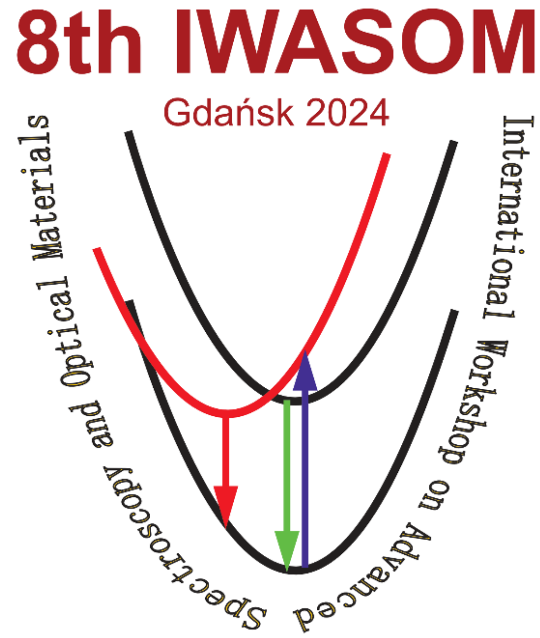
University of Gdańsk

CMSD

FRUG

BOOK OF ABSTRACTS

The Eight International Workshop
on Advanced Spectroscopy and Optical Materials
July 7-12, 2024, Gdańsk, Poland



Ministry of Science and Higher Education
Republic of Poland

HONORARY PATRONAGE
Mayor of the City
of Gdańsk

The Eight International Workshop
on Advanced Spectroscopy and Optical Materials
July 7-12, 2024, Gdańsk, Poland

Organized by;

Institute of Experimental Physics, University of Gdansk
Foundation for the Development of the University of Gdansk

IWASOM International Scientific Committee

M. Back, Italy
L. Bausa, Spain
P. Bojarski, Poland
A. Carneiro, Portugal
P. Dereń, Poland
W. Drozdowski, Poland
M. Godlewski, Poland
M. Krośnicki, Poland
R. S. Liu, Taiwan
S. Mahlik, Poland
M. Malinowski, Poland
W. Stręk, Poland
A. Suchocki, Poland
M. Suta, Germany
J. Ueda, Japan

Local Organizing Committee

A. Baran (Co-secretary), J. Barzowska, P. Bojarski, M. Czarnomska, K. Dorywalski, N. Górecka, E. Gruszczyńska, M. Grzegorczyk, M. Kamiński, A. Kowalska, M. Krośnicki, K. Krysiak, A. Lazarowska, T. Leśniewski (Secretary), A. Lewkowicz, S. Mahlik (Chair), N. Majewska, M. Mazurek, J. Moszczyński, M. Starost, A. Synak, K. Szczodrowski

Scientific Program

Sunday, July 7, 2024

Location: Main Hall, Faculty of Mathematics, Physics and Informatics, Institute of Experimental Physics, 57 Wita Stwosza Str., Gdansk

Time	Event
15:00 – 18:00	Registration

Monday, July 8, 2024

Location: Main Hall, Faculty of Mathematics, Physics and Informatics, Institute of Experimental Physics, 57 Wita Stwosza Str., Gdansk

Time	Event
08:00 – 09:00	Registration

Location: Room D005, Faculty of Mathematics, Physics and Informatics, Institute of Experimental Physics, 57 Wita Stwosza Str., Gdansk

Session: Phosphors: recent progress, new materials, and applications I

Session chair: Andries Meijerink

Time	Code	Presenting author	Title, authors
09:15 – 09:30		Opening ceremony	
09:30 – 10:00	TL1	Michele Back	Cr^{3+}-activated phosphors: Yesterday, today and tomorrow M. Back
10:00 – 10:30	IL1	Ru-Shi Liu	Near-infrared phosphors: unlocking the potential for next-gen LEDs R. S. Liu
10:30 – 11:00	IL2	Shohei Kodama	Recent development of fast red/NIR oxide phosphors doped with Eu^{2+} S. Kodama, T. Saito, I. Yanase, H. Takeda
11:00 – 11:30		Coffee break	

Session: Luminescent sensors I

Session chair: Michele Back

Time	Code	Presenting author	Title, authors
11:30 – 12:00	TL2	Daniel Jaque	Luminescence thermometry for live sciences D. Jaque
12:00 – 12:30	IL3	Justyna Zeler	Advancements in Luminescence Thermometry Utilizing co-dopants Interactions J. Zeler, J. Jedoń, P. Łukaszczuk, M. Sójka, C. D. Brites, L. D. Carlos, Y. Zorenko, V. Gorbenko, E. Zych
12:30 – 12:45	O1	Marcin Nyk	Two-photon excited luminescence of colloidal quantum dots for heavy metal ions detection M. Nyk, A. Siomra, D. Wawrzyńczyk, M. Samoć
12:45 – 13:00	O2	Adam Kabański	The influence of the metal ion on spectroscopic properties of [DMA] $M(HCOO)_3$: Cr^{3+} ($M = Zn^{2+}, Mn^{2+}, Mg^{2+}$) hybrid perovskites for luminescence thermometry A. Kabański, M. Ptak, D. Stefańska
13:00 – 14:30		Lunch	

Session: Theory and modeling

Session chair: Philippe Goldner

Time	Code	Presenting author	Title, authors
14:30 – 15:00	IL4	Valera Veryazov	How can accurate (and not so accurate) calculations be used in spectroscopy? V. Veryazov
15:00 – 15:30	IL5	Marek Krośnicki	Multi-configurational calculations of the electronic structure of crystalline solids; local excited states, band gaps and valency M. Krośnicki
15:30 – 15:45	O3	Dominika Jelonek (Kaczmarczyk)	Photophysical and chiroptical properties of rhenium(I) complex bearing pyrazino-phenanthroline helicene ligand D. Kaczmarczyk, M. Srebro-Hooper
15:45 – 16:00	O4	Mohamed Taibeche	First-principles calculation of electronic structure of Li^+ co-doped Eu^{3+}-doped ZnO for photodynamic therapy (PDT) application M. Taibeche, W. Zerman, L.Guerbous, A. Bouhemadou
16:00 – 16:30		Coffee break	

Session: Radioluminescence, optically and thermally stimulated luminescence in solids

Session chair: Winicjusz Drozdowski

Time	Code	Presenting author	Title, authors
16:30 – 17:00	IL6	Shusnuke Kurosawa	Transparent ceramics scintillators and quick material search S. Kurosawa
17:00 – 17:30	IL7	Yuriy Zorenko	Synchrotron radiation in luminescence research: recent advances in the study of single crystals and single crystalline phosphors Y. Zorenko
17:30 – 17:45	O5	Karol Bartosiewicz	Engineering atomic size mismatch in La^{3+}, Pr^{3+} codoped $Lu_3Al_5O_{12}$ garnet single crystals for tailored structure and functional properties K. Bartosiewicz, B. Albini, D. Szymański, P. Socha, T. Horiai, M. Yoshino, A. Yamaji, S. Kurosawa, R. Kucerkova, P. Galinetto, A. Yoshikawa
17:45 – 18:00	O6	Patarawagee Yasaka	Red-emitting tellurite glasses: a combined investigation of physical, structural, optical and luminescence properties for potential red-light source and scintillation materials P. Yasaka, W. Wongwan, K. Boonin, J. Kaewkhao
18:00 – 20:00		Welcome reception	

Tuesday, July 9, 2024

Location: Room D005, Faculty of Mathematics, Physics and Informatics, Institute of Experimental Physics, 57 Wita Stwosza Str., Gdansk

Session: Optical control and detection of quantum systems

Session chair: Ewelina Lipiec

Time	Code	Presenting author	Title, authors
09:30 – 10:00	TL3	Luisa Bausá	Integration of ferroelectrics, plasmonic nanostructures and 2D materials for application for nanophotonics L. E. Bausá
10:00 – 10:30	IL8	Sebastian Maćkowski	Molecular switching with single upconverting nanocrystals S. Mackowski
10:30 – 10:45	O7	David Hernández -Pinilla	Monolithically integrated Q-switched plasmonic nanolaser D. Hernández-Pinilla, P. Molina, G. López-Polín, M. Chhowalla, P. Ares, J. Gómez-Herrero, M. Ramírez, L. E. Bausá
10:45 – 11:00	O8	Alicja Stachowiak	Impact of side alkyl chain geometry on diketopyrrolopyrrole derivatives: spectroscopic properties, aggregation, and thin film organization A. Stachowiak, K. Kędzierski, K. Rytel, A. Dudkowiak
11:00 – 11:30		Coffee break	

Session: Luminescent sensors II

Session chair: Philippe Smet

Time	Code	Presenting author	Title, authors
11:30 – 12:00	IL9	Marcin Runowski	New strategies for luminescence thermometry and manometry M. Runowski, P. Woźny, T. Zheng, K. Soler-Carracedo, J. Moszczyński, V. Lavín, I. R. Martín, S. Mahlik
12:00 – 12:30	IL10	Łukasz Marciniak	Lifetime-based luminescence manometry on the transition metal ions doped phosphors M. Szymczak, M. Runowski, W. Piotrowski, P. Woźny, S. Mahlik, L. Marciniak
12:30 – 12:45	O9	Maja Szymczak	Tri-modal optical pressure sensor based on Cr^{3+} ions luminescence M. Szymczak, J. Jaśkielewicz, M. Runowski, J. Xue, S. Mahlik, L. Marciniak
12:45 – 13:00	O10	Ajeesh Kumar Somakumar	Mn^{2+} luminescence in ZnS under high pressure A. Somakumar, Y. Zhydachevskyy, D. Wlodarczyk, S. Haider, J. Barzowska, K. Bindu, Y. Edathumkandy, T. Zayarniuk, A. Szewczyk, S. Narayanan, A. Lysak, H. Przybylinska, E. Anila, A. Suchocki
13:00 – 14:30		Lunch	

Session: Luminescent sensors III

Session chair: Marcin Runowski

Time	Code	Presenting author	Title, authors
14:30 – 15:00	IL11	Mu-Huai Fang	Energy-saving colloidal quantum dots composites for short-wave infrared photodetector M. H. Fang
15:00 – 15:15	O11	Ewa Mijowska	Photoelectrochemically active 2D heterostructure based on MoS_2/borophene for hydrogen evolution D. Baranowska, G. Leniec, B. Zielińska, E. Mijowska
15:15 – 15:30	O12	Beata Wielgus-Kutrowska	Photophysical properties of green fluorescent protein in solution and polyvinyl alcohol film at room temperature B. Wielgus-Kutrowska, J. Krasowska, E. Alexander, Z. Gryczynski, I. Gryczynski
15:30 – 15:45	O13	Vasyl Stasiv	Chemical tuning of photo- and persistent luminescence of Cr^{3+}-activated β-Ga_2O_3 by alloying with Al_2O_3 and In_2O_3 V. Stasiv, Y. Zhydachevskyy, V. Stadnik, V. Hreb, V. Mykhaylyk[c], L. Vasylechko, A. Luchechko, T. Wojciechowski, P.Sybilski, A. Suchocki
15:45 – 16:00	O14	Dagmara Kulesza	Beyond luminescence to understand phosphors. the case of Ba_2LaNbO_6:Mn and its derivatives D. Kulesza, J. Jedoń, M. Buryi, M. G. Brik, M. Piasecki, S. Mahlik, A. M. Srivastava, E. Zych
16:00 – 16:15	O15	Ismail Mekkaoui Alaoui	Fluorescence time decay of 1,2-Indanedione-arginine and applications I. Mekkaoui Alaoui
16:15 – 16:30		Conference photo	
16:30 – 19:00		Poster session	

Wednesday, July 10, 2024

Location: Conference room, Hotel Haffner, 59 Jana Haffnera Str., Sopot

Session: Introduction to Advanced Spectroscopy and Optical Materials I

Session chair: Sebastian Mahlik, Tadeusz Leśniewski

Time	Code	Presenting author	Title, authors
09:45 – 10:00		Coffee break	
10:00 – 10:30	TL4	Andries Meijerink	Experimental techniques in optical spectroscopy A. Meijerink
10:30 – 11:00	TL5	Ignacy Gryczyński	Fluorescence: from basics to advanced topics I. Gryczyński
11:00 – 11:15		Coffee break	
11:15 – 11:45	TL6	Markus Suta	Radiative and non-radiative transitions: different and yet so similar M. Suta
11:45 – 12:15	TL7	Albano Carneiro	From basics to advanced: intensity and energy transfer in lanthanide-based compounds A. N. Carneiro Neto
12:15 – 12:30		Coffee break	
12:30 – 13:00	TL8	Philippe Smet	Basics and quirks of thermoluminescence and optically stimulated luminescence P. F. Smet, V. Fritz, D. Van der Heggen
13:00 – 13:30	TL9	Przemysław Dereń	Two-photon absorption, upconversion, photon avalanche, cross relaxation: exploring commonalities and mechanisms with practical examples P. J. Dereń
13:30 – 15:00	Lunch		

Session: Introduction to Advanced Spectroscopy and Optical Materials II

Session chair: Marcus Suta

Time	Code	Presenting author	Title, authors
15:00 – 15:30	TL10	Winicjusz Drozdowski	Tailoring the properties of rare earth activated oxide scintillators by bandgap engineering W. Drozdowski
15:30 – 16:00	TL11	Marek Godlewski	Excitonic recombination processes in solids M. Godlewski
16:00 – 16:30	TL12	Andrzej Suchocki	Spectroscopic properties of Mn^{2+} and Fe^{3+} dopants A. Suchocki
16:30 – 19:30		Free Time in Sopot	
19:30 – 21:00		Dinner on the Beach	

Thursday, July 11, 2024

Location: Room D005, Faculty of Mathematics, Physics and Informatics, Institute of Experimental Physics, 57 Wita Stwosza Str., Gdansk

Session: Nanoscale optical materials, control and detection of quantum systems

Session chair: Przemysław Dereń

Time	Code	Presenting author	Title, authors
09:30 – 10:00	IL12	Philippe Goldner	Rare earth doped crystals for integrated quantum photonics P. Goldner
10:00 – 10:30	IL13	Ewelina Lipiec	Mind the gap! Plasmonic nanocavity for spectroscopic trapping of local molecular rearrangements in artificial lipid monolayers E. Lipiec, A. Chahaj-Brekiesz, M. Czaja, J. Kobierski, D. Lupa, S. Seweryn, K. Skirlińska-Nosek, K. Sofińska, M. Szymoński, A. Wnętrzak
10:30 – 10:45	O16	Marta Gordel-Wójcik	Nanoparticle-based system of gold nanoshells and silver sulfide quantum dots for enhancing optical response M. Gordel-Wójcik, M. Pietrzak, J. Tracz
10:45 – 11:00	O17	Michał Żebrowski	Kinetic of the power-dependent up-conversion luminescence in Er^{3+}/Yb^{3+}-doped single nanocrystal M. Żebrowski, M. Ćwierzona, M. Nyk, A. Bednarkiewicz, S. Maćkowski, D. Piątkowski
11:00 – 11:30		Coffee break	

Session: Phosphors: recent progress, new materials, and applications II

Session chair: Łukasz Marciniak

Time	Code	Presenting author	Title, authors
11:30 – 11:45	O18	Rajalingam Thangavel	Magnetoresistance in van der Waals MoS_2/ZnO/VS_2 trilayer heterostructure for spintronics application R. Thangavel, S. Lahiri, M. Kumar
11:45 – 12:00	O19	Dagmara Stefańska	White light generation with high CRI D. Stefańska, M. Adaszyński, D. Szymański
12:00 – 12:15	O20	Karol Lemański	Stokes and anti-Stokes emission of $CaAl_2SiO_6$ polycrystals doped with Pr^{3+} ions K. Lemański, N. Rebrova, P. Zdeb, P. J. Dereń
12:15 – 12:30	O21	Mykhailo Chaika	Concentration-dependent emission spectra in Cr^{3+}:ggg transparent nanoceramics M. Chaika, P. Głuchowski
12:30 – 12:45	O22	Nadiia Rebrova	Upconversion properties of Pr^{3+} doped $A_3Y(PO_4)_3$ (A=Sr, Ba) phosphors N. Rebrova, R. Lisiecki, P. Zdeb, P. J. Dereń

12:45 – 13:00	O23	Patrycja Zdeb	Unlocking the potential of Pr^{3+}-doped borates in the field of visible to UVC upconversion P. Zdeb, N. Rebrova, P. J. Dereń
13:00 – 14:30		Lunch	

Session: Characterization techniques for optical materials

Session chair: Krzysztof Dorywalski

Time	Code	Presenting author	Title, authors
14:30 – 15:00	IL14	Michał Piasecki	Interrelationships between the luminescent transitions and nonlinear optics in RE activated phosphate, arsenide and vanadate compounds M. Piasecki, A. M. Srivastava, M. G. Brik, W. W. Beers, C. G. Mad, W. E. Cohen
15:00 – 15:15	O24	Grzegorz Leniec	Investigation of the local environment of luminescent chromium ions in the near-infrared (NIR-I/II) range by electron paramagnetic resonance (EPR) technique G. Leniec, E. Mijowska, Y. H. Hsiao, M. H. Huang, K. C. Chen, C. L. Chien, W. T. Huang, N. Majewska, M. Kamiński, S. Mahlik, S. L. Huang, R. S. Liu
15:15 – 15:30	O25	Mateusz Rebarz	ELI ERIC: new capabilities for applications in molecular, bio-medical and material science M. Rebarz, S. Espinoza, J. Andreasson
15:30 – 15:45	O26	Stefan Schweizer	Interlaboratory comparison on absolute photo- luminescence quantum yield measurements of scattering luminescent materials S. Schweizer, S. Fiedler, F. Frenzel, C. Würth, I. Tavernaro, M. Grüne, A. Engel, U. Resch-Genger
15:45 – 16:00	O27	Andrii Schyichuk	Excitation and emission bands of oxygen vacancies in rare earth bixbyite oxides: experiment and calculations A. Shyichuk, J. Trojan-Piegza, E. Zych
16:00 – 16:30		Coffee break	

Session: Glasses, hybrid and organic optical materials

Session chair: Albano Carneiro

Time	Code	Presenting author	Title, authors
16:30 – 16:45	O28	Bohdan Padylak	Optical and EPR spectroscopy of the $Li_2B_4O_7$:Cu,Eu and $Li_2B_4O_7$:Mn,Sm glasses (the review) B. V. Padlyak, I. Kindrat, A. Drzewiecki, V. Adamiv, I. Teslyuk
16:45 – 17:00	O29	Audrey Potdevin	Strategies for increasing Cr^{4+} content in YAG:Cr matrix for laser applications R. Thévenet, A. Potdevin, F. Réveret, G. Chadeyron
17:00 – 17:15	O30	Miguel Andrés Hernández-Rodríguez	All-photonic tunable molecular transistor based on trivalent lanthanide ions luminescence M. A. Hernández-Rodríguez, A. N. Carneiro Neto, C. D. S. Brites

17:15 – 17:30	O31	Antonio Varriale	Cyanobacteria water contaminations. A fluorescence-based method to detect the presence of toxic microcystin molecules in water A. Varriale, A. Capo, A. Pennacchio, C. Montagnese, A. Hadjiantonis, P. Demosthenous, A. Giusti, M. Staiano, S. D'Auria
17:30 – 17:45	O32	Taras Zhezhera	Optical properties of Bi_3TeBO_9 crystalline materials doped with rare earth ions T. Zhezhera, P. Gluchowski, A. Miklaszewski, M. Chrunik, A. Majchrowski, D. Kasprowicz
19:00 – 24:00		Conference Banquet	

Friday, July 12, 2024

Location: Room D005, Faculty of Mathematics, Physics and Informatics, Institute of Experimental Physics, 57 Wita Stwosza Str., Gdansk

Session: Phosphors: recent progress, new materials, and applications III

Session chair: Marek Krośnicki

Time	Code	Presenting author	Title, authors
09:30 – 09:45	O33	Neeraj Kumar Mishra	Strategy to probe multimodal light emissions from Eu^{3+}/Yb^{3+} activated garnet nanophosphor for LED device and solar cell applications N. K. Mishra, K. Kumar
09:45 – 10:00	O34	Saiful Islam Khan	Physical and electrochemical characterization of laser processed anodic semitransparent titania oxide nanotubes formed out of Ti-Au co-sputtered alloy S. I. Khan, K. Siuzdak, K. Grochowska
10:00 – 10:15	O35	Joachim Grzybowski	Theoretical spectroscopic studies on [6] helicene-based chiral conjugated oligomers J. Grzybowski, D. Tabor, M. Srebro-Hooper
10:15 – 10:30	O36	Katarzyna Orzechowska	Theoretical studies on fluorescence properties of 5-(4-nitrophenyl)-1,3,4-thiadiazol-2-amine K. Orzechowska, A. Matwijczuk, M. Srebro-Hooper
10:30 – 10:45	O37	Miroslaw Batentschuk	Phosphors for the improvement of silicon solar cell efficiency: general considerations and examples with new materials - $AgIn_5S_8/ZnS$ core-shell nanocrystals and $Cs_2Ag_xNa_{1-x}Bi_yIn_{1-y}Cl_6$ powders M. Kong, O. Raievska, O. Stroyuk, A. Barabash, C. Erban, A. Osvet, M. Batentschuk, C. J. Brabec
10:45 – 11:00	O38	Kaushal Kumar	Upconversion nano-particles as photo-acoustic contrast enhancer for OCT imaging K. Kumar
11:00 – 11:30		Coffee break	

Session: Novel fluorophores, optical materials, devices for biosensing, biomedical and environmental applications

Session chair: Anna Synak

Time	Code	Presenting author	Title, authors
11:30 – 12:00	IL15	Roman Sobolewski	Terahertz time-domain spectroscopy imaging studies of biomaterials R. Sobolewski
12:00 – 12:30	IL16	Sabato D’Auria	Biomolecules as new avenues for the design of optical biosensors S. D’Auria
12:30 – 12:45	O39	Paula Gawryszewska	A new look at the ligand-lanthanide energy transfer pathways P. Gawryszewska, A. N. Carneiro Neto, E. Kasprzycka, A. Lipa, J. Nasalska, V. A. Trush, L. Michnik, V. M. Amirkhanov, O.L. Malta, J. Legendziewicz
12:45 – 13:00		Closing Ceremony	
13:00 – 14:30		Lunch	

Poster session

Code	Presenting author	Title, authors
P1	Muhammad Tahir Abbas	Phase Transition Luminescence Thermometry Based on $LaAlO_3:Eu^{3+}$ M. T. Abbas, M. Szymczak, Ł. Marciniak
P2	Nikola Bednarska-Adam	Luminescence properties of Eu^{3+} and Dy^{3+} ions in germanate ceramics Li_2AGeO_4 (A = Zn, Mg) N. Bednarska-Adam, M. Kuwik, W. A. Pisarski, J. Pisarska
P3	Gulnara Beketova	Optical properties of double perovskite $Cs_2Ag_{0.2}Na_{0.4}In_{0.6}Si_{0.4}Cl_6$ G. Beketova, T. Leśniewski, N. Górecka, K. Szczodrowski, S. Mahlik, N.Zhanturina
P4	Oskar Bogucki	Innovative luminescent materials for lighting and sensory applications O. Bogucki, M. Kaczkan, A. Kozłowska
P5	Kitipun Boonin	Examining the impact of samarium doping on the properties of boro-tellurite glass for optical applications K. Boonin, P. Yasaka, J. Kaewkhao
P6	Jakub Bożek	Implementation of a genetic algorithm concept in an open source software for the ellipsometric data evaluation J. Bożek, K. Dorywalski
P7	Katsiaryna Chernyakova/ Renata Karpicz	Estimation of the degree of surface defectiveness of the $Ti_3C_2T_x$ films K. Chernyakova, R. Karpicz, M. Ivanovskaya, E. Ovodok, I. Azarko, I. Audzeichyk
P8	Vitalii Chornii/ Vasyl Stasiv	Properties of “phosphate-tungstate glass - $K_2Eu(PO_4)(WO_4)$ crystalline phosphor” glass-ceramics V. Chornii, S.G. Nedilko, V. Sheludko, K. Voynalovych, V. Stasiv, K. Terebilenko
P9	Martyna Czarnomska/ Emilia Gruszczyńska	Practical application of fluorescent dyes in forensic science M. Czarnomska, E. Gruszczyńska, A. Lewkowicz, P. Bojarski, S. Steinborn, Ł. Balwicki
P10	Emilia Gruszczyńska/ Marta Starost	Molecular spectroscopy in time of death estimation E. Gruszczyńska, M. Starost, M. Czarnomska, A. Lewkowicz, P. Bojarski, Ł. Balwicki
P11	Krzysztof Dorywalski	Effect of growth conditions on the optical properties of In_2S_3 thin films in the broad FIR–DUV spectral range K. Dorywalski, L. Bychto, B. Andriyevsky
P12	Konrad Drozdowski	Scintillation properties of GOS and GYAGG ceramics activated with cerium and praseodymium ions K. J. Drozdowski, M. E. Witkowski, W. Drozdowski, L. Swiderski, W. Chewpraditkul, D. Huang, D. Zhu, J. Li

P13	Mohanad Eid	Exploring lead-free liquid-ionic perovskite crystals as novel scintillators M. S. Eid, K. J. Drozdowski, M. E. Witkowski, R. Subagyo, Arramel, Y. Kusumawati, D. Kowal, M. Makowski, M. Danang Birowosuto, W. Drozdowski
P14	Shirly Espinoza	Ellagic acid thin films studied by time-resolved ellipsometry S. Espinoza, M. Levichkova, E. Bittrich
P15	Vitalii Gorbenko	LPE growth and investigation of optical and photoelectrical properties of Ce^{3+} and Ce^{3+},Mg^{2+} doped $Gd_3Sc_2Al_3O_{12}$ and $Gd_{1.5}Lu_{1.5}Sc_2Al_3O_{12}$ single crystalline films V. Gorbenko, T. Zorenko, S. Witkiewicz-Łukaszek, M. Kaminski, S. Mahlik, A. Majewski-Napierkowski, Y. Zorenko
P16	Natalia Górecka	Controlling europium oxidation state in diopside through flux concentration N. Górecka, T. Leśniewski, M. Łapiński, Y. T. Tsai, S. Mahlik, A. Bielicka-Giełdoń, K. Szczodrowski
P17	Syed Shabhi Haider	Properties of ultrasound induced luminescence of $LiTaO_3$:Pr at kHz and MHz frequency ranges S. S. Haider, J. Barzowska, P. F. Smet, A. Suchocki
P18	Ivan Halimski	Trans-stilbene aggregates and crystallites in polystyrene films: microscopy and spectroscopy I. Halimski, R. Karpicz, A. Dementjev, M. Jankunec, J. Chmeliov, M. Macernis, D. Abramavicius, L. Valkunas
P19	Alexandre Hebbrecht	Optimizing luminescence of terbium doped Y_2O_3 thin-films grown by CVD and spin-coating methods A. Hebbrecht, M. A. Arranz-Martinez, A. Tallaire, P. Goldner
P20	Paulina Janowicz	Novel photoacoustic spectroscopy methodology for biosensing of complex environmental water contamination: Baltic sea studies P. Janowicz, S. Pogorzelski, P. Rochowski, K. Boniewicz-Szmyt
P21	Anam Javaid	Phase transition based luminescence thermometry of ZnP_2O_7:Eu^{3+} A. Javaid, M. Szymczak, M. Kubicka, Ł. Marciniak
P22	Mikołaj Kamiński	Optical properties of Ni^{2+} short-wave infrared emission under extreme conditions M. Kamiński, R. S. Liu, S. Mahlik
P23	Paulina Kapuśniak	Optical properties of lead-free $Cs_2Na_{0.6}Ag_{0.4}InCl_6$:$Bi^{3+}$ double perovskite P. Kapuśniak, E. C. C. Kiss, A. Suchocki, Y. Zhydachevskyy, J. Wang, C. G. Ma, M. G. Brik, P. Brągiel, M. Piasecki
P24	Renata Karpicz	Structure and photocatalytic properties of black titania nanotubes R. Karpicz, M. Ivanovskaya, S. Poznyak, E. Ovodok, D. Kotsikau
P25	Renata Karpicz	Carbon states in the anodic alumina films formed in electrolytes containing formic acid K. Chernyakova, I. Matulaitienė, G. Grincienė, A. Jagminas, R. Karpicz

P26	Dobrosława Kasprowicz	Luminescence of $Bi_3TeBO_9{:}Yb^{3+}$ phosphors D. Kasprowicz, T. Zhezhera, P. Głuchowski, M. Nowicki, M. Chrunik, B. Szczęśniak, A. Majchrowski
P27	Ihor Kindrat/ Bohdan Padlyak	Effect of Ag co-doping on Pr^{3+} luminescence in lithium tetraborate glasses I.I. Kindrat, B.V. Padlyak, R. Lisiecki, A. Drzewiecki, V.T. Adamiv
P28	Emeric Kiss	Luminescence properties of $Rb_2SnCl_6{:}Te^{4+}$ at high pressures E. C. C. Kiss, P. K. Kapusniak, A. Suchocki, Y. Zhydachevskyy, J. Wang, C. G. Ma, M. Piasecki, M. G. Brik, C. Avram
P29	Jakub Kłos/ Wit Krośnicki	Magnetite electronic structure from multi configurational ab-initio calculation K. Nalikowski, J. Kłos, W. Krośnicki, V. Veryazov, M. Krośnicki
P30	Agata Kowalska	New core-shell nanocomposites - synthesis, characterization, and fluorescence properties A. Kowalska, E. Adamska, P. Bojarski, B. Grobelna, A. Synak
P31	Karolina Kowalska	Titanate-germanate glasses doped with rare earth ions for infrared photonics K. Kowalska, M. Kuwik, J. Pisarska, W. A. Pisarski
P32	Dharmendra Kumar	Examining ambipolar, nitrogen-doped polycyclic aromatic hydrocarbons for enhanced efficiency in TADF OLED emission D. Kumar, M. Lindner, P. Data
P33	Agata Lazarowska	Dual role of oxygen-related defects in the luminescence kinetics of $AlN{:}Mn^{2+}$ A. Lazarowska, M. Kamiński, N. J. Cherepy, S. Mahlik, R. S. Liu
P34	Tadeusz Leśniewski	Full energy structure of the Cr^{3+} activator in $Cs_2NaInCl_6$ double halide perovskite host under pressure T. Leśniewski, M. Mazurek, N. Górecka, K. Szczodrowski, S. Mahlik
P35	Pola Łukaszczuk	Temperature dependent luminescence of $SrAl_{12}O_{19}{:}Eu^{2+},Eu^{3+},Cr^{3+}$ thermometric phosphors P. Łukaszczuk, J. Zeler, M. Sójka, T. Leśniewski, S. Mahlik, M. Brik, M. Piasecki, E. Zych
P36	Natalia Majewska	Spectroscopic and photoelectric studies: insights into quenching phenomena of nir materials N. Majewska, S. Mahlik
P37	Artur Majewski-Napierkowski	Luminescence of the Sc^{3+} isoelectronic impurities and antisite defects in $(Y,Lu,Gd)_3Al_5O_{12}$ garnets A. Majewski-Napierkowski, J. Pejchal, M. Nikl, K. Bartosiewicz, Y. Zorenko
P38	Michał Mazurek	Optical properties of $Cs_2NaInCl_6{:}Cr^{3+}$ for application in pc-LED infrared emitters M. Mazurek, T. Leśniewski, N. Górecka, K. Szczodrowski, S. Mahlik
P39	Mohamed Mehnaoui	Structure and luminescent properties of Dy^{3+}- doped $Ca_{10-2x}Dy_xLi_x(PO_4)_6O_2$ $(0 \leq x \leq 1)$ oxyapatites for white LEDs application M. Mehnaoui, G. Yannick, G. Panczer, G. Boulon, R. Ternane

P40	Szymon Mirczak	Usage of deep learning in FTIR spectra analysis of functional groups S. Mirczak, J. Bożek, C. Muszalski, T. Urbańczyk, M. Krośnicki
P41	Jan Moszczyński	Simultaneous generation of higher harmonics and upconversion luminescence in lanthanide-doped nanoparticles for optical coding and anti-counterfeiting applications J. Moszczyński, M. Runowski, P. Woźny, I. R. Martín, K. Soler-Carracedo, T. Zheng, S. Feldmann
P42	Kamil Nalikowski	Ab-initio study of Thorium activator in CaF_2 crystal an outlook for electron-nuclear bridge process. K. Nalikowski, V. Veryazov, M. Krośnicki
P43	Saranya Narayanan	Pressure-induced luminescence study of $MAPbBr_3$: Mn perovskites S. Narayanan, Y. Zhydachevskyy, C. G. Ma, J. Wang, A. Suchocki
P44	Serhii Nedilko	Optical and luminescent properties of the paper filled with $SrAl_2O_4$:Eu,Dy oxide and carbon nanotubes S. Nedilko, V. Chornii, V. Barbash, O. Yashchenko, V. Scherbatskyy, S. Haider, A. Suchocki
P45	Nadiia Rebrova	Luminescent properties of Pr^{3+} doped $LiBaF_3$ crystallites P. Zdeb, A. Grippa, P. J. Dereń, N. Rebrova
P46	Nadiia Rebrova	Luminescence properties of $ACaF_3$ (A=K, Rb, Cs) doped with Pr^{3+} ions A. Grippa, P. Zdeb, A. Voloshinovskii, A. Pushak, P. J. Dereń, N. Rebrova
P47	Paweł Rochowski	The benefits of photoacoustic methods applied to membrane transport studies P. Rochowski, S. Pogorzelski, P. Niedziałkowski
P48	Pavels Rodionovs	Long persistent UV-A luminescence in $Sr_3MgSi_2O_8$:Ce^{3+} P. Rodionovs, G. Doke, G. Krieke, D. Nilova, A. Antuzevics
P49	Radosław Rogowski	Near-infrared thermally activated delayed fluorescence and heavy-atom effect in organic exciplexes R. Rogowski, I. E. Serdiuk, M. Mońka, D. Grzywacz, B. Liberek, P. Bojarski
P50	Anna Shakhno	High-pressure luminescence and Raman spectroscopy of the single crystalline films of $Ca_3Sc_2Si_3O_{12}$:Ce and $Ca_2YMgScSi_3O_{12}$:Ce garnets A. Shakhno, M. Kamiński, S. Mahlik, T. Runka, V. Gorbenko, T. Zorenko, S. Witkiewicz-Lukaszek, Y. Zorenko
P51	Andrii Shyichuk	Excitation and emission bands of oxygen vacancies in rare earth bixbyite oxides: technical details A. Shyichuk, J. Trojan-Piegza, E. Zych
P52	Karol Szczodrowski	Lanthanide ions (Eu^{3+}, Er^{3+}, Pr^{3+}) as luminescence and charge carrier centers in Sr_2TiO_4 K. Szczodrowski, M. Behrendt, J. Barzowska, N. Górecka, N. Majewska, T. Leśniewski, M. Łapiński, S. Mahlik

P53	Joanna Śmiarowska	Efficient NIR emission in SiO_2-LaF_3:Nd^{3+} sol-gel nano-glass-ceramics J. Śmiarowska, N. Pawlik, T. Goryczka, W. A. Pisarski
P54	Yurii Syrotych	Raman and luminescent spectroscopy of Ce^{3+} doped $Tb_3Al_5O_{12}$ single crystalline film phosphors grown onto $Gd_3Al_{2.5}Ga_{2.5}O_{12}$ and $Y_3Al_5O_{12}$ substrates Y. Syrotych, V. Gorbenko, P. Radomski, T. Runka, Y. Zorenko
P55	Zafari Umar	Electronic structure of Mn^{2+}-doped phosphors Z. Umar, O. Khyzhun, T. Yamamoto, M. G. Brik, M. Novita, M. Piasecki
P56	Tomasz Urbańczyk	LIF emission spectra of CdAr molecule T. Urbańczyk, J. Koperski
P57	Marcin Witkowski	A new approach to analyzing the results of basic thermoluminescence methods M. E. Witkowski, A. Chruścińska
P58	Yaroslav Zhydachevskyy	Excitation mechanisms of Mn-related luminescence in $YAlO_3$:Mn crystals Y. Zhydachevskyy, Y. Hizhnyi, I. Romet, I. Kudryavtseva, V. Stasiv, Xinyu Zhang, S. Nedilko, A. Lushchik, A. Suchocki
P59	Yaroslav Zhydachevskyy/ Viktor Borysiuk	Excited states of luminescence centers in “$KBi(MoO_4)_2$ @phosphate-molybdate glass” ceramics V. Borysiuk, A. Oliynyk, Y. Hizhnyi, S. Nedilko, Y. Zhydachevskyy
P60	Yaroslav Zhydachevskyy/ Vitalii Chornii	Optical properties of $K_3Tb(PO_4)_2$ green phosphor V. Chornii, S. G. Nedilko, K. Terebilenko, V. Zozulia, V. Boyko, Y. Zhydachevskyy
P61	Yaroslav Zhydachevskyy/ Yuriy Hizhnyi	Atomic and electronic structures of interfaces in oxide glass-ceramic composites Y. Hizhnyi, V. Chornii, Y. Zhydachevskyy, S. G. Nedilko
P62	Tetiana Zorenko	Optical and photoelectrical properties of Ce^{3+} and Mg^{2+}-Si^{4+} co-doped $Gd_3Ga_5O_{12}$ and $Gd_3Ga_3Al_2O_{12}$ single crystalline films T. Zorenko, V. Gorbenko, S. Witkiewicz-Łukaszek, A. Majewski-Napierkowski, M. Kaminski, S. Mahlik, T. Leśniewski, Y. Zorenko

INVITED LECTURES

Cr^{3+}-activated phosphors: Yesterday, today and tomorrow

Michele Back[#]

Department of Molecular Sciences and Nanosystems, Ca' Foscari University of Venice,
Via Torino 155, 30172 Mestre – Venezia, Italy

A significant boost in the development and investigation of Cr^{3+}- doped crystals was triggered by the discovery of the ruby laser by Maiman in 1960 [1]. Renewed interest arose from the crucial role of chromium in persistent luminescent materials, where it works as an electron trap and/or luminescent center [2], and from the peculiar near-infrared (NIR) emissions resulting from the $3d^3$ electronic configuration, which have potential for bioimaging [3]. Moreover, in addition to the search for pressure sensors with higher sensitivity than the standard ruby [4,5], the possibility to tune and control the position and the relative intensity of the sharp spin-forbidden $^2E \rightarrow {}^4A_2$ and the broadband spin-allowed $^4T_2 \rightarrow {}^4A_2$ transitions by designing host properties, has generated great interest in the scientific community for the development of temperature sensors [6]. More recently, Cr^{3+}- doped crystals characterized by the $^4T_2 \rightarrow {}^4A_2$ broadband emission have been extensively investigated for phosphor-converted NIR LEDs [7].

In this tutorial lecture, spectroscopic features and the most important parameters describing the effect of the environment on the $3d^3$ electrons of Cr^{3+} ions will be described considering the most popular theories. The models used to calculate important parameters and their limitations will be discussed, highlighting the parameters that should be considered for evaluating the performance of the phosphors. Trends and prediction models for the selection of suitable hosts for specific applications will be critically reviewed. Finally, open questions, current challenges and future perspectives will be presented.

[1] Maiman T. H. (1960) Nature, 187, 493.
[2] Zhuang Y., Katayama Y., Ueda J. and Tanabe S. (2014) Opt. Mater., 36, 1907.
[3] Maldiney T., Bessière A., et al. (2014) Nat. Mater., 13, 418.
[4] Forman R. A., Piermarini G. J., Barnett J. D. and Block S. (1972) Science, 176, 284.
[5] Back M., Ueda J., Hua H. and Tanabe S. (2021) Chem. Mater., 33, 3379.
[6] Back M., Trave E., Ueda J. and Tanabe S. (2016) Chem. Mater., 28, 8347.
[7] De Guzman G. N. A., Fang M.-H., Liang C.-H., Bao Z., Hu S.-F. and Liu R.-S. (2020) J. Lumin., 219, 116944.

[#] corresponding author: michele.back@unive.it

Luminescence thermometry for live sciences

Daniel Jaque[#]

Nanomaterials for Bioimaging Group (nanoBIG), Departamento de Física de Materiales,
Facultad de Ciencias, Universidad Autónoma de Madrid, Madrid, Spain

Luminescence thermometry represents a powerful technique for elucidating temperature dynamics within biological systems. In this tutorial talk, we delve into the foundational principles underpinning luminescence-based temperature sensing in bioapplications. From the intricate interplay between temperature-responsive materials and detection methodologies to achieving sub-degree resolution within living cells and in vivo, we navigate through the latest advancements in this field. We explore how recent innovations in nanothermometers offer not only enhanced performance but also multifunctionality, enabling precise monitoring of metabolic processes within individual cells and internal organs. Despite rapid progress, we also address potential challenges, such as biases in fluorescence-based detection, and discuss strategies for mitigating them.

[#] corresponding author: daniel.jaque@uam.es

Integration of ferroelectrics, plasmonic nanostructures and 2D materials for application for nanophotonics

L.E. Bausá#

Dept. Física de Materiales, and Condensed Matter Physics Center (IFIMAC),
Universidad Autónoma de Madrid, 28049-Madrid, Spain

Layered transition metal dichalcogenides (TMDs) are a fascinating class of atomically thin materials in which d-electrons interactions result in unique physical phenomena, with significant implications across various domains including electronics, spintronics, and optoelectronics. Specifically, monolayer (1L) MoS_2 is currently receiving considerable attention due to its electronic and optoelectronic characteristics as a direct bandgap semiconducting 2D material.

Different physical or chemical strategies can be used to tune the electronic and optical properties of monolayer TMD for diverse optoelectronic applications.

In this study, we present the integration of ferroelectrics, plasmonic nanostructures, and 2D materials into a single monolithic device, achieved without the need for complex processing methods. The mutual interactions among these constituents within the hybrid system is analyzed. Specifically, three main investigations are undertaken: i) the combined impact of ferroelectricity and light on the optoelectronic properties of monolayer MoS_2 deposited on domain-engineered ferroelectric crystals, ii) the optical behavior of MoS_2 deposited on a metallic chain of silver nanoparticles, and iii) the extreme light-matter interaction phenomena to demonstrate pulsed laser operation at the nanoscale [1].

[1] Ramírez M.O. et al (2023) Laser Photonics Rev 2300817, 1–7.

corresponding author: luisa.bausa@uam.es

Experimental Techniques in Optical Spectroscopy

Andries Meijerink[#]

Debye Institute of Nanomaterials Science, Utrecht University, The Netherlands

This tutorial lecture aims to teach students (and we are all students) operating principles of the various components used in optical spectroscopy, outline common pitfalls that can compromise results in luminescence spectroscopy and finally give an overview of recent developments and advanced spectroscopic techniques. I will start with a basic introduction to the three types of elements needed: light sources, light dispersing elements and light detectors. Different types of lamps and lasers will be discussed, the characteristics of grating monochromators will be outlined and photomultiplier tubes and CCD detectors are explained. Both steady state spectral measurements and time resolved spectroscopic techniques (MCS, TCSPC, streak camera) will be discussed. Problems that may arise from e.g. second order effects, detector saturation, spectral correction will be illustrated with examples from the literature.

In the second part there is a focus on recent developments: fs/ps pump-probe spectroscopy, confocal techniques, single particle/single ion spectroscopy, synchrotron studies, high resolution cathode luminescence and combining techniques such as luminescence with thermoluminescence or photoconductivity. The insights obtained during this tutorial will hopefully help to be more effective in recording meaningful spectra, limit erroneous results and give new ideas to solve scientific problems with new spectroscopic tools.

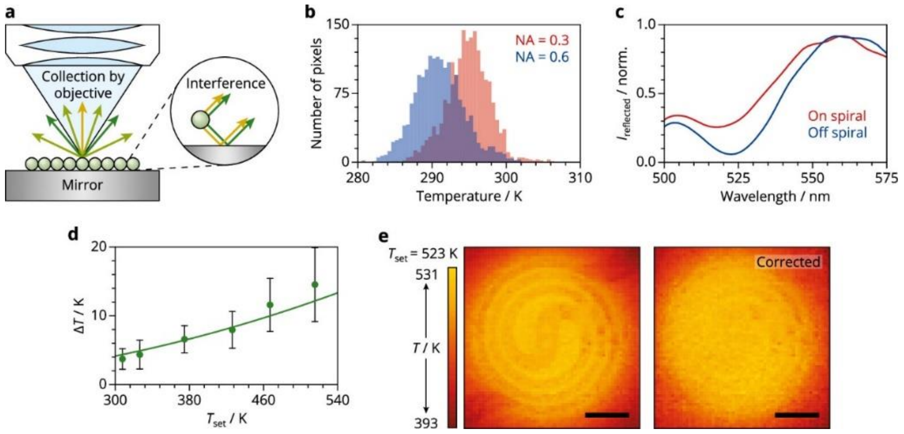


Figure 1 – High resolution emission measurements of a microheater for mapping of the 2D temperature profile with µm resolution using a confocal microscope.

[#] corresponding author: a.meijerink@uu.nl

Fluorescence: From Basics to Advanced Topics

Ignacy Gryczyński#

Department of Physics and Astronomy, Texas Christian University, Fort Worth, TX, 76129,
United States of America

This course will provide instruction and discussion on the proper execution of fluorescence experiments. The concepts of fluorescence anisotropy, “G-factor” correction and ‘Magic Angle” conditions will be explained. I will also describe advanced experiments with laser pulses utilizing stimulated emission depletion (STED) to control fluorescence intensity and anisotropy.

corresponding author: gryczynski.ignacy@gmail.com

Radiative and non-radiative transitions: Different and yet so similar

Markus Suta#

Inorganic Photoactive Materials, Institute of Inorganic Chemistry, Heinrich Heine University Düsseldorf,
Universitätsstr. 1, 40225 Düsseldorf, Germany

Usually, photoluminescence is concerned with an optimization of the spontaneous radiative decay pathway, whose foundations were already laid down by the advent of (cavity) quantum electrodynamics. In contrast, the non-radiative pathway, i.e. the coupling of the transition dipole moment to vibrational modes, has only got into a closer focus since the early 1970s [1]. One major finding was the energy gap law for multi-phonon transitions with a limited temperature dependence [2], while broad-band emission is thermally very labile due to a so-called non-radiative crossover [3]. Theoretical approaches to the non-radiative channel have ever been tackled but often require very sophisticated techniques and still do not satisfactorily agree even in the order of magnitude with experimental data. An interesting impetus was given by Burshtein in 2010 [4] that, after pioneering works by Orlovskii and Pukhov [5] as well as Ermolaev and Sveshnikova [6], indicated that non-radiative transition rates should also be related to transition oscillator strengths. From a quantum field theoretical perspective, this would be very intuitive and implies that many control parameters known for radiative transitions should also hold for non-radiative transitions. Such an understanding is key to the design of luminescent thermometers [7], but could even open up new avenues to control the quantum efficiency of phosphors in general.

Within this lecture, I want to give a brief historical account on major theoretical and experimental breakthroughs in the understanding of radiative and non-radiative decay in phosphors and demonstrate how theoretical approaches to the non-radiative transition can be explicitly verified by careful experiments [8]. This is supposed to break with the paradigm that radiative and non-radiative decay channels are two different but indeed are much more related than may be actually expected.

[1] a) Bixon, M., Jortner, J. (1968), *J. Chem. Phys*. 48, 715–726; b) Englman, R., Jortner, J. (1970), *Mol. Phys.*, 18, 145–164.

[2] a) L. A. Riseberg, L. A., Moos, H. W. (1968), *Phys. Rev*. 174, 429–438; b) van Dijk, J. M. F., Schuurmans, M. F. H. (1983), *J. Chem. Phys*. 78, 5317–5323.

[3] a) Englman, R., Barnett, B. (1970), *J. Lumin.* 3, 37–54; b) Struck, C. W., Fonger, W. H. (1975). *J. Lumin.* 10, 1–30.

[4] Burshtein, Z. (2010), Opt. Engin., 49, 091005.

[5] a) Pukhov, K. K., Sakun, V. P. (1979), *Phys. Stat. Sol. B*, 95, 391. b) Orlovskii, Y. V., Reeves, R. J., Powell, R. C., Basiev, T. T., Pukhov, K. K. *Phys. Rev. B* 1994, 49, 3821.

[6] a) Ermolaev, V. L., Sveshnikova, E. B. (1979), *J. Lumin.*, 20, 387–395; b) Sveshnikova, E. B., Ermolaev, V. L. (2011), *Opt. Spectrosc.*, 111, 34–50.

[7] a) Suta, M., Meijerink, A. (2020), *Adv. Theory Simul.*, 3, 2000176; b) Brites, C. D. S., Marin, R., Suta, M., Neto, A. N. C., Ximendes, E., Jaque, D., Carlos, L. D. (2023), *Adv. Mater.* 35, 2302749.

[8] a) Geitenbeek, R. G., de Wijn, H., Meijerink, A. (2018), *Phys. Rev. Appl.*, 10, 064006; b) Suta, M., Antić, Ž., Đorđević, V., Kuzman, S., Dramićanin, M. D., Meijerink, A. (2020), Nanomaterials, 10, 543; c) van Swieten T. P., Steenhoff, J. M., Vlasblom, A., de Berg, R., Mattern, S. P., Rabouw, F. T., Suta, M., Meijerink, A. (2022), *Light: Sci. Appl.* 11, 343.

corresponding author: markus.suta@hhu.de

From Basics to Advanced: Intensity and Energy Transfer in Lanthanide-based Compounds

Albano N. Carneiro Neto[#]

Department of Physics, CICECO - Aveiro Institute of Materials, University of Aveiro,
Aveiro, 3810-193, Portugal

The aim of this tutorial lecture is to explore the fundamental aspects of intensity in lanthanide-based compounds, covering introductory to advanced concepts. The presentation will address simulations of emission intensity through a blend of Judd-Ofelt theory [1,2], intramolecular energy transfer theory [3,4], and rate equations modeling [5]. By breaking down complex concepts into simplified explanations, such as electronic transition selection rules, attendees will gain a clear understanding of the underlying processes in lanthanide-based photoluminescence phenomena.

Moreover, the impact of temperature on energy transfer rates will also be addressed, exploring how temperature variations can alter the population dynamics of emitting levels and, consequently, the intensity of emitted light [6]. Through discussions and illustrative examples, the lecture aims to deliver basic knowledge to the audience for the accurate prediction of the luminescent properties of lanthanide compounds, enabling the application of these principles in their own research.

[1] Judd, B. R. (1962) Phys. Rev., 127, 750–761.
[2] Ofelt, G. S. (1962) J. Chem. Phys., 37, 511–520.
[3] Weissman, S. I. (1942) J. Chem. Phys., 10, 214–217.
[4] Carneiro Neto, A. N.; Teotonio, E. E. S.; de Sá, G. F.; Brito, H. F.; Legendziewicz, J.; Carlos, L. D.; Felinto, M. C. F. C.; Gawryszewska, P.; Moura Jr., R. T.; Longo, R. L.; Faustino, W. M.; Malta, O. L. (2019) Handbook on the Physics and Chemistry of Rare Earths, (Eds. Bünzli, J.-C. G. and Pecharsky, V. K.), Vol. 56, 55–162.
[5] Grant, W. J. C. (1971) Phys. Rev. B, 4 (2), 648–663.
[6] Carneiro Neto, A. N.; Mamontova, E.; Botas, A. M. P.; Brites, C. D. S.; Ferreira, R. A. S.; Rouquette, J.; Guari, Y.; Larionova, J.; Long, J.; Carlos, L. D. (2022) Adv. Opt. Mater., 10 (5), 2101870.

[#] corresponding author: albanoneto@ua.pt

Basics and quirks of thermoluminescence and optically stimulated luminescence

Philippe F. Smet#, Verena Fritz, David Van der Heggen

LumiLab research group, Department of Solid State Sciences,
Ghent University, Krijgslaan 281-S1, 9000 Gent (Belgium)

Many luminescent materials feature non-luminescent defects, which can act as charge trapping defects. This can lead to a strongly delayed emission after exciting the material, a feature that is used in glow-in-the-dark or persistent phosphors, certain dosimetry materials, storage phosphors, mechanoluminescent materials etc. Typically, heat, pressure or photons are used to release the trapped charges, after which emission of light occurs. To study the behaviour of those materials, one often turns to measurements of the thermoluminescence (TL; where the temperature of the sample is increased at constant rate) and/or the optical stimulated luminescence (OSL; where the sample is irradiated with light of certain energy). This yields information on the total number of trapped charges, the optical response of trapped charges[1], the energy needed to release the charges (related to the trap depth[2]), non-radiative decay paths…

In this tutorial lecture, we start from the basics of TL[2,3] and OSL[3] measurements, and the associated guidelines to perform accurate and reproducible measurements. In a second step the focus lies on what information can be extracted from those measurements, especially in view of extracting trapping parameters (such as trap depth distributions[4]) which is not as straightforward as it might seem. A particular aspect is the issue of overfitting thermoluminescence glow curves in the case of multiple trap depths. Special attention is given to the often strong role of thermal quenching processes, and how to avoid this interference[5].

Finally, the use of more advanced TL and OSL measurements is illustrated by some specific cases where those measurements proved pivotal to understand the underlying mechanism of trapping and detrapping processes[1,5].

[1] Van der Heggen D., et al. (2023) J. Phys. Chem. Lett. 14, 10151–10157
[2] Bos A.J.J. (2006) Radiat. Meas. 41, 45–56
[3] Yukihara E.G. (2023) Ceramics International 49, 24356-24369
[4] Van den Eeckhout K., et al. (2013) Phys. Rev. B 87, 045126
[5] Fritz V., et al. (2024) ACS Photonics, https://doi.org/10.1021/acsphotonics.4c00124

corresponding author: philippe.smet@ugent.be

Two-Photon Absorption, Upconversion, Photon Avalanche, Cross Relaxation: Exploring Commonalities and Mechanisms with Practical Examples

Przemysław J. Dereń#

Instytut Niskich Temperatur i Badań Strukturalnych im. W. Trzebiatowskiego PAN, ul. Okólna 2,
50-422 Wrocław, Poland

The captivating phenomenon of invisible laser radiation inducing vibrant green emission has intrigued many observers. While most spectroscopists are acquainted with the fundamental mechanisms underlying this phenomenon, this lecture aims to delve deeper into both well-known and lesser-explored pathways.

We will study familiar mechanisms such as absorption from excited states (ESA) and energy transfer through upconversion (ETU, formerly known also as APTE) [1], alongside less conventional processes involving dopant ions that result in photon emission with energies surpassing those of excitation. Specific questions will be addressed, such as whether upconversion intensity is always proportional to the square of the pumping power [2], or if pulse excitation leads to the same mechanisms as continuous excitation [3].

The lecture will also delve into the details of two-photon absorption and the generation of an avalanche of photons [4], outlining the conditions conducive to its formation, as well as elucidating methods to differentiate between processes like ESA and APTE.

Furthermore, strategies to enhance the efficiency of upconversion processes will be discussed. Practical applications of these mechanisms will be highlighted, shedding light on their utilization thus far, while also addressing the limitations encountered and strategies for overcoming them.

This work was supported by The National Science Centre (NCN) under the OPUS 21 project, grant no. UMO-2021/41/B/ST5/03792, which is gratefully acknowledged.

[1] Auzel F., 104 (2004) Chem. Rev. 104, 139–174.
[2] Pollnau M., Gamelin D. R., Lüthi S. R, Güdel H. U., and Hehlen M. P., 61 (2000) Phys. Rev. B, 3337 – 3346
[3] Dereń P.J., Joubert M.-F., Krupa J.-C., Mahiou R., Yin M., 341 (2002) J.All. Comp., 134-138.
[4] Chivian J. S.; Case W. E.; Eden D. D., 35 (1979) Appl. Phys. Lett., 124–125

corresponding author: p.deren@intibs.pl

Tailoring the Properties of Rare Earth Activated Oxide Scintillators by Bandgap Engineering

Winicjusz Drozdowski#

Institute of Physics, Faculty of Physics, Astronomy and Informatics,
Nicolaus Copernicus University in Toruń, ul. Grudziądzka 5, 87-100 Toruń, Poland

Scintillation light yield, i.e. the number of photons emitted by the studied material following the absorption of an unit of energy (1 MeV) delivered by ionizing radiation, seems to be one of the most important parameters used to rate and compare scintillators. Models have been proposed to predict theoretical limits for particular compounds and there are various scintillators that indeed display light yields close to such estimations [1]; the well-known $LaBr_3$:Ce is one of the examples. On the other hand, many materials are characterized by scintillation yields much lower than it could be expected.

An interesting case is provided by $Lu_3Al_5O_{12}$:Pr (LuAG:Pr). First it was observed that its somewhat disappointing room temperature scintillation yield could be enhanced significantly by increasing temperature to 400-450 K. Soon afterwards, this behavior was attributed to the existence of shallow electron traps and their temperature-dependent contribution to the scintillation mechanism, more precisely to the trap-mediated route of the energy transfer between the LuAG host and the Pr^{3+} ions. Furthermore, an active role of traps was demonstrated by a novel experiment combining X-ray and laser excitation [2]. The magnitude of the trap related scintillation yield loss in LuAG:Pr was estimated as about 30-40%.

In this Tutorial Lecture the most important methods that have successfully been introduced to reduce the unfavorable influence of traps on the light yield of selected oxide scintillators will be reviewed. Attention will be focused on the approach known as “bandgap engineering”, nevertheless some other concepts will also be discussed.

[1] Dorenbos P. (2002) NIM, A486, 208-213.
[2] Drozdowski W., Dorenbos P., Drozdowska R., Bos A.A.J., Poolton N.R.J., Tonelli M., Alshourbagy M. (2009) IEEE TNS, 56, 320-327.

corresponding author: wind@fizyka.umk.pl

Excitonic recombination processes in solids

Marek Godlewski[#]

Institute of Physics, Polish Academy of Sciences
02-668 Warsaw, Al. Lotników 32/46, Poland

Free excitons were first observed experimentally in ionic materials. Nature of the relevant recombination process was explained by Frenkel – Frenkel exciton. Then, an analogous process was proposed for semiconductors – Wannier-Mott exciton. In both the cases exciton is an excited state of a perfect crystal. Soon after impurity/defects bound excitons were observed experimentally. These are excited state of defects/impurities. In the lecture I will explain mechanisms of binding of such excitons. I will introduce Haynes rule and concept of satellite lines of bound excitons.

Whereas donor or acceptor bound excitons result in radiative recombination and observation of spectrally sharp luminescence lines, this often is not the case for excitons bound at deep defects. It is now believed that both rare earth (RE) and transition metal (TM) ions can bound excitons. Such excitons, in most of the cases, decay nonradiatively by an energy transfer, which results in intra-shell RE or TM excitation.

[#] corresponding author: godlew@ifpan.edu.pl

Spectroscopic properties of Mn^{2+} and Fe^{3+} dopants

Andrzej Suchocki[#]

Institute of Physics, Polish Academy of Sciences, Al. Lotników 32/46, 02-668, Warsaw, Poland

Mn^{2+} ions in solids exhibit luminescence in the spectral regions between green and far red, depending on the local environment and distances between central ions and ligands. The basic optical properties of this dopant are well described by the crystal field theory for d^5 electronic configuration. According to this theory, all optical transitions at ambient conditions occur between the $^6A_1$ ground state and higher energy excited states with a different spin, thus being strongly spin-forbidden, having very small transition probability and long decay times of luminescence. Fe^{3+} ions with the same d^5 electronic configuration as Mn^{2+} ions show very similar optical properties. Usually, the optical transitions, especially between the ground and the first excited level are also strongly coupled with the lattice, thus both absorption and luminescence spectra are broad, often without 0-phonon lines, even at very low temperatures. An externally applied pressure may strongly influence the spectral position of luminescence as well as the luminescence decay kinetics of the ions with a d^5 electronic structure. High-pressure luminescence experiments may help to distinguish between possible valence states of Mn ions.

Both Mn^{2+} and Fe^{3+} may substitute other ions in the sites with tetrahedral and octahedral symmetry with coordination numbers 4 and 6, respectively. In this different coordination, they exhibit different electron-phonon coupling, which is reflected in their luminescence properties, especially by the appearance of sharp zero-phonon lines in the spectra. Relatively weak electron-phonon coupling is observed in a tetrahedral environment.

Fe dopant ions for a long time were considered as the luminescence quenchers. Indeed, in some materials, the luminescence of Fe ions is not observed, although their presence is undoubtful there. Recently, there have been many publications devoted to the properties of Fe^{3+} ions in various hosts.

In this presentation results of optical studies of several compounds doped with Mn^{2+} and Fe^{3+} ions will be presented, showing their particular properties in different hosts, including $Gd(Zn,Mg)B_5O_{10}$:Mn, $LiGaO_2$:Fe, and some others. The difficulties in the interpretation of the optical spectra will be discussed.

Acknowledgments: This work was partially supported by the Polish National Science Center program SHENG2 of Poland-China cooperation, project number: 2021/40/Q/ST5/00336 and NCN Program 2019/33/B/ST8/02142.

[#] corresponding author: suchy@ifpan.edu.pl

Near-Infrared Phosphors:
Unlocking the Potential for Next-Gen LEDs

Ru-Shi Liu#

Department of Chemistry, National Taiwan University, Taipei 106, Taiwan

Phosphor-converted technology-based NIR light-emitting diodes are a compelling alternative to the conventional infrared light source due to their excellent energy-saving, mobility, and customization capabilities. Producing luminescent phosphors with different tuning structure methods is trustworthy for controlling the range of NIR regions (NIR-I, 700–1000 nm; NIR-II, 1000–1700 nm). Creating isolated luminescent centers of Cr^{3+} and rare-earth elements is the typical inorganic NIR phosphors design strategy. However, this strategy often fails to meet the required quantum efficiency and thermal stability due to concentration and thermal quenching mechanisms. Therefore, exploring alternative approaches to improve the performance of these phosphors is needed. NIR phosphors' luminescence properties of peak position, spectrum distribution, and thermal stability remarkably differ based on the crystal system. This talk will present a more comprehensive analysis of the local environment to improve our understanding of the luminescence properties of luminescent centers and their energy transformation.

corresponding author: rsliu@ntu.edu.tw

Recent development of fast red/NIR oxide phosphors doped with Eu^{2+}

Shohei Kodama#, Tomoki Saito, Ikuo Yanase, Hiroaki Takeda

Graduate school of Science and Engineering, Saitama University, Saitama, Japan

Red and near-infrared phosphors are commonly used as light sources in white light-emitting diodes (LEDs), white lasers, and scintillators. In recent years, there has been a significant increase in the demand for broad- and fast-emitting red and near-infrared phosphors. $Eu:Ca_3Sc_2Si_3O_{12}$ has gained attention as a chemically stable phosphor capable of producing broad, red, or near-infrared and fast emission due to its near-infrared emission of 873 nm and fast photoluminescence decay of 95.1 ns [1, 2]. However, the synthesis of single-phase $Ca_3Sc_2Si_3O_{12}$ remains a challenge. In this study, we synthesized $Eu:CaSc_2O_4$ as an alternative phosphor to $Eu:Ca_3Sc_2Si_3O_{12}$, and evaluated its emission properties.

Mixed powders of Eu_2O_3, $CaCO_3$, and Sc_2O_3. were sintered at 1500 °C for 5 h in an N_2+10%H_2 reducing atmosphere to synthesize $Eu:CaSc_2O_4$. The crystal phase was identified using powder X-ray diffraction. The luminescence, photoluminescence emission, and excitation properties were evaluated at 10 K and 300 K in a synchrotron facility (BL3B, UVSOR-III). Photoluminescence decay curves were also measured.

$Eu:CaSc_2O_4$ exhibited a single-crystal phase of $CaSc_2O_4$. Photoluminescence excitation and emission spectra were successfully measured. $Eu:CaSc_2O_4$ exhibits broad near-infrared emission at approximately 750 nm under the excitation of UV or visible photons, as shown in Figure 1. In addition to Eu^{2+} emission, Eu^{3+} emission was also observed.

The photoluminescence decay curve of $Eu:CaSc_2O_4$ was fitted by a double exponential function, and the decay constants were estimated to be 3.10 ns (19%) and 16.3 ns (81%). $Eu:CaSc_2O_4$ exhibits outstanding fast decay among near-infrared phosphors. In this presentation, details of the emission properties are explained.

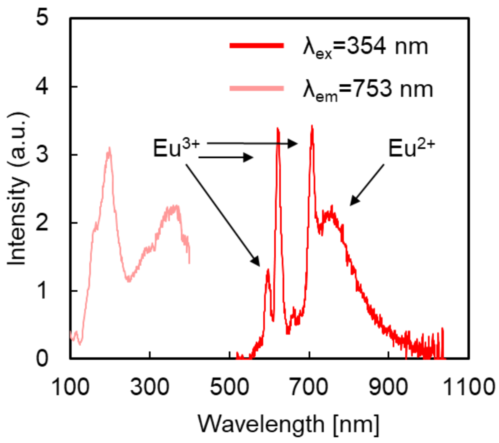


Figure 1. Photoluminescence excitation and emission spectra of $Eu:CaSc_2O_4$

[1] L. Zhou *et al.*, Chemistry of Materials. 28 (2016) 2834.

[2] I.V. Berezovskaya *et al.*, Chemical Physics Letters. 585 (2013)11.

corresponding author: shokodama@apc.saitama-u.ac.jp

Advancements in Luminescence Thermometry Utilizing co-dopants Interactions

J. Zeler[1#], J. Jedoń[1,2], P. Łukaszczuk[1], M. Sójka[3], C. D. S. Brites[4], L. D. Carlos[4], Y. Zorenko[5], V. Gorbenko[5], E. Zych[1]

[1] Faculty of Chemistry, University of Wroclaw, 14 F. Joliot-Curie Street, Wroclaw 50–383, Poland
[2] Department of Chemistry and Chemical Engineering, Chalmers University of Technology, SE-412 96 Gothenburg, Sweden
[3] GE Aerospace 1 Research Circle, Niskayuna, New York, 12309, USA
[4]Phantom-g, CICECO-Aveiro Institute of Materials, Department of Physics, University of Aveiro, 3810-193 Aveiro, Portugal
[5] Department of Physics, Kazimierz Wielki University, Powstancow Wielkopolskich Street, 2, Bydgoszcz, PL-85090, Poland

Luminescent thermometers provide numerous continuously extending methods for absolute temperature determination. Mostly, temperature-dependent changes in the intensity ratio of emission bands, the emission kinetics, the emission band/line width, or the luminescence band/line peak position are utilized.

In our project, we selected aluminate materials, at first $SrAl_{12}O_{19}$ and $Y_3Al_5O_{12}$, substituted with Cr^{3+}/Eu^{2+} and Tb^{3+}/Pr^{3+}, respectively, to explore their potential for luminescent thermometers exploiting the aforementioned methods. The functionalization of phosphors via co-dopant interactions is a promising approach to managing properties useful for thermometric purposes. Co-doping entails launching complex, manageable interactions to tailor the material's luminescent behavior. By elucidating the intricacies of co-dopant interactions, this research promotes the rational design and optimization of functionalized phosphors for luminescent thermometry applications.

In the $SrAl_{12}O_{19}$ host, the mechanism of energy transfer between specific activators, Cr^{3+} and Eu^{2+}, will be tracked to develop the material's superior thermometric properties in a wide range of temperatures, from cryogenic to around 500 K, maintaining high accuracy and sensitivity of measurements. The co-existence of two dopants in the thick single crystal substrate of YAG:Tb garnet and a thin single crystalline film of YAG:Pr grown using the LPE method on it also appeared as a great tool to shape and improve luminescence thermometry purposes [1]. The possibility to efficiently excite, individually or simultaneously, the Tb^{3+} and Pr^{3+} dopants by their intense 4f→5d allowed transitions is executed to reach relative thermal sensitivity values higher than 1% K^{-1} over the range of temperatures as wide as 100–625 K. This research validates that using intra- and inter-configurational transitions of lanthanides allows designing wide-range accurate luminescence thermometers.

The research was financed by the Polish National Science Centre under grant 2018/31/B/ST4/00924 (JZ, JJ, PŁ, EZ) and 2019/33/B/ST3/00406 (YZ, VG).

[1]. Jedoń J, Zych E, Zeler J, Gorbenko V, Zorenko J, (2024) Adv. Optical Mater, 2303284, 1-17

corresponding author: justyna.zeler@uwr.edu.pl

How can accurate (and not so accurate) calculations be used in spectroscopy?

Valera Veryazov#

Computational Chemistry, Lund University, Lund 22100, Sweden

Precise computational calculations of electronic structure are essential in spectroscopy. Density Functional Theory is the predominant choice, while ab initio post Hartree-Fock methods, such as multiconfigurational theory[1], remain less explored due to the high computational cost.

This lecture highlights limitations of DFT in accurately describing common spectroscopic phenomena ranging from potential energy surfaces to electronic spectra. Conversely, the multiconfigurational approach offers practical solutions to these challenges [2-4]. Additionally, the lecture thoroughly examines the current limitations and potential applications of multiconfigurational theory in molecular and solid-state spectroscopy, providing insights into the evolving field of computational spectroscopy.

[1] BO Roos, R Lindh, PÅ Malmqvist, V Veryazov, P-O Widmark (2016) "Multiconfigurational Quantum Chemistry", Wiley & Sons.
[2] ED Larsson, M Krosnicki, V Veryazov (2022) Chem. Phys., 562, 111549
[3] ED Larsson, V Veryazov (2023) J Chem Phys, 159, 114117
[4] F Aquilante et al, (2020) J Chem Phys, 152, 214117

corresponding author: valera.veryazov@teokem.lu.se

Multi-configurational calculations of the electronic structure of crystalline solids; local excited states, band gaps and valency.

Marek Krośnicki#

Institute of Theoretical Physics and Astrophysics, Faculty of Mathematics, Physics and Informatics,
University of Gdańsk, ul. Wita Stwosza 57, 80-308 Gdańsk, Poland

Multi-configurational methods of quantum chemistry have established a significant position in ab-initio calculations of the local excited electronic states of an activator ion embedded in a crystal matrix. Barandiaran and Seijo paved the way for applying of multi-reference methods to crystalline luminescence materials by implementing ab-initio model potentials (AIMP) optimized within a self consistent calculations on perfect host [1]. The recently developed code SCEPIC [2] (Self-Consistent Embedded Potential for Ionic Calculations) along with the new MOLCAS package [3], allows for intuitive and minimal input generation of embedding potentials for ionic crystals. In this talk we will show applications of these recent developments in calculations of local defect electronic states. In particular, we will present how atomic valence redefined for crystalline solids [3] can be used to describe the properties of mixed valence compound like $Fe^{3+}[Fe^{2+}Fe^{3+}]O_4$. Moreover, we will use full valence quantity to discuss the different local environments of radioactive ^{229}Th located in CaF_2 crystal in the context of recent experiments on nuclear transitions [5].

[1] Zoila Barandiarán, Jonas Joos, Luis Seijo, Luminescent Materials: A Quantum Chemical Approach for Computer-Aided Discovery and Design, SSMATERIALS, volume 322 (2022)
[2] Larsson E. D. , Krośnicki M. , Veryazov V. (2022), A program system for self-consistent embedded potentials for ionic crystals, Chem. Phys. 562, 111549
[3] Manni G. L. et al. (2023) J. Chem. Theory Comput 19, 20, 6933-6991
[4] Veryazov V., Everestov R. A. (1991) Theor. Chim. Acta, 81, 95-103
[5] Tiedau J. et. al. (2024) Phys. Rev. Lett. 132, 182501

---

corresponding author: marek.krosnicki@ug.edu.pl

Transparent Ceramics Scintillators and Quick Material Search

Shusnuke Kurosawa#

Tohoku University, Osaka University

Scintillators with higher gamma-ray sensitivity are required to various fields such as medical imaging, astronomy, and gamma-ray detection efficiency (gamma-ray stopping power, σ) depends on effective atomic number (Z_{eff}) and density (ρ); σ is proportional to ρ $(Z_{\mathrm{eff}})^{a}$, where a is 4-5. Positron emission tomography (PET) camera with scintillation materials is used in medical imaging, and these scintillator is required to have high gamma-ray sopping power and short decay time. Ce-doped Lu_2SiO_5 (Ce:LSO) is conventional scintillator, because Lu has a high atomic number of 71, good attenuation length of 1.16 cm at 511 keV and fast decay time of around 40 -50 ns. Meanwhile, this crystal has intrinsic background noise from ^{176}Lu, and Y-admixed Ce:LSO, Ce:$(Lu,Y)_2SiO_5$, is also the standard materials in medical imaging to suppress this intrinsic background. Here, the effective atomic number for Ce:$(Lu,Y)_2SiO_5$ is around 62, while this scintillator still has intrinsic background.

Hafnium has a high atomic number of 72, and intrinsic background is negligible. $SrHfO_3$ doped with Ce (Ce:SHO), for example, are attractive scintillation material due to a high density of 7.65 g/cm3, a high effective atomic number of around 60 and no intrinsic background. Since Ce:SHO and other Hf-containing materials have high melting temperatures of over 2500°C, we prepared transparent ceramics by the spark plasma sintering (SPS) process [1,2]. The scintillation decay time for Ce and Al-doped $SrHfO_3$ was estimated to be faster (21.6 ± 0.9 ns) than that for Ce:$(Lu,Y)_2SiO_5$, and Ce:SHO can be the next-generation materials for the PET camera.

The SPS process enable us to obtain the transparent samples within a few hours, and quick material search is realized. Also, other techniques are applied to material search. In this paper, I review Hf-based and high-effective-atomic number scintillators and their growth techniques.

[1] S. Kurosawa et al., (2013) Radiat. Meas., 56, 155,
[2] H. Chiba, S. Kurosawa et al., (2016) Radiat. Meas., 90, 287

corresponding author: kurosawa@imr.tohoku.ac.jp

Synchrotron radiation in luminescence research: recent advances in the study of single crystals and single crystalline phosphors

Yuriy Zorenko[1,2#]

[1]Physical Faculty of Kazimierz Wielki University in Bydgoszcz, 85-090 Bydgoszcz, Poland
[2]Medical Physics Department, Prof. Franciszek Łukaszyk Oncology Center, 85-796 Bydgoszcz, Poland

Fundamental differences in the methods and conditions of materials preparation from a high-temperature melt (crystals) and the melt-solution (single-crystalline films) cause significant differences in their luminescent properties. Such differences are caused by various types of intrinsic defects, their concentration, distributions of the dopant ions between cationic sites and the interaction of dopants with defect and dopant centers in the different crystalline forms of the same material.

In the case of oxide crystals growing from high-temperature melt, the contribution of defect centers (oxygen and cation vacancies, antisite defects and their aggregates) in the intrinsic luminescence of matrixes or in the emission of dopants in them may be very significant. This can significantly perturbate the observation of native luminescent properties of oxide hosts and the emission properties of dopants in such materials. Meanwhile, host defect content can be strongly reduced in these oxide films grown using low-temperature liquid-phase epitaxy (LPE) method from melted fluxes. Furthermore, the preferred distribution of dopants between various cation sites may be substantially different in films and crystal phosphors. However, LPE grown films may contain flux components that can also significantly affect the luminescent properties of materials as emission and trapping centers.

Therefore, only a detailed comparison of the luminescent properties of complex oxide compounds prepared in bulk crystal and single crystalline film forms makes it possible to detect a more realistic picture of internal and doped luminescence in these oxides against the background luminescence of defect centers. The use of a combination of optical and EPR spectroscopy together with luminescence spectroscopy under synchrotron radiation excitation with energy in the exciton range and in the range of interband transitions of these compounds opens a unique opportunity to correctly compare the luminescent properties of complex oxides in various crystalline forms.

The aim of this presentation is to show the characteristic examples of comparison of the structure of luminescent centers in crystals and film phosphors based on the Eu^{3+} doped Lu_2O_3 lutetia, Pb^{2+} doped Ga_2O_3 oxide, transition metal doped $MgAl_2O_4$ spinel and Ce^{3+} doped $R_2Si_2O_7$ (R=Lu, La, Gd) pyrosilicates, using the conventional spectral methods as well as the time-resolved luminescent spectroscopy at new VUV stations at P66 line at PETRA3 ring, DESY, Germany.

Acknowledgments. This work was supported by Polish NCN 2019/33/B/ST3/00406 projects. Investigation with SR at Superlumi station at DESY were performed in the frame of I-20210147 EC, I-20220044 and I-20220864 projects.

corresponding author: zorenko@ukw.edu.pl

Molecular switching with single upconverting nanocrystals

Sebastian Maćkowski[#]

Nanophotonics Group, Faculty of Physics, Astronomy and Informatics,
Nicolaus Copernicus University in Toruń, Grudziądzka 5/7, 87-100 Toruń, Poland

We will discuss two sets of experiments focused on optical manipulation of DTE-py2 photochromic molecules that feature two photocyclization states: ON (fluorescent) and OFF (non-fluorescent).

The first class of experiments will focus on inducing the photochromic reaction of DTE-py2 molecules via infrared excitation of $NaYF_4:Er^{3+}/Yb^{3+}$ up-conversion nanoparticles. The results show that we can switch DTE-py2 molecules from OFF to ON state by exciting a single $NaYF_4:Er^{3+}/Yb^{3+}$ nanoparticle with 980 nm wavelength and observe emission in the visible range. The processes that take place in such a structure can be further enhanced by incorporation of silver nanowires.

The functionality of silver nanowires associated with the ability to transfer energy along the wires via surface plasmon polaritons, provides a way to remotely control the state of the photochromic molecules. Up to 5 photoswitching events have been observed for such an assembly, where a microdroplet of DTE-py2 molecules was precisely deposited on one end of the nanowire.

The nanowires themselves can also be used for modifying the efficiency of the photochromic reaction, the DTE-py2 molecules. In this case, plasmonic excitations in silver nanowires lead to increased photoswitching upon excitation with wavelengths matching the resonance band. In addition, fluorescence intensity of DTE-py2 molecules is enhanced due to coupling with the nanowires.

The results of comprehensive fluorescence microscopy studies carried out on several experimental architectures involving DTE-py2 photochromic molecules indicate that it is possible to control the spectral dependence of photoswitching dynamics and the efficiency of this process through assembly of plasmonically active or near-infrared active up-converting molecular hybrid nanostructures.

[#] corresponding author: mackowski@umk.pl

New Strategies for Luminescence Thermometry and Manometry

Marcin Runowski[1#], Przemysław Woźny[1], Teng Zheng[2], Kevin Soler-Carracedo[1,3],
Jan Moszczyński[1], Victor Lavín[3], Inocencio R. Martín[3], Sebastian Mahlik[4]

[1]Adam Mickiewicz University, Wydział Chemii, Uniwersytetu Poznańskiego 8, 61-614, Poznań, Poland
[2]Hangzhou City University, School of Information and Electrical Engineering, Hangzhou 310015, China
[3]Universidad de La Laguna, Faculty of Physics, Apdo Corr. 456., La Laguna, E-38200, Tenerife, Spain
[4]University of Gdansk, Faculty of Mathematics, Physics and Informatics, Gdansk 80-308, Poland

Optical pressure and temperature sensors, i.e., luminescent manometers and thermometers, offer new possibilities for remote and non-invasive investigation and monitoring of changes in physicochemical and spectroscopic properties of materials under extreme conditions. This can be done by monitoring and analyzing selected spectroscopic parameters, such as band intensity ratio, emission line shift, or luminescence decay times. However, the limitation for optical readouts is usually the quenching of the luminescence signal in a given material, i.e., in the active part of the sensor under high pressure or temperature conditions.

Here we show some new, promising strategies for the development of advanced and ultrasensitive pressure and temperature sensors, based on organic and inorganic materials containing lanthanide and d-block metal ions. The factors affecting the enhancement of luminescence signal intensity and sensor sensitivity will be discussed. These goals can be achieved through inter-ionic energy transfer, temperature/pressure-induced intersystem configurational crossover, increased light-to-heat conversion efficiency in a vacuum, by simultaneous use of parametric and non-parametric processes, and by using materials exhibiting both photo- and mechano-luminescence. [1-5]

Acknowledgments: This work was supported by the Polish National Science Centre, grant no. 2023/50/E/ST5/00021.

[1] M. Runowski, D. Marcinkowski, K. Soler-Carracedo, A. Gorczyński, E. Ewert, P. Woźny, I.R. Martín, ACS Appl. Mater. Interfaces 15 (2023) 3244–3252.
[2] T. Zheng, M. Runowski, I.R. Martín, K. Soler-Carracedo, L. Peng, M. Skwierczyńska, M. Sójka, J. Barzowska, S. Mahlik, H. Hemmerich, F. Rivera-López, P. Kulpiński, V. Lavín, D. Alonso, D. Peng, Advanced Materials, 35 (2023) 2304140.
[3] C. Hernández-Álvarez, P.I. Martín-Hernández, I.R. Martín, F. Rivera-López, H. Hemmerich, M. Grzegorczyk, S. Mahlik, M. Runowski, Adv. Opt. Mater. (2024) 2303328.
[4] X. Qiu, T. Zheng, M. Runowski, P. Woźny, I.R. Martín, K. Soler-Carracedo, C.E. Piñero, S. Lebedkin, O. Fuhr, S. Bräse, Advanced Functional Materials, (2024) 2313517.
[5] L. Marciniak, P. Woźny, M. Szymczak, M. Runowski, Coordination Chemistry Reviews, 507 (2024) 215770.

corresponding author: runowski@amu.edu.pl

Lifetime-based luminescence manometry on the transition metal ions doped phosphors

Maja Szymczak[1], Marcin Runowski[2], Wojciech Piotrowski[1], Przemyslaw Wozny[2],
Sebastian Mahlik[3], Łukasz Marciniak[1#]

[1] Institute of Low Temperature and Structure Research, Polish Academy of Sciences,
Okolna 2, Wroclaw 50–422, Poland
[2] Faculty of Chemistry, Adam Mickiewicz University, Uniwersytetu Poznanskiego 8,
Poznan 61-614, Poland
[3] Institute of Experimental Physics, Faculty of Mathematics, Physics and Informatics, University of Gdansk,
Wita Stwosza 57, 80-308 Gdansk, Poland

The employment of luminescence for development of sensors capable of detecting physical quantities, such as temperature and pressure, offers rapid, electrically passive, precise, and remote measurement capabilities. While spectral pressure sensors have been recognized for several decades and are extensively utilized, lessons from luminescence thermometry experiments indicate that the emission spectrum's shape, and consequently the pressure readout, may be influenced by the absorption and scattering of emitted light by the medium hosting the phosphor or present in the optical pathway between the detector and the phosphor [1]. Given these considerations, in certain scenarios, luminescence kinetics, which are not subject to such interferences, emerge as a more dependable metrological figure of merit.

Materials doped with transition metal ions, particularly those with a $3d^3$ electronic configuration, are deemed highly suitable for these applications. For such ions, an enhancement in the crystal field strength interacting with the dopant ion due to applied pressure modifies the overlap of the wave functions of the ^2E and $^4T_2$ states. This alteration influences the probability of radiative processes, leading to a elongation of luminescence decay profile—an effect distinctly different from that observed in for example lanthanide ions and of significant application relevance. Moreover, the careful selection of the host material's chemical composition, ensuring minimal thermal shortening of the emitting level's luminescence lifetime across a specific temperature range, facilitates the development of a thermally independent, highly sensitive luminescence lifetime-based pressure sensor. During the lecture the implementation of described approach will be presented based on phosphors doped with Mn^{4+} ions (e.g., $K_2Ge_4O_9$[2], $Sr_4Al_{14}O_{25}$[3], $SrGdAlO_4$[4]) and Cr^{3+} (e.g., $Li_3Sc_2(PO_4)_3$[5]).

Acknowledgements This work was supported by the National Science Center (NCN) Poland under project no. DEC-UMO- 2020/37/B/ST5/00164.

[1] L. Labrador-Páez, et al. M. Pedroni, A. Speghini, J. García-Solé, P. Haro-González, D. Jaque, , Nanoscale. 10 (2018) 22319–22328
[2] M. Szymczak, W. Piotrowski, P. Wozny, M. Runowski, L. Marciniak, , J. Mater. Chem. C (2024) DOI: 10.1039/D3TC04812H
[3] M. Pieprz, W. Piotrowski, P. Woźny, M. Runowski, L. Marciniak, , Adv. Opt. Mater. 12 (2024) 2301316.
[4] M. Pieprz, M. Runowski, P. Woźny, J. Xue, L. Marciniak, , J. Mater. Chem. C 11 (2023) 11353-11360.
[5] Szymczak M, Jaśkielewicz J., Runowski M., Xue J., Mahlik S. and Marciniak L. (2024) Adv. Funct. Mater., 2314068.

corresponding author: l.marciniak@intibs.pl

Energy-saving Colloidal Quantum Dots Composites for Short-wave Infrared Photodetector

Mu-Huai Fang#

Research Center for Applied Sciences, Academia Sinica, Taipei 11529, Taiwan

Short-wave infrared (SWIR) quantum dots (QDs) are one of the emerging nanomaterials and have drawn immense attention in the field of photodetector. It is, however, still challenging to resolve the voids between the QDs after surface modification, impeding the conduction of the photoelectrons and hindering the practical application of quantum-dot-based photodetectors. Besides, the chemical stability of the QDs after surface modification still needs to be promoted. Here, we synthesize the QDs in which the characteristic absorption peak can be tuned in 900–1700 nm. To achieve the goals above, the composites that QDs hybrid with the metal-organic framework (MOF) and halide-based double perovskite (DP) are demonstrated.[1] In QD@MOF, the particle stacking and preferred orientation of the thin film are characterized by two-dimensional grazing-incidence small- and wide-angle X-ray scattering (GISAXS/GIWAXS). Besides, the chemical bonding between QD and MOF is proved by X-ray absorption near-edge structure spectra. The QD@MOF is applied to graphene field-effect transistors (FETs) to evaluate their potential for practical application. The responsivity and detectivity of the QD@MOF device are 301 A/W and 1.49×10^{10} cm $Hz^{1/2}$ W^{-1}, respectively. The chemical stability is significantly enhanced compared to the non-hybrid one. By contrast, in the QD@DP, the QD is proved to be embedded into the structure of the DP. The responsivity and detectivity of QD@DP graphene FET are 15000 A/W and 1.31×10^{12} cm $Hz^{1/2}$ W^{-1}, respectively, significantly promoted compared to the non-hybrid device. This research provides insight into developing energy-saving QD-based SWIR photodetectors.

[1] Huang, P.-Y.; Zhang, Y.-Y.; Tsai, P.-C.; Chung, R.-J.; Tsai, Y.-T.; Leung, M.-K.; Lin, S.-Y.; Fang, M.-H. (2023) Adv. Opt. Mater., DOI: 10.1002/adom.202302062.

corresponding author: fangmuhuai@gate.sinica.edu.tw

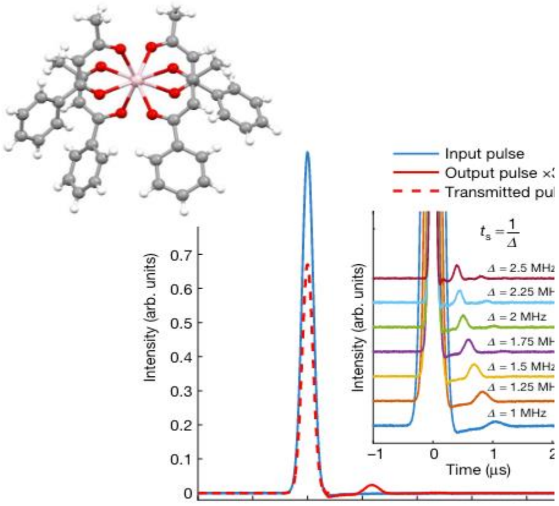
Rare earth doped crystals for integrated quantum photonics

Philippe Goldner#

Institut de Recherche de Chimie Paris, Chimie ParisTech, CNRS, Université PSL, Paris, France

Systems with both spin and optical transitions offer a range of functionalities for quantum technologies. They allow storage and entanglement of photonic quantum states for quantum communications, interfacing processing nodes with optical networks for distributed quantum computing, or efficient detection for quantum sensing. Among various solid-state systems currently considered, rare-earth doped materials stand out as they combine, at cryogenic temperatures, long-lived optical and spin quantum states. In addition, they offer optical transition in a wide spectral range, including telecom wavelengths, high chemical stability, and easy doping in many hosts, thus enabling using large ensembles of centers with uniform properties.

Quantum-grade rare earth doped materials are developed in different forms. They include bulk crystals, like Y_2SiO_5, in which many early demonstrations were performed [1], and more recently nanostructured materials such as nanoparticles, or molecular crystals, aiming at integration into nanophotonics devices. In this talk, we will present some of our recent results in the field [2-4], as well as the challenges to be addressed to bring rare-earth doped materials up to the highly demanding requirements of quantum technologies.



[1] A. Ortu et al., Simultaneous Coherence Enhancement of Optical and Microwave Transitions in Solid-State Electronic Spins, Nature Mater. 17, 8 (2018).
[2] S. Liu et al., Defect Engineering for Quantum Grade Rare-Earth Nanocrystals, ACS Nano 14, 9953 (2020).
[3] D. Serrano et al. , Ultra-Narrow Optical Linewidths in Rare-Earth Molecular Crystals, Nature 603, 241 (2022).
[4] C. Deshmukh et al., Detection of Single Ions in a Nanoparticle Coupled to a Fiber Cavity, Optica, 10, 1339 (2023).

corresponding author: philippe.goldner@chimieparistech.psl

Mind the gap! Plasmonic nanocavity for spectroscopic trapping of local molecular rearrangements in artificial lipid monolayers

Ewelina Lipiec[1#], Anna Chahaj-Brekiesz[2], Michał Czaja[1,3], Jan Kobierski[4], Dawid Lupa[1], Sara Seweryn[1,3], Katarzyna Skirlińska-Nosek[1,3], Kamila Sofińska[1], Marek Szymoński[1], Anita Wnętrzak[4]

[1]Jagiellonian University, Faculty of Physics, Astronomy, and Applied Computer Science, M. Smoluchowski Institute of Physics, Łojasiewicza 11, 30-348 Kraków, Poland
[2]Faculty of Chemistry, Jagiellonian University, Gronostajowa 2, 30–387 Kraków, Poland
[3] Jagiellonian University, Doctoral School of Exact and Natural Sciences, Krakow, Poland
[4]Department of Pharmaceutical Biophysics, Faculty of Pharmacy, Jagiellonian University Medical College, 31-007 Kraków, Poland

Various biologically significant processes are driven by the local heterogeneity of a lipid membrane leaflet including extracellular and intracellular transport or cell-cell and cell-extracellular matrix (ECM) communication. Despite the best scientific efforts, the local molecular structure and composition of lipids raft assemblies are still poorly understood. Further characterization of lipid nanodomains heterogeneity, as well as local structural rearrangements, will develop a current understanding of raft function in human physiology and pathogenesis of plethora diseases. [1]

The combination of scanning probe microscopy (SPM, including atomic force microscopy (AFM) and scanning tunneling microscopy (STM)) and vibrational spectroscopy called tip-enhanced Raman spectroscopy (TERS), will be introduced as an efficient tool in studies of model lipid membranes. TERS combines the nanometric spatial resolution of SPM and the chemical selectivity of the Raman spectroscopy, providing information on the chemical structure of nano-volume samples. The high enhancement of electromagnetic field, which increases the Raman scattering cros-section, results from the combination of an electromagnetic 'lightning rod effect' and excitations of localized surface plasmons. The most intensive field is present in the plasmonic nanocavity between the metal probe and the metal surface.

Selected important aspects of nanoscale investigation into the local chemical structure and composition of artificial lipid layers will be discussed:

i) an application TER hyperspectral mapping in studies of lipid monolayers of:
1) dipalmitoylphosphatidylcholine (DPPC), 2) 1,2-Dipalmitoyldipalmitoyl-sn-glycero-3-phosphoethanolamine (DPPE), and 3) cardiolipin (CL), and their mixtures for revealing of local molecular distribution, orientation, phase separation, and formation of domains,
ii) a comparison of AFM-TERS and STM-TERS in nanospectroscopic maping of the model lipid membranes,
iii) an application of density-functional theory (DFT) and molecular dynamics - towards correct interpretation of the obtained spectral results,
iv) a correlation between the local chemical structure and nanomechanical properties of the investigated lipid monolayers,
v) an implementation of STM-TERS in water - a protective role of solvent [2].

[1] K. Sofińska, D. Lupa, A. Chachaj-Brekiesz, M. Czaja, J. Kobierski, S. Seweryn, K. Skirlińska-Nosek, M. Szymonski, N. Wilkosz, A. Wnętrzak, E. Lipiec, (2022) Adv. Colloid Interface Sci. 2022, 301, 102614
[2] E. Lipiec, J. Kaderli, J. Kobierski, R. Riek, K. Skirlińska-Nosek, K. Sofińska, M. Szymoński, Renato Zenobi, (2021),Angew. Chem. Int. Ed., 2021, 133 4595-4600

corresponding author: Ewelina.Lipiec@uj.edu.pl

Interrelationships between the luminescent transitions and nonlinear optics in RE activated phosphate, arsenide and vanadate compounds

M. Piasecki[1,2#], A. M. Srivastava[3], M. G. Brik[1,4,5,6], W. W. Beers[3],
Chong-Geng Ma[4], W. E. Cohen[3]

[1]Institute of Physics, Jan Długosz University, , Częstochowa, Poland
[2]Inorganic Chemistry Department, Uzhhorod National University, Uzhhorod, Ukraine
[3]Current Chemicals, Cleveland, OH 44110, USA
[4]School of Optoelectronic Engineering & CQUPT-BUL Innovation Institute,
Chongqing University of Posts and Telecommunications, Chongqing, People's Republic of China
[3]Institute of Physics, University of Tartu,, Estonia
[5]Centre of Excellence for Photoconversion, Vinca Institute of Nuclear Sciences,
University of Belgrade, Serbia
[6]Academy of Romanian Scientists, Bucharest, Romania

We discuss the influence of orbital hybridization on the intensity of the hypersensitive transition in isostructural vanadate arsenide and phosphate systems. We found out that the same mechanism is also responsible for the efficiency of second harmonic generation (SHG). Second harmonic generation (SHG) is a nonlinear process in which a crystal converts lower frequency radiation to higher frequency. The bonding covalence within the acentric anionic groups, that are the basic structural moiety of the crystal framework (such as PO_4, AsO_4, VO_4, SiO_4, GeO_4, etc.), is chiefly responsible for the SHG activity. The importance of orbital hybridization on the SHG efficiency is exemplified by the striking difference in optical nonlinearity between isostructural titled compounds. While the vanadate is efficient, the phosphate shows no SHG activity, although the calculated SHG coefficients (pm/V) for both compounds are non-zero. The difference in the SHG efficiency has been clarified by examining the electronic band structure of these compounds. Our analysis supports the polarizability of $(XO_4)_3$- (X = P, As, V) over local site distortion effects as the intensity enhancing mechanism of the $^5D_0\rightarrow{}^7F_2$ transition. The connection between the mechanism of hypersensitivity and second harmonic generation (SHG) is presented.

[1] A M Srivastava, M G Brik, W W Beers, Chong-Geng Ma, M Piasecki, W E Cohen (2023) J.Lumin. 257, 119709.
[2] A. M. Srivastava , M G Brik, B. Lou, W W Beers, Chong-Geng Ma, M Piasecki, W E Cohen (2023) ECS J. Solid State Sci. Technol. 12 066001

corresponding author: m.piasecki@ujd.edu.pl

Terahertz Time-Domain Spectroscopy Imaging Studies of Biomaterials

Roman Sobolewski[#]

Departments of Electrical and Computer Engineering and Physics and Astronomy,
Materials Science Program, and the Laboratory for Laser Energetics
University of Rochester, Rochester, NY 14627-0321, USA

Terahertz (THz) radiation is situated between the infrared and microwave regions in the electromagnetic spectrum with a bandwidth ranging from 0.3 to 30 THz and has numerous interesting applications in various fields, ranging from security screening, e.g., at airports, through ultrafast communications and radioastronomy, to nonionizing biomedical spectroscopy and imaging. One of the most interesting forms of THz radiation are subpicosecond in duration bursts of electromagnetic (EM) waves. These EM bursts are called THz transients, since they are typically characterized by approx. a 0.1 to 5 THz spectral range. We present our THz time-domain spectroscopy (THz-TDS) technique that has been utilized to study a variety of biomaterials ranging from gelatin-based hydrogels mimicking human skin tissue to formalin-fixed-paraffin-embedded murine pancreas and liver tumors. Our experimentally measured time-domain transients were, subsequently, analyzed using, developed by us, a maximum a-posteriori probability estimation technique to generate high-resolution, 2-dimensional maps of THz-range refractive index n and absorption coefficient α parameters, as imaging markers [1]. We also present precisely distinguishable differences in n and α markers between images of radiation-treated and unirradiated tumor samples. Once medically accepted, the THz-TDS imaging could augment *ex-vivo* histopathology tumor diagnostics and be widely used in Tissue Biobanks at cancer institutions.

This work was supported in part by the University of Rochester, University Research Awards Program. Additional supported was provided by the US Department of Energy [National Nuclear Security Administration] and University of Rochester "National Inertial Confinement Program" under Award Number DE-NA0004144.

[1] Chakraborty D., Mills B. N., Cheng J., Komissarov I., Gerber S. A., and Sobolewski R., (2023) *ACS Omega* 8, 9925–9933.

[#] corresponding author: roman.sobolewski@rochester.edu

Biomolecules as new avenues for the design of optical biosensors

Sabato D’Auria#

Department of Biology, Agriculture and Food Sciences, National Research Council of Italy

Since several years, researcher have acknowledged the importance of integrating biological molecules into the design of artificial devices. Biosensors are a combination of signal transducers and biomolecules, and they have a fundamental role in medical diagnosis, food safety and environmental control. The compactness, portability, high specificity, and sensitivity are the motives that the design of biosensors is considered to have a high potential in all analytical practices. Consequently, modern biotechnological strategies are exploiting the use of proteins, enzymes and antibody as components of sensors for analyses of high social interest. In particular, the idea is to take advantage of the extremely wide range of selective affinities sculpted into the various biomolecules by natural biological evolution. The number of potential molecules specifically recognized by different biomolecules is enormous and it sorts from small molecules to macromolecules (including protein themselves). The advantages of using proteins as components of biosensors is discussed.

References
Emergent biosensing technologies for analyses of high social interest A. Camarca, A. Varriale, A. Capo, A. Pennacchio, A. Calabrese, C. Giannattasio, C. Murillo Almuzara, S. D’Auria, M. Staiano Sensors (2021) 21, 906. https://doi.org/10.3390/s21030906

Photonic label-free biosensors for fast and multiplex detection of Swine Viral Diseases M. Gómez, C. Sánchez, S. Peransi, D. Zurita, S. Recuero, M. Rodrigo, S. Simón, G. Manessis, A.I. Gelasakis, I. Bossis, A. Camarca, A. Capo, M. Staiano, A. Varriale, S. D’Auria, G. Balka, L. Dénes, M. Frant, L. Nannucci, M. Bonasso, A. Giusti, A. Griol Sensors (2022) 22(3):708. doi: 10.3390/s22030708

---

corresponding author: sabato.dauria@cnr.it

ORAL PRESENTATIONS

Two-photon excited luminescence of colloidal quantum dots for heavy metal ions detection

Marcin Nyk#, Agnieszka Siomra, Dominika Wawrzyńczyk, Marek Samoć

Institute of Advanced Materials, Faculty of Chemistry, Wrocław University of Science and Technology,
Wyb. Wyspianskiego 27, PL-50370, Wrocław, Poland

Over many years numerous research groups have been pursuing the quest for better third-order nonlinear optical (NLO) materials [1] that would be useful for the emerging applications in laser technologies, telecommunication and biophotonics [2]. Therefore, we demonstrate in the quantitative manner the ability of colloidal quantum dots (QDs) to exhibit NLO response in an expanded spectral range of wavelengths [3]. The results shed light on the potential applicability of this nanomaterial as two-photon excited luminescence based sensor for metal ions detection – including heavy metal ions [4].

[1] Zareba J.K., Nyk M., Samoc M. (2021) Advanced Optical Materials, 9, 2100216.
[2] Nawrot K.C., Zareba J.K., Toporkiewicz M., Chodaczek G., Wawrzynczyk D., Kulbacka J., Bazylinska U. and Nyk M. (2021) International Journal of Nanomedicine, 16, 3649-3660.
[3] Nawrot K.C., Sharma M., Cichy B., Sharma A., Delikanli S., Samoc M., Demir H.V., Nyk M. (2022) ACS Photonics, 9, 256-267.
[4] Siomra, A., Wawrzyńczyk D., Samoć M., Nyk M. (2024) RSC Advances, 14, 2439-2446.

corresponding author: marcin.nyk@pwr.edu.pl

The influence of the metal ion on spectroscopic properties of [DMA]M(HCOO)$_3$: Cr^{3+} (M = Zn^{2+}, Mn^{2+}, Mg^{2+}) hybrid perovskites for luminescence thermometry

Adam Kabański[#], Maciej Ptak, Dagmara Stefańska

Institute of Low Temperature and Structure Research, Polish Academy of Sciences,
ul. Okólna 2, Wrocław, 50-422, Poland

Temperature is one of the most significant conditions in a various field of science and technology. Thus, the accurate monitoring of this parameter makes a necessary to develop sensing solutions fitted to specific requirements. Even though conventional sensors provide sufficient characteristics for the majority of the undemanding applications, the specific scientific, industrial, and biomedical sectors require to use of remote sensing systems. Luminescent thermometry - the novel approach to temperature monitoring, may overcome the limitations of the conventional sensing systems.

The group hybrid perovskites with the general formula [A]BX$_3$, where A is an organic cation (e.g. DMA$^+$), B stands for a metal cation (e.g. Mn^{2+}) and X is for the anion (e.g. HCOO-), has attracted increasing attention due to their multifunctional properties.[1,2] By changing the composition of the host materials, the luminescence of the Cr^{3+} can be modulated. The crystal field strength (Dq/B) induces the main emission type of the chromium trivalent ions: narrow spin-forbidden $^2E_g \rightarrow {}^4A_{2g}$ or broad spin-allowed $^4T_{2g} \rightarrow {}^4A_{2g}$ transitions. The luminescence of the Cr^{3+} ion in the investigated structures is strongly dependent on the temperature. The temperