with a period of several tens or hundreds of micrometers. It couples light from the core to the cladding modes that are subsequently attenuated and hence appear as dips in the grating transmission spectrum. The position and amplitude of the dips are sensitive to the mechanical forces applied to the fibre, which is used to make strain, pressure and curvature sensors [2].

Here we study the grating response to small movements transversal to the fibre and comparable to typical CVPs. To calibrate the sensors, we use an independent calibration tool designed specifically to measure the grating response to a localized perturbation at different grating curvatures as working points. From the data we infer the amplitude of the CVP.

Together with the electrophysiological signals, the CVP signals obtained from the sensors can provide significant information on heart function which is inaccessible to the electrocardiogram. The low cost and easy handling of the fibre sensors increase their prospects to become the sensors of choice for novel diagnostic devices.

- [1] J. Allen, Physiol. Meas. 28 (2007) R1–R39.
- [2] S. W. James, R. P. Tatam, Meas. Sci. Technol. 14 (2003) R49-R61.

FEATURES OF OPTICAL ANISOTROPY OF EUROPIUM AND TERBIUM IRON GARNETS

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The results of investigation of magnetic linear birefringence (MLB) and magnetic linear dichroism of Tb₃Fe₅O₁₂ (TbIG) iron garnet on ${}^{7}F_{6} - {}^{7}F_{0}$ and ${}^{7}F_{6} - {}^{7}F_{1}$ optical transitions and Eu₃Fe₅O₁₂ (EuIG) iron garnet on ${}^{7}F_{0} - {}^{7}F_{6}$ upon variation of the directions of the magnetization vector I relative to the electric vector E linearly polarized light that propagates through single crystal iron garnets are presented. The measurements were made on Tb₃Fe₅O₁₂ and Eu₃Fe₅O₁₂ single-crystal samples in the form of plates 100 μ m thick cut in the (110) and (100) plane at the temperatures T = 82 and in a magnetic field H= 20 kOe. The absorption spectra of the linearly polarized light were studied. It is shown that MLB and dichroism in the region of the ${}^{7}F_{6} - {}^{7}F_{0}$ absorption band reach values 10^{-4} . First experimentally discovered nonreciprocity of MLB spectra and dichroism with the change of the relative orientation of the magnetization vector I and the light wave vector. This effect may use as a base for the design of the different transducers, for example, magnetooptical optical channels commutator.

THE POSSIBILITY OF USING A PLASTIC OPTICAL FIBRE AS SENSING ELEMENT IN CIVIL STRUCTURAL HEALTH MONITORING

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Today, the need for low-cost sensors, suitable for installation into civil structures for long-term monitoring over time, increases rapidly. Demands of the civil market are becoming the more rigorous in terms of resolution, accuracy and resistance to many external influences and corrosion. Fibre-optic sensors [1] possess characteristics that may provide some capabilities required by modern construction applications. In this paper a low-cost fibre-optic sensor primarily intended for application in civil structural health monitoring is presented. Proposed sensor is based on a plastic optical fibre as a sensing element. Sensing optical fibre is optimized for measuring small curvature displacements [3-5]. Behavior of the sensor is firstly measured on flexible structures in order to achieve characteristic of the sensor. The characterized sensor is mounted on a fragile material construction in order to investigate the potential of implemented sensor for crack detection.

- [1] E. Udd, W. B. Spillman Jr., Fiber Optic Sensors: An Introduction for Engineers and Scientists, 2nd ed., John Wiley & Sons, Inc, 2011.
- [2] O. Ziemann, J. Krauser, P. E. Zamzow and W. Daum, POF Handbook: Optical Short Range Transmission Systems, 2nd ed., Springer, 2008.
- [3] A. Djordjevich, M. Boskovic, Sensor. Actuat. A- Phys., 51(1996) 193-198.
- [4] M. S. Kovacevic, A. Djordjevich, D. Nikezic, Ieee Sens. J., 8(2008), 227-232.
- [5] H. Di, Y. Fu, Opt. Laser Technol., 43(2011) 586-591.

OPTICAL MEASUREMENT OF NANO-VIBRATIONS

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Possible optical setups for measurement of the peak-to-peak value of an ultrasonic transducer are described in this work. The Michelson interferometer with the calibrated nanopositioner in reference path and laser Doppler vibrometer were used for the basic measurement of vibration displacement. Langevin type of ultrasonic transducer is used for the purposes of Electro-Ultrasonic Nonlinear Spectroscopy (EUNS) and for this purposes the parameters of produced mechanical vibration have to been well known. The ultrasonic transducer has mechanical vibration about 200nm on resonant frequency. Resonant frequency of our actuators is near 30 kHz. Moreover monitoring of mechanical vibration frequency shift with mass load and sample-transducer coupling is important for EUNS measurement. It was used Michelson homodyne type vibrometer and Laser Doppler vibrometer for the experimental measurement. It was experimentally verified that sample influence on the resonant frequency of transducer is negligible. Experimental results show that except mechanical vibration at resonant frequency there is several parasitic vibration frequencies. Thus monitoring and accurate measurement of a mechanical vibration is important for EUNS results interpretation.

ABSOLUTE FLUORESCENCE QUANTUM YIELD OF POLY(3-HEXYLTHIOPHENE) SOLUTION BY THERMAL LENS SPECTROMETRY

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Thermal Lens Spectrometry (TLS) [1,2], as well as all photothermal methods, relies in the measurement of the fraction of absorbed energy converted in heat (ϕ), which in turn is proportional to luminescence quantum efficiency (η) - the ratio of the number of photons emitted to the number of photons absorbed. The Thermal Lens Spectroscopy has been widely used to measure accurately the η of solids and liquids [3,4], by means of two methods: Reference Sample, and Multiwavelength. In the first way, some thermal-optical properties of the sample must be known, or else, an undoped sample (or the solvent of the solution), in which the fluorescence is neglectible, has to be used as a reference, which gives the name to the method. In the second routine, which can be used when η is constant with excitation wavelength, those thermal-optical properties are directly obtained together with η . In this study, we have used TLS to measure η of Poly(3-hexylthiophene) suspended in chloroform in function of concentration and excitation wavelength. $\eta = 0.39 \pm 0.04$ was found to be constant in the range of measured concentrations (from 10-4 to 0.6 mg/mL), and not dependent on excitation in the UV-VIS region (335 – 500 nm). Photodegradation effect also has been analyzed. Although, for the aged sample, emission depends on excitation wavelength, we found η approximately constant with excitation in the UV-VIS range.

- [1] S. Jun, R. D. Lowe, R. D. Snook, Chem. Phys. 165 (1992) 385-396.
- [2] A. Marcano, et al., J. Opt. Soc. Am. B Opt. Phys. 23 (2006) 1408-1413.
- [3] M. L. Baesso, et al., Phys. Rev. B 57 (1998) 10545-10549.
- [4] S. M. Lima, et al., Appl. Phys. Lett. 78 (2001) 3220-3222.

THERMAL SHIFTS AND BROADENING OF RYDBERG LEVELS IN Bell IONS

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Long-living Rydberg states in neutral atoms and ions attract much attention in modern researches on quantum information processing [1] and high-precision measurement of blackbody radiation (BBR) characteristics in atomic clocks [2]. Thermally induced shifts of Rydberg-state energy levels at room temperature reach several kHz and may be measured with a precision of mHz by means of frequency combs [3]. Therefore, transitions to Rydberg states may serve as a BBR thermometer. Be⁺ ions are considered as rather suitable objects both in metrological and quantum processing regards. In this communication we report on theoretical calculations of natural widths and BBR-induced shifts and widths of Rydberg states in these ions.

The natural (spontaneous) width G_{nl}^{sp} of a Rydberg state $|nl\rangle$, determined by the total rate of spontaneous decays into all lower states, is reciprocal to the natural lifetime $t_{nl} = 1/G_{nl}^{sp}$, which has a general dependence on the principal quantum number n,

$$t_{nl} = t_l^0 n^3 C_l(n), \qquad (1$$

where t_l^0 is an asymptotic constant, $C_l(n)$ is a smooth function in a wide region of its argument, which tends to unity for n? 1 and may be presented in terms of a cubic polynomial of n^{-1} : $C_l(n) = 1 + t_1/n + t_2/n^2 + t_3/n^3$. Numerical values of coefficients t_1, t_2, t_3 in this polynomial and the factor t_l^0 where determined from the curve fitting polynomial interpolation procedure for *nS*-, *nP*- and *nD*-state (*l*=0, *l*, 2) spontaneous decay rate data calculated in the framework of the Fues model potential [4]. The fractional departure of approximation (1) with so determined constants is below 1% in the region of 7 < n < 1000.

A similar procedure was used for determining polynomials in the double interpolation procedure for the fractional rates $R_{nl}^{d(e,ion)}(T) = \mathbf{G}_{nl}^{d(e,ion)}(T)/\mathbf{G}_{nl}^{sp}$ of the BBR-induced decay (excitation, ionization) [5]. The departure of approximate results from the calculated data is below 3% in the region of 10 < n < 1000.

The thermal shifts, calculated for nS-, nP- and nD-states with principal quantum number n up to 200, demonstrate some specific behavior for small n, tending to usual asymptotic values for high n [6].

- X. L. Zhang, A. T. Gill, L. Isenhower, T. G. Walker and M. Saffman, Phys. Rev. A. 85 (2012) 042310
- [2] V. D. Ovsiannikov, A. Derevianko and K. Gibble, Phys. Rev. Lett. 107 (2011) 093003
- [3] R. Holzwarth, Th. Udem, T.W. Hänsch, J.C. Knight, W.J. Wadsworth, P. St. J. Russel Phys. Rev. Lett. 85 (2012) 2264 – 2267
- [4] N.L. Manakov, V.D. Ovsiannikov, L.P. Rapoport, Physics Reports 141 (1986) 319 433
- [5] V.D. Ovsiannikov, I.L. Glukhov, E.A. Nekipelov, J Phys B: At. Mol. Opt. Phys. 44 (2011) 195010
- [6] J W Farley and W H Wing Phys. Rev. A 23 (1981) 2397

TIME-RESOLVED DETECTION OF LIGHT INDUCED HEATING OF BIO-MOLECULAR SOLUTION

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After photoexcitation to the electronic excited states of any molecules in condensed phases, the photon energy should be converted to the translational energy of the solvent (heating). The heating time is related with the speed of the relaxation process. Using a femtosecond pulsed laser, heat induced structural change in ultrafast time scale can be obtained. There are several techniques to detect such photo-induced heating process, such as the transient lens, transient grating and photoacoustic methods. Here, we mainly used the transinet grating (TG) and transient lens (TrL) method for the detection in time-domain. Because these methods are sensitive to the refractive index change around the photoexcited region, the time dependence of the density, pressure, and temperature changes, which accompany refractive index change, can be monitored over a broad range of timescales. By fitting the signal with that simulated based on thermal diffusion, the temporal evolutions of the temperature distribution and molecular volume changes were determined.

We applied this technique to a time-resolved detection of enthalpy change of biomolecules in solution. For example, we studied the reaction intermediate species of phototropin (phot) on the basis of their thermodynamic properties, such as changes in enthalpy, thermal expansion, and heat capacity. Phototropins are blue light sensor proteins that regulate phototropism, chloroplast relocation, and stomatal opening. Phot is a blue light sensign protein in plants and it contains LOV domains and a linker region. For the first intermediate of the reaction, the values of these properties were similar to those of the ground state for both LOV2 and LOV2-linker. A relatively large thermal expansion volume (0.09 cm³mol⁻¹K⁻¹) and a positive heat capacity change (4.7 kJ mol⁻¹K⁻¹) were detected for the intermediates. These characteristic features were interpreted in terms of structural fluctuation and exposure of hydrophobic residues in the linker domain, respectively. The enthalpy change of the intermediate was significantly greater. The results demonstrate clear picture of photo-reactions of the protein.

 Studies of photo-induced protein reactions by spectrally silent reaction dynamics detection methods: Applications to the photoreaction of the LOV2 domain of Phototropin from Arabidopsis Thaliana, M. Terazima, Biochim.Biophys.Acta, 1814,1093–1105(2011).

NEURAL COMPUTATION AND GENETIC OPTIMIZATION APPLICATION IN PULSED PHOTOACOUSTICS

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In this paper application of neural computation and genetic optimization in pulsed photoacoustics is discussed.

Artificial intelligence is applied for simultaneous determination of the laser beam spatial profile and vibrational-to-translational relaxation time of the polyatomic molecules in gases [1][2]. Specifically, feed forward multilayer perception networks and real-coded genetic algorithms [3][4] have been used.

To achieve high precision real time estimation of laser beam spatial profile and vibrational-to-translational relaxation time from photoacoustic signals, neural networks are trained with suitable theoretical and experimental data [5]. Genetic optimization has been used for the same problem of simultaneous determination of the laser beam spatial profile and relaxation time by fitting the perceived photoacoustic signal with the theoretical one [6].

Observed benefits from application of artificial intelligence techniques in pulsed photoacoustics and advantages over previously developed methods are discussed, such as real-time operation, high precision, possibility to find solution in wide solution space, simplicity and others.

Also, applicability for practical applications, such as the real-time in-situ measurements of atmospheric pollutants, along with possible further developments of obtained results are argued as well.

- [1] M.D. Rabasovic, D.D. Markushev, Measurement Science & Technology 21 (2010), 065603.
- [2] M. D. Rabasovic, J. Nikolic and D. D. Markushev, Appl. Phys. B, 88, 309 (2007).
- [3] G. Dreyfus, Neural networks: methodology and applications, Birkhäuser-Springer, 2005.
- [4] D. E. Goldberg, Genetic algorithms in search, optimization and machine learning, Addison-Wesley, Inc., Reston, USA, 1989.
- [5] Ž. Ćojbašić, V. Nikolić, I. Ćirić, Lj. Ćojbašić, Thermal Science 15(2) (2011), 321.
- [6] M. Ristanović, Ž. Ćojbašić, D. Lazić, *Control Eng Pract* 20(6), (2012), 610-617.

MICROSTRUCTURAL CHANGES ARISEN BY PICOSECOND LASER SHOCK PEENING OF NIMONIC 263 SHEET

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Nickel based superalloy Nimonic 263 samples were exposed to picosecond laser shock peening process. The samples were submerged into the transparent liquid and the absorbent material was applied onto the surface. The material was treated at 170 ps pulse duration and wavelength of 1064 and 532 nm, while pulse energy and exposition time varied. The microstructures arisen by different process parameters were analyzed and discussed. Spots obtained by the laser interaction with material are observed by optical and scanning electron microscope and analyzed by energy-dispersive spectroscopy. Vickers microhardness tests are performed. Surface morphology changes of the irradiated samples are determined and surface roughness is calculated. The investigations are intended to contribute to the study on the level of microstructure and mechanical properties improvements due to laser shock peening process.

THE EFFECT OF LASER PULSE DURATION ON INTERMIXING IN AI/Ti MULTILAYERS

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Laser processing represents a very powerful technique for materials modification due to high processing temperatures and short heating and cooling cycles. Titaniumaluminides, especially γ -AlTi, are promising materials for high temperature applications. In this study, a different number of (Al/Ti) bilayers (5 with a total thinckness of ~ 130 nm and 10 with a total thinckness of ~ 260 nm) were deposited by d.c. ion sputtering onto Si (100) wafers. Laser irradiations of these samples with picoand nano-seconds pulses were performed in air. In nanoseconds regime, the samples were irradiated by laser beam with energy of 0,188 J (fluence ~ 0,470 J/cm²) per pulse, wavelength 1064 nm, and pulse duration was 6 ns. In picoseconds regime, the samples were irradiated with energy of 0,085 J per pulse (fluence ~ 0,45 J/cm²), wavelength 1064 nm and pulse duration was 150 ps. Compositional and structure analyses were done by X-ray diffraction (XRD), atomic force microscopy (AFM), Auger electron spectroscopy (AES) and transmission electron microscopy (TEM).

The energies used in this study were less than ablation threshold fluence, so removal of the material caused by laser irradiation was not observed. For both pulse duration regimes a thin oxide layer was formed on the sample surface. The results show that γ -AlTi and AlTi₃ intermetallic phases were formed for both pulse duration regimes. In case of five bilayers, irradiated with a picosecond-pulsed laser, almost all layers are intermixed, while in ten bilayer structures some layers close to the substrate remain unmixed. In nanoseconds regime, all deposited layers are intermixed mutually and with the Si substrate, which yielded the formation of intermetallic as well as silicide compounds. The results of evaluation indicate that the influence of the heat affected zone (HAZ) is responsible for the amount of intermixed material.

- [1] Dieter Bäuerle, Laser Processing and Chemistry, third ed., Springer-Verlag Berlin Heidelberg, 2000.
- [2] Peter Schaaf, Laser Processing of Materials: Fundametals, Applications and Developments, Springer-Verlag Berlin Heidelberg, 2010.
- [3] D. Peruško, S. Petrović, J. Kovač, Z. Stojanović, M. Panjan, M. Obradović, M. Milosavljević, Laser induced formation of intermetallics and riples in multilayered Al/Ti nano-structures, Journal of materials science, Vol. 47, No. 10, February 2012,

OPTICAL PROPERTIES OF PHOTONIC CRYSTALS: UNCOUPLED PHOTONIC BAND GAPS

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Abstract: We theoretically investigated the symmetry properties of the modes in the two-dimensional square lattice photonic crystals in order to obtained phenomena that would enable new frontiers in the applications of the photonic crystals. For that purpose we used group theory, plane wave expansion and finite-difference time-domain theoretical methods. Particularly attention was given to search of the uncoupled *B* modes that cannot propagate through the photonic crystals because they are symmetry forbidden. The existence of the uncoupled modes in this structure enabled to define new physics phenomena: uncoupled photonic band gaps. For the frequency ranges inside the uncoupled photonic band gaps in the photonic crystals could at least improve application of the existed photonic materials and structures or enable usage of the new ones for the applications in photonic devices.

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- [1] K. Sakoda, Optical Properties of Photonic Crystals, second ed., Springer-Verlag, Berlin, 2005.
- [2] W. M. Robertson, G. Arjavalingam, R. D. Meade, K. D. Brommer, A. M. Rappe, and J. D. Joannopoulos, Phys. Rev. Lett. 68 (1992) 2023-2026.
- [3] K. Sakoda, Phys. Rev. B 52 (1995) 7982-7986.
- [4] T. F. Krauss, R. M. De La Rue, and S. Brand, Nature 383 (1996) 699-702.
- [5] K. Busch, G. von Freymann, S. Linden, S. F. Mingaleev, L. Tkeshelashvili, and M. Wegener, Physics Reports 444 (2007) 101-202.
- [6] Dj. Jovanović, B. Nikolić, T. Radić, D. M. Djokić, and R. Gajić, (to be published).

COMPLEX BEHAVIOR OF VCSELs WITH OPTICAL INJECTION

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Semiconductor lasers which are small and integrable, cheap to produce, electrically pumped and easy to modulate, have high efficiencies, but also show a number of properties generally seen as drawbacks. Due to a combination of intrinsic, material related, properties leading to relaxation oscillations and self-phase modulation, these lasers are very sensitive to external perturbations. Among these, optical injection and external optical feedback are the most notable, as they may lead to destabilization of the laser's output. It is now well established that such instabilities are manifestations of highly complex structures of nonlinear dynamics and bifurcations [1-4].

Considering the full set of Maxwell-Bloch equations valid for VCSELs (vertical-cavity surface-emitting lasers) with optical injection, the field and population dynamics are investigated numerically. Previously it was shown that these systems are capable of satisfying the necessary conditions for establishment of transverse localized structures and cavity solitons [5]. Using the same parameters, the dynamics of the system is analyzed from the perspective of nonlinear dynamics. In particular, this model which includes polarization variable shows complex behavior in region where existence of CSs are expected. These behaviors are different in the vicinity of Hopf and saddle-node bifurcations compared with that of stable stationary points. This is also studied in points where CSs can be excited. We show that the response of the system to small perturbations is qualitatively different in the above mentioned regions.

From the dynamical systems point of view, relaxation oscillations of the semiconductor laser are altered because of the injection locking occurring due to optical injection. This injection locking, which occurs via Hopf bifurcation when stable periodic orbit (sustained relaxation oscillations) shrinks onto unstable stationary point making it stable, is the origin of enhanced relaxation oscillations in terms of its frequency. This issue is fully covered in this work and it is shown that the pump current is the relevant bifurcation parameter.

- [2] S. Wieczorek, B. Krauskopf, D. Lenstra, Opt. Commun. 172 (1999) 279.
- [3] B. Krauskopf, AIP Conf. Proc. 548 (2000) 1.
- [4] K. Panajotov, M. Sciamanna, I. Gatare, M. Arteaga, H.T hienpont, Adv. in Opt. Tech. 469627 (2011).
- [5] X. Hachair and et al: IEEE J. Sel. Top. Quant. Electron. 12 (2006) 339.

S.H. Strogatz, Nonlinear Dynamics and Chaos, Addison-Wesley Publishing Company, Reading, MA, 1996.

INVESTIGATION OF BISTABILITY AND ITS STABILITY IN COUPLED CAVITIES ARRAY WITH SATURABLE NONLINEARITY

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Since the optical bistability and domain in which system shows two homogeneous solutions are important in existence of soliton, so in this paper optical bistability in array of coupled cavities in medium with saturable nonlinearity has been investigated. Also, the linear stability analyses of homogeneous solutions of the system have been studied in two systems (conservative and lossy case). It has been shown that inclination of the holding beam can change the modulation instability range.

Electromagnetic field is a continuous function of both space and time, but with approximation we can expand the field to discrete modes. For achieving such light discretization, coupled waveguide arrays can be used practically [1]. The light propagation in linear arrays was first observed by Yariv's group in GaAs waveguide arrays [2], and was first theoretically studied by Johns [3].the process of optical formation in such systems is a balance between nonlinearity and discrete diffraction effects.

We consider an array of coupled optical cavities with saturable nonlinearity governed by the equation [4]:

$$i\partial_t A_n + \delta A_n + \frac{\alpha |A_n|^2}{1 + |A_n|^2} A_n + c(A_{n+1} + A_{n-1} - 2A_n) = P \exp(iQn)$$
(1)

Homogeneous PW solution in the form of $A_n(t) = A \exp(iQn)$ satisfies:

$$\left(\delta + \frac{\alpha \left|A\right|^2}{1 + \left|A\right|^2}\right)A = p \tag{2}$$

Instability domains of PW in (|A|-q) parameters space have been shown in fig.2 (a) for different values of Q where interior domain is unstable

Also, we repeat the same steps for system with linear loss by taking the imaginary part of δ parameter nonzero.

- [1] Lederer F, Stegeman G I, Christodoulides D N, Assanto G, Segev M, Silberberg Y 2008 "Discrete solitons in optics," Physics Reports 463, 1–126,.
- [2] Somekh S, Garmire E, Yariv A, Garvin H L, and Hunsperger R G 1973 "Channel Optical Waveguides and Directional Couplers in GaAs—Imbedded and Ridged," Appl. Phy. Lett. 22, 46.
- [3] Jones A L 1965,"Coupling of Optical Fibers and Scattering in Fibers," J. Opt. Soc. Am. 55, 261 .
- [4] Yulin A V and Champneys A R 2010, "Discrete snaking : multiple cavity solitons in saturable media,".

THE FIRST-PRINCIPLES STUDY OF ANTI-SITE BI DEFECT IN THE Bi₁₂TiO₂₀ SILLENITE CRYSTAL

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A family of sillenite crystals $Bi_{12}MO_{20}$ (M = Ti, Ge, Si) attracts significant attention mostly because of pronounced photorefractive property of its members that is used in many applications [1]. Among the sillenites the most attention is paid to the $Bi_{12}TiO_{20}$ (BTO) since it exhibits advantages for holographic recording owing to relatively low optical activity in the visible range that prevents undesirable interference of light diffracted from holographic pattern [2]. Optical recording requires a presence of photoactive centers, usually defects or impurities, which provide localized energy levels within the band gap and change electric and optical properties of the compound. In the case of the BTO these centers originate from the intrinsic defects, but the exact type of the latter is still not definitely identified in spite of considerable experimental effort [3].

In this work we present a theoretical study of anti-site intrinsic Bi_{Ti} defect in the BTO which is formed by wrong occupation of the Ti^{4+} sites by the Bi^{3+} ions. As a tool we used the first-principles Full Potential Linear Augmented Plane Wave method, based on density functional theory and implemented in the Wien2k computer code. We discussed the structural, energetic, electronic and optical properties of the Bi_{Ti} defect in its three possible charge states: neutral, negative and positive.

It is demonstrated that within the neutral defect the Bi $6s^2$ lone pair is broken (contrary to the existing opinions) making the valence state of the Bi 4+. Addition of one electron to the defect populates the Bi 6s orbital (Bi³⁺), while the removal of one electron empties this orbital (Bi⁵⁺). All three types of defects produce bands within the fundamental gap of the BTO, with different occupation and energy. They produce additional peaks and shoulders in optical absorption spectrum, which is analyzed, compared to the spectrum of the pure BTO [4,5] and interpreted in terms of calculated electronic structure. Results of the present study clearly demonstrate that the neutral Bi_{Tī} defect acts simultaneously as a donor and an acceptor and that could be responsible for photorefractive effect in the BTO and its ability to be used for holographic recording.

- [1] E. A. Barbosa, R. Verzini, and J. F. Carvalho , Opt. Commun. 263 (2006) 189.
- [2] A. T. Efremidis et al, Appl. Phys. B 95 (2009) 467.
- [3] J. Frejlich et al, J. Appl. Phys. 101 (2007) 043101.
- [4] A. F. Lima and M. V. Lalic, Comput. Mater. Sci. 49 (2010) 321.
- [5] A. F. Lima, S. A. S. Farias and M. V. Lalic, J. Appl. Phys. 110 (2011) 083705.

AN AB INITIO STUDY OF ELECTRONIC STRUCTURE AND OPTICAL PROPERTIES OF MULTIFERROIC PEROVSKITES PbVO₃ AND BiC₀O₃

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Within density functional theory with the generalized gradient approximation (GGA), GGA plus on-site Coulomb repulsion method, and improved version of exchange potential suggested recently by F. Tran and P. Blaha, Phys. Rev. Lett. 102 (2009) 226401 (TB-mBJ), we investigate the electronic structure and optical properties of noncentrosymmetric multiferroic perovskites PbVO₃ and BiCoO₃. These two compounds, although similar in lattice distortions and population of crystal-field levels, behave quite differently because of the different interplay between the fundamental Kramers degeneracy and the single-ion anisotropy in them. The main characteristic of the calculated TB-mBJ electronic structures is significant rearrangement of the V and Co 3d states near their valence bands tops as compared to earlier GGA and GGA+Ucalculations of these compounds. This fact causes the different optical responses of the title compounds as well, which are analyzed and interpreted in terms of the calculated electronic structures. A comparison of the calculated properties with available experimental data indicates that the TB-mBJ approach provides a better description of the electronic and optical properties of $PbVO_3$ and $BiCoO_3$ compounds than the standard GGA and GGA+U approaches.

ALL OPTICAL TUNABLE BEAM SPLITTER BASED ON PHOTONIC CRYSTAL WAVEGUIDES

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The beam splitter is a fundamental element for many optical communication systems. By means of a beam splitter, signals from separate sources can be combined, or the received power can be divided between two or more channels. Beam splitters can be used as multiplexers (gathering different wavelengths together) and de-multiplexers (separating different wavelengths from each other) in WDM (wavelength division multiplexing) systems. Several types of beam splitters has been proposed before [1-3] Photonic crystal (PhC) offers a new structure to construct devices with dimensions of a few wavelengths of light for future photonic integrated circuits, and it makes us the ability to engineer the electromagnetic fields in microscopic detail. It is common to use heterostructure photonic crystal lattice to increase the coupling efficiency between waveguides in photonic crystal devices. Especially heterostructure lattices have been designed for increasing the transmission in Y-branches and bends before in [4, 5].

In this work we propose a Y-splitter in a two-dimensional photonic crystal structure which provides us the ability to control dividing power into two waveguides by another optical beam. To the best of the authors' knowledge, this is the first time of designing an all optical tunable beam splitter. In this scheme, we use the nonlinearity feature of photonic crystal to control the power ratio of the output waveguides. Using the Kerr nonlinearity property and engineering the elliptical cavity's dimensions we can manage the coupling power of the input waveguide to each of the output waveguides. In our design, in order to reach the highly perfect structure with the lowest amount of loss we used optimized heterostructure Square-Hexagonal lattice configuration introduced and studied in [4].

- [1] S. Y. Lin, E. Chow, J. Bur, S. G. Johnson, and J. D. Joannopoulos, "Low-loss, wide-angle Y splitter at 1.6-_m wavelengths built with a two-dimensional photonic crystal," *Opt. Lett.*, vol. 27, no. 16, pp. 1400–1402, 2002.
- [2] H. Takeda and K. Yoshino, "Tunable light propagation in Y-shaped waveguides in twodimensional photonic crystals utilizing liquid crystals as linear defects," *Phys. Rev. B*, vol. 67, p. 073106, 2003.
- [3] K. Inoue, Y. Sugimoto, N. Ikeda, Y. Tanaka, K. Asakawa, H. Sasaki, and K. Ishida, "Ultra-small photonic-crystal-waveguide-based Y-splitters useful in the near-infrared wavelength region," *Jpn. J. Appl. Phys.*vol. 43, no. 4A, pp. L 446–L 448, 2004.
- [4] Sharkawy, A., S. Shi, and D.W. Prather, "Heterostructure photonic crystals: theory and applications" Appl. Opt. 41, 7245-7253 (2002).
- [5] A.Ghaffari, F.Monifi, M.Djavid, and M.S.Abrishamian, "Analysis of photonic crystal power splitters with different configurations", *Journal of Applied Science* (8), pp. 1416-1425, (2008).

MODELING AND SIMULATION OF HIGHER ORDER FWM CROSSTALKS IN MULTICHANNEL DWDM OPTICAL COMMUNICATION SYSTEMS

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Transmission capacity can significantly be enhanced by using wavelength division multiplexing (WDM) networks. Taking the channel spacing in WDM networks as dense as possible leads to optimal usage of the limited optical amplifier bandwidth. In order to provide high data rates per channels as well as long spans between fiber amplifiers in an optical link, we need a relatively high optical power level. These high-power values in addition to the close channel spacing results in nonlinear crosstalk between the channels due to the nonlinear properties of the transmission fiber [1].

Four-wave mixing (FWM) is considered as one of the most destructive nonlinear effects of signals at various wavelength channels [2,3]. Because of the phase matching condition for FWM, fibers with a nonzero but relatively small amount of chromatic dispersion have been suggested [4,5]. Non-zero dispersion fibers (NZDF's) have non-zero dispersion value for the optical signal wavelength, and are considered as an appropriate candidate to be used in optical communication networks. Since the total FWM power is not easily computable, we usually disregard the higher order crosstalks, and only consider the first order power. Several techniques have been proposed to eliminate the first order power penalty in WDM networks[6,7]. Yet, in some cases the value of higher order FWM power seems more important. For example, when in a multichannel system we use unequal channel spacing method, the higher order FWM-effect plays a significant role.

In this work, we focus on deriving a theoretical model for distortion power in WDM networks with NZDSF fibers produced by higher order crosstalks for the first time. We have investigated the higher order FWM power theoretically and by numerical simulations. We derive an expression for second order power penalty by dividing the fiber into finite number of elements and applying the boundary conditions. At the end of each element we derive the first order FWM power for all wavelengths and use these values to calculate the second order FWM power in the next element. Consequently, we can compute the total second order FWM power penalty at the end of the fiber.

- A.R. Chraplyvy, Limitations on lightwave communications imposed by optical fiber nonlinearities, J. Lightwave Technol. 8 (1990) 1548–1557.
- [2] D. Marcuse, A.R. Chraplyvy, R.W. Tkach, Effect of fiber nonlinearity on long-distance transmission, J. Lightwave Technol. 9 (1991) 121–128.
- [3] R.W. Tkach, A.R. Chraplyvy, F. Forghieri, A.H. Gnauck, R.M. Derosier, Four-photon mixing and highspeed WDM systems, J. Lightwave Technol. 13 (1995) 841–849.
- [4] K. Inoue, Four-wave mixing in an optical fiber in the zero-dispersion wave-length region, J. Lightwave Technol. 10 (1992) 1553–1561.
- [5] D. Marcuse, Bit-error rate of lightwave systems at the zero-dispersion wave-length, J. Lightwave Technol. 9 (1991) 1330–1334.
- [6] M. Noshad, A. Rostami, "Optimum compensator positioning to reduce four-wave mixing in wavelength division multiplexing optical communication systems using dispersion-managed fibers", Fiber and Integrated Optics, vol. 30, Iss. 4, (2011), 252-258
- [7] M. Noshad, A. Rostami, "FWM minimization in WDM optical communication systems using the asymmetrical dispersion-managed fibers", Optik, Vol. 123, Iss. 9, (2012), 758–760

AB INITIO CALCULATIONS OF ELECTRONIC AND OPTICAL PROPERTIES OF CrF₂

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 CrF_2 crystal has been investigated during the last years [1-5] due to its interesting optical and spectroscopic properties. The local symmetry of the chromium ion was usually approximated to D_{4h} [4] or D_{2h} [5], higher than the actual triclinic C_i one [6] so, consequently, the informations about the splitting of Cr^{2+} *d* orbitals are controversial.

The aim of this study is to present the results of the *ab initio* calculations (with the use of the CRYSTAL09 computer program [7]) of the electronic and optical properties of CrF_2 , considering the real distorted geometry of the $[CrF_6]^{4-}$ octahedron. The electronic band structure and the density of states calculations (with orbital projections) allowed us to obtain and describe the $Cr^{2+} 3d$ orbital energy level diagram in CrF_2 .

The results are discussed and compared with experimental data and with other theoretical calculations.

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- [1] W.W. Holloway Jr., M. Kesgian, Spectrochim. Acta 22 (1966) 1381.
- [2] D. Oelkrug Von and Ber. Bunsengs, Phys. Chem. 70 (1966) 736.
- [3] P.E. Lim, J.W. Stout, J. Chem. Phys. 63 (1975) 4886.
- [4] Li Cui-Lian et al., Physica B 205 (1995) 335.
- [5] Xiai-Mig Tan, Xiao-Yu Kuang, Kuang-Wei Zhou, Cheng-Lu and Qin-Sheng Zhu, J. Phys. Condens. Matter 18 (2006) 1705.
- [6] K.H. Jack, R. Maitland, Proc. Chem. Chem. Soc. (1957) 232.
- [7] R. Dovesi, R. Orlando, B. Civalleri, C. Roetti, V.R. Saunders and C.M. Zicovich-Wilson, Z.Kristallogr. 220 (2005) 571-573.

MONTE CARLO SIMULATION OF OPTICAL REFLECTION FROM A THREE-DIMENSIONAL ROUGHENED MODEL

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Methods of geometrical optics have been successfully used to calculate the reflection of optical radiation from rough surfaces. In one of the basic works [1] the analytical model assumes that the surface consists of small, randomly disposed, mirror-like facets. However, multiple reflections of three-dimensional objects are not accounted by this model.

Later, a Monte Carlo modeling of optical radiation transfer from random rough surfaces was proposed [2]. For each ray this model allows generation of a random tetrahedral pit with walls that reflect according to Fresnel's law. The drawback of the model [2] is the lack of radiation transfer between neighbor pits.

To solve this problem Monte Carlo modeling of the optical reflection for threedimensional geometry with rough surface is presented.

The geometry of the object is represented in two levels of abstraction: the macroscopic and microscopic. At the macro scale the surface of the object is smooth (without roughness). Roughness is introduced only at the micro scale. The micro-scale model consists of a second-order solids (ellipsoids, cones, paraboloids, spheres, hyperboloids) on a substrate of finite size.

When a particle crosses surface at the macro scale, we turn to the micro-scale model. In every act of particle interaction with the figures of the microgeometry only specular reflection is calculated. The particle path continues until crosses the smooth surface.

The model has been verified on a problem with known solution. It was compared to previously published results: the analytical work for asymmetric V-shaped groove with ideal-specular reflection at the micro scale and Monte Carlo simulation of scattering from a conical cavity with an ideal diffuse reflection at micro scale.

The simulation was compared with experimental results for materials with a certain degree of random roughness. The optimal size of microstructure was studied in numerical simulations. This method was applied for calculating a number of practical geometries.

[1] Torrance K. E., Sparrow E. M., J. Opt. Soc. Am. 57, 1105 (1967).

[2] Hanssen, L. M. and Prokhorov, A. V., Proc. SPIE 7065, 7065W 1-12 (2008).

MODELLING OF LIGHT PROPAGATION IN BI-PERIODIC LITHIUM NIOBATE WAVEGUIDE ARRAYS

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We explore analytically and numerically light propagation in bi-periodic lossless waveguide arrays in photorefractive, photovoltaic lithium niobate crystals that exhibit a self-defocusing, saturable nonlinearity [1]. Additional periodicity is responsible for opening of a new mini-gap in which light propagation is forbidden, enabling extended nonlinear light-matter interaction and occurrence of novel types of gap solitons. There are two complementary realizations of such arrays: the first one with constant spacing between waveguides whose width alternates between two values [2, 3], and the second one in which the spacing between waveguides of constant width repeatedly changes between two values [4-6]. In this contribution, we study the latter case.

Mathematically, when the coupling between adjacent elements of the array is weak, system dynamics may be fairly well described by a set of linearly coupled differencedifferential equations with two coupling constants and two integrals of motion: power (P) and Hamiltonian (H).

We obtain approximate analytical solutions for strongly localized structures that were found in both the mini-gap and the first gap of a band-gap diagram and investigate their stability by direct numerical simulations (based on the fifth-order Runge-Kutta method) and convexity of the H(P) curves [7]. We also investigate in which way the size of the mini-gap influences the stability of gap solitons.

Extensive numerical simulations of interactions of two co-propagating beams show that, depending on the type of localized structures, their mutual phase, distance and angle, it is possible to achieve solitons' fusion, repulsion, elastic interactions, periodic beating, etc., which might be useful for better understanding and development of future all-optical routers and switches [8].

- [1] F. S. Chen, J. Appl. Phys. 40 (1969) 3389-3393.
- [2] A. A. Sukhorukov and Yu. S. Kivshar, Opt. Lett. 27 (2002) 2112-2114.
- [3] R. Morandotti, D. Mandelik, Y. Silberberg, J. S. Aitchison, M. Sorel, D. N. Christodoulides, A. A. Sukhorukov, and Yu. S. Kivshar, Opt. Lett. 29 (2004) 2890-2892.
- [4] R. A. Vicencio and M. Johansson, Phys. Rev. A 79 (2009) 065801.
- [5] A. Kanshu, C. E. Rüter, D. Kip, V. Shandarov, P. P. Beličev, I. Ilić, and M. Stepić, Opt. Lett. 37 (2012) 1253-1255.
- [6] A. Kanshu, C. E. Rüter, D, Kip, J. Cuevas, and P. G. Kevrekidis, arXiv:1202.0830 (2012).
- [7] N. Akhmediev, A. Ankiewicz, and R. Grimshaw, Phys. Rev. E 59 (1999) 6088-6096.
- [8] G. I. Stegeman and M. Segev, Science 286 (1999) 1518-1523.

THE REFLECTIVITY OF A RECTANGULAR HUBBARD PLANE

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The Hubbard model (HM) has been proposed in the middle of the last century [1], but it spite of that it has been solved only for the one dimensional case [2]. Apart from purely mathematical interest, the HM is widely regarded as a theoretical model useful in work on systems of correlated electrons, where it gives results for the electrical conductivity which are in good agreement with experiments. As the conductivity is related with the reflectivity, the reflectivity of 1D systems of correlated electrons has been recently calculated using known results for the conductivity [3].

The aim of this paper is to present a calculation of the reflectivity of a rectangular square lattice of side length a. The conductivities along the two axes are assumed to be mutually independent, and they are given by the 1D HM. Defining the conductivity of the lattice as

 $\sigma = [\sigma_x^2 + \sigma_y^2]^{1/2}$ and using the expression for the reflectivity obtained in [3], one easily gets the expression for the reflectivity of a rectangular Hubbard lattice.

The paper will present details of the calculation which leads to the expression for the reflectivity of a 2D rectangular lattice, as well as hints of some possibilities for the applications of this expression in material science.

J.Hubbard, Proc.Roy.Soc. A240, (1957) 539 –560.
 E.H.Lieb and F.Y.Wu, Physica A, 321 (2003),1-27.
 V.Čelebonović, Acta Phys.Polonica A,112 (2007), 949-952.

A MODELING APPROACH OF THE FARADAIC IMPEDANCE OF DYE-SENSITIZED SOLAR CELLS BASED TITANIUM-OXIDE-MODIFIED CARBON NANOTUBE

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Faradaic impedance is the resistance depending on the frequency related to the time constant of elementary processes as the photoexcitation electrode, electron transfer, the reaction charge transfer and distribution. Figure 1 shown the equivalent circuit of electrochemical impedance which consists of five parameters as follows: the contact resistance interface (transparent-conducting oxide resistance/ carbon nanotube: RTCO / CNT) and the capacity of this interface (CTCO / CNT), the total resistance of the substrate and the solution (Rs), the transfer resistance (Rct_1) and the capacity of the counter electrode(C_1), the charge transfer resistance (Rct₂) and the capacitor (C_2) and of photoelectrode and the impedance of distribution of I-3 against the electrode (ZW). The transmission line model (TLM) is introduced in the equivalent circuit. The equivalent lumped constant circuit cannot be used for the curve fit of the spectra when the impedance power distribution occurs within the pore of the porous electrode. The TLM is well known for presenting the electrochemical properties of the porous electrode. Some researchers have studied the current distribution in porous electrodes of CNTs (carbon nanotubes) using the equivalent circuit shown in Figure 1. Thus, we aim in this communication to present a modeling approach of the faradaic impedance of



Dye-sensitized solar cells with a titanium-oxide-modified carbon nanotube.

Fig-1

- [1] Bisquert, J., 2002. Theory of the impedance of electron diffusion and recombination in a thin layer. The Journal of Physical Chemistry B 106, 325–333.
- [2] Ferber, J., Stangl, R., Luther, J., 1998. An electrical model of the dyesensitized solar cell. Solar Energy Materials and Solar Cells 53, 29–54.

STRUCTURE AND DYNAMICS OF AN X_n-TYPE MOLECULE (n=3, 4, 6) FROM A SPONTANEOUS SYMMETRY BREAKING THEORY

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Using recently found symmetries of the electronic effective potential and the potential seen by nuclei which are valid for any isolated molecule [1], we have analyzed stable molecular configurations and vibrational modes of homonuclear 3-, 4- and 6-atomic molecules. We used symmetry-adapted expansion of the electronic effective potential with respect to nuclear coordinates around the origin, up to the second order (lowest non-trivial approximation). In this lowest non-trivial approximation, for positive coefficient in the expansion, a molecule of the type X_3 (i.e. X_4 , X_6) has stable configuration of equilateral triangle (i.e. regular tetrahedron, regular octahedron). Within this approximation we derived approximate formulae that relate each vibrational frequency of the molecule with the equilibrium nearest neighbor distance in this molecule, the mass and the charge of the nucleus X. Although derived within lowest non-trivial approximation, the formulae gave correct order of magnitude for vibrational frequencies and reasonable agreement with experiment for their ratio. This might be of use in interpretation of optical spectroscopy experiments done, for example, on H_3^+ , P_4 , As_4 or Al_6 molecules.

[1] V. Damljanović, arXiv: 1111.4788v2[math-ph]

OSCILLATOR STRENGTHS OF THE INTERSUBBAND TRANSITIONS IN SEMICONDUCTOR SPHERICAL QUANTUM DOT

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Oscillator strengths have been studied for the series of intersubband optical transitions $nl \rightarrow n'l'$ ($l \le 4$) in spherical quantum dot. Energy spectrum calculations are performed under effective mass approximation by assuming a spherically symmetric confining potential of finite depth. On the basis of the analytical solutions of the Scrödinger equation for quantum dot without impurity, and the Scrödinger and Poisson equations for quantum dot with hydrogenic impurity located in the center, energy of states and corresponding wave functions are determined. Oscillator strength of each transition depend on the energy difference of two states and dipole matrix element i.e. wave functions of states. The effects of increasing dot size and the presence of hydrogenic impurity on the oscillator strength for CdTe/ZnTe QD are investigated, and presented in this paper.

- [1] D. Stojanović, R. Kostić Acta Phys. Pol. A 120 (2011) 234 237.
- [2] Lj. Stevanović, J. Phys. B: At. Mol. Opt. Phys. 43 (2010) 165002.
- [3] S. Bhattacharyya, N. R. Das, Phys. Scr. 85 (2012) 045708.
- [4] A. Ozmen, Y. Yakar, B. Cakır, U. Atav, Opt. Comm. 282 (2009) 3999 4004.

SIMULATION OF PHOTOCONDUCTIVE DETECTOR OPERATION USING FINITE ELEMENT ANALYSIS

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Photoconductive cell is one of the common optical detectors used in measurement system of some instruments. The concept is based on the semiconductor conductivity change as a function of radiation intensity. Typically, a photoconductive detector consists of a piece of photoconductive strip and metals mounted on an insulation base and two wires, which are connected to the measurement system. It is known that the photoconductive cell resistance decreases with radiation intensity. Hence, three main factors which determine the resistance of the cell as a function of radiation intensity are the shape and orientation of the strip, the metal base dimension and the type of semiconductor used. Therefore, in this work, the factors which influence the resistance of the photoconductive cell are studied by using finite element analysis (FEA) software. Different shapes and orientations of the strip, metal base dimensions and semiconductor types are modelled by the FEA software. The models that have been developed are used to simulate the resistance of the cell as a function of radiation intensity. The resistance is calculated as a ratio between the potential difference between two points connecting to external wires and current induced in the semiconducting strip. Variation in the semiconducting strip conductivity and the overall dimensions of the photoconductive detector can affect the resistance of the cell as a function of radiation intensity.
SIMULATION OF PULSE PROPAGATION IN NONLINEAR DISPERSIVE OPTICAL FIBERS

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Pulse propagation in dispersive nonlinear has become popular research activities, in part stimulated to optical fiber communication systems. The refractive index nonlinearity and the group velocity dispersion effect propagation of optical pulse in optical fibers. Self-phase modulation (SPM) is a nonlinear optical effect of light matter interaction. An ultra short pulse of light, when travelling in a medium, will induce a varying reactive index of medium due to optical Kerr effect. Phase shift in the pulse will be produced by this variation in reactive index. The propagation of optical pulses is generalized nonlinear Schrödinger equation (NLSE).We analyze pulse propagation in nonlinear dispersive in optical fiber.

PULSE PROPAGATION DYNAMICS IN THE PRESENCE OF CONTINUOUS-WAVE FIELD

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We present theoretical results for the propagation dynamics of a electromagnetic field's puls through a medium with rubidium atoms, while other, continuous-wave electromagnetic field is present. Results are obtained by solving the set of Maxwell-Bloch equations for the interacting atoms with two electromagnetic fields. Additionally, static magnetic field is applied, dependence of which is calculated, yielding the well-known Hanle configuration. Frequencies of electromagnetic fields are resonant with the $F_g \square F_e = F_g \pm 1$, hyperfine transition in Rb.

When the above stated conditions are met, the well known effects of electromagnetically induced transparency [1] and absorption [2] are observable. We analyze in which way two electromagnetic fields affect each other and compare with the results for the single-laser case. Motivated by the recent results [3,4,5], we next analyze change of parameters which can lead to optical switching, i.e. transformation from electromagnetically induced absorption to transparency and vice versa.

- [1] E. Arimondo, Progress in Optics 35 (1996) 257.
- [2] A. M. Akulshin, S. Barreiro, A. Lezama, Phys. Rev. A 57 (1998) 2996.
- [3] D.V. Brazhnikov, A.V. Taichenachev, and V.I. Yudin, Eur. Phys. J. D 63 (2011) 315–325.
- [4] D. V. Brazhnikov, A. V. Taichenachev, A. M. Tumaikin, V. I. Yudin, I. I. Ryabtsev, and V. M. Entin, JETP Letters 91 (2010) 625–629.
- [5] J. Kou, R. G. Wan, Z. H. Kang, L. Jiang, L. Wang, Y. Jiang, and J. Y. Gao, Phys.Rev. A 84 (2011) 063807.

BOSE-EINSTEIN CONDENSATES IN OPTICAL LATTICES

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We investigated the time evolution of counterpropagating Bose-Einstein condensate (BEC) in two dimensional square optical lattices. A Bose–Einstein condensate [1, 2] is the ultimate coherent atom source: a collection of atoms, all in the same state, with an extremely narrow momentum spread. An optical lattice is a practically perfect periodic potential for atoms, produced by the interference of two or more laser beams. Combining a BEC with an optical lattice provides an opportunity for exploring a quantum system analogous to electrons in a solid state crystals but with unprecedented control over both the lattice and particles.

Our approach here is similar to the one given in [3]. We study the interaction of two counterpropagating (CP) condensates that are initially confined to the so-called pancake shape [4, 5] and propagate head-on along the square optical lattice. We numerically consider the evolution of two BECs for which it is possible to take separated wave functions. The behavior of BEC in an optical lattice is well described by the system of nonlinear Gross-Pitaevskii equations, which we solved numerically. By applying the Petviashvili iteration method [6], we investigated the existence of solitonic solutions in the case of counterpropagating matter waves, and analyzed their stability during propagation. We have displayed how the counterpropagating BECs evolve due to their mutual interaction and form stable breathing localized solutions, pinned by the lattice. We show how the proper choice of characteristic parameters of involved waves can stabilize BEC during the propagation.

- M. H. Anderson, J. R. Ensher, M. R. Matthews, C. E. Wieman and E. A. Cornell, Science 269 (1995) 198–201.
- [2] K. B. Davis, M. O. Mewes, M. R. Andrews, N. J. van Druten, D. S. Durfee, D. M. Kurn and W. Ketterle, Phys. Rev. Lett. 75 (1995) 3969–3973.
- [3] T. Mayteevarunyoo and B. A. Malomed, Physical Review A 74 (2006) 033616, 1-10.
- [4] E. A. Ostrovskaya and Yu.S. Kivshar, Phys. Rev. Lett. 93 (2004) 160405, 1–4.
- [5] B. J Dabrowska, E. A Ostrovskaya and Y. S Kivshar, J. Opt. B: Quantum Semiclass. Opt. 6 (2004) 423–427.
- [6] V. I. Petviashvili, Plasma Phys. 2 (1976) 469–472.

DEFECT CONTROLLED ANDERSON LOCALIZATION OF LIGHT IN PHOTONIC LATTICES

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Anderson localization is the absence of extended free propagation of waves in a disordered medium [1-3]. It has become an important part of recent investigations of random photonic lattices, and has been studied experimentally in both one-dimensional and two-dimensional systems with randomized lattice potentials. These experiments motivated numerous theoretical studies, including the analysis of wave spreading in nonlinear disordered systems and lasing in photonic crystals. Also, in recent years, there has been an increased interest in the study of defect states in photonic lattices [4], and also formation of defect channels [5]. These defects disrupt the periodicity of the crystal, creating optical states within the otherwise forbidden bandgap frequencies. However, the insertion of point-like or line-like defects into photonic crystals or waveguide arrays may provide an additional physical mechanism for light confinement, and a possibility to control light propagation in photonic lattices; light can be localized within the defect regions and manipulated by engineering the defect geometry and placement. It has recently attracted special attention, owing to their novel physics and possible various potential applications like high-quality waveguide structures, more complex integrated circuits like beam splitters and optical routers, or laser cavities [5, 6].

To extend on the ideas of these concepts, we analyze the transverse light localization in disordered photonic lattice with different defect types. We analyze how lattice defects affect and modify Anderson localization of light. It is considered specifically differences in the localization in photonic lattice with three different defect types, including also a case with the lattice with no defect. We investigate how the transverse localization of light in such geometries depends on both the strength of disorder and on the strength of nonlinearity in the system. The character of such localization is nontrivial, depending on join influence of all parameters: defect geometry, disorder level and nonlinearity strength. While in the linear regime, the localization is the most pronounced in the lattice with the simplest defect type, in the nonlinear regime this is not the case. We also investigate the effect of different input beam width on various regimes of Anderson localization. In the case of a broad input beam the inclusion of defects enhance localization in both linear and nonlinear regimes, as compared to the lattice with no defect. But, higher disorder level is needed to reach the same localization like for a narrow input beam; i.e to observe the same localization lengths.

- [1] P.W. Anderson, Phys. Rev. 109 (1958) 1492-1505.
- [2] S. John, Phys. Rev. Lett. 53 (1984) 2169-2172.
- [3] A.Lagendijk, B.Tiggelen, and D.S. Wiersma, Phys. Today 62 (2009) 24-29.
- [4] O. Painter, J. Vuckovic, and A. Scherer, J. Opt. Soc. Am. B, 16 (1999) 275-285.
- [5] P.V. Braun, S.A. Rinne, F. Garcia-Santamaria, Adv. Mater. 18 (2006) 2665-2678.
- [6] S.A. Rinne, F. Garcia-Santamaria, P.V. Braun, Nat. Photon. 2 (2008) 52-56.

MODELLING OF RADIATION DAMAGE IN PLASTIC **OPTICAL FIBRES**

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The radiation damage of step-index plastic optical fibres at γ -ray irradiation was modelled. Previous ray-tracing approaches [1-3] have been designed for undoped cylindrical light guides, where a propagation ray is reflected by total internal reflection only. These geometric principles were extended and further developed into a method of ray-tracing suitable for a particle-doped system. In this model, the particles (microspheres) represent the anomalies that are formed after the fibre exposure to gamma radiation. Attempt was made to trace rays within randomly distributed anomalies as radiation damages, as illustrated in Figure 1, with randomly oriented surfaces, calculating each time the fraction of absorbed power.



Figure1: Radiation induced anomalies as inhomogeneities in optical fibres

The results indicate that the radiation damage of the plastic optical fibres depends strongly on the dose rate. Radiation induced attenuation was calculated based on equation

$$\alpha = -\frac{10}{L_0} \log \left[\frac{P_T(\lambda, t)}{P_T^0(\lambda)} \right]$$

where $L_{\rm p}$ is the irradiated length of fibre, $P_{\rm T}(\lambda,t)$ is optical power in the irradiated fibre and $P_T^0(\lambda)$ is the optical power of the reference fibre. Based on the numerical results obtained in our model, the function α versus time for different dose rates was determined.

- M. S. Kovacevic, D. Nikezic, A. Djordjevich, Appl. Optics 44, (2005) 3898-3903 [1]
- [2] M. S. Kovacevic, D. Nikezic, A. Djordjevich, Meas. Sci. Technol. 15 (2004) 1756-1761
- [3] M. S. Kovačević, D Nikezić, Phys. Scr. (2012) doi:10.1088/0031-8949/2012/T149/014029
- [4] J. Blaha, M. Finger, M Finger Jr., A. Janata, M. Slunecka, V. Sluneckova, C. Simane, M. Sulc, M Vognar, Czech. J. Phy. 54, (2004) 183-191
- [5] H. Henschel, O. Kohn, H.U.Schmidt, SPIE 1399 (1990) 49-63
- [6] E.J. Friebele, M.E. Gingerich, G.H. Sigel, Appl. Phys. Lett. **32** (1978) 619-621
 [7] S.O'Keeffe, A.Fernandez, C.Fitzpatrick, B.Birchard, E.Levis, Meas.Sci.Technol. **18** (2007) 3171-3176
- [8] Ge Wenping, Y. Yongmin, G. Xiaojin, Act. Phot. Sinica 33 (2004) 40-42

VORTEX COMPLEXES IN 2D ONE-SITE COUPLED LATTICE SYSTEMS

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Existence, stability and dynamical properties of the vortex soliton complexes formed of two identical vortices with topological charges S=1 and 2 [1,2,3], in the system with two identical one-site coupled two-dimensional (2D) uniform lattices are investigated. Lattice system with self-attractive on-site cubic nonlinearity is modeled by two coupled nonlinear differential-difference 2D Schrödinger equations

$$i\frac{d\phi_{n,m}}{dz} + \frac{C}{2}(\phi_{n+1,m} + \phi_{n-1,m} + \phi_{n,m+1} + \phi_{n,m-1} - 4\phi_{n,m}) + \varepsilon\psi_{n,m}\delta_{n,0}\delta_{m,0} - \gamma|\phi_{n,m}|^2\phi_{n,m} = 0$$

$$i\frac{d\psi_{n,m}}{dz} + \frac{C}{2}(\psi_{n+1,m} + \psi_{n-1,m} + \psi_{n,m+1} + \psi_{n,m-1} - 4\psi_{n,m}) + \varepsilon\phi_{n,m}\delta_{n,0}\delta_{m,0} - \gamma|\psi_{n,m}|^2\psi_{n,m} = 0$$

The linear stability analysis show that, in the absence of inter-lattice coupling, vortices in component lattices of types *a*, *b* (ground state vortices), *e*, *g* (broad vortices) with S = 1, and for *j* and *k* with S = 2 are characterized by the stability windows in the corresponding existence regions [2].

In coupled lattice systems the stability windows of the vortex complexes in general shrink with increasing the inter-lattice coupling parameter. Two main classes of complexes are formed by on-site vortices and off-site ones. In the first class the coupling between complex's components is done through the pivot points where the vortex amplitudes are zero. The result is a vortex complex which is very robust to perturbation although the linear stability analysis indicates the excitation of the EV spectrum with increasing number of the complex EVs with positive real part.

By increasing the coupling strength between the off-site vortices, which are coupled through the pivot points where the soliton amplitude is finite, gives rise to highly unstable complexes. The last is confirmed by the dynamical calculation. Finally, it is shown that the complexes formed of broad vortices as the vortex structure e transform at the critical value of the coupling parameter to the complexes formed of on-site vortices with configuration type d.

The one-site coupled vortex complexes' symmetry properties are considered, and the symmetry breaking is indicated in certain cases at the critical values of the coupling strength.

- P. G. Kevrekidis, B. A. Malomed, A. R. Bishop, D. J. Frantzeskakis, Physical Review 65 (2001) 016605.
- [2] G.Gligorić, A. Maluckov, M. Stepić, Lj. Hadžievski, B. A. Malomed, Journal of Physics B 43 (2010) 055303
- [3] M. Petrovic, A. Maluckov, Lj. Hadžievski, G.Gligorić, B. A. Malomed , Physical Review E 84 (2011) 026602

MODELING THE ELECTROMAGNETICALLY INDUCED TRANSPARENCY IN SPHERICAL QUANTUM DOT WITH HYDROGENIC IMPURITY

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Semiconductor quantum dots have the optical properties suitable for optoelectronic devices due to the effects of spatial confinement on their carriers. They are addressed as an artificial atoms since their energy levels resemble the structure of atomic media. This analogy makes the quantum dots the promising candidates for potential applications in designing the optical processes and optical phenomena associated with quantum coherence effects like EIT in the solid-state mesoscopic heterostructures.

In this paper the spherical quantum dot with hydrogenic impurity is modeled by Y-type four-level atom interacting with three laser fields: pump, probe and control fields. Effect of spatial confinement is described by the model of hydrogen atom confined in the center of spherical box and through the spacing between two highest lying levels. They appear as well separated or the nearly degenerated levels depending of the confining box radius.

Solving optical Bloch equations in the steady-state regime, the real and imaginary parts of the corresponding element of the density matrix are obtained. It is discussed their variations with detuning, relative phase between the probe and control fields, and the angle between the corresponding dipole matrix elements. It is found that EIT can be obtained only for specific relations between the field detunings and the mutual orientation between the dipoles included in the transitions to the highest levels.

- [1] J.L. Zhu, J. J. Xiong, B.L. Gu, Phys. Rev. B 41 (1990) 6001-6007.
- [2] J. Banacloche, Y.G. Li, S. Jin, M. Xiao, Phys. Rev. A 51 (1995) 576-584.
- [3] H.X. Ying, Z.A. Shou, W. Ying, L.X. Gang, Commun. Theor. Phys. 57 (2012) 866-872.
- [4] Lj. Stevanović, J. Phys. B 43 (2010) 165002 1-11.
- [5] B.P. Hou, S.J. Wang, W.L. Yu, W.L. Sun, Phys. Rev. A 69 (2004) 053805 1-6.

INVESTIGATION OF URBACH'S RULE REGION IN UNDOPED AND CU DOPED (80-x)Sb₂O₃-20Li₂O-xMoO₃ GLASSES

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The aim of this study is to analyze the interactions of the excitations by the light absorption (excitons) with phonons of the crystal lattice. We report on optical absorption of undoped and Cu doped glasses at room temperature. The explanation of the "crystalline" and "glassy" Urbach's rule [1, 2] is given. The dynamic disorder and exciton-phonon interaction constant are calculated. The total cross-section of the impurity absorption σ_a is determined for all samples. The shape of the Urbach's energy is investigated also.

I.A. Vainshtein, A.F. Zatsepin, V.S. Kortov, Glass Phys. Chem. 25 (1999) 67.
 I.A. Weinstein, A.F. Zatsepin, Phys. Status Solidi C1 (2004) 2916.

ACCELERATION CONTROL AIRY BEAMS WITH OPTICALLY INDUCED PHOTONIC LATTICES

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Airy beams are a well-known family of stationary freely accelerating wave forms [1]. The finite-energy Airy beam is characterized by a main intensity lobe that decays exponentially to zero on one side and decays with damped oscillations on the other. The interest for these beams lies in the fact that, if they have a sufficiently wide apodization, the main intensity lobe propagates free of diffraction while bending in the direction transverse to propagation or accelerating along the propagation direction if the temporal profile of the pulse is Airy shaped. The ballistic-like properties of the Airy beam [2] lend it to particular applications ranging from trapping of particles along curved paths [3] and self-bending plasma channels [4] to ultrafast self-accelerating pulses [5] and Airy light bullets accelerating in both transverse dimensions and in time [6]. Over the years, Airy beams have been systematically investigated in higher dimensions, particularly in the areas of optics and atom physics. In terms of experimental realization, optics has thus far provided a fertile ground in which the properties of such nonspreading localized waves can be directly observed and studied in detail.

We analyze how an optically induced photonic lattice affect and modify acceleration of Airy beams in one- and two-dimensions. Various conditions for the propagation and existence of Airy beams are considered. In addition to the linear properties of Airy beams, nonlinear propagation of high-intensity Airy beams is also studied. We investigate how the strength of medium's nonlinearity, lattice period, and lattice intensity influence enhancement as well as reduction of beam acceleration. Acceleration control of Airy beams using different lattice defects is also investigated.

- [1] G.A. Siviloglou, J. Broky, A. Dogariu, and D.N. Christodoulides, Phys. Rev. Lett. 99 (2007) 213901.
- [2] G.A. Siviloglou, J. Broky, A. Dogariu, and D.N. Christodoulides, Opt. Lett. 33 (2008) 207-209.
- [3] J. Baumgartl, M. Mazilu, and K. Dholakia, Nat. Photonics 2, (2008) 675–678.
- [4] P. Polynkin, M. Kolesik, J. V. Moloney, G. A. Siviloglou, and D. N. Christodoulides, Science 324, (2009) 229–232.
- [5] A. Chong, W. H. Renninger, D. N. Christodoulides, and F. W. Wise, Nat. Photonics 4, (2010)103– 106.
- [6] D. Abdollahpour, S. Suntsov, D. G. Papazoglou, and S. Tzortzakis, Phys. Rev. Lett. 105, (2010) 253901.

CONTROL OF ELECTRON AND HOLE LOCALIZATION BY INTERNAL HETEROSTRUCTURE OF SPHERICAL CORE/BARRIER/SHELL NANOPARTICLES

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We present possibility of spatial control of exitonic wave functions in core/barrier/shell i.e. quantum dot-quantum well (QDQW) nanoheterostructure. Calculations are performed in effective mass model and first-order perturbation theory. In this particular case, CdSe/ZnS/CdSe nanoparticle, influence of core, barrier and shell widths on electron, hole and consequently exciton properties are analyzed. We present detailed results about electron and hole energies of lowest *s*, *p* and *d* states and spatial properties of corresponding wave functions.

For some geometries electron and hole are both localized in core or in shell giving Type-I localization, and for the other geometries in separated parts of nanoparticle giving Type-II localization. For known material parameters type of localization can be controlled by structure. As each localization regime is useful for specific applications, analysis of these results can be used to establish principles in core/barrier/shell properties design.

AB INITIO STUDY OF OPTICAL PROPERTIES OF SUBSTOICHIOMETRIC MgH₂

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Despite the extensive investigations of MgH₂ and related systems, optical properties of substoichiometric MgH_{2-x} compounds are known only sparsely. These properties are important from at least two reasons: MgH₂ is a possible candidate for switchable mirrors applications, and in-situ monitoring of Mg/H optical properties could provide valuable information about hydriding/dehydriding processes. We have performed *ab initio* electronic structure calculations of various rutile type substoichiometric MgH2 structures, in order to investigate influence of hydrogen vacancies concentration on optical properties of material. Our results show that introduction of hydrogen vacancies induce formation of vacancy levels in energy gap of MgH₂. The widths of these states are directly proportional to vacancies concentration, eventually leading to closing of gap and formation of metallic-like picture. Even at small vacancies concentration, optical conductivity is influenced significantly since the low frequency limit of imaginary part of dielectric function falls into optical region. The direct consequence is the change of transparency and color as function of hydrogen vacancy concentration, a feature that is observed experimentally during hydrogen desorption of this material.

FABRICATION, STRUCTURE, AND LUMINESCENCE PROPERTIES OF Al₂O₃/ZnO COAXIAL NANOWIRES

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Al₂O₃/ZnO coaxial nanowires were successfully synthesized on (100) Si substrates by thermal evaporation of a mixture of Al and TiO₂ powders followed by atomic layer deposition of ZnO. X-ray diffraction, scanning electron microscopy and transmission electron microscopy (TEM) analyses showed that the diameters and lengths of the coaxial nanowires were a few hundreds of nanometers and a few tens of micrometers, respectively, and the ZnO shell layer thickness ranged from 8 to 11 nm. TEM and X-ray diffraction analyses indicated that the cores and shells of the coaxial nanowires comprised a single crystal rhombohedral-structured α -Al₂O₃ and a polycrystalline simple hexagonal structured ZnO respectively. Photoluminescence measurements revealed that the Al₂O₃ nanowires had a strong emission band centered at approximately 710 nm in a red region as well as a weak emission band centered at approximately 340 nm in a near-ultraviolet region. In contrast, Al₂O₃/ZnO coaxial nanowires had two emission bands: a strong emission band centered at approximately 570 nm in the yellow region and a weak emission band at approximately 340 nm in the near-ultraviolet region. The vellow emission might be from the ZnO shells in the Al₂O₃/ZnO coaxial nanowires whereas the weak near-ultraviolet emission might be from the Al_2O_3 cores in the core-shell nanowires.

- [1] X.S. Fang, C.H. Ye, X.X. Xu, T. Xie, Y.C. Wu, L.D. Zhang, J. Phys.: Condens. Matter 16 (2004) 4157–4163.
- [2] C. Li, H. Huang, S. Yang, R. Zheng, W. Yang, Z. Liu, S. Ringer, Mater. Lett. 63 (2009) 1016– 1018.

ANALYSIS OF SOIL CONTAMINANTS THROUGH THE TECHNIQUE OF FINGERPRINTING

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The process of soil degradation is a serious problem worldwide, with environmental consequences that cause social and economic implications. Currently, there are numerous techniques and methods for soil analysis. Digital printing is a chemicalmathematical method to identify the sources of origin of an element in a given sample, via natural tracers analyzed by spectroscopic techniques. This work aims to analyze the soils of the river basins nearby agricultural activities areas in São Paulo State and make a correlation with two types of agricultural inputs often used, by the method of fingerprintig and statistical tests such as the F test. Four types of soil, within a radius of 10 km from the basin, were analyzed by plasma mass spectrometry (ICP-MS) and Fourier Transform Infrared Spectroscopy (FT-IR). Afterwards, these 4 samples were correlated with two types of inputs used on farms nearby. To evaluate the process of analysis and to establish which chemicals that could be used in data interpretation, standards certified by the IAEA were used as reference. After the application of statistical tests, it could be noted that three soil samples contained trace elements of two agricultural inputs, which indicates a possible soil contamination of river basins to agricultural activity nearby.

OPTICALLY INDUCED CHANGES OF THIN FILM SURFACE TEMPERATURE

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In this paper the theoretical model of optically induced surface temperature changes is presented, which includes multiple reflections of incident beam at the boundaries of a sample. The model is compared with existing models and correction factor is derived. It is shown that there are a few cases of optically transparent thin films for which this correction can significantly affect the values of the surface temperature and consequently the photothermal evaluated sample properties.

THE PHOTOCONDUCTIVITY OF SILVER NANOPARTICLE ENSEMBLES ON DIELECTRIC SURFACE: THE ROLE OF STRUCTURAL DEFECTS IN THE SURFACE AND THE ENVIRONMENT

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Advances in nanophysics and nanotechnologies have led to an increased interest in experimental and theoretical researches of metal nanoparticle ensembles (MNEs) on transparent insulators. For effective technological application of such systems, it is necessary to study effects and processes occurring in systems of nanoparticles under the electric, thermal and light actions. In the present work an investigation of the photoconductivity of silver MNE on quartz and sapphire substrates and of the influence of the plasmon resonance excitation on the photoconductivity was performed.

The experiments were performed with silver MNEs, prepared in the ultrahigh vacuum by the method of thermal evaporation of silver on the quartz substrate. Such evaporation method leads to the Volmer-Weber growth mechanism of MNE. The size and the form of particles are defined by the evaporation conditions and the subsequent thermal processing.

Electrical as well as photoelectrical properties of the metal nanoparticle ensembles (MNEs) were investigated. For measurement of the dark conductivity and the photoconductivity of silver MNE two silver electrodes were deposited above the MNE. The value of the current was registered by the digital picoammeter KEITHLEY. The exponential temperature dependence of the conductivity in the MNEs was obtained. Since lnI depends linear on 1/T, an activation energy concept of the conductivity can be applied. An activation energy for Ag nanoparticles on SiO₂ is E = 1 eV and for Ag nanoparticles on Al₂O₃ is E = 0.48 eV. The photoconductivity of MNEs has been related to their extinction spectra. A clear evidence of the photoinduced conductivity of the MNEs was obtained. For all investigated Ag MNEs on insulator substrates the threshold of the photoconductivity was obtained. In the case of Ag MNEs on SiO₂ its equal 2.1 eV.

The mechanism of the photoconductivity is interpreted in the framework of the model of thermally activated jumps of electrons through the traps of the substrate. The influence of adsorbated gases on the conductivity and photoconductivity has been revealed. So the possibility of the such systems application as chemical sensors has been showed.

LUMINESCENCE PROPERTIES OF NEW RED PHOSPHOR KCa(PO₃)₃ DOPED WITH Eu³⁺ IONS

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The new polycrystalline phosphate $KCa(PO_3)_3$ was obtained. The Eu^{3+} ions were used as a probe to characterize structural and optical properties of the new material. The samples were prepared by a conventional solid state route. The reagents were firstly grounded in agate mortar in stoichiometric ratio, then heated at 200°C for 4 h, at 400°C for 3 h and at 600°C for 4 h. The XRD measurements confirmed that the pure phase samples were obtained.



Fig. 1. The emission and excitation spectra of KCa(PO₃)₃ doped with 5% of Eu³⁺ ions.

The luminescence properties of KCa(PO₃)₃ doped with 5% of Eu³⁺ were measured. The excitation and emission spectra are showed in Fig. 1. In the excitation spectra there is a strong and wide band centered at 220 nm assigned to the charge transfer between oxygen and europium ions. There are also 4f-4f bands visible in the region from 300 to 530 nm with maximum at 389.5 nm. The emission spectrum consists of intense and narrow bands assigned to the ⁵D₀ \rightarrow ⁷F_J transitions. The decay profile monitored at 615 nm was single exponential and calculated decay time was $\tau = 2.7$ ms.

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RAMAN HETERODYNE DETECTION OF HYPERFINE TRANSITIONS IN Eu³⁺:Y₂SiO₅

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In this work we present a characterization of the hyperfine structure of the ${}^{7}F_{0}$ manifold of Eu³⁺ in Y₂SiO₅ matrix.

The Zeeman-shifted levels are detected using a heterodyne Raman technique, that allows for optical detection of nuclear magnetic resonance.

In particular, we focused on the 34.5 MHz ground state transition, in which the coherence was excited via a resonant RF magnetic field. By applying a static magnetic field B up to about 90 Gauss perpendicularly to the resonant RF field, the I_z degeneration was removed and four transitions were observed, corresponding to the 7F_0 ($I_z = \pm 3/2 \rightarrow \pm 1/2$) hyperfine energy levels (fig 1).

Coherence lifetimes T_2 were determined by spin refocusing experiments. A variable static magnetic field was applied in order to show the effect of magnetic decoupling on the coherence properties of the system. Coherence lifetimes up to 14 ms were measured, indicating this material as a good candidate for quantum storage applications.

Further investigations will be carried out in order to increase the coherence lifetimes via dynamical decoupling techniques and via the individuation of the so-called ZEFOZ (ZEro First Order Zeeman shift) transitions.



Fig 1: Observed transitions in 151 Eu:Y₂SiO₅ corresponding to the ${}^{7}F_{0}$ ground state (I_z = ±3/2 \rightarrow ±1/2) hyperfine energy levels

NANOSTRUCTURED GLASSCERAMICS FOR LUMINESCENT TEMPERATURE SENSORS

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Glass-crystalline materials – are composite heterophase media, usually consisting of glassy matrix (glass phase) and micro-or nanoscale dielectric or semiconductor crystals (crystalline phase) dispersed in glass host. If the activator (eg, chromium, erbium, ytterbium, etc.) is incorporated in the crystalline phase, the spectral, luminescent and lasing characteristics of the glass-ceramics can be close to the characteristics of laser crystal analogs. Thus, the glass-ceramics combining the best properties of glasses and crystals, allow to create optical fibers and planar waveguides with new and unique optical properties, that can be realized for design and fabrication of fiber-optic temperature sensors.

In the present work we have prepared nano-glassceramics of the system of $30SiO_2$ -18PbF₂-7.5Al₂O₃-5ZnF₂-29CdF₂-3YF₃ mol % doped with different ErF₃ consentration (0.05-0.5 mol %) and constant of YbF₃ concentration (3 mol %). In the system, the crystalline phase of PbYOF₃ is precipitated upon the secondary heat treatment at 515°C [1]. Also we studied nano-glassceramics of the system of K₂O – Al₂O₃ – B₂O₃ doped with chromium ions. In the system, the crystalline phase of Al₂O₃:Cr³⁺ is precipitated upon the secondary heat treatment at 600°C and 700°C.

Purpose of this study was to investigate the temperature dependence of the luminescence spectra and up-conversion luminescence decay time in two glass-ceramics types.

During the experiment, we measured the luminescence lifetime of Cr^{3+} ions in the temperature range of 25-450°C and at low temperature of 77K. Also, we measured up-conversion luminescence spectra of Er^{3+} ions in the temperature range of 25 - 450°C.

We calculated the relative sensitivity of the test samples to identify the most suitable material for the manufacture of fluorescent temperature sensors. It was shown that chromium- and erbium-doped glass-ceramics have the temperature sensitivity that closes to well-known crystalline analogs. We make a conclusion that, the chromium- and erbium-doped glass-ceramics are very promising materials for fabrication of fiber fluorescent temperature sensors.

[1] V.A. Aseev, V.V. Golubkov, E.V. Kolobkova, N.V. Nikonorov // Lead oxifluoride lanthanides in glass-like matrix // Glass Physics and Chemistry, 2012, V.38, №1, P11-18.

EFFECTS OF ELECTRIC AND MAGNETIC FIELDS ON THE EXCITON STATES IN A TYPE-I NANORING ON A NANODISK

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We report on a theoretical study of the states of the neutral exciton in a ring-like realistic-shape GaAs nanodots embedded in the (Al,Ga)As matrix. The considered systems are grown by the droplet-epitaxy (DE) and are usually characterized by a few nanometer high ring laid down on a holed flat disk. Similar to experimental structures, the ring have a smaller radius than the disk. For the realistic definition of dot crosssection a sum of Gaussian functions is adopted in the model. The effects of perpendicular electric and magnetic fields are considered, where the exciton energy levels are computed by employing our exact diagonalization approach. For type I band alignment localization for the electron and the hole are similar, and therefore, the excitonic Aharonov-Bohm (AB) oscillations are strongly suppressed by the Coulomb interaction. We show that electric field have beneficial effect on separation of the electron and the hole, that leads to an increase of both the vertical and the in-plane polarization of the exciton, and consequently the oscillations of the ground exciton energy level are revealed. Furthermore, for certain values of electric field, the exciton ground state can turn "dark" in some magnetic field windows, predicting a striking optical manifestation of the excitonic Aharonov-Bohm effect. Thus, the exciton ground state oscillations with magnetic field in realistic strain-free quantum dots can be realized and efficiently tuned by applying electric field. An amplitudes of induced oscillations are comparable to those recently measured in type I band alignment strained selfassembled nanorings.

GROWTH BEHAVIOR, SURFACE STRUCTURE AND OPTICAL CONSTANTS OF NANOCRYSTALLINE YTTRIUM OXIDE THIN FILMS

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Yttrium oxide (Y_2O_3) has received significant attention in recent years in view of its possible integration into a wide range of scientific and technological applications. Y_2O_3 films exhibit excellent electronic properties such as transparency over a broad spectral range (0.2–8 μ m), high dielectric constant (~14–18), high refractive index (~2), large band gap (~5.8 eV), low absorption (from near-UV to IR), and superior electrical breakdown strength (>3 MV/cm). These properties make Y_2O_3 films interesting for various electrical, optical and electro-optic devices. In addition, lattice mismatch and low leakage current with silicon (Si) substrates opens several other avenues to integrate the material with Si-based devices for emerging nanotechnology. Therefore, controlled growth and manipulation of microstructure, particularly at the nanoscale dimensions, has important implications for the design and applications of Y_2O_3 films. The present work was performed on the growth and optical characterization of nanocrystalline Y₂O₃ films made by magnetron sputter-deposition. We found, through an examination employing structural and optical analytical tools, that there exists a correlation between the microstructure and optical properties, specifically the grain-size dependent optical constants and their dispersion profiles.

Yttrium oxide (Y₂O₃) thin films were grown onto Si(100) substrates using reactive magnetron sputter-deposition at temperatures ranging from room temperature (RT) to 500°C. The effect of growth temperature (T_s) on the microstructure and optical constants of Y2O3 films were investigated. The structural studies employing X-ray diffraction (XRD) and reflection high-energy electron diffraction (RHEED) indicate that the films grown at room temperature (RT) are amorphous while the films grown at T_s =300-500 °C are nanocrystalline and crystallize in cubic structure. Grain-size (L) increases from ~ 5 to 40 nm with increasing T_s. Depth profiling has been produced with Ar+ ion bombardment and XPS analysis. Spectroscopic ellipsometry measurements indicate that the size-effects and ultra-microstructure were significant on the optical constants and their dispersion profiles of Y_2O_3 films. A significant enhancement in the index of refraction (n) (from 2.03 to 2.25) is observed in well-defined Y_2O_3 nanocrystalline films compared to that of amorphous Y2O3. The observed changes in the optical constants were explained on the basis of increased packing density and crystallinity of the films with increasing $T_{\rm s}$. A direct, linear L-*n* relationship found for Y₂O₃ films suggest that tuning optical properties for desired applications can be achieved by controlling the size and structure at the nanoscale dimensions.

SYNTHESIS AND ELECTRONIC STRUCTURE OF ORTHORHOMBIC MOLYBDATE RbNd(MoO₄)₂

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Double molybdates display a variety of crystal structures and possess useful electro-physical, optical and catalytic properties. Complex molybdates containing Ln^{3+} ions in low-symmetry positions are promising for creation of new effective laser mediums. Present study is aimed to synthesize the RbNd(MoO₄)₂ microcrystals and evaluate for the first time the electronic structure of this binary molybdate. Formation of RbNd(MoO₄)₂ was previously found in quasi-binary system Rb₂MoO₄-Nd₂(MoO₄)₃ [1] and crystal structure of the compound was refined by Rietveld analysis in space group *Pbcn* [2].

Middle-temperature solid state synthesis was applied to create the RbNd(MoO₄)₂ microcrystals. As starting materials, MoO₃ (99.9%), Rb₂CO₃ (99.99%) and Nd₂O₃ (>99.9%) were used. Initially rubidium molybdate and neodymium molybdates were prepared by solid state reactions. To avoid a loss of molybdenum oxide due to its high volatility, heat treatment of stoichiometric mixtures was started at $T = 450^{\circ}$ C and followed by step-wise temperature increasing up to $T = 600^{\circ}$ C (Rb₂MoO₄) and 800°C (Nd₂(MoO₄)₃), respectively. These molybdates were mixed and annealed at $T = 550-600^{\circ}$ C by 90h to yield RbNd(MoO₄)₂. Phase composition of the products was verified with XRD analysis. Final product was formed by slightly agglomerated plate-like crystals with typical dimensions $12 \times 6 \times 1$ µm. Crystal habit is appeared to be governed by layered crystal structure.

The full potential linearized augmented plane wave (FP-LAPW) method as incorporated in the WIEN97 code has been used to calculate total and partial densities of states of the constituent atoms of RbNd(MoO₄)₂. To verify the theoretical results, in the present work, the X-ray emission Mo $L\beta_{2,15}$ and O $K\alpha$ bands representing the energy distribution of mainly the Mo 4d- and O 2p-like states, respectively, as well as the X-ray photoelectron (XPS) valence-band and core-level spectra have been measured for RbNd(MoO₄)₂ microcrystals. XPS valence-band and core-level spectra were measured using the UHV-Analysis-System assembled by SPECS (Germany). The system is equipped with a PHOIBOS 150 hemispherical analyzer. A base pressure of a sublimation ionpumped chamber of the system was less than 6×10^{10} mbar during the present experiments. The Mg K α radiation (E = 1253.6 eV) was used as a source of XPS spectra excitation. The XPS spectra were measured at the constant pass energy of 25 eV. The energy scale of the spectrometer was calibrated by setting the measured Au $4f_{7/2}$ and Cu $2p_{3/2}$ binding energies to 84.00 ± 0.05 eV and 932.66 ± 0.05 eV, respectively, with respect to the Fermi energy, $E_{\rm F}$. Energy drift due to charging effects was calibrated, taking the XPS C 1s (284.6 eV) core-level spectrum of hydrocarbons. A rather good agreement of the experimental data and theoretical FP-LAPW results regarding the occupation of the electronic states within the valence-band region of RbNd(MoO₄)₂ has been achieved in the present study. Core level parameters of $RbNd(MoO_4)_2$ have been compared with those of other molybdates and Rb- and Nd-containing oxide crystals.

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- [1] M.V. Mokhosoev, E.I. Get'man, F.P. Alexeev, Dokl. Akad. Nauk. USSR 185 (2) (1969) 361-362.
- [2] V.V. Atuchin, O.D. Chimitova, T.A. Gavrilova, M.S. Molokeev, Sung-Jin Kim, N.V. Surovtsev, B.G. Bazarov, J. Cryst. Growth 318 (2011) 683-686.

STABILITY OF PHOTOLUMINESCENCE OF GLASS-EMBEDDED CdSe NANOCRYSTALS UNDER X-RAY IRRADIATION

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CdSe nanocrystals and core/shell structures on their base embedded in dielectric media have been under intense research due to the confinement-related effects in their optical spectra and related possible applications, especially in view of the tunability of their luminescence maximum over the visible spectral range by variation of the nanocrystal size. Hence, studies of irradiation effects on their luminescence are quite interesting. Here we report on photoluminescence (PL) studies of X-ray irradiated CdSe nanocrystals grown in borosilicate glass.

The samples of borosilicate glass with CdSe nanocrystals were irradiated using an X-ray tube with a Mo anticathode (40 kV, 20 mA). Additive irradiation provided the dose increase from 400 do 3200 Gy. PL was excited by the second harmonic (380 nm) of pulsed (10 ns, 10 Hz) titanium-sapphire laser. PL spectra (450–850 nm) were measured using a Solar TII (Belarus) MS 7504i monochromator with a Hamamatsu HS101H CCD camera. The instrumental width did not exceed 2 nm. All measurements were performed at 300 K.

Chemical composition of the glass-embedded CdSe nanocrystals was confirmed by Raman data, their average diameter was estimated as 7.3 nm from the confinement-related peak position in the optical absorption spectra. The PL spectrum of the non-irradiated sample with the 7.3-nm CdSe nanocrystals exhibits a maximum at 672 nm (1.85 eV). With the irradiation dose increase up to 3200 Gy, the PL intensity remains unchanged, exhibiting only slight fluctuations, evidently resulting from the differences in the concentration of the nanocrystals over the sample area. Neither any changes in the spectral position or the lineshape of the PL peak are observed. Such stability of the PL intensity under X-ray irradiation contradicts earlier data [1] where irradiation of glass-embedded $CdS_{1-x}Se_x$ nanocrystals with intense femtosecond laser pulses results in a strong (by three to four orders of magnitude) decrease of the PL intensity as well as the data for y-irradiated CdSe/ZnS core-shell structures [2]. Earlier, for borosilicate glass-embedded CdSe and $CdS_{1-r}Se_r$ nanocrystals, a smearing of the near-edge confinement-related features and an apparent blue shift of the absorption edge were reported under high-energy electron [2] or X-ray [3] irradiation. They were explained by the ionization of the nanocrystals which capture electrons from the irradiation-excited electron-hole pairs (the holes are trapped by radiation-induced colour centres formed in the glass matrix), thus disabling optical transitions from the lowest-energy states. Evidently, deep traps corresponding for the 1.85eV luminescence, are not involved in this process.

R. Osellame, R. Martinez Vazquez, G. Cerullo, R. Ramponi, O. Svelto, V. Russo, A. Li Bassi, C. E. Bottani, Phys. Rev.B 76 (2007) 045340-1–045340-7.

^[2] N. J. Withers, K. Sankar, B.A. Akins, T.A. Memon, T. Gu, J. Gu, G.A. Smolyakov, M.R. Greenberg, T.J. Boyle, and M. Osiński, Appl/ Phys. Lett. 93 (2008) 173101-1–173101-3.

^[3] A.V. Gomonnai, Yu.M. Azhniuk, V.V. Lopushansky, I.G. Megela, I.I. Turok, M. Kranjčec, V.O. Yukhymchuk, Phys. Rev. B 65 (2002) 245327-1–245327-7.

^[4] Yu. M. Azhniuk, M. V. Prymak, V. V. Lopushansky, A. M. Solomon, Yu. I. Hutych, A. V. Gomonnai, D.R.T. Zahn, J. Appl. Phys. 107 (2010) 113528-1–113528-8.

OPTICAL POLYMER MATERIALS WITH PHOTOCONTROLLED FLUORESCENCE

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The advancement of information technologies requires the improvement of optical information carriers, in particular, optical disks in the direction of increasing the information capacity and the rate of processing optical information. In this connection, of special interest is the development of multilayer optical disks providing nondestructive fluorescent readout of optical information for bitwise working (WERM) and archival (WORM) 3D optical memory.

This paper present the nearest results of own investigations in this technical field.

For bitwise working optical memory, optical polymer materials based on thermally irreversible photochromic diarylethenes (I) exhibiting only photoinduced reversible transformations between two forms A and B as well as fluorophores (phenalenon (II) or quantum dots CdSe/ZnS) were worked out.



Nondestructive fluorescent readout of optical information has been achieved by using fluorescent resonance energy transfer (FRET) which was realized by selection of the photochromic compound and fluorophore with adjusted spectral characteristics.

Optical polymer light-sensitive materials for archival optical memory are based on irreversible photochemical transformation of chromones (III) from the nonluminescent compound A to the flurescent product B.



Functional properties of these developed light-sensitive polymer materials were studded. It was shown that multilayer structures including alternating light-sensitive and wave-guide polymer layers provide the development optical disks of super high information capacity (more 1TB).

CALCULATION THE OPTICAL ENERGY SPECTRA AND g-FACTORS OF Cr⁵⁺:Y(V,P)O₄

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The phosphors materials YVO_4 and YPO_4 doped with Cr^{5+} ions $(3d^1)$ have technological importance with numerous applications. The chromium ions substituted for pentavalent V or P ions, in tetrahedral coordinated oxygen ions. According to crystal-field Theory (CFT), a ${}^{2}B_{1}$ ground state is expected for the Cr⁵⁺ ion, but EPR [1] as well as optical absorption and emission [2] experiments show that the actual ground state is a ${}^{2}A_{1}$. The aim of this paper is to present a unified treatment of the optical spectra and EPR parameters and to establish the actually ground state for considered systems. The exchange charge model (ECM)[3] and the geometry of the doped crystals were used to calculate the crystal field parameters (CFP) with taking into account the effects of the covalent bond formation between the Cr^{5+} and O^{2-} ions. The calculated CFP values were used for diagonalization of the Cr^{5+} Hamiltonian in a complete basis set spanned by all wave functions of the LS terms of $3d^1$ electron configuration. The whole energy spectra and wave functions are obtained by diagonalization of complete d1 energy matrix of the Hamiltonian, in a distorted tetrahedral field. Further, the calculation of the ground state EPR parameters were carried out by using the obtained wave functions. The results of calculations are agree with experimental data [1,2], and suggest that the actually ground state energy of the energy levels scheme is ${}^{2}A_{1}$ for both title systems.

- [1] M. Greenblatt, J. H. Pifer, B. R. McGarvey and B. M. Wranklyn, J. Chem. Phys. 74, (1981)6014 .
- [2] M. F. Hazenkamp, A. C. Stückl, E. Cavalli and H. U. Güdel, Inorg. Chem. 39,(2000) 251
- [3] B.Z.Malkin, "Crystal field and Electron-Phonon Interaction in Rare-Earth Ionic Paramagnets" in Spectroscopy of solids containing rare-earth ions, edited by A. A. Kaplyanskii, B. M. Macfarlane, North Holland, Amsterdam, pp. 33-50, 1987

STRUCTURE AND MICROSTRUCTURE PROPERTIES OF BALL MILLED Fe-30%Zn

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Binary alloy of Fe-30%Zn composition prepared by high energy ball milling of elemental pure iron and pure zinc powders, has been investigated by X-ray diffraction (XRD), secondary electron microscopy (SEM), and differential scanning calorimetry (DSC), as a function of milling time.

The XRD analysis showed the formation of Fe(Zn) solid solution after 24 hours of milling.Microstructural analysis using the Rietveld refinement confirmed the nanostructure character of the obtained powders, with grain size reaching 20 nm. The morphology of the milled powders, investigated by SEM, confirmed the decreasing behavior in the scale of the features composing the final milled powders. The DSC spectrum exhibited broad exothermic band related to structural relaxation and to the incorporation of Zn into the Fe unit cell.

CRYSTALLIZATION KINETICS OF Zn₂SiO₄ POWDERS PREPARED VIA POLYMER INDUCED SOL-GEL METHOD

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Zinc silicate (Zn_2SiO_4) has been identified as a suitable host matrix for many transition metal and rare earth dopant ions, providing excellent luminescent properties in the blue, green and red spectral zones. For instance, phosphors based on manganese-doped Zn_2SiO_4 are important materials for lamps and plasma display panels and when doped with rare-earth ions are used for CRT and tricolor phosphors.

Zinc silicate powders were produced with polymer (PEG) assisted sol-gel synthesis [1, 2]. The resulting powders were initially fired in two ways: in conventional furnace (CF) and in microwave oven (MW), and then treated in furnace at 1453 K for 1h.

With this study we aimed to determine the influence of different type of ignition (MW and CF) of zinc silicate powders on their crystallization. Samples were characterized with differential thermal analysis (DTA) using different heating rates (5, 10, 20, 40 K/min) to study the kinetics of crystallization process. Kinetic parameters were calculated with two non-isothermal methods based on the Arrhenius equation: Kissinger [3] and Ozawa [4] peak methods, that relates the dependence of the exothermic peak temperature on the heating rate. The values of apparent activation energy of crystallization under linear heating condition were 460 kJ/mol and 500 kJ/mol for samples produced in MW and CF, respectively. The obtain values are also confirmed using free-approach methods (Flynn-Wall-Ozawa and Kissinger-Akahira-Sunose).

- [1] R. Krsmanović, Ž. Antić, I. Zeković, M.D. Dramićanin, J. Alloy. Compd. 480 (2009) 494-498.
- [2] R.M. Krsmanović, Ž. Antić, M. Mitrić, M.D. Dramićanin, M.G. Brik, Appl. Phys. A 104 (2011) 483–492.
- [3] H.E. Kissinger, Anal. Chem. 29 (1957) 1702-1706.
- [4] T. Ozawa, J. Therm. Anal. Calorim. 2 (1970) 301-324.

SPECTROSCOPIC CHARACTERIZATIONS OF Pr³⁺/Yb³⁺ CO-DOPED OXYHALIDE TELLURITE GLASSES AND ITS CERAMICS

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The glass and its ceramic containing nano-crystallite particles co-doped with Pr^{3+}/Yb^{3+} rare earth ions have been successfully prepared by heat treatment of the precursor oxyhalide glass samples synthesized by conventional melt-quench method. The glass sample has been characterized by thermal measurement showing its glass transition temperature (T_g), and onset crystallization temperature (T_c). X-ray diffraction pattern verifies the precipitation of nano-crystals into the ceramic samples. Upconversion emission spectra recorded on excitation with 976 nm wavelength of diode laser show intense emission bands from Pr^{3+} ion. Emission of Pr^{3+} enhances approximately thirty times when Yb^{3+} ion is added with the matrix due to sufficient energy transfer from Yb^{3+} to Pr^{3+} ions. The Stark splitting and the intensity of different emission bands enlarge effectively when we approach to ceramics from glasses. Upconversion emission is intense enough and can be observed by the naked eyes.

SYNTHESIS, STRUCTURE, AND LUMINESCENCE PROPERTIES OF ZnO-CORE/In₂O₃-SHELL NANOTUBES

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ZnO-core/In₂O₃-shell nanotubes were fabricated by thermal evaporation of Te powders and sputtering of In₂O₃. The intensity of the major emission from the core-shell nanowires showed strong dependence on the shell layer thickness. The strongest emission was obtained for the sputtering time of 15 min or the shell layer thickness of ~15 nm and its intensity was approximately 40 times higher than that of the major emission from the as-synthesized In₂O₃ nanowires. This enhancement in emission intensity is attributed to the subwavelength optical resonant cavity formation in the shell layer. The major emission intensity was enhanced further and blue-shifted by annealing, which might be attributed to the increase in the In interstitial and O vacancy concentrations in the ZnO cores during annealing.

J.P. Richters, T. Voss, D.S. Kim, R. Scholz, Nanotechnology 19 (2008) 305202-305205.
 Z.L. Wang, J. Phys.: Condens. Matter. 16 (2004) R829.

SUPERCRITICAL EPITAXIAL NANOLAYERS OF LEAD SELENIDE

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Application of lead selenide in IR photodetectors, lasers and coatings for solar cells has stimulated the study of the structural and optical properties of thin layers. The present paper deals with obtaining of PbSe nanolayers. The optical and structural investigations of these layers verified the presence of effective "negative" pressure in them. The possibilities for using this effect are discussed.

The PbSe layers (the initial value was a=6.126 Å) were grown by the method of molecular epitaxy with a "hot" wall on KCl substrates (a=6.290 Å). The layers thickness varied over the range of 20-2000 nm. Special emphasis was made on the layers <200 nm in thickness. When the layer thickness changed from 180 to 5 nm, the tangential lattice constant, measured by the method of X-ray diffraction, changed from 6.149 to 6.188 Å. For the layer 18 nm thick, the line of the diffraction reflection was overlapped by the substrate line, and the lattice constant of the layer made up 6.210Å. The deformations in the layers in respect to the PbSe monocrystal varied from 0.004 to 0.014. Taking into consideration that the calculated critical thickness of the layers grown on KCl substrates made up 2 nm, the revealed residual deformations at significantly larger thickness of the layers showed that the layers had already been supercritical.

As the layers became thinner, the tangential lattice constant of the layers approached the substrate lattice constant. That points to the fact that the deformations (strains) in the layers are connected with the mismatch between the lattice constants of the layer and the substrate. If the changes in the lattice constants had been connected with the discrepancy between the thermal expansion coefficients of the layer and the substrate, the PbSe layer must have had the lattice constant less than 6.126 Å, as the KCl substrate shrinks at cooling.

The epitaxial layers were monocrystalline. At the thickness of >100 nm, the dispersity with crystallites 100-300 nm in size was revealed, and the angular distance among them made up tenths of a minute, At the thickness of layers <100 nm, the texture appeared additionally, and the angular distance among the crystallites was already equal to tenths of a degree. Though even in this case the basic peak of the diffraction reflection shifted towards smaller angles as the layer thickness decreased, i.e. the tangential lattice constant increased.

As the layers stretched and the tangential lattice constant increased, respectively increased the forbidden gap width E_g , for the given thickness it increased from 338 to 432 meV. This means that the increment of the forbidden gap width made up 50% in respect to the unstrained PbSe layer ($E_g = 286 \text{ meV}$ at 300K). It should be noted that, when determining E_g by the transmission spectra, because of the reduction in the relaxation time of current carriers, in thin layers increases the absorption by free carriers. It is of interest to mention that functions of straightening $\alpha^2 = f(hv)$ and $(\alpha hv)^2 = f(hv)$ yield the same value of E_g [1]. The increases in the tangential lattice constant and the forbidden gap width in the strained layers of IV-VI semiconductors fit in with the notion of "negative" pressure. With its introduction, it is of interest to consider the problem of formation of the quasidielectric state. When Cr and In are used for doping the PbSe layers, their levels shift deep into the increased forbidden gap, electrically active nonstoichiometric defects are compensated and the concentration of current carriers decreases significantly[2]. Such an approach can be applied to a wide range of compositions of solid solutions of IV-VI compounds.

- A. M. Pashaev, O. I. Davarashvili, Z.G. Akhvlediani, M. I. Enukashvili, L. P. Bychkova, M. A. Dzagania. J. Mater Sci. Eng., 2012,2, 2.
- [2] O.I. Davarashvili, L.P. Bychkova, M.I. Enukashvili, M.A. Dzagania. Bulletin Nat. Acad. Sci. Georg., 2009, 35, 4, 479-484.

RED TO GREEN UPCONVERSION IN Ho³⁺, Yb³⁺ CODOPED LiKYF₅ CRYSTALS

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Excited at around 640 nm by a laser diode or by a tunable laser, the Ho^{3+} ions incorporated in low-phonon energy hosts are capable of emitting in the blue green range as well as in the near-infrared. In this work, we are interested in the green emission of Ho^{3+} , Yb^{3+} codoped LiKYF₅ crystal and in its excitation mechanism at around 640 nm, a wavelength seven hundred times more efficient than the near-infrared (974 nm) excitation wavelength.

The codoped crystals of composition LiKY_{0.97}Ho_{0.01}Yb_{0.02}F₅ were synthesized by hydrothermal method. They are of a good optical quality. Absorption and excitation spectra were recorded at room temperature. A number of peaks are present whose majority corresponds to transitions from the ⁵I₈ ground state to various multiplets of the Ho³⁺ ion, whereas the Yb³⁺ ion only gives three peaks located between 960 and 1000 nm. Room temperature emission spectra under different excitation wavelengths are also recorded in the range 300-800 nm.

Direct excitation into the GSA (${}^{5}I_{8} \rightarrow {}^{5}F_{5}$) band of Ho³⁺ leads to green (${}^{5}F_{4}$, ${}^{5}S_{2} \rightarrow {}^{5}I_{8}$) and blue (${}^{5}F_{3} \rightarrow {}^{5}I_{8}$) emissions. Their intensities plotted as a function of the excitation power show a quadratic dependence at low power suggesting that these emissions are generated by a sequential two-photon excitation process.

The corresponding fluorescence decays obtained after red excitation confirm that the emitting levels are populated through a two-step absorption process involving the reservoir level ${}^{5}I_{7}$.

ANNEALING EFFECT ON THE MICROSTRUCTURE AND PHOTOLUMINESCENCE OF Eu³⁺-DOPED GdVO₄ POWDERS

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Vanadates have potential applications in different light emitting and laser devices. They crystallize at room temperature, thus making possible the use of low temperature chemistry synthesis, avoiding typical agglomeration of nanoparticles at high reaction temperatures. Here we studied pure $GdVO_4$ and Eu^{3+} doped $GdVO_4$ (0.5, 1, 2 and 3at.% Eu³⁺) samples produced via precipitation synthesis route. As synthesized samples were annealed at different temperatures (300°C, 600°C, 800°C and 1000°C) for 2 hours, to improve their crystallinity. All XRD patterns could be indexed as tetragonal zircon structure. As-synthesized powders are composed of nanorods (diameter ~ 5 nm, length ~ 20 nm) organized in bundles, which by annealing grow to hexagonal crystals (50 to 100 nm in size). Energy band gap is calculated from the diffuse reflection spectra and obtained values in the range 3.1 eV - 3.3 eV give the evidence of quantum size effect for the as-synthesized nanostructures. Photoluminescence emission spectra were recorded using two different excitation wavelengths (330 nm and 466 nm), to excite directly the host matrix and Eu³⁺ ions, respectively. We analyzed in details the influence annealing temperature and concentration of Eu³⁺ ions on the optical properties (emission and excitation spectra and life time) of synthesized Eu^{3+} -doped GdVO₄ samples.

INFLUENCE OF CHLORIDE AND BROMIDE AGENTS ON THE LUMINESCENCE OF SILVER MOLECULAR CLUSTERS IN PHOTOTHERMOREFRACTIVE GLASSES

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Phototermorefractive (PTR) glass is a new photosensitive material that allows to precipitate silver molecular clusters (SMCs) under UV irradiation and metallic nanoparticles possessing surface plasmon resonance in local area of glass host by photo-thermo-induced crystallization. Also these silver nanoparticles can play a role of nucleation centers for growth of secondary crystalline phases (NaF, AgBr). The effect of chloride and bromide agents, as well as UV radiation dose, heat treatment time and temperature on luminescence and absorption spectra of SMCs in PTR glass was studied in present work.

In the work we investigated the PTR glasses of Na₂O-ZnO-Al₂O₃-SiO₂ system doped with photosensitive dopant of Ce³⁺ and different concentrations of Ag₂O (0.07 and 0.13 mol%). The glasses contain different type of halides (Br, Cl, F) with concentrations in the range (0 - 2 mol%). All PTR glasses were irradiated by UV radiation and some of them were heated at temperatures less than T_g .

It is shown that:

- UV radiation results in a formation of neutral SMCs, that have an absorption band within of 250-450 nm and a luminescence band in wide visible range of 400- 850 nm;

- the increase of silver content results in the strong increase of SMCs luminescence intensity (about 10 times);

- the increase of concentration of Br as well as Cl in the PTR glasses results in the increase of SNCs luminescence intensity;

- at same concentrations of halides the SMCs luminescence intensity in the PTR:Br glasses is higher than PTR:Cl glasses. The maximum of SMCs luminescence band for PTR:Br glasses is shifted to a long wavelength spectral range in comparison with PTR:Cl glasses;

- UV radiation and the following heat treatment of PTR:Br and PTR:Cl glasses increases luminescence intensity of SMCs.

Mechanisms of influence of chloride and bromide agents and low temperature heat treatment on luminescence of SMCs have been discussed.

LUMINESCENT GLASSES WITH SILVER MOLECULAR CLUSTERS FOR DOWN-CONVERSION OF RADIATION IN SOLAR CELLS

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The highest possible transformation effectiveness of entire solar spectrum into electricity is the main requirement for solar cells. However, the efficient spectral gap of photoelectric converters (PC) is limited. The use of cascaded PCs in which every cascade element transforms a fraction of solar spectrum dramatically affects the complexity of a solar cell. One of the possible solutions to this problem implies spectral transformation of long-wave and short-wave radiation of the Sun into the spectral range of maximum PC effectiveness. For long-wave radiation transformation up-conversion in media containing rear-earth metal ions can be used. The down-conversion of short-wave radiation may be implemented in luminescent media, in particular, luminescent glasses with silver molecular clusters (SMC). The main requirements for these glasses are the following: high luminescence brightness in the range of PC maximum effectiveness, wide luminescence excitation band in violet and ultraviolet spectral regions and low absorption coefficient in the visible range.

In this work oxy-fluoride and silicate glasses containing neutral SMC Ag_n (n = 1-4) have been studied. The research has shown that the SMC luminescent bands lay in the spectral area of maximum effectiveness for a PC based on amorphous silicon.



1 – solar spectrum at sea level; 2 - PC based on amorphous silicon effectiveness as a function of wavelength; 3 - luminescence excitation spectrum; 4, 5 – SMC luminescence bands in oxy-fluoride glass ($4 - \lambda_{ex} = 365 \text{ nm}$, 5 - $\lambda_{ex} = 405 \text{ nm}$).

Luminescence excitation band lies in the spectral range of 350-450 nm peaking near 400 nm. Excitation wavelength reduction leads to short-wave shift of luminescence bands.

LUMINESCENT OPTICAL WAVEGUIDES WITH SILVER MOLECULAR CLUSTERS

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Planar and strip waveguides are of interest as radiation sources in integral optics and sensors. Previous research has shown that glasses containing silver molecular clusters (Ag_n, n=1-4) have bright luminescence in the spectral range 500-650 nm. The main objectives of the present work have been the study of waveguide modes excitation efficiency in a gradient planar waveguide that possesses luminescent properties, and also of how external influences – temperature and IR radiation – affect luminescence. In the work luminescent properties of planar waveguides containing silver molecular clusters grown in silica glass using ion exchange [1] have been studied. The glasses contained a photosensitive component – Ce ions and a reducer – Sb ions [2]. The waveguide thickness was between 20 and 60 microns, length – between 5 and 10 mm. Silver molecular cluster luminescence was excited by 365 and 405 nm radiation.

The research has shown that luminescence in the waveguides occurs directly after ion exchange. It indicates that partial reduction of Ag atomic and molecular ions takes place in the waveguide during the ion exchange. After the exposure to 309 nm UV irradiation that lies in Ce ions absorption band luminescence brightness considerably increases. The captured luminescence radiation leads to formation of a number of waveguide modes. Infrared (800-1000 nm) and temperature exposure leads to reduction of luminescence intensity. Continuous thermal treatment at the temperature above 500 $^{\rm OC}$ causes long-wavelength shift of the luminescence band and reduction of its intensity. The origin of this effect is silver nanocrystal formation due to Ag atoms concentration on silver molecular clusters as a result of thermal diffusion.

[1] A. Tervonen, B. R. West, S. Honkanen, Optical Engineering 50 (2011) 71-107.

[2] Silver nanoparticles, ed. by D.P. Perez., In-Tech, Vukovar, 2010

THE EFFECTS OF LITHIUM AND ERBIUM CODOPED ZnO ON THE STRUCTURAL AND CATHODOLUMINESCENT PROPERTIES OF ZnO THIN FILMS PREPARED BY SPRAY PYROLYSIS

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Lithium and Erbium codoped Zinc oxide thin films have been successfully deposited on heated glass substrates using spray pyrolysis technique. This study is an investigation of the Li effect on the enhancement of Cathodoluminescent (CL) intensity on the Er monodoped. Crystallinity, morphology and luminescence characteristics were investigated in detail by X-Ray Diffraction (XRD); Scanning Electron Microscopy (SEM) and Cathodoluminescent (CL). The Li-Er codoped ZnO films show higher intensity of blue and red emissions than the Er monodoped ZnO films. The behaviour of that enhancement is attributed to the modification of the local symmetry of the Er3+ ion, which increases the intra 4f transition of Er3+ ion. The blue and red emissions have an important effect to improve the capacity of data storage.

INFLUENCE OF THE ZIRCONIUM CONCENTRATION AS CODOPING AGENT ON THE OPTICAL PROPERTIES OF EUROPIUM DOPED ZnO THIN FILMS

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Recently, Zinc Oxide (ZnO), as a future materiel, has attracted much attention from scientific community. With a wide band gap of 3.4 eV and large exciton binding energy of 60 meV, it has been studied since 1935. ZnO has improved its importance for blue and ultra violet optical devices. It will be a promising candidate semiconductor materiel for the new generation of optoelectronic materials. These applications are either dependent upon, or are affected by, impurities and defects. Moreover, rare earth (RE) elements in wide band gap semiconductors would be useful in optoelectronic applications.

Highly transparent thin films of ZnO doped with europium and codoped with zirconium have been prepared by reactive chemical pulverisation spray pyrolysis technique. The influence of Eu and Zr as doping and codoping agents on the structural and optical properties of ZnO thin films was carefully investigated. These films were studied using X-ray diffraction Photoluminescence and THG measurement. All the films obtained are transparent in the visible region (85%). The X-ray diffraction analysis indicates that all films are polycrystalline in nature and clearly shows the appropriate incorporation of Er and Zr atoms in the ZnO films. The dopants impurities introduced into the ZnO nanostructures can modulate the local structure and cause the dramatic change luminescence mechanisms.
DETERMINATION OF THERMALLY STIMULATED LUMINESCENCE CHARACTERISTICS OF GLOW CURVES IN YTTRIYUM BASED PHOSPHORS

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Determination of thermally stimulated luminescence (TSL) chracteristics of glow curves is an important area for thermoluminescence dosimetry (TLD) researchs.

In this study, Yttriyum based phosphors were prepared by solid state reaction, from homogeneous mixture consisting of Y_2O_3 , Eu_2O_3 , Tb_4O_7 , Ta_2O_5 , Nb_2O_5 , and Na_2SO_4 as flux. Thermally stimulated luminescence (TSL) of phosphors were reported. TSL characteristics of those phosphors were investigated and reported after exposure to β irradiation, UV (310 nm) illumination and X-ray irradiation in the present study.

Due to valuable features of yttriyum based phosphors, like as high sensitivity to UV, β and X-ray irradiation, stability, repeatability, linear dose response, these innovative phosphors are promising to improve TLD materials

 E.C. Karsu, E. J. Popovici, A. Ege, M. Morar, E. Indrea, T. Karali, N. Can, Luminescence Study of Some Yttriyum-tantalate Based Phosphors, Journal of Luminescence, 131, 1052–1057, 2011

BAND INTERACTION, BAND MIXING AND NONPARABOLICITY EFFECTS IN Hg_{1-x}Cd_xTe/CdTe QUANTUM WELL LASERS

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We present a **k.P** theoretical study of energy band interactions, band mixing and nonparabolicity effects in $Hg_{1-x}Cd_xTe/CdTe$ quantum well Lasers and their influence on electronic and optical properties of this system.

In this purpose, we use and compare various parabolic and nonparabolic effective-massbased models by taking into account energy band interactions around the Brillouin zone centre and the respective contributions of the lowest conduction band states (BC) together with the top 3 valence band states heavy (HH), light (LH) and spin-orbit (SO) split-off hole bands.

The nonparabolic models are based on Luttinger-Kohn H[NxN] multiband **k.P** formalism [1,2] where N is the number of bands involved (N=4,6 or 8 including spin degeneracy).

We show that 8-band Luttinger-Kohn H[8x8] multiband **k.P** model is the more accurate model in describing the band interactions, band mixing and band nonparabolicity effects in $Hg_{1-x}Cd_xTe/CdTe$ quantum well Lasers in the whole alloy composition range.

We show the strong influence of the nonparabolicity and the band mixing which increases with decreasing alloy x in $Hg_{1-x}Cd_xTe/CdTe$ quantum well as a result of the energy band gap reduction.

These effects appear as a significant red shift (increase) of the fundamental laser emission wavelength λ .

Our results show that the nonparabolicity and the band mixing effects induce significant corrections which must be taken into account in $Hg_{1-x}Cd_xTe/CdTe QW$ laser design.

- [1] J.M. Luttinger and W. Kohn, Phys. Rev. 97, 869 (1955)
- [2] J.M. Luttinger, Phys. Rev.102, 1030 (1956)

TUNING THE ELECTRONIC PROPERTIES OF NATURALLY NANOSTRUCTURED COMPOUNDS

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Advanced nanostructured materials with variable functionalities are indispensable part of modern materials science. In particular, compounds with nanopores and -channels (e.g. zeolites) enable easy tuning of their electronic properties by changing the ionic content of those nanospaces. Since 2002 extensive investigation of electronic properties of 12CaO·7Al₂O₃ (C12A7) compound has been carried out, when conversion of this insulating oxide into electronic conductor was demonstrated [1]. It is now well established that highly variable properties and the resulting functionality of C12A7 is due to its unique crystal structure. Its unit cell consists of 12 positively charged (+4 per unit cell) interconnected cages with an inner free space of ≈ 0.4 nm diameter. Various negative ions (O^2 , O, OH, H, F, C[, etc) can be incorporated up to very high concentrations ($\approx 2.3 \times 10^{21}$ /cm³) inside these cages to maintain charge neutrality of this highly flexible lattice, resulting in notable changes in the electronic properties of C12A7. Another class of materials well suited for materials engineering are apatites with hexagonal crystal structure and possessing open channels along the hexagonal axis. Analogously to C12A7 the electroneutrality of apatite crystals is provided by variable anions in these channels. Two of Ca-phosphate apatites $Ca_{10}(PO_4)_6(X)_2$ (X=OH, F) are obviously the most well-known, because these are the main inorganic constituents of all mammalian bones and teeth. In our previous works the energy gap value of stoichiometric C12A7 (≈ 6.8 eV) was determined and excitonic effects occurring were investigated by various luminescence spectroscopy methods [2,3]. For Ca-phosphate apatites, despite of very high potential for various applications (e.g. biocompatible compounds and light emitting materials), some basic optical properties (even energy gap width) remain still to be investigated.

In order to fill this gap of knowledge, we have undertaken a systematic study of these naturally nanoporous materials. Several methods, solid state and combustion synthesis, were used to prepare these materials in the form of powders or ceramics. Cathodoluminescence and time resolved vacuum ultraviolet (VUV) luminescence spectroscopy was exploited in studies carried out at the SUPERLUMI station of HASYLAB at DESY (Hamburg, Germany) and the FINEST branch-line at MAX-Lab (Lund, Sweden). In our present study the possibility for tuning band gaps in VUV spectral range will be demonstrated. Recorded afterglow creation and luminescence excitation spectra under VUV excitation enabled us to conclude that the replacement of O^{2-} ions with F⁻ in the cages of C12A7 shifts the onsets of host absorption from $\approx 6.8 \text{ eV}$ to $\approx 5.8 \text{ eV}$ and from $\approx 7.8 \text{ eV}$ to $\approx 8.4 \text{ eV}$ in the case of replacement of OH⁻ with F⁻ in the channels of Ca-phosphate apatites. The O²⁻ ions inside cages of C12A7 form the dominating trapping centres for valence band holes and their replacement with electrons or F⁻ ions facilitates efficient self-trapping of holes at the framework oxygen ions. The peculiarities of relaxation processes of intrinsic electronic excitations were analyzed taking into account published band structure calculations.

- [1] K. Hayashi, S. Matsuishi, T. Kamiya, M. Hirano, H. Hosono, Nature 419 (2002) 462.
- [2] E. Feldbach, V.P. Denks, M. Kirm, et al, J. Mater. Sci.: Mater. Electron. 20 (2009) S260.
- [3] E. Feldbach, V.P. Denks, M. Kirm, K. Kunnus, A. Maaroos, Radiation Meas. 45 (2010) 281.

OPTICAL PROPERTIES OF Er³⁺, Yb³⁺, Tm³⁺ AND Dy³⁺ DOPED CERAMIC, PHOSPHATES AND FLUOROINDATE GLASSES

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Of the many potential applications having rare earth ions (RE) immersed in various organic and inorganic materials, one of the problems limiting for its use in the visible and infrared range has been the high rate of non-radiative relaxation in materials with high phonon frequency. To better exploit the optical properties of rare earth ions, we are seeking host materials in which the phonon frequency are comparable to those of the crystals, to reduce non-radiative transitions of RE ions immersed in them. We are presently working with ceramic glasses, and through heat treatment, growing nanocrystals around of the RE ions in order to lower the phonon frequency, and so decrease the non-radiative relaxation in these host materials^[1]. For specific applications, is necessary to vary the concentrations in the materials which are immersed the RE ions, and them optimize the concentrations of these ions, as single doping or as co-doping for obtain the better optical behavior. Samples of glass ceramic oxyfluorides, phosphates and fluoroindatos, with different concentrations of Er³⁺, Yb³⁺, Tm³⁺ and Dy³⁺were prepared. Through dilatometry technique, Tg was obtained for ceramic samples, and with a heating systematic, nano-crystals were grown in different sizes, which are associated with the RE ion concentration and time of heat treatment, also show good homogeneity and optical quality. Furthermore, through X-ray diffractograms, absorption and emission spectroscopy at room temperature was accompanied the evolution of crystal growth. Any transitions have been identified into 4f^N configuration. and optimized the concentration of ions to obtain the best behavior in order to evaluate its potential application, for example, temperature sensors and silicon solar cells. From absorption spectra information, Judd-Ofelt model[2,3] is used for calculate characteristic optical parameters of the RE ion, to identify different spectral ranges that are associated with the solar spectrum, and potential transitions that can be used in upconversion and down-conversion processes, and photoluminescence, focused its application in solar cells, for increase its efficiency[4]. Also have been identified and analyzed, energy gaps of relaxation non-radiative, which can be transformed into radiative transitions, reducing the frequency phonon in ceramic materials. In-same way, with the results of emission spectroscopy in co-doped samples, the lifetimes of selected transitions, are evaluated potential applications in temperature sensors. The results are consistent with those reported in recent literature, and present great possibilities for technological application.

- [3] G. S. Ofelt, J. Chem. Phys. 37 (1962) 511
- [4] C. Strümpel, M. McCann, G. Beaucarne, V. Arkhipov, A. Slaoui, V. Svrcek, C. del Cañizo, I. Tobias, Solar Energy Materials & Solar Cells 91 (2007) 238–249

V. K. Tikhomirov, K. Driesen, C. Görller-Walrand, and M. Mortier, Optics Express, Vol. 15, No 15(2007)9335

^[2] B.R. Judd, Phys. Rev. 127(1962) 750

RAMAN SCATTERING FROM ZnO(Mn) NANOPARTICLES

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Nanocrystaline samples of ZnO(Mn) were synthesized by wet chemical method. Samples were characterized by X-ray diffraction to determine composition of the samples (ZnO, Mn_3O_4 , $ZnMn_2O_4$ and $ZnMnO_3$) and the mean crystalline size (from 9 to above 100 nm). In this paper we report the experimental spectra of Raman scattering (from 200 to 1600 cm⁻¹). Main characteristic of experimental Raman spectrum in 200 to 1600 cm⁻¹ spectral region are: sharp peak at 436 cm⁻¹ and broad multi phonon structure at ~ 1150 cm⁻¹, typical for ZnO; sharp peak at approximately 653 cm⁻¹ typical for spinel structures as it is Mn_3O_4 nanoparticles.

NANOSTRUCTURED Er³⁺/Yb³⁺ CO-DOPED SiO₂-Nb₂O₅ PLANAR AND CHANNEL WAVEGUIDES FOR PHOTONICS

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The growing demand for faster internet and telecommunication networks has aroused researcher's interest in materials for photonic applications. Over the last years, erbiumdoped materials such as Erbium-Doped Fiber Waveguide Amplifiers (EDFAs) and Erbium-Doped Planar Waveguide Amplifiers (EDPWAs) have received increasing attention, especially for use in integrated photonic systems. The development of planar integrated circuits allows combination of properties like switching, guiding, wavelength-division multiplexing (WDM), splitting, and light amplification, among others. In this sense, the study of optical properties of rare-earth doped thin films represents a fundamental step in the development of new active components such as optical amplifiers. This paper reports on the structural and optical characterization of new $\text{Er}^{3+}/\text{Yb}^{3+}$ co-doped (100-x)SiO₂-xNb₂O₅ planar and channel waveguides deposited on SiO₂/Si and Si(100) substrates by dip-coating. The waveguides exhibited uniform refractive index, efficient light injection, and low losses at 1538 nm. Channels with an excellent surface profile were fabricated by focusing a femtosecond laser onto the films surface. In parallel, the sols were annealed at 900, 1000, and 1100°C, to get the nanocomposites. X-ray diffraction, HRTEM, Raman, and FTIR were employed for densification and crystallization processes investigations. Crystallization accompanying host densification was identified with orthorhombic (T-phase) or monoclinic Nb₂O₅ nanocrystals dispersed in the amorphous SiO₂ phase, depending on the niobium content and annealing temperature. Enhanced NIR luminescence of the Er³⁺ ions was observed for the Yb³⁺ co-doped planar samples, indicating efficient energy transfer from the Yb³⁺ to the Er^{3+} ions, as well as, a broad bandwidth, which can be explained by the occupation of distinct symmetry sites by the lanthanide ions and the large number of distinct sites observed in the Nb₂O₅ complex crystalline structure. A broader bandwidth was achieved for the materials containing the T-phase, which also displayed higher luminescence intensity and longer ${}^{4}I_{13/2}$ lifetime. The upconversion dynamic was also investigated as a function of the Nb2O5 content and annealing. Based on the upconversion emission spectra and 1931CIE chromaticity diagram, it is shown that color can be tailored by composition and pump power. The glass ceramic films are attractive materials for photonic applications in optical amplifiers and WDM devices, as well as in upconversion lasers and near infrared-to-visible upconverter in solar cells.

LUMINESCENT PROPERTIES OF SALTS BASED ON 3-CYANO-4-DICYANOMETHYLENE-5-OXO-4,5-DIHYDRO-1H-PYRROLE-2-OLATE ANION AND INORGANIC CATIONS

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Physical properties of organic and metalorganic compounds are defined by i) electronic structure of a key molecule and ii) intermolecular contacts between a key molecule and its molecular environment. Consequently in order to engineer a new substance with needed property one can:

-change electronic structure of a key molecule by means of chemical modification;

-alter interactions between a key molecule and its molecular environment.

Our investigations revealed that for new organic 3-cyano-4-dicyanomethylene-5-oxo-4,5dihydro-1H-pyrrole-2-olate anion (HA⁻) it is possible to vary both luminescence maximum wavelength (in spactral range starting from UV to Red) and luminescence intensity by means of altering intermolecular contacts (π - π stacking, hydrogen bond, coordination bond with transition metal cation) between HA⁻ and surrounding molecules [1-4].

In first part of our work we dealt with an effect of intermolecular contacts on wavelength of HA⁻ luminescence. Our investigations [2, 3] showed that

- in crystal a) shortening of distance between neighboring anions HA⁻ in stack causes a bathochromic shift of luminescence spectrum maximum; b) hydrogen bonding between adjacent HA⁻ anions causes hypsochromic shift of luminescence spectrum maximum.

- in solution a) increase in solvent dielectric constant causes a bathochromic shift of luminescence spectrum maximum.

In second part of our work we dealt with an effect of intermolecular contacts on intensity of HA⁻ luminescence. Our research showed that

- in crystal a) coordination bond with *d*-row metal cation with incomplete *d*-electron shell (Cu^{2+}, Mn^{2+}) causes liminescence quenching of HA⁻; b) coordination bond with *d*-row metal cation with complete *d*-electron shell (Zn^{2+}, Cd^{2+}) doesn't quench liminescence of HA⁻.

- in solution a) addition of Cu^{2+} to HA⁻ in acetonitrile causes 100-fold increase in luminescence intensity of HA⁻ (without spectrum shift); b) addition of other *d*-row metal cations (Cd²⁺, Zn²⁺, Ni²⁺, Co²⁺, Mn²⁺) doesn't influence luminescence spectrum of HA⁻.

Based on electrospray-mass-spectrometry, quantum-chemical calculations and literature data we proposed a model explaining HA⁻ luminescence enhancement by copper(II) cations [4].

- Tafeenko V.A., Panin G.N., Baranov A.N., Bardasov I.N., Aslanov L.A. Luminescent properties of three structures built from 3-cyano-4-dicyanomethylene-5-oxo-4,5-dihydro-1H-pyrrol-2-olate and cadmium // Acta Cryst., C63 (2007), m541-m547.
- [2] Tafeenko V.A., Gurskiy S.I, Baranov A.N., Kaisarova T.V., Aslanov L.A. Luminescence properties of three structures built from 3-cyano-4-dicyanomethylene-5-oxo-4,5-dihydro-1H-pyrrol-2-olate and alkaline metals (Na, K and Rb) // Acta Cryst., C65 (2009), m52-m55.
- [3] Tafeenko V.A., Gurskiy S.I., Fazylbekov M.F., Baranov A.N., Aslanov L.A. Luminescence properties of the structure built from 3-cyano-4-dicyanomethylene-5-oxo-4,5-dihydro-1H-pyrrol-2olate and caesium(I) // Acta Cryst., C66 (2010), m32-m34.
- [4] Gurskiy S.I., Tafeenko V.A. The luminescent properties of structures built from 3-cyano-4dicyanomethylene-5-oxo-4,5-dihydro-1H-pyrrole-2-olate and copper(I,II) cations // Cryst. Eng. Comm, 14 (2012), p. 2721-2731.

LUMINESCENCE AND PHOTODESTRUCTION OF SILVER NANOCLUSTERS AND NANOPARTICLES IN PHOTOTHERMOREFRACTIVE GLASS

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Phototermorefractive (PTR) glasses are perspective material for highly efficient volume phase holograms recording. PTR-glasses allow to precipitate silver nanoclusters (SNCs) under UV irradiation and metallic nanoparticles possessing surface plasmon resonance (SPR) in local area of glass host by photo-thermo-induced crystallization. Also these silver nanoparticles can play a role of nucleation centers for secondary crystalline phases (NaF, AgBr) precipitation. The luminescence and absorption spectra of SNCs and silver nanoparticles during their formation and photodestruction in PTR glass was studied in present work. It is shown that:

- the virgin PTR-glass has no luminescence in the visible range;

- UV exposure of virgin PTR-glass resulted in formation of SNCs in the glass host and appearance of additional absorption in range of 250-500 nm. These SNCs resulted in appearance of intensive luminescence in the wide spectral range of 450-950 nm with maximum near 550 nm at laser excitation at 405 nm;

- the following heat treatment at temperature near Tg= 495° C resulted in growth of silver nanoparticles with appearance of absorption band in spectral range of 450-550 nm with maximum near 455 nm (SPR) and full luminescence quenching.

- the irradiation of SNCs with the use of pulse (10 ns) laser radiation (532 nm) resulted in the small reduction of additional SNCs absorption and strong reduction of luminescence intensity. It can be explained by partial photoionization process of SNCs with formation of silver ions;

- the irradiation of silver nanoparticles with the use of pulse (10 ns) laser radiation (532 nm) resulted in the SPR absorption band reduction until its diapeared. This effect depends on the exposure dose. At the same time the luminescence band appears in spectral range of 550- 850 nm with maximum near 650 nm.We made a conclusion that the pulse laser irradiation resulted in photofragmentation of nanoparticles with creation of atoms, clusters, and small particles as well as photoionisation of atoms with creation of silver ions.

FLUORESCENCE INVESTIGATION OF CdSe-DOPED SiO₂-P₂O₅ SOL-GEL FILMS

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In the present work, $SiO_2-P_2O_5$ films doped with CdSe were prepared and investigated for temperature sensors applications. The films were synthesized by sol-gel method, the sol being spin coated on glass substrates. The sols were prepared from tetraethoxysilane and phosphoric acid as precursors for SiO₂ and P₂O₅, respectively together with ethanol and water as reaction environment and hydrolysis reagent, respectively [1, 2]. The films were deposited at three rotation rates: 1000 rpm, 2000 rpm and 3000 rpm, starting in the first day after the sol preparation moment and going on, several days, till the gelification took place. The films deposited at each rotation rate were annealed at different temperatures up to 900°C in order to investigate the influence of the thermal treatment on the fluorescence features. Further fluorescence investigations in the range 20-150°C were made for thermal treated samples and their sensing capacities were evaluated.

- M. Elisa, B. A. Sava, A. Volceanov, R. C. C. Monteiro, E. Alves, N. Franco, F. A. Costa Oliveira, H. Fernandes, M. C. Ferro, J. Non-Cryst. Solids, 356 (2010), 495-501
- [2] I. C. Vasiliu, M. Gartner, M. Anastasescu, L.Todan, L. Predoană, M. Elişa, C. Negrilă, F. Ungureanu, C. Logofătu, A. Moldovan, R. Bîrjega, M. Zaharescu, *Thin Solid Films*, 515 (16) (2007), 6601-6605

SYNTHESIS AND CHARACTERIZATION OF Ln₂TeO₆ AS HOST STRUCTURE FOR INORGANIC PHOSPORS DOPED WITH Eu³⁺

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Nanocrystalline Ln_2TeO_6 (Ln = Y, La, Sm, Gd) have been prepared by a Pechini sol–gel process using lanthanide nitrates and telluric acid as precursors. All sampleswere characterized by X-ray diffraction (XRD), atomic force microscopy (AFM), Raman and Fourier transform infrared spectroscopy (FT-IR), as well as thermogravimetric analysis (TG). The AFM study reveals that the samples consist of particles with average crystal size ranging from 70 to 110 nm. The results of X-ray diffraction indicate that Ln2TeO6 (Ln = Y, La,Sm, Gd) crystallize isotypically with the orthorhombic La₂TeO₆ in the space group $P2_12_12_1$. The infrared and Raman spectra show that the TeO₆ groups are independent vibrating groups and the results obtained were discussed on the basis of the site symmetry analysis derives from the structural data.

 $La_2TeO_6:Eu^{3+}$ nanophosphors were prepared by Pechini sol-gel process, using lanthanide nitrates and telluric acid as precursor

On the other hand, the optical properties of the inorganic phosphors were studied. The photoluminescence intensity and chromaticity were improved for excitation at 254 and 395nm. Theoptimized phosphor $La_{1.90}Eu_{0.10}TeO_6$ could be considered as an efficient redemitting phosphor for solid-state lighting devices based on GaN LEDs.

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- [1] Justel T., Nikols H. and Ronda C., Agew. Chem. Int. Ed. 37 (1998) 3084
- [2] Quang Y.Q. and Steckle A.J., Appl. Phys. Lett. 82 (2003) 502
- [3] Llanos J. and Castillo R. J.Lumin 130 (2010) 1124
- [4] Höppe H.A. Angew.Chem.Int.Ed. 48 (2009) 3572

SPECTROSCOPIC STUDY OF A FLUORIDE CRYSTALS DOPED WITH PRASEODYMIUM IONS (Pr³⁺)

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Rare earth-doped fluoride single crystals are considered to be an important class of optical device materials due, mainly, to their low phonon energies. They play a very significant development of laser amplifiers optical role in the for communications. Among the rare earth, trivalent praseodymium ions (Pr^{3+}) have potential for laser applications due to a large number of available energy levels in the visible and near infrared domains. Recently, it has been used for laser operation in fluoride and glass fiber hosts [1].

We have studied the optical properties of Pr^{3+} doped KYF₄ and KY₃F₁₀ single crystals from the KF – YF₃ pseudo-binary system. Room temperature absorption spectra were recorded in order to investigate spectroscopic properties by using the Judd-Ofelt (JO) analysis. The emission spectra, associated to ${}^{3}P_{1}$, ${}^{3}P_{0}$ and ${}^{1}I_{6}$ to ${}^{3}H_{6}$ and ${}^{3}F_{2}$ levels, have been also registered between 560 and 700 nm. They have been calibrated in emission cross-sections using the usual Fuchtbauer-Ladenburg formula. We have also determined the ${}^{3}P_{0}$ fluorescence lifetime to be compared to the radiative lifetime given par the JO calculation.

[1] A. Richter, E. Heumann, E. Osiac, G. Huber, W. Seelert, A. Dieninng, Opt. Lett. 29 (22) (2004) 2638

SPECTROSCOPIC PROPERTIES OF Eu³⁺ IN THE Mg₂Si₅Al₄O₁₈ CORDIERITE POLYCRYSTALLINE POWDERS

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Europium doped cordierite powder has been prepared by a sol-gel method. Cordierite belongs to the cycloaluminosilicates group and its chemical formula is $Mg_2Si_5Al_4O_{18}$. It crystallizes in a hexagonal crystal system with a space group P6/mcc¹.

Formation of the crystalline cordierite phase as well as estimation of the mean crystallite size has been followed by the X-ray powder diffraction technique. HR-TEM microscopy has been employed in order to study morphology of the resulting products, their particle aggregation as well as grain size and its distribution. Spectroscopic behavior i.e. excitation and emission spectra as well as emission kinetics of the Eu³⁺ doped cordierite has been studied in details and discussed in terms of dopant concentration. Preliminary studies revealed that decay time profile of sample with 1% of Eu³⁺ has a diexponential character with two components (1.55 μ s and 0.4 μ s). Zero phonon line of emission (${}^{5}D_{0} \rightarrow {}^{7}F_{0}$) indicates also two sites of europium in obtained host lattice.



Fig 1. The 300 K emission spectrum of Mg₂Si₅Al₄O₁₈: Eu³⁺ (1%), $\lambda_{exc} = 266$ nm. In the inset decay time profile of emission monitored at λ_{obs} =615nm.

[1] P.Predecki, J.Haas, J. Faber, R.L.Hitterman, J. Am. Ceram. Soc., 70 (1987) 175, Acknowledgements

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LUMINESCENCE PROPERTIES OF TWO-COMPONENT CRYSTALS WITH FLUORITE-TYPE STRUCTURE

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Crystals MF₂ (M = Ca, Sr, Ba) with fluorite-type structure are widely use for many applications. The search of the new materials with the required properties is a complication of its chemical composition. In binary systems MF₂-M'F₂ (M, M' – alkaline earth elements) the isovalent solid solutions $M_{1-x}M'_xF_2$ are formed. Two-component $M_{1-x}M'_xF_2$ (0 < x < 1) crystals were taken as the subject of this investigation. It is caused by interest to Ca_{1-x}Sr_xF₂ solid solution crystals as optical materials [1, 2] and its possible application as scintillator materials and for study physical processes in mixed cation solutions. Crystals were grown by Bridgman technique [3].

We carried out investigations of optical (reflectance) and luminescence (luminescence, luminescence excitation spectra, time decay) properties at RT and LHT in the region of energies of photon from the edge of the fundamental absorption ($hv \leq E_g$) to the multiplication of excitation region ($hv \geq 2E_g$) at the SUPERLUMI station (HASYLAB, Hamburg, Germany) [4]. Also, luminescence properties with energy of photon $hv > 10E_g$ and with high intensity of exciting flow were investigated at experimental station at BW3 beam-line (HASYLAB, Hamburg, Germany). Investigations were carried out both for the undoped M_{1-x} M'_xF_2 (M, M' = Ca, Sr, Ba) crystals and for doped with Ce³⁺ ions which are in possession of fast luminescence.

For all crystals the intense intrinsic luminescence (bands situated at approx. 3.5 - 5.5 eV) of coexistence singlet (LHT) and triplet (RT, LHT) self-trapped excitons (STE) revealed (see e. g. [5]). For barium-containing crystals additionally revealed cross-luminescence, which is typical for BaF₂ crystals. Crystals doped with trivalent ions of cerium show intensive luminescence, attributed to interconfigurational 5d –4f transitions in Ce³⁺ ions, in the 3 – 4 eV region. Intensity of Ce³⁺ luminescence is several times greater than for STE luminescence. With cation proportion variation from Sr²⁺ to Ca²⁺ the changing of energy gap width is occurring, that revealed in shifting of excitonic peak in reflectance spectra. In addition, with cation proportion variation, were observed the changing of Ce³⁺ luminescence band position.

[1] A. Kaminskii, R. Mikaelyan, I. Zygler, Phys. Status. Solidi B. 31, No 2, 85, (1969).

- [3] D.N. Karimov, O.N. Komar'kova, N.I. Sorokin, et. al., Crystallography Reports. 55, 518 (2010).
- [4] G. Zimmerer, Radiation Measurements. **42**, 859 (2007).
- [5] J. Becker, M. Kirm, V.N. Kolobanov, et. al. Proc. Of The Third International Conference on Excitonic Processes In Condensed Matter EXCON'98. 98-25, 415.

^[2] T. Basiev, S. Vasil'ev, M. Doroshenko, et al., Quantum Electronics, 37, No 10, 934 (2007) (in russian).

PECULIARITIES OF OPTICAL AND LUMINESCENT PROPERTIES OF LANTHANUM – GALLIUM TANTALATE CRYSTALS

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Lanthanum – gallium tantalate crystal $La_3Ga_{5.5}Ta_{0.5}O_{14}$ (langatate - LGT) is a crystal from the lanthanum – gallium silicate family. The space group of symmetry is P321. Crystals from this family are grown by the Czochralski method.

Currently, the data of langatate luminescent properties are slightly investigated. Thereby the main object of this paper is the complex investigation of the influence of single crystal obtaining conditions (the growth atmosphere) on optical and luminescent properties of LGT crystals.

The experiment required using the polar cut samples made from crystals grown in the athmospheres of argon (Ar) and of argon with oxygen $(Ar+O_2)$. The influence of different growth atmospheres on optic transmission spectra of LGT crystals was investigated [1]. Decrease of oxygen concentration in growth atmosphere of crystal leads to the considerable improvement of their optical characteristics. Crystals grown in Ar atmosphere are almost colorless, while those grown in $(Ar+O_2)$ atmosphere are of bright orange color.

Results of the first obtained luminescent properties of langatate single crystals grown in different atmospheres were investigated. The luminescence was excited with third harmonic of YAG:Nd³⁺ laser with energy of 2mJ. Wide emission spectra were observed with a maximum at ~450 nm. Increasing of oxygen concentration in growth atmosphere luminescent intensity decreases.

Isothermal annealing was carried out at temperatures from 500 0 C to 1000 $^{\circ}$ C with an increment of 100 $^{\circ}$ C, each sample was held within 4 hours at only one temperature in the air. The samples were annealed at 1000 $^{\circ}$ C in vacuum. Annealing in different atmospheres leads to opposite results: in air coloration became more intensive, in vacuum crystals became colorless. All samples were investigated with methods of optical spectroscopy, diffuse reflection spectroscopy, optical microscopy, atomic force microscopy, X-ray photoelectron spectroscopy before and after annealing. The luminescent properties of the same samples were investigated. Influence of annealing on luminescence intensity is not significant.

Anisotropy of absorption centres was observed in all investigated samples. Obtained results are evidence of isothermal annealing having a profound effect on both optical properties and surfaces states of polar cuts of $La_3Ga_{5.5}Ta_{0.5}O_{14}$ crystals. It depends on the growth atmosphere. A significant effect of the growth atmosphere and annealing temperature on optical and luminescent characteristics of langatate crystals is revealed.

[1] Optical properties of Lanthanum – Gallium Tantalate at Different Growth and Post-Growth Treatment Conditions/ O.A. Buzanov, E.V. Zabelina, N.S. Kozlova //Crystallography Reports. – 2007. – Vol. 52. - № 4. – pp. 691-696.

PREPARATION OF OF Re₂O₃ (Re=Y, Lu) NANOPOWDERS AND OPTICAL CERAMICS

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Rare-earth oxides RE_2O_3 (RE=Y, Lu) optical ceramics with different rare-earth dopants are promising luminescent and laser materials. It is necessary to use appropriate starting nanopowders to obtain high-quality optical ceramics. Commercial nanopowders usually do not satisfy to all the requirements so several laboratory techniques have been developed to manufacture highly sinterable Y_2O_3 and Lu_2O_3 powders. We paid special attention to agglomeration of these oxides' nanopowders prepared by chemical precipitation because agglomerates formation is one of the most important reasons spoiling the regular packing of nanoparticles in compacts for ceramics sintering and inducing high pores concentration and additional optical losses in the ceramics. Two methods of chemical precipitation of initial precursors were compared: heterogeneous precipitation with starting water solutions of nitrates, chlorides and sulfates and ammonia (ammonium hydroxide or ammonium bicarbonate) as precipitating agent, and homogeneous precipitation with Y or Lu chloride added to urea solution. The maximum nanoparticles agglomeration at heterogeneous precipitation was found in nitrates solutions, with 3-dimensional agglomerates many microns in size, it was lower in chlorides and sulfates solutions. In all cases the initial nanoparticles have similar size and shape, mainly, quasispherical form with diameter 50-80 nm. Agglomeration is connected with formation of strong hydrogen bonds between nanoparticles during the precipitation process. By that the bonds system is conserved during subsequent high temperature heat treatment of precursors, and oxides nanopowders are fully agglomerated already after heating above 1000 °C for some minutes.

At low salt concentration spherical oxides nanoparticles can be obtained by homogeneous precipitation with rather sharp size distribution in 200-300 nm range or with bimodal distribution with smaller particles under 100 nm, depending on experimental conditions.

The oxides nanopowders were used for compacts fabrication which gave transparent ceramics after vacuum sintering. Optical properties of the pure ceramics and those doped with Eu and Yb were investigated. More transparent samples were obtained using powders with low agglomeration. X-ray luminescence of Lu₂O₃:Eu³⁺ was investigated. The scintillation characteristics of Lu₂O₃:Eu³⁺ ceramics under excitation with α -particles (²³⁸Pu source, E=5.46 MeV) were determined. The powders were used also together with commercial Al₂O₃ nanopowders for fabrication of yttrium aluminum garnet Y₃Al₅O₁₂ ceramics doped with Nd and Yb. Samples with transparency above 80% in visible range were obtained and their spectral and luminescent properties were investigated.

GAMMA IRRADIATION TECHNIQUE FOR PLASMONIC NANOENGINEERING OF Ag/HYDROGEL NANOCOMPOSITES

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Combining metallic nanoparticles with host materials whose dielectric properties can be tuned by means of an external control is one route to create "active plasmonics". Here a soft-matter periodic structure made from a PVA or PNiPAAm hydrogel matrix and Ag nanoparticles synthesized *in situ* by gamma irradiation is reported. These hydrogel networks act as a fluid filled host whose refractive indexes can be varied by using temperature variations. This has a strong influence on the position of the plasmonic absorption peak of the nanoparticles. In general, this combination enables the transduction of physical or chemical forces into an optical signal, arising from the localized surface plasmon resonance (LSPR) and plasmon coupling effects in metal nanoparticles and their aggregates [1,2]. Possible applications of these nanostructured systems are in optical sensors, biosensors, and various miniaturized devices.

Among various techniques, gamma irradiation method is very suitable for *in situ* generating metal nanoparticles in hydrogel matrix by radiolytic products of water, using liquid filled cavities in hydrogels as nanoreactors (template synthesis) [3]. The radiation technique does not require any extra substances and does not need any further purification.

In this work, radiolytically synthesized Ag/PVA and Ag/PNiPAAm hydrogel nanocomposites are characterized by UV-Vis absorption spectroscopy, SEM and TEM microscopy. Due to discrete size domains of synthesized Ag nanoparticles in intrinsic regime, optical properties of synthesized nanosystems are analyzed by Hayakawa quasistatic approximation of the Mie theory [4]. The estimated mean particle radii are employed to calculate the optical extinction spectra using the classical electromagnetic theory, the Mie model. A red-shift of the position of the LSPR band with respect to the calculations is smaller for the larger particles and is related to changes in the dielectric constants involved. Moreover, the values obtained for average radius are employed to determine the average number of atoms belonging to spherical nanoclusters in metallic phase and the cluster density in the sample. Obtained differences in investigated parameters are related to different stabilization action of hydrogel matrixes during radiolytic synthesis of nanocomposite systems.

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- [1] L. De Sio, R. Caputo, U. Cataldi, C. Umeton, J. Mater. Chem. 21 (2011) 18967-18970.
- [2] I. Tokarev, S. Minko, Soft Matter. 8 (2012) 5980-5987.
- [3] A. Krklješ, J. Nedeljković, Z.Kačarević-Popović, Polym. Bull. 58 (2007) 271-279.
- [4] C.L. Veenas, K.M. Nissamudeen, S.L. Smitha, V. Biju, K.G. Gopchandran, J. Optoelectr. Advanc. Mater. 11 (2009) 114-122.

SYNTHESIS, UPCONVERSION SPECTRUM OF Er- AND Yb-DOPED GADOLINIUM OXIDE NANOPOWDER AND ITS USE IN FLUORESCENCE THERMOMETRY

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Gadolinium oxide (Gd_2O_3) nanopowder represents a promising single-phase multifunctional nanoprobe possessing a combination of magnetic and optical properties within single nanoparticle. [1] Gd_2O_3 is also a promising host matrix for luminiscent rare-earth ions to produce downconversion or upconversion phosphors for optical imaging applications. [2]

In this contribution we describe the synthesis of Er- and Yb-doped Gd_2O_3 nanopowders prepared by combustion method. The phase purity and nanoparticles morphology were investigated by X-ray powder diffraction (XRD) and scanning electron microscopy (SEM). Synthesized materials which show intensive upconversion and fluorescence in green area (520 – 570 nm) were used as fluorescence thermometers where the temperature is detected on a basis of changes of absorption maxima intensities in fluorescent spectra. Additionally, we investigated the effect of heating under IR illumination. We showed that Er- and Yb-doped Gd_2O_3 products can be used as fiber sensors and contactless thermometer devices for temperature measurements by excitations in UV range up to 800 °C and in IR range up to 300 °C.

- C.C. Huang, C.H. Su, W.M. Li, T.Y. Liu, J.H. Chen, C.S. Yeh, Adv. Funct. Mater. 2009, 19, 249-258.
- [2] G. Tian, Z. Gu, X. Liu, L. Zhou, W. Yin, L. Yan, S. Jin, W. Ren, G. Xing, S. Li, Y. Zhao, J. Phys. Chem. C 2011, 115, 23790-23796.

TEMPERATURE AND PRESSURE DEPENDENCE OF SPECTRAL POSITIONS AND WIDTHS OF ${}^5D_0 \rightarrow {}^7F_J$ EMISSION LINES FROM Eu³⁺ IONS IN CaF₂ CRYSTAL

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Crystalline CaF₂, having a simple cubic structure and a large band gap, is a promising optical material for technology and an interesting object for fundamental research. In this work we have measured temperature (*T*) and pressure (*P*) dependences of the spectral positions and widths of the emission zero-phonon lines (ZPLs), corresponding to ${}^{5}D_{0} \rightarrow {}^{7}F_{0,1,2}$ electronic transitions in Eu³⁺ ions doped into CaF₂ crystal (impurity Eu³⁺ centres of trigonal C_{3v} symmetry), with the goal to clarify roles of the electron-phonon coupling, the thermal expansion and the Debye temperature of crystals in these dependences.

By raising the temperature between 112 and 493 K at ambient pressure, all the lines broaden and shift to the blue. Both these effects can be explained by the dephasing of electronic transitions due to the Raman scattering of acoustic phonons by impurity ions [1,2]. It was found that the *T*-shift of the lines is mainly caused by change of the electronphonon coupling in impurity centres and not by the thermal expansion of the host crystal. Note that the line related to the magnetic dipole transition ${}^5D_0 \rightarrow {}^7F_1$ shows much smaller *T*shift than the lines connected with the electric dipole transitions ${}^5D_0 \rightarrow {}^7F_0$ and ${}^5D_0 \rightarrow {}^7F_2$ in CaF₂:Eu³⁺ as well as in SrFCI:Sm²⁺ studied earlier [3].

By increasing the purely hydrostatic pressure (using helium gas as a pressure-transmitting medium) in the range 0.001 - 7.3 kbar at room temperature, the width of all the lines studied somewhat decreases, most of the lines shift to the red and a few of them to the blue, the splitting of ${}^{7}F_{1}$ and ${}^{7}F_{2}$ multiplets in the crystal field increases, and the energy difference between ${}^{5}D_{0}$ level and the barycentre of the crystal-field levels of ${}^{7}F_{0}$, ${}^{7}F_{1}$ and ${}^{7}F_{2}$ multiplets decreases. The *P*-induced narrowing of ZPLs in CaF₂: Eu³⁺ and also in SrFCI:Sm²⁺ [4] crystals can be explained as caused by *P*-induced decrease of the electron-phonon coupling coefficient in the framework of the Raman mechanism and to a lesser extent by decrease in the density of states for acoustic phonons due to *P*-induced increase in the energy distance between ${}^{5}D_{0}$ level and the barycentre of the crystal-field levels of ${}^{7}F_{J}$ multiplets is mainly caused by changes in a direct interaction of external pressure with impurity centres and not by the *P*-induced contraction of the host crystal.

It is notable that high intensity of the emission ZPL line corresponding to the strongly forbidden 4f - 4f transition ${}^{5}D_{0} \rightarrow {}^{7}F_{0}$ in the trigonal (C_{3v}) Eu³⁺ center of CaF₂ crystal cannot be explained in the framework of known mechanisms and needs further studies.

^[1] D.E. McCumber, M.D. Sturge, J. Appl. Phys. 34 (1963) 1682-1684.

^[2] B. Di Bartolo, Optical Interactions in Solids, Wiley, New York, 1968 (Chapter 15, pp. 341-377).

^[3] A. Kuznetsov, A. Laisaar, J. Kikas, Opt. Mater. 32 (2010) 1671-1675.

^[4] A. Kuznetsov, A Laisaar, J. Kikas, J. Lumin. 129 (2009) 1589-1593.

LUMINESCENT SPECIES IN NANOSCALED LAYER STRUCTURES

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Layered structures are attractive as matrices for luminescent species because of their confinement in low dimensional interlayer spaces. New aspects in optical, luminescent and photochemical properties of the guest species could be found in these two-dimensional matrices. The most prominent representatives for such layered materials are clay minerals [1], which we intend to modify as strictly anisotropic, luminescent nanoobjects.



Figure 5. Left: Crystal structure and geometry of Laponite. Ln^{3+} sandwiched in the interlayer. Right: Emission spectra of the Tb^{3+} and Eu^{3+} ions in $[Eu_xTb_{1-x}(Pic)_3]_{0,2}$ -Laponite (squares: x = 0; circles: x = 1; rhombohedra: x = 0.3). Spectra normalised to the quantity of corresponding luminescent ions.

RD Laponite (a synthetic hectorite type clay), chemical composition $Na_{0.7}[Mg_{5.5}Li_{0.3}O_{20}(OH)_4]$ (see the fig. 1), can be completely delaminated to yield glass clear aqueous suspensions. This is due to the small diameter of the platelets (about 25 - 30 nm) and inherently present surface charges. Our investigations show that careful control of the latter enables the laponite platelets to serve as phase transfer carriers to otherwise completely hydrophopic species via surface adsorption [2]. Alternatively, they may be organized to still soluble sandwich-like structures, able to accommodate polyvalent cations, complexes or neutral organic molecules within the interlayers formed by each two clay platelets.

We investigated nanoscaled Laponite clays, doped with various luminescent lanthanide species (the emission spectra of $[Eu_xTb_{1-x}(Pic)_3]_{0.2}$ -Laponite are shown in fig. 1 as an example) as well as with a range of hydrophobic organic laser dyes (Lumogen red, LDS 765, Rhodamine G) in the solid state and aqueous dispersions. Due to their favourable dimensions and solubilities, these novel hybrids hold the promise to become valuable materials for the fabrication of, e.g., thin optical layers, sensors, immunoassays or functional polymer additives.

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[2] M. M. Lezhnina, U. H. Kynast, Opt. Mater, 33 (2010) 4-13.

^[1] T. Shichi, K. Takagi, J. Photoch. Photobio. C, 1 (2000) 113-130.

SPECTROSCOPIC PROPERTIES OF Eu³⁺, Dy³⁺ AND Tb³⁺ IONS IN LEAD-SILICATE GLASSES OBTAINED BY CONVENTIONAL HIGH-TEMPERATURE MELT-QUENCHING TECHNIQUE

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Rare earth-doped lead silicate glasses are promising materials for near-infrared luminescence [1] and up-conversion [2] applications. Here we present new results for lead silicate glasses singly doped with europium, dysprosium and terbium ions. Europium and dysprosium ions are extensively used as a spectroscopic probe for studying the structures and the local symmetry of the solid-state materials. Glass systems doped with terbium ions are known as promising materials emitting green light.

Dipole-magnetic transition ${}^{5}D_{0}{}^{-7}F_{1}$ weakly depends on the crystallographic environment, that's why the ratio of the intensity of the ${}^{5}D_{0}{}^{-7}F_{2}$ dipole-electric transition to the intensity of the magnetic-dipole ${}^{5}D_{0}{}^{-7}F_{1}$, known as fluorescence intensity ratio R is a measure of the covalency between the Eu³⁺ and surrounding ligand. Increasing of R factor inform about degree of disorder center and contribution of grovalent bonds. The Y/B factor is relation of intensity bands connected with ${}^{4}F_{9/2}{}^{-6}H_{13/2}$ to ${}^{4}F_{9/2}{}^{-6}H_{15/2}$ transitions and it is also a measure of covalency between Dy^{3+} ions and the nearest surrounding - O^{2-} or F⁻ ions. With increasing ratio Y/B, the part of covalent bonds around the optically active dopant increased.

Based on excitation and emission measurements as well as luminescence decay analysis some spectroscopic parameters for these lanthanide ions were determined. The intensity ratios R (Eu³⁺) and Y/B (Dy³⁺) were calculated. Moreover, luminescence lifetimes for ⁵D₀ state of Eu³⁺ ions and ⁴F_{9/2} state of Dy³⁺ ions were determined. The same method was used for Tb³⁺ ions in lead silicate glass.

^[1] M. Bettinelli, A. Speghini, M.G. Brik, Opt. Mater. 32 (2010) 1592-1596.

^[2] J. A. Capobianco, G. Prevost, P. P. Proulx, P. Kabro, M. Bettinelli, Opt. Mater. 6 (1996) 175-184.

SPECTROSCOPIC, LUMINESCENT AND LASER PROPERTIES OF NANOSTRUCTURED CaF₂:Tm MATERIALS

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Rare-earth-doped ceramic materials are of interest in the modern laser physics. At the present time, significant progress has been achieved in the development of technologies of obtaining oxide ceramic with rare-earth ions [1]. Fluoride ceramics is a promising material for use as active media of solid-state lasers. The microstructure and spectralluminescent properties of ceramics CaF_2 :Nd, CaF_2 :Yb submitted in works [2, 3]. In Ref. [4] we presented results of the researches of structural, absorption and luminescent properties of the ceramic CaF_2 :Tm.

This paper studies structural, spectral-luminescent and laser properties of ceramics and single crystals CaF₂:Tm. CaF₂:Tm single crystals were grown by vertical directional solidification (Bridgman method). CaF₂:Tm ceramic samples were prepared by hot forming via crystal deformation.

Tm-doped CaF₂ ceramic samples have been studied by SEM and AFM. The absorption and luminescence spectra of the CaF₂:Tm ceramic and single crystals have been measured. We have estimated the shape of the gain band for the two-micron laser transition ${}^{3}F_{4} \rightarrow {}^{3}H_{6}$ at different relative population inversion parameters. The gain band of the crystals and ceramic extends from 1700 to 2000 nm.

Two-micron lasing is obtained for the first time on the ${}^{3}F_{4} \rightarrow {}^{3}H_{6}$ transition of Tm³⁺ ions in diode-pumped CaF₂:Tm ceramic. Diode pumping at 798 nm led to lasing at 1898 nm. The threshold of 3,1 W was observed.

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- [1] J. Lu, M. Prabhu, J. Song, C. Li, et al., Appl. Phys. B, 71, 4, 2000.
- [2] M.Sh. Akchurin, R.V. Gainutdinov, E.A. Garibin, Yu.I. Golovin, et al., Inorganic Materials: Applied Research, 2, 2, 2011.
- [3] T.T. Basiev, M.E. Doroshenko, P.P. Fedorov, V.A. Konyushkin et al., Optics Letters, 33, 5, 2008.
- [4] F.A. Bol'shchikov, E.A. Garibin, P.E. Gusev, A.A. Demidenko, et al., Quantum Electron, 41, 3, 2011.

INFRARED SPECTROSCOPY MEASUREMENTS OF GRAPHENE

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Graphene is a single atomic layer of carbon atoms in a hexagonal close-packed array structure. This unique two-dimensional material is attracting much attention in the research community due to its promising electronic and optical properties and potential applications in photonics [1,2,3].

In this work we provide optical characterization of graphene via fourier transform infrared spectroscopy (FTIR) in the near to mid infrared (NIR-MIR) range. Graphene samples are prepared on Si/SiO₂ substrates using micromechanical exfoliation of natural graphite. Gold contacts are placed on the samples using ultraviolet (UV) photolithography in order to allow for electronic doping during experiments. The reflectance of the graphene samples is measured and effects of different thicknesses of samples (ranging from single-layer up to few (<10)-layer) are investigated. Furthermore, different doping levels introduced by nitrogen and oxygen doping as well as applied voltage are investigated. From the obtained data, a fourphase Fresnel coefficient model is used to simulate the measured sample, and a surface conductivity model of graphene is used to calculate the optical conductivity [4]. Our findings show that the conductivity saturates to the universal optical conductivity due to the dominance of the interband component, and increases linearly with the number of graphene layers. Our results are in good agreement with previous experimental and theoretical work [4,5,6,7].

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- K. S. Novoselov, A. K. Geim, S. V. Morozov, D. Jiang, Y. Zhang, S. V. Dubonos, I. V. Grigorieva and A. A. Firsov, Science, 306 (2004) 666-9.
- [2] A.K. Geim and K.S. Novoselov, Nature Mater., 6 (2007) 183.
- [3] F. Bonaccorso, Z. Sun, T. Hasan and A.C. Ferrari, Nat. Photon., 4 (2010) 611-622.
- [4] G. W. Hanson, J. Appl. Phys., 103 (2008) 064302.
- [5] K. F. Mak, M. Y. Sfeir, y. Wu, C. H. Lui., J. A. Misewich and T. F. Heinz, Phys Rev. Lett. 101 (2008) 196405
- [6] Z. Q. Li, E. A. Henriksen, Z. Jiang, Z. Hao, M. C. Martin, P. Kim, H. L. Stormer and D. N. Basov, Nat. Phys., 4 (2008) 532-535.
- [7] L. Yang, Nano Lett. 11 (9) (2011) 3844-7.

FORMATION OF METALLIC AND SEMICONDUCTOR NANOPARTICLES BY LASER ABLATION IN DIFFERENT MEDIA WITH IN SITU SPECTROSCOPIC DIAGNOSTICS

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Generation of semiconductor MSCs by laser ablation of solid target in vacuum has been commonly reported (see, for example, [1,2]). Recently, Ag nanoclusters (NCs) caused great interest as an alternative for highly luminescent semiconductor NPs in bio- and medical applications due to their small size, high PL quantum yield and low toxicity. The present work focuses on formation of CdSe MSCs and Ag NCs by laser ablation in liquid media.

Produced colloidal solutions of NPs were studied by optical spectroscopy (absorption, photoluminescence (PL), PL excitation (PLE), Raman scattering). Size of NPs was determined by dynamic light scattering (DLS) method.

Absorption spectrum of Ag colloidal solution (not shown here) has several broad peaks at 515, 435 and 365 nm wavelengths that indicate preferable formation of some specific sizes of Ag NPs. The peak at 365 nm may be attributed to Ag NCs formation. However, PL quantum yield of the prepared Ag colloid was negligibly small.



Figure 1: PL spectrum of CdSe colloidal solution

The PL spectrum of CdSe colloidal solution (shown in the Figure 1) has a narrow peak at 427 nm, which is probably related to CdSe MSCs, and a wide peak centered at about 470 nm that reflects broad NPs size distribution or/and defect related PL of the MSCs [3].

We have shown successful production of L-cysteine stabilized "magic" sized clusters of CdSe among the other CdSe nanoparticles, and formation of Ag nanoclusters as well as Ag nanoparticles by laser ablation of the solid targets in water.

- [1] A. Kasuya, et. al., Nature materials, 3 (2004) 99-102.
- [2] A. Dmytruk, I. Dmitruk, I. Blonskyy, R. Belosludov, Y. Kawazoe, and A. Kasuya. Microelectron. J 40 (2009) 218.
- [3] Yeon-Su Park, Andriy Dmytruk, Igor Dmitruk, Atsuo Kasuya, Yukihiro Okamoto, Noritada Kaji, Manabu Tokeshi, and Yoshinobu Baba, J Phys Chem C 114 (2010) 18834-18840.

BaAl₂O₄:Cu SYNTHESIZED BY SOLID-STATE REACTION METHOD AND THE LUMINESCENCE PROPERTIES

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Cu-doped barium aluminate phosphor $(BaAl_2O_4)$ was synthesized by solid - state method at 1350°C. The crystallinity and phase structure of the $BaAl_2O_4$: Cu was investigated by using X-Ray diffraction (XRD), and the morphology was determined by a scanning electron microscope (SEM). SEM investigation exhibited the phospor powders. The luminescence properties of the Cu- doped phosphor was studied and RL spectra was showed that the presence of additives and the give informations about the electronic transitions.

THE INVESTIGATION OF MAGNETO-OPTICAL PROPERTIES OF THIN-FILM MAGNETIC STRUCTURES

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This study reports on the performance of a multilayer film structures which are very prospective material for the thin-film magnetic sensors. The magnetic and magnetooptical (MO) properties of iron and cobalt thin films and also FM/NML/FM trilayers (with NML = Cu, Mo, Hf, Ta; FM = Fe, Co), prepared by using a magnetron sputtering system have been presented. FM layer thickness t_{Fe} and t_{Co} in trilayers was variable from 25 to 100 Å and the nonmagnetic layer (NML) thickness t_{NML} - from 5 to 2000 Å. In NML/FM samples the nonmagnetic layer thickness was variable from 0 to 400 Å. The measurements were performed on the magneto-optical magnetometer and by using of spectral technique.

The dependencies of hysteresis characteristics (the saturation field and the coercivity) of Fe films on NML thickness were found. The dependence of the transverse Kerr effect (TKE) magnitude on t_{Fe} was established. It was shown experimentally that Kerr effect is sensitive to the magnetization up to a certain depth range below the surface of ferromagnetic - the information depth.

It was discovered that the in-plane hysteresis characteristic of the trilayers are strongly dependent on t_{NML} . So the existence of the exchange coupling between FM layers through NML and its oscillatory behavior (from antiferromagnetic (AF) to ferromagnetic (F) order) were experimentally established. It was found that period AF-F-AF oscillations of exchange coupling is equal to 5-10 Å.

INORGANIC RED PHOSPHOROS FOR WHITE LIGHT-EMITTING DIODES BASED ON Re AND Tm ACTIVATED NANO-GLASSCERAMICS

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White light-emitting diodes (LEDs) have attracted considerable attentions now due to promising features such as low energy consumption, long lifetime, small size, fast switching, as mercury free nonpolluting environment, so have a great perspective for applications in display backlights, transport and general lighting, advanced communication technique, etc. [1]. There are two main approaches for producing white light with LEDs. In the first one, white light is generated by additively mixing of multiple primary color LEDs with a high luminous efficacy (LE) since there is no Stokes losses. But the color rendering index (CRI) depends on the number of selected primary color LEDs that leads to increase their cost. In the second approach, white light is generated by single or multiple phosphors using down-conversion of blue light pumped from InGaN chip into visible light. For example, the single yellow Y₃Al₅O₁₂:Ce phosphor has already commercially used with blue-emitting InGaN chip to fabrication low cost phosphor converted white LEDs (pc-WLEDs) but its application is limited by their low CRI. Therefore, to improve CRI of pc-WLEDs it is important to develop an appropriate red phosphors with low cost, high chemical stability and high conversion efficiency.

In this paper, a new type of red phosphor representing a fluoride silicate and fluorophosphates glassceramics doped with Eu^{3+} or Mn^{2+} ions, were synthesized using technology developed and applied earlier by Aseev et al. [2]. Samples of the lead fluoride silicate and fluorophosphates glasses were prepared using a conventional high temperature synthesis form raw materials.

The fluoride silicate glassceramics were used as host materials due to their attractive and suitable properties, such as high chemical and thermal stability, high optical transparency, and high solubility for optically active dopants. These red phosphors with combination of green-yellow phosphors were applied to fabricate the pc-WLEDs on the blue InGaN chips. The optical properties of pc-WLEDs were measured and the effects of the prepared red phosphors on their emission characteristics were investigated. The experiments showed that glass and glassceramics doped with Eu³⁺ and Mn²⁺ ions have intensity bands of luminescence in red range of spectrum excitation by UV radiation at 355 nm and blue light at 465 nm: radiation of trivalent europium at 618 (${}^{5}D_{0} \rightarrow {}^{7}F_{2}$) and 701 nm (${}^{5}D_{0} \rightarrow {}^{7}F_{4}$), luminescence band of manganese with maximum at 620 nm (${}^{4}T_{1} \rightarrow {}^{6}A_{1}$). By selecting the most appropriate compositions of the red phosphors the spectral power distributions (SPD) of pc-WLEDs were shown to be optimized to improve CRI for selected color temperatures.

^[1] S. Ye, F. Xiao et al, Materials Science and Engineering, R71, (2010) 1-34.

^[2] V.A. Aseev et al, Optics and Spectroscopy 106, (2009) 691-696.

LOW TEMPERATURE UP-CONVERSION LUMINESCENCE OF NANO-GLASSCERAMICS DOPED WITH YTTERBIUM-ERBIUM IONS

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Currently, transparent glassceramics are of great interest for the modern element base of photonics. Because they stay at intermediate state between crystalline materials and glasses, these glassceramics combine itself the best properties of crystals and glasses. If the dopants (erbium, ytterbium, neodymium, etc.) enter the crystalline phase, the spectral, luminescence and laser characteristics of the glassceramics become close to those of laser crystal analogues.

In the present work we have prepared nano-glassceramics of system of $30SiO_2$ -18PbF₂-7.5Al₂O₃-5ZnF₂-29CdF₂-3YF₃ -5YbF₃ mol % doped with different Er³⁺ consentration (0.05-0.5 mol %). In these systems, the crystalline phase is precipitated upon heat treatment at 515°C.

It was shown that rare-earth ions was incorporated in the crystalline phase. An X-ray diffraction analysis of the samples after the secondary heat treatment showed that the crystalline phase has a composition of $PbYOF_3$. In case of erbium glassceramics the lattice constant was 5.75 A and in case of ytterbium - 5.67A. Increase of time treatment results in the increase of the size of nanocrystals up to 30-40 nm.

Up-conversion luminescence of erbium ions excited by InGaAs laser diode (975 nm) was measured in the spectral range of 400-700 nm. Luminescence spectra have been investigated at low (77K) and room (300K) temperatures.

It was shown that that emitting probabilities of different transitions were changed during the thermal treatment. After the heat treatment the relative intensities of luminescence transitions have been changed. For instance, the intensities of transitions with the maxima at 475, 530 and 550 nm have been reduced in comparison with 670 nm, while a new transitions at UV band (365 nm) have been arisen. In addition, the intensity of the transition in blue range (405 nm) has been grown up. The arise of additional bands became possible due to the increase of probability of radiative transitions from these levels. The heat treatment results in a significant modification of luminescence spectra. Appearance of Stark structure in luminescence spectra and their deformation have been demonstrated. The luminescence studies provide the independent confirmation of the X-ray phase analysis conclusion that the rare earth ions are incorporated in to the crystalline phase.

RE-doped nano-glassceramics are promising candidates for different photonics applications, like fiber and waveguide lasers and sensors.

- V.A. Aseev, V.V. Golubkov, E.V. Kolobkova, N.V. Nikonorov, Glass Physics and Chemistry. 38 (2012) 11–18.
- [2] V.A. Aseev et al, Optics and Spectroscopy 106, (2009) 691-696.

MODELING OF THE EFFECT OF RADICALS ON PLASMAS USED FOR ETCHING IN MICROELECTRONICS

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Plasma etching represent one of the critical steps in manufacturing of integrated circuits. Further optimization of plasma equipment is needed since new generations in technology require different plasma chemistry. In this paper, we will study the influence of radicals on the plasma characteristics, since it was often neglected in plasma models. The radicals dominate attachment of electrons as the basic etching mixture is weakly electronegative and they also affect the drift velocity through modified momentum balance. We have used numerical solutions to the Boltzmann equation and Monte Carlo simulations (MCS) to determine the transport coefficients of electrons. Determined coefficients are then applied in particle in cell (PIC) simulations to investigate how properties of plasma changes when complete representation of atomic physics is included. Such calculations are usually based on compilations of cross sections from different sources [1]. Requirement to establish reliable transport coefficients for CF_4 plasmas is especially demanding since practical conditions include many reactive species.

Free radical species, such as CF_y (y=1-3) and fluorine atoms, play important and complex roles in plasma processing. We calculated electron transport coefficients for pure CF₄ and in X/CF₄ mixtures (X= F, F₂, CF, CF₂ and CF₃) for the conditions overlapping with those used in plasma technologies for semiconductor production. In this paper we shall only consider CF₂. Set of cross sections for CF, CF₂ and CF₃ is based on work of Rozum *et al.* [2]. Set of cross sections for F₂ is from [3] and for F is according to Gudsmundsson [4].

- [1] M. Kurihara, Z. Lj. Petrović and T. Makabe, J. Phys. D: Appl. Phys. 33 (2000) 2146-2153.
- [2] I. Rozum, P. Limao-Vieira, S. Eden and J. Tennyson, J. Phys. Chem. Ref. Data, Vol. 35, No.1 (2006) 267-284.
- [3] W. L. Morgan, Plasma Chemistry and Plasma Processing 12 (1992) 449-476.
- [4] J. T. Gudmundsson, J. Phys. D: Appl. Phys. 35 (2002) 328-341.

SPECTRAL AND LUMINESCENCE PROPERTIES OF TRANSPARENT NANO-GLASSCERAMICS DOPED WITH YTTRIUM AND NEODYMIUM IONS

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Transparent nano-glassceramics doped with rare earth ions (Er, Eu, Tm, Nd, and Pr) are of the great interest for photonics because they occupy an intermediate state between glasses and crystalline materials and combine the best properties of glasses (possibilities of molding and pressing, pulling optical fibers, and carrying out ion exchange to fabricate waveguide structures) and crystals (high spectral and luminescence characteristics, thermal and mechanical strength). Rare-earth ions with fluoride environment (especially in the case of heavy-metals fluorides) have lower phonon energies. This oxygen-free environment of rare earth ions decreases the probability of non-radiative excitation relaxation, which leads to an increase in the luminescence quantum yield in comparison with the case of oxygen environment. Thus, transparent fluorine-containing nano-glassceramics doped with rare earth ions are promising media for up-conversion lasers and broadband optical amplifiers.

The investigation of the precipitation of crystalline phases in lead-fluorine nanoglassceramics and studding their spectral and luminescence properties have been presented in the work. The samples of virgin glasses were prepared with the following composition: $30SiO_2$ - $15AlO_{3/2}$ - $29CdF_2$ - $18PbF_2$ - $5ZnF_2$ - $xNdF_3$ - $(3-x)YF_3$, where x=3.0; 2.9; 2.5; 1; 0.5; 0.2; 0.1; 0. To obtain transparent nano-glassceramics the glass samples were heated at temperature of $500^{\circ}C$ during 2 hours. Luminescence of neodymium ions excited by laser diode (808 nm) was measured at room (300K) temperature in spectral range of 820-1500 nm.

X-ray diffraction (XRD) analysis and simultaneous thermal analysis (DSC) observation of nano-glassceramics doped with NdF₃ in concentration from 0 up to 2.9 mol% revealed the precipitation of PbYOF₃ crystallites about 25 nm in size among the glass matrix. The increase of neodymium concentration results in the increase of the lattice constant from 5.74 up to 5.82 A. The nano-glassceramics doped with NdF₃ of 3 mol% revealed the precipitation of NdF₃ crystallites about 20 nm in size.

Spectral and luminescence properties of nano-glassceramics has been investigated in IR range. It was shown that that emitting probabilities of different transitions changed during the thermal treatment. The heat treatment results in appearance of fine Stark structure in absorption and luminescence spectra. The entry of rare-earth ions in crystal phase results in broadening of emission spectra because of fluoride surrounding. The combination of spectral and fluorescent measurements with the XRD and DSC analysis allowed us to conclude that neodymium ions incorporated into the crystalline phase of PbYOF₃. Neodymium-doped nano-glassceramics are promising candidates for different photonics applications, like active media for lasers and light amplifiers and converters.

OPTICAL ABSORPTION AND EMISSION OF NI DOPED (80-x)Sb₂O₃-20K₂O-xMoO₃ GLASSES

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These glasses were synthesized by conventional method [1] in the ternary system $(80-x)Sb_2O_3-20K_2O-xMoO_3$ doped with 0.1 (mol. %) of NiO. The optical absorption spectra of Ni doped glasses in the spectral range 660-1270 nm consist of four maxima around 720 nm, 760 nm, 810 nm and 1210 nm which are related to the octahedral environment. The maxima intensity decreases with increasing x. The energetic diagram of the electron transitions in the Ni ion is presented and the Racah's parameters are calculated also. Visible emission has been obtained at room temperature.

[1] M. T. Soltani, A. Boutarfaia, R. Makhloufi, M. Poulain, J. Phys. Chem. Solids 64 (2003) 2307-3012.

LUMINESCENT PHOTO-THERMO-REFRACTIVE NANOGLASSCERAMICS FOR PHOTONIC APPLICATIONS

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Spectral, luminescence, and lasing properties of polyfunctional photo-thermo-refractive nanoglassceramics doped with ytterbium and erbium ions for microchip laser have been investigated for the first time. Gain coefficient was obtained of 0.014 cm⁻¹ at 1.5 mkm. The nanoglassceramics is a promising candidate for integrated micro-chip lasers at 1.5 mkm.

Polyfunctional materials are very attractive for laser applications. For example, photothermo-refractive (PTR) nanoglassceramics doped with erbium and vtterbium combines itself three opportunities: lasers or amplifiers fabrication, volume Bragg gratings (VBG) recording, and planar waveguides fabrication with the use of ion exchange technology. The laser PTR nanoglassceramics exhibited good photorefractive characteristics and ion exchangeable properties. In the present work spectral, luminescence, and lasing properties of the nanoglassceramics have been investigated. The nanoglassceramics were doped with different erbium content (from 0.26*E20 to 2.26*E20 ions/cm3) and ytterbium of 17.8*E20 ions/cm3. Ground and exited state absorption cross-sections, emission cross-sections, erbium (1535 nm) and ytterbium (980 nm) lifetimes, quantum yields, Judd-Ofelt parameters, Yb-Er non-radiative transitions probabilities have been measured. Population inversion was determined with use of two techniques: (i) variation of ground state absorption and (ii) exited state absorption. Population inversion was achieved ~52%. Gain/loss spectra and inversions of populations for different pump powers have been measured for different erbium concentrations. Gain coefficient was obtained of 0.014 cm⁻¹ at 1.5 mkm. Holographic characteristics of nanoglassceramics doped with ytterbium and erbium ions have been investigated. Holograms with diffraction effective up to 96% have been recorded on these samples. Advantages of the new laser PTR nanoglassceramics in comparison with commercial laser glasses have been discussed.

PHOSPHOR CONVERTED WHITE LED WITH IMPROVED CRI

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White LEDs, based on blue LED chips coated with a yellow emitting phosphor (YAG:Ce), were first reported in 1997 [1]. The blue chip/YAG:Ce system has many advantages, but the lamps fabricated in this manner give a poor colour rendering and there are several other disadvantages which are well-documented [2].

LEDs using YAG:Ce phosphor on blue chip have high color temperature, and only "cool white" emission can be obtained. When the conversion phosphor is situated in close proximity of the LED chip, given the small chip area and the limited phosphor area, temperatures of 400 to 450 K are reached. Efficiency of YAG:Ce phosphor coated LEDs decreases at these temperatures. The reduction is related to the concentration quenching at higher temperatures [3]. Another problem associated with use of YAG:Ce is the "halo effect" (blue/yellow colour separation). YAG:Ce is not properly mixed in resin due to high density, resulting in colour unevenness [4].

In this paper modification of YAG:Ce phosphor for improving CRI, by introducing Gd^{3+} , Pr^{3+} or Tb^{3+} [5,6] at Ce^{3+} site is reported.

Instead of the conventional solution combustion synthesis, we used the modified procedure which led to the formation of the desired compounds in a single step. Stoichiometric amounts of hydrated nitrates of yttrium, aluminium and cerium were thoroughly mixed with urea/glycine. A china dish containing the paste was inserted in a furnace preheated to 500 ^oC. Within minutes the paste foamed and a flame was produced which lasted for several seconds. X-ray diffraction patterns were recorded on Philips PANalytical X'pert Pro diffractometer. PL characteristics in the range of 200–700 nm, at room temperature were studied using a Hitachi F-4000 spectrofluorimeter. The phosphor (3 wt %) was dispersed in a transparent silicone resin and LED was then fabricated by coating the blue LED chip (CREE 458 nm, 300 micron) with the epoxy resin. The electroluminescence (EL) spectra, colour temperature, CIE chromaticity coordinates, CRI and lumen output at room temperature were measured using a 300 mm integrating sphere and lumen meter (Hangzhou Zhongwei Photoelectricity Company ZVision ZW 3900). The measurements were carried out at 3.2 V, 20 mA.

A red shift in the emission was observed by introducing Gd^{3+} , or Tb^{3+} at Ce^{3+} site. In Pr^{3+} co-doped sample red emission is observed due to Ce^{3+} -> Pr^{3+} energy transfer. This led to improvement in CRI from 65-70 for YAG:Ce based LED to 78-82, for LEDs fabricated from the co-doped phosphors.

- [1] S.Nakamura and G.Fasol The Blue Laser Diode: GaN Based Light Emitters and Lasers. Heidelberg: Spring; (1997)
- [2] Philippe F. Smet, Anthony B. Parmentier, and Dirk Poelman J. Electrochem. Soc.158 (2011) R37-R54.
- [3] V. Bachmann, C. Ronda and A. Meijerink, Chem. Mater. 21 (2009) 2077-2084.
- [4] Toshihide Maeda, Shozo Oshio, Katsuaki Iwama, Hiromi Kitahara, Tadaaki Ikeda, Hidenori Kamei, Yasuyuki Hanada, Kei Sakanoue patent US7,422,504 (2008)
- [5] Y. S. Lin, R. S. Liu, and B. M. Cheng, J. Electrochem. Soc. 152 (2005) J41-J45.
- [6] S. Fujita, A. Sakamoto, and S. Tanabe, IEEE J. Sel. Top. Quantum Electron., 14 (2008) 1387

LONG LASTING LUMINESCENCE IN GARNET BASED PHOSPHORS

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Long-lasting phosphorescence is a phenomenon due to the thermal stimulated recombination of holes and electrons at traps which leave holes or electrons in a long-lived excited state at room temperature [1]. As novel functional materials, the long afterglow phosphors are drawing more and more attention in recent years because of their applications in traffic signs, emergency signage, watches and clocks, textile printing etc.

Recently, long lasting luminescence has been reported in YAG doped with Pr^{3+} [2] or Ce^{3+} [3] processed in reducing atmosphere. However, YAG:Ce emission is yellow which is not attractive for long lasting applications. On the other hand Ga substituted garnets give green emission at shorter wavelengths. It would be interesting to study whether such Ga substituted garnets also give long lasting phosphorescence. Recently, we have reported [4] combustion synthesis of YAG and related garnets activated with Ce^{3+} . In this paper, we report long lasting phosphorescence in these phosphores.

Instead of the conventional solution combustion synthesis, we used the modified procedure which led to the formation of the desired compounds in a single step. Stoichiometric amounts of hydrated nitrates of yttrium, aluminium and cerium were thoroughly mixed with urea/glycine. A china dish containing the paste was inserted in a furnace preheated to 500 ⁰C. Within minutes the paste foamed and a flame was produced which lasted for several seconds. X-ray diffraction patterns were recorded on Philips PANalytical X'pert Pro diffractometer. PL characteristics in the range of 200–700 nm, at room temperature were studied using a Hitachi F-4000 spectrofluorimeter, with 1.5 nm spectral slit width. For preparing the long lasting phosphors, combustion synthesized phosphors were further heated at 950 C in reducing atmosphere provided by burning charcoal.

Phosphors were exposed to unfiltered UV radiations of Hg lamp. Thermoluminescence glow curves were recorded on home made TL Reader with a heating rate of 1.6 °C per second using RCA 931 B PMT.

Persistent emission was observed in all three phosphors. Longest decay was observed for YAG:Ce (6.2, 120 sec). For Ga substituted phosphors the corresponding values are (8.5, 131.5 sec). Glow curves for all the phosphors contained a dominant glow peak around134 °C. LL spectra are similar to PL spectra. LL emission of Y(Al,Ga)G is thus in the desired green region.

- [1] J. Kuang, Y. Liu, B. Lei. J. Lumin. 118 (2006) 33-38.
- [2] Su Zhang, Chengyu Li, Ran Pang, Lihong Jiang, Lili Shi, Qiang Su J.Lumin 131 (2011) 2730-2734
- [3] Su Zhang, Chengyu Li, Ran Pang, Lihong Jiang, Lili Shi, Qiang Su J. RARE EARTHS 29 (2011) 426-430
- [4] K.V.K. Gupta, A. Muley, P. Yadav, C.P. Joshi and S.V. Moharil Appl.Phys.B 105 (2011) 479-484

SYNTHESIS AND CHARACTERIZATION OF LUMINESCENT BLUE NANOPOWDERS SUITABLE FOR NEW LIGHTING DEVICES

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Recently, the research on phosphors and more especially nanophosphors has attracted considerable attention since they have been widely used for modern lighting devices. The emergence of new lamps is driven by the presence of mercury which is a toxic chemical element in most of lighting sources and by environmental issues to reduce global energy consumption. Consequently, replacement solutions became necessary. The current research is mostly turned towards two directions of development:

- free-Hg lamps where the Hg-vapour is replaced by a Xe or Xe-Ne plasma, for which the discharge lies in the VUV spectral range,

- combination of luminescent materials which can be efficiently pumped by the UV/blue emitting GaN LEDs [1].

Conventionally, phosphors used in these devices are obtained via an energy greedy solid state reaction process requiring a several hour-heat treatment at high temperatures and leading to large size and irregular shapes. These features can affect optical properties and do not allow the shaping of the materials as homogeneous films. To compensate for these drawbacks, works are then focused on the improvement of usual phosphors, notably by developing new synthesis methods which result in powders with a narrow distribution of grains size.

We report here the elaboration of a blue nanostructured phosphor excitable by both UV and VUV radiations: Eu^{2+} doped BaMgAl₁₀O₁₇ (BAM) synthesized by a microwave induced solution combustion synthesis [2]. Structural and morphological properties of powders have been studied by means of X-ray diffraction, scanning and transmission electron microscopies. As shown in Figure 1, BAM:Eu powder exhibits a specific platelet nanomorphology. Besides, the optical features recorded upon UV and/or VUV excitations have evidenced that such a blue phosphor is suitable for applications in a new generation of lighting devices: its combination with other phosphors, a red and a green ones for example, and with a UV LED or with a system using a plasma excitation allows the generation of white light. Figure 2 exhibits the blue emission of the powder excited at 254 nm. Morphological and optical properties have also been compared with those of commercial blue phosphor.



Fig. 1: SEM image of blue powder



Fig. 2: Room temperature emission spectrum under a 254 nm excitation

S. Ye, F. Xiao, Y.X. Pan, Y.Y. Ma, Q.Y. Zhang, Mater. Sci. Eng. R 71 (2010) 1-34
N. Pradal, A. Potdevin, G. Chadeyron, R. Mahiou, Mater. Res. Bull.46 (2011) 563-568

RADIATIVE CHARACTERISTICS OF DOPED NANOCRYSTALS

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Nanocrystals doped with ions of transition groups (rare-earth ions and ions of the iron group) have been increasingly studied during the last time because of their potential application in many fields [1–6].

Here we present results of the theoretical study of the optical characteristics for the small-radius optical centers in the subwavelength ellipsoidal nanocrystals embedded in a medium.

Previously, we studied this problem for the nanocrystals and the medium with magnetic permeability's $\mu_{crystal} = \mu_{medium} = 1$ [7]. Now we removed this limitation and obtained analytical expressions for the decay rate and the related optical characteristics of the optical centers for general case.

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- [1] P. Tanner, in: P. Hänninen, H. Härmä (Eds.), Lanthanide Luminescence: Photophysical, Analytical and Biological Aspects, Springer-Verlag. Berlin, Heidelberg, 2011, pp. 183-234.
- [2] F. Pellé, M. Dhaouadi, L. Michely, P. Aschehoug, A. Toncelli, S. Veronesi, M. Tonelli, Phys. Chem. Chem. Phys. 13 (2011) 17453-17460. [3] Z. Andrić, M.D. Dramićanin, M. Mitrić, V. Jokanović, A. Bessière, B. Viana, Opt. Mater. 30 (2008) 1023-1027.
- [4] Yanhua Wang, Yongsheng Liu, Qingbo Xiao, Haomiao Zhu, Renfu Li, Xueyuan Chen. Nanoscale. 3 (2011) 3164-3169.
- [5] Chang-Kui Duan, Hongli Wen, P.A. Tanner, Phys. Rev. B 83 (2011) 245123(I)-245123(VI).
- [6] K. K. Pukhov, T. T. Basiev, Yu. V. Orlovskii, Opt. and Spectr. 111 (2011) 386–392 [Opt. i Spektr. 111 (2011) 415–421].
- [7] K. K. Pukhov, T. T. Basiev, Opt. Mater. 32 (2010) 1664-1667.

ROLE OF COMPLEXING AGENTS ON ELECTRODEPOSITED Zn-Ni ALLOY FROM ALKALINE MEDIUM BATH

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Binary alloy of Fe-30%Zn composition prepared by high energy ball milling of elemental pure iron and pure zinc powders, has been investigated by X-ray diffraction (XRD), secondary electron microscopy (SEM), and differential scanning calorimetry (DSC), as a function of milling time.

The XRD analysis showed the formation of Fe(Zn) solid solution after 24 hours of milling. Microstructural analysis using the Rietveld refinement confirmed the nanostructure character of the obtained powders, with grain size reaching 20 nm. The morphology of the milled powders, investigated by SEM, confirmed the decreasing behavior in the scale of the features composing the final milled powders. The DSC spectrum exhibited broad exothermic band related to structural relaxation and to the incorporation of Zn into the Fe unit cell.
STRUCTURAL, OPTICAL AND CRYSTAL FIELD ANALYSES OF ZnS:Mn²⁺ NANOPARTICLES SYNTHESIZED VIA REVERSE MICELLE ROUTE

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Zinc-sulphide is a II-VI semiconductor compound with a wide direct band gap of 3.68 eV. With addition of only few ppm of suitable dopant (Ag^+, Cu^{2+}, Mn^{2+}) ZnS can be used as luminescent material in CRT, thin-film electroluminescent panels, x-ray screens, for photocatalysts, infrared materials, sensors, LED and bio-devices.

This study concerns detailed structural, spectroscopic and crystal field studies of ZnS nanoparticles, pure and doped with Mn^{2+} ions, successfully synthesized via reverse micelle method. Synthesized ZnS small-size nanoparticles (3-5 nm) have a much larger energy band gap (~ 4.7 eV) than reported for the bulk ZnS (3.6 eV), confirming the quantum confinement effect. The actual concentrations of Mn²⁺ ions has been determined by quantitative chemical method to be ~ 25 times less than their nominal concentration in the precursor solution. The EPR spectra provided an evidence on the existence of two distinct environments for dopant Mn²⁺ ions: the interior (core) and on/near the surface of the nanoparticles, and demonstrate that manganese ions are preferentially situated on the nanoparticles surface. Photoluminescence spectra of Mn-doped ZnS consist of two broad bands: a blue band centered at 425 nm originating from the self-activated emission in ZnS host and the orange band centered at 600 nm arising from ${}^{4}T_{1} \rightarrow {}^{6}A_{1}$ radiation transition in Mn^{2+} ions (Fig.1). So far, and to the best of our knowledge, we observed the longest decay time component for the orange emission of about 3.3 ms. The crystal field calculations of the Mn²⁺ energy levels demonstrated a good agreement between theoretical and experimental results. The presented combination of the structural, spectroscopic and CF analyses provide us with detailed information about studied ZnS samples and can be readily applied to other similar systems as well.



Figure 6Left hand side: UV-vis absorption spectra of ZnS, ZnS:1%Mn²⁺ and ZnS:5%Mn²⁺ (corresponding energy gaps estimated to be $E_g = 4.71$, 4.66 and 4.64 eV, respectively). Right hand side: Photoluminescence emission spectra of ZnS, ZnS:1%Mn²⁺ and ZnS:5%Mn²⁺ NPs, obtained under excitation at $\lambda_{exc} = 332$ nm.

OPTICAL LUMINESCENCE STUDYES OF XANTHATES ADSORBTION LAYER AT SOLID-LIQUID INTERFACE

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Physical and chemical adsorbtion processes of xanthate molecules at solid-liquid interface represent a condition to modify the floatability for many non-ferrous minerals which undergo the separation processes of metallic compounds from the gangue. In this article we propose optical luminescence as method of evaluation of the kinetics of adsorbtion processes, to determine the time to achieve the dynamic balance for the thin layers which are formed.

The method is based on the determination of the intensity for the integral optical radiation obtained from the adsorbtion thin layer which was stimulated with a monochromatic pulsating optical signal. The measurements of the luminescence signals were made in similar conditions the other method used to study the kinetics of interface processes, namely the radiometric determination using radioactive marking of the xanthates,. The radiometric method is based on the radiometric response of the adsobtion layer as a function of the concentration for the xanthate molecules on the surface of the minerals.

The luminescence was studied for the galena, sphalerite and calcopiryte minerals with various organic xanthats, for different concentrations of the solution and diverse values of the pH and temperature.

Using this method one gained information on the kinetics for the adsobtion of xanthates by evaluation of the integrated luminescence response as a function of time. A good correlation with the sequential (radiometric) investigation methods was observed. Also a better expression of the time to achieve equilibrium of formation for the adsorbtion layer was obtained, which is hard to establish through other methods.

- [1] R.N. Bhargava, J Lumin. 70 (1996) 85-94,
- [2] Y.I.T. Isobe, M. Senna, J Phys. Chem. Solids. 57 (1996) 373–379,
- [3] K. Sooklal, B.S. Cullum, S.M. Angel, C.J. Murphy, J Phys. Chem. B. 100 (1996) 4551-4555,
- [4] J. Huang, Y. Yang, S. Xue, B. Yang, S. Liu, J. Shen, Appl. Phys. Lett 70 (1997) 2335–2337,
- [5] R. Todoran, D. Todoran, Phys. Mac., 57/59 (2008) 35-40,
- [6] R. Todoran, J. Sharkany, Proc. of SPIE 3687 (1999), 26-28,
- [7] D.B. Hough, H.M. Rendall, in D.G. Parfit, C.H. Rochester (Eds.), Adsorption from Solution at the Solid/Liquid Interface, Academic Press, London, 1983, pp 15-20.

FREE-ELECTRON LASER AND SYNCHROTRON STUDIES OF IMPURITY-TRAPPED EXCITONS IN FLUORIDE MATERIALS

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Impurity-trapped excitons in rare-earth doped materials play an important role in both the radiative and non-radiative decay processes of the excited configurations of the rare-earth ions. Theoretical [1] and experimental [2] studies suggest that the non-radiative decay of an excited $4f^{N-1}5d$ configuration to the $4f^{N}$ ground configuration can be mediated by trapped exciton states, where the 5d electron becomes delocalised.

We have demonstrated that it is possible to directly measure the energy levels of impurity-trapped excitons in CaF₂:Yb²⁺, SrF₂:Yb²⁺ and NaMgF₃. This has only previously been inferred from indirect measurements, such as temperature dependent lifetime and photoluminescence quenching and photoconductivity [3]. Our technique utilises the radically different decay rates of the exciton excited states to generate a transient photoluminescence enhancement. A UV pulse is used to excite the interconfigurational $4f^{N}$ - $4f^{N-1}5d$ transitions of divalent ytterbium. The excited electron delocalises subsequently forming the impurity trapped exciton state. IR excitation from the Dutch free electron laser (FELIX) is then used to probe intra-excitonic transitions which can be observed as an enhancement of the exciton photoluminescence over a short time window determined by the emission lifetime of the excited states.

For both CaF_2 : Yb^{2+} and SrF_2 : Yb^{2+} we observe sharp transitions arising from changes in the wave function of the localised 4f hole or the relative spin of the 4f hole and the delocalised electron and broad bands associated with delocalised electrons and infrared induced trap liberation. Quantitative account of the sharp spectral features is possible using a parametrised crystal-field model [4]. Power- and temperature-dependence measurements give additional information on the dynamics of the excited states and reveal a complex interplay between excited-state absorption and electron-trap liberation [5].

The UV-FEL studies are supplemented by UV and VUV synchrotron excitation measurements. These experiments allow us to monitor energy transfer between conductionband electrons and impurity-trapped excitons. Measurements at different temperatures and excitation energies gives insight into the coupling between bulk and localised states.

- [1] G. Sánchez-Sanz, L. Seijo and Z. Barandiarán, J. Chem. Phys. 133 (2010) 114509.
- [2] M. Grinberg and S. Mahlik, J. Non-Cryst. Solids 354 (2008) 4163.
- [3] B. Moine, B. Courtois and C. Pedrini, J. Phys. 50 (1989) 2105.
- [4] M. F. Reid, P. S. Senanayake, J.-P. R. Wells, G. Berden, A. Meijerink, A. J. Salkeld, C.-K. Duan and Roger J. Reeves, Phys. Rev. B 84 (2011) 113110.
- [5] P. S. Senanayake, J.-P. R. Wells, M. F. Reid, G. Berden, A. Meijerink, and R. J. Reeves, App. Phys. Lett. 100 (2012) 041902.

EFFECT OF SUBSTITUTION ELEMENT IN IN CoFe_{2-x}In_xO₄ ON MORPHOLOGY, MAGNETIC AND OPTICAL PROPERTIES

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Cobalt ferrite $CoFe_{2-x}In_xO_4$ (x = 0.05, 0.1 and 0.5 moles) was obtained by original fast hydrothermal method and the effects of substitution element (Fe^{3 +} was substituted by In³⁺⁾ on morphology, magnetic and optical properties were investigated.

The obtained nanoparticles samples with different concentrations of substitute (In^{3+}) were characterized by X-ray diffraction that shows a high degree crystallization with diffraction peaks correspond to the cubic spinel structure and crystallite sizes were determined from the full-width at half maximum (FWHM) using the Scherrer equation [1], nanoparticles dimension are in range between 11,8 and 17.6 nm as in table (1) below.

	Lattice param	neters	Unit cell volume		
CoFe _{2-x} In _x O ₄	a=b=c (Å)	α=β=γ (°)	(Å ³)	of particles (nm)	Space group
x=0	8,39(1)	90	591,564	17,6	F d -3 m
x=0,05	8,405(2)	90	593,82	13,8	F d -3 m
x=0,1	8,403(3)	90	593,26	11,8	F d -3 m
x=0,5	8,427(3)	90	598,45	13,8	F d -3 m

Table 1. Crystallographic data obtained by Rietveld refining of diffraction spectra.

The EDX confirm the presence of indium in cobalt ferrite. We observe where Fe^{3+} was substituted In^{3+} (x = 0.05 and 0.1) is formed single phase and where x=0.5 X-ray diffraction reviewed new peaks characteristics secondary phase In_2O_3 .

The Selected Area *Electron Diffraction* showed that circles correspond to specific interplanetary distances families of crystalline planes are assigned to compound $CoFe_{1,9}In_{0,1}O_4$. From HRTEM image can be observed crystallographic planes formed for compound $CoFe_{1,9}In_{0,1}O_4$ that are consistent with data from X-ray diffraction.

The TEM micrograph of cobalt ferrite $CoFe_{2-x}In_xO_4$ obtained by original fast hydrothermal method shows a narrow distribution and nanoparticle are have cubic shape with a size of ~ 20nm.

In order to determine the optical properties we used FT-IR and UV-Vis measurements. From FT-IR spectroscopy we determined the vibration peak and confirmed the presence of In and Co oxides. UV-Vis revealed the band gap of cobalt ferrite $CoFe_{1.9}In_{0.1}O_4$.

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 G. Nabiyouni, R. Sahraei, M. Toghiany, M. H. Majles Ara, K. Hedaya, Rev.Adv.Mater.Sci. 27(2011) 52-57

SYNTHESIS AND PHOTOLUMINESCENCE PROPERTIES OF (CH₃NH₃)₂PbBr₄ PEROVSKITE

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Organic–inorganic layered hybrids are a class of interesting compounds due to their unique structures of alternately stacking sheets of organic and inorganic components with collaborative properties in the molecular scale. A great deal of attention has been paid to the preparation and characterization of organic–inorganic layered hybrids because of their unique electrical and optical features. Inorganic host / organic guest layered hybrid crystal, namely PbBr4(CH3NH3)2, is successfully prepared by a novel method and the luminescence spectra obtained from photoluminescence measurement are studied. The structures of the crystal are characterized through X-ray diffraction. Dependence of luminescence intensity to temperature and peak points of spectra are investigated from 15 to 285 K. Some normalized photoluminescence spectra are shown in the figure 1. Note that the spectra have been shifted for clarity.

(uu

) WHW.





Figure 1: Photoluminescence spectra excited at 364 nm for temperatures ranging from 15 K to 285 K.

Figure 2: FWHM as a function of temperature

The coresponding FWHM of all of the photoluminescence spectra is depicted below. As it can be seen, FWHM increases linearly with temperature.

- K. Gauthron, J-S. Lauret, L. Doyennette, G. Lanty, A. Al Choueiry, S.J. Zhang, A. Brehier, L. Largeau, O.Mauguin, J. Bloch, and E. Deleporte, OPTICS EXPRESS Vol. 18, No. 6 (2010) 5912-5919
- [2] S. Zhang, G. Lanty, J. S. Lauret, E. Deleporte, P. Aude-bert, and L. Galmiche, Acta Mater. 57 (11) (2009) 3301–3309.
- [3] Ziyong Cheng, Jun Lin, CrystEngComm, 2010, 12, 2646–2662
- [4] T. Ishihara, J. Takahashi, and T. Goto, Phys. Rev. B 42 (17) (1990) 11099–11107.
- [5] K. Tanaka, F. Sano, T. Takahashi, T. Kondo, R. Ito, and K. Ema, Solid sate comm. 122 (2002) 249–252.
- [6] T. Hattori, T. Taira, M. Era, T. Tsutsui, and S. Saito, Chem. Phys. Lett. 254(1-2), 103–108 (1996).

THERMAL STUDIES AND LUMINESCENCE OF COBALT DOPED (80-x)Sb₂O₃-20Na₂O-xWO₃ GLASSES

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Low phonon energy alkali-antimonite glasses doped with cobalt oxide have been investigated by UV-Vis-NIR absorption and thermal measurements as a function of the glass composition. Stable glass samples in the $(800-x)Sb_2O_3$ - $20Na_2O-xWO_3$ system have been prepared by the conventional melt-quenching method. The influence of Co_3O_4 concentrations on the evolution of the observed absorption bands and characteristic temperature Tg has been specified. On this base, the environment of cobalt ions in this glass has been clarified. Intense emission at 755 nm has been obtained using 550 nm excitation at room temperature. The obtained results indicate that these new low phonon energy glasses could be a serious candidate for laser application.

- [1] M.T. Soltani, A. Boutarfaia, R. Makhloufi, C. Benhamideche and M. Poulain, XIII ISNOG, extended abstract, September 9-13, 2002, Pardubice, Czech Republic.
- [2] M.T. Soltani, A. Boutarfaia, R. Makhloufi, and M. Poulain, J.Phys.Chem.Solids 64 (2003) 2307-2312.
- [3] P. Petkova, M.T. Soltani, S. Petkov and V. Nedkov, Urbach's Rule in Undoped and Co-Doped (80x)Sb₂O₃-20Na₂O-xWO₃ Glasses, Acta physica Polonica A, 121, 2012, 1

STRUCTURE AND LUMINESCENCE PROPERTIES OF THERMALLY NITRIDED Ga₂O₃ NANOTUBES

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The structure and luminescence properties of thermally nitrided Ga_2O_3 nanotubes were examined. Transmission electron microscopy and X-ray diffraction confirmed the formation of a uniform GaN shell layer on the surface of the nanotubes by thermal nitridation. The core and shell of the nitrided nanowires were monoclinic-structured single crystal Ga_2O_3 and wurtzite-type hexagonal close-packed structured-single crystal GaN, respectively. The as-synthesized Ga_2O_3 nanonanotubs exhibited a broad emission band at approximately 520 nm in the green region. In contrast, the nitrided Ga_2O_3 nanotubes exhibited a much stronger emission band at approximately 480 nm in the blue region, which must originate from the newly formed GaN shell layer. The origin of the enhancement of the luminescence of the Ga_2O_3 nanotubes by thermal nitridation is discussed.

- [1] L. Fu, Y. Liu, P. Hu, K. Xiao, G. Yu, D. Zhu, Chem. Mater. 15 (2003) 4287-4291.
- [2] K.W. Chang, J.J. Wu, Appl. Phys. A 76 (2003) 629–631.

ESR INVESTIGATION OF THE ENHANCING EFFECT OF CODOPED REE ON THE Mn RED EMISSION IN CaGa $_2S_4$ SINGLE CRYSTALS

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We have so far reported the enhancing effect of some of REEs on the Mn red emission in Ca and Sr thiogallates, ^{1,2)} and also reported the study of the substitutional sites of Mn and Eu in CaGa₂S₄ single crystals through ESR measurements.^{3,4)} Especially the Ca thiogallate is thought to be an appropriate material to realize three primary colors using only one host compound, since it has a wide band gap of about 4.3 eV, its single crystal can be grown rather easily and it emits various colored light when REEs are doped. However there is a drawback of lacking a good red activator. The Mn red emission we have found is a good one but still not strong enough to be practically used as phosphor. The correlation between more than two dopants in a host compound has long been a problem to be solved in the luminescent field. The present work aims to clarify the mechanisms of the enhancing effect above mentioned and finally strengthen the red emission in the compounds above.

Our previous study shows that both Mn and Ce ions work as good activators in $CaGa_2S_4$ to emit red and blue light, respectively, ^{1,2)} and has predicted that when both atoms are doped together, they may form a kind of clusters in the host to enhance the Mn red emission by reducing the Ce blue one at the same time. ⁵⁾

To check the possibility for such a cluster to be formed in the host, we have performed ESR measurements in the 4.2 K to 300 K temperature range using single crystals doped with both Mn and Ce. We have obtained the temperature and microwave power dependent data together with the road map of each resonance line by rotating the crystal axis around the axis of the exciting field. Further, we have measured ESR of CaGa₂S₄ single crystals doped with both Mn(0.2 mol%) and either of La or Yb in the same amount. The La and Yb elements are used since the former has a large enhancing effect on the Mn red emission but gives no ESR signals, while the latter has no enhancing with small ESR signals.^{1,2)} Thus they are regarded as very good probes to investigate the enhancing mechanisms through ESR.

Strong correlations are found in the measured ESR spectra of the crystals with and without enhancing effect on the Mn red emission. Based on these results, we will discuss the mechanisms of correlation between Mn and other dopants and the possibility of cluster formation in codoped Ca thiogallate hosts.

- [1] F. Boitier, C. Hidaka, T. Takizawa, J. Lumin, 129 (2009) 554
- [2] T.Obonai, C.Hidaka, and T.Takizawa, phys. stat. sol. A 206 (2009) 1026
- [3] T. Oonai, C. Hidaka, S. Nomura, and T. Takizawa, Opt. Materials. 32 (2010) 1637
- [4] T. Takizawa, T. Obonai, S. Nomura, and C. Hidaka, Jpn. J. Appl.Phys. 50 (2011) 05FG01
- [5] A.Suzuki, C.Hidaka, T.Takizawa and S.Nomura, submitted to J.Lumin.

DEFECT DETECTION IN ALUMINIUM USING PULSE THERMOGRAPHY FOR A SAMPLE WIDTH PERIODIC STRUCTURE

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This paper presents an extraction of meaningful data from experimental results obtained by IR video thermography used for pulsed defectoscopy on an aluminium test sample [1]. The comparison of noise reduction between conventional and the Wiener filtering method is conducted. The origin of noise is attributed to both intrinsic limitations imposed by thermal diffusion, and extrinsic factors including camera sensitivity, noise, input energy and reflected background radiation. The filtered results, of temperature contrast, on the test plate surface (basic harmonic, mean value and Wiener filter of IR pixels along the central line) [2] are presented.

Equally spaced grooves were produced on one side of an aluminium sample, making a periodic defect structure with certain space frequency and of certain depth. The second side of the sample was illuminated by a short light pulse and the temperature distribution on the illuminated side was analyzed by pulse infra-red thermography. The temperature distribution obtained on the sample surface was also periodic, showing maximum above the grooves (defects), and minimum above positions with no defects [3].

Experimental results were obtained by a standard thermal imaging camera. The IR camera FLIR SC620 generates a thermal image of the test samples observed, then converts it to a visible image and then transmits that image to the display unit. The time history of the surface temperature after absorption of a short light pulse is used to obtain information about the subsurface structure and the thermo-physical properties of the material [4].

- C. Ibarra-Castanedo, M. Genest, P. Servais, X.P. Maldague, A. Bendada, NDT&E 22 No. 2-3 (2007) 199-215.
- [2] Lj. Tomić, J. Elazar, B. Milanović, Proceedings of the Abstract 3rd Conference MediNano. Belgrade, Serbia, October 18-19 (2010) 77.
- [3] H.S. Carslaw, J.C. Jaeger, Conduction of Heat in Solids, second ed., Oxford, Clarendon, 1959.
- [4] X.P. Maldague, Theory and Practice of Infrared Technology for Nondestructive Testing, John Wiley & Sons, Inc., New York, USA, 2001, pp. 347–355.

OPTICAL PROPERTIES OF PDMAEMA-CO-AA SEMICONDUCTOR NANOCOMPOSITES

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Nanostructured cadmium selenide (CdSe) and lead sulfide (PbS) semiconductors were prepared in poly(2-(dimethylamino)ethyl methacrylate-co-acrylic acid) matrix. The obtained nanoparticles were characterized by using optical and structural methods. Co-polymers were synthesized in two different mol ratios of PDMAEMA: acrylic acid monomer units (1:2, 1:1). TEM analysis confirmed the presence of the nano-sized CdSe and PbS particles. In the case of CdSe, a shift of the onset of the optical absorption towards lower wavelengths was observed. X-ray diffraction analysis revealed that both CdSe and PbS nanoparticles have cubic crystal structure.

NOVEL ORGANO-COLLOIDAL SYNTHESES OF DIFFERENT Sb₂S₃ NANORODS AND NANOWIRES, THEIR OPTICAL PROPERTIES, GROWTH AND SELF-ASSEMBLY OF AMORPHOUS SPHERICAL Sb₂S₃ NANOPARTICLES IN WIRES/RODS FORMATION

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We report the novel organic syntheses, optical properties, growth and self-assembly of antimony trisulfide (Sb₂S₃) amorphous nanospheres to nanowires/nanorods via a simple, low-cost and modified colloidal synthetic methods. The current synthetic methods are modified on the already modified well-developed technique for colloidal synthesis by using "green" and low-cost paraffin liquid as the solvent and different acids (oleic acid (OA), 2-ethylhexanoic acid (EHA) and their mixture). Morphological, optical and structural analyses were performed on the all synthesized samples. The optical band-gap energies of the Sb₂S₃ nanowires/nanorods are found to be ~1.5-1.6 eV, for all the samples observed. Also, the refinement showed that Sb₂S₃ nanowires/nanorods grow along the [010] direction. It was observed that Sb₂S₃ nanowires/rods, probably involving both mechanisms, Ostwald-ripening and self-organization of spherical nano particles through oriented-attachment of individual nanoparticles. The optical band-gap energy found for amorphous Sb₂S₃ nanospheres was also ~1.5 eV.



SEM micrographs, photograph of Sb₂S₃ nanowires dispersed in isopropil alcohol and their band gap energies.

SYNTHESIS, STRONG ROOM-TEMPERATURE PL, PHOTOCATALYTIC ACTIVITY AND A SYNERGY OF ZnO AND ZnWO₄ IN ZnO/ZnWO₄ ROD-LIKE NANOPARTICLES

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Zinc oxide (ZnO)/zinc tungstate (ZnWO₄) rod-like nanoparticles with diameters in the range of 6–11 nm and length of about 30 nm were synthesized by a low temperature soft solution method at 95 °C in the presence of non-ionic copolymer surfactant. It was found that their crystallinity was enhanced with the increase of heating time from 1 h up to 120 h. The photoluminescence (PL) measurements showed very strong, narrow UV band peaked at 3.30 eV and a broad visible band peaking at 2.71 eV with a shoulder at about 2.53 eV, for λ_{exc} < 300 nm. Quite large variations in the intensities of the two PL bands were observed for different excitation wavelengths. The intensity of the main visible band decreases with decreasing excitation energy and disappears when samples are excited λ = 320 nm (E_{exc} = 3.875 eV). We found that observed optical properties originate from ZnO phase. UV band gap PL had high intensity for all applied excitations, probably induced by $ZnWO_4$ phase presence on the surface. In addition, two values were found for direct band-gap energy of ZnO/ZnWO₄ rod-like nanoparticles 3.62 and 3.21 eV, determined from reflectance spectrum. Photocatalytic activity of ZnO/ZnWO₄ nanopowders was checked using photodegradation of selected dyes as model system. Obtained results were correlated with specific surface area, particle sizes, crystallinity and ZnO/ZnWO₄ ratio of the samples. The photocatalytic behaviour of ZnO is strongly dependent on the formation of ZnWO₄ phase, of the obtained rod-like nanoparticles. As crystallinity of ZnWO₄ component in the ZnO/ZnWO₄ increase, photocatalytic activity also increases. The main findings can be explained by charge transfer reactions that follow light absorption by ZnO and ZnWO₄ in nanocomposite.

SPECTROSCOPIC PROPERTIES OF NEWLY FLUX GROWN CUBIC RE₂O₃:Yb³⁺ (RE=Y,Gd,Lu) CRYSTALS FOR HIGH-POWER DIODE-PUMPED LASER SYSTEMS

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Developing large laser grade cubic rare-earth sesquioxides (RE₂O₃, RE=Sc,Y,Gd,Lu) single crystals doped with RE³⁺ ions stands as one of the most challenging endeavours of today's crystal growth [1,2]. Recent studies on cubic RE₂O₃ single crystals have demonstrated the laser potential of these materials and highlighted the extreme thermodynamic conditions in which their growth takes place [1-3]. In particular, the laser performances of Lu₂O₃:Yb³⁺ crystals make it likely to outperform better-known rivals such as YAG:Yb³⁺ or $KY(WO_4)_2$: Yb³⁺ for 976 nm diode-pumped systems [4]. On the other hand, Gd₂O₃: Yb³⁺ crystals are promising candidates for diode pumped laser systems capable of delivering high energy pulses at low frequencies. This paper will present several mm³-sized Yb³⁺-doped Y₂O₃, Gd₂O₃ and Lu₂O₃ single crystals which were recently grown in air at half their melting point temperature by a newly designed high-temperature solution growth method [5], and characterized by means of X-ray diffraction, Fourier transformed infrared (FTIR) spectroscopy and electron probe microanalysis (EPMA). We will show the spectroscopic characterizations (absorption and emission cross sections, visible anti-Stokes emission, resonant and non resonant fluorescence decays) of these RE₂O₃:Yb³⁺ (RE=Y,Gd,Lu) single crystals of the cubic phase, which demonstrate that this flux growth process allows for achieving optimal doping for high-power laser applications, impedes the dissolution of OH⁻ groups in the crystals, hinders the formation kinetics of Yb³⁺ pairs that would lead to detrimental cooperative emission around 500 nm and stabilizes directly the Yb³⁺ ions oxidation state without resorting to post-growth thermal annealings. The optimal ms-long experimental lifetime and the large energy storage parameter make these new crystals a priori competitive for high average or peak output powers delivery under diode pumped quasi-four level operation. It will be shown that Gd₂O₃:Yb³⁺ crystals display substantially different spectroscopic features, among which broader absorption bands and smaller peak absorption cross sections at the zero-phonon line, than those of Y_2O_3 : Yb^{3+} and Lu_2O_3 : Yb^{3+} crystals.

- [1] A. Yoshikawa and V. Chani, MRS Bulletin, 34 (2009) 266-270.
- [2] Akihiro Fukabori, Valery Chani, Kei Kamada, Federico Moretti and Akira Yoshikawa, *Cryst. Growth & Des.*, 11 (2011) 2404–2411.
- [3] R. Peters, C. Kränkel, K. Petermann and G. Huber, J. Cryst. Growth, 310 (2008) 1934-1938.
- [4] C. R. E. Baer, C. Kränkel, C. J. Saraceno, O. H. Heckl, M. Golling, R. Peters, K. Petermann, T. Südmeyer, G. Huber and U. Keller, *Optics Letters*, 35 (13) (2010) 2302-2304.
- [5] Ph. Veber, M. Velázquez, V. Jubera, S. Pechev and O. Viraphong, *CrystEngComm*, **13** (16) (2011) 5220-5225.

STUDY ON CHEMILUMINESCENCE OF LUMINOL IN AQUEOUS STRONTIUM AND BARIUM HYDROXIDES USING VARIOUS OXIDANTS

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The chemiluminescence (CL) of luminol in aqueous alkaline solution of alkaline metal hydroxides has been studied using various oxidants such as potassium ferricyanide, potassium permanganate, and potassium persulphate, as single oxidants. Addition of each oxidant to aqueous alkaline-luminol solution results in chemiluminescence. The chemiluminescence intensity of each oxidant is recorded using Fuess spectrograph. The microphotometric analysis of CL emission spectra on resolution reveals the presence of two excited species formed explained with suitable mechanisms.

 Hideyki, Y, Kiyoshi U, Junichi I, Hitoshi N, Masatoshi Y, Chemiluminescent propertied of some luminol related compounds (II). *Dyes Pigments* 41 (1999) 177-182.

STUDY OF STRUCTURAL, OPTICAL, AND ELECTRICAL PROPERTIES OF AG DOPED TIO₂ THIN FILMS PREPARED BY SOL-GEL ROUTE

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Ag doped dioxide titanium (TiO2) films were prepared by Sol-Gel route using Dip coating technique. The electrical, optical properties in the Ag doped TiO2 films as functions of Ag content were investigated. The X-ray diffraction spectra indicated the presence of anatase phase for all TiO2 films deposited. When the Ag content of Ag doped TiO2 was above 4% the films became amorphous. All of the Ag doped TiO2 films had 85% transmittance in the visible wavelength range, with a strong absorption around 400 nm. The optical band gap increased from 3,01 eV to 3,2 eV for Ag content up from 1% to 4%.

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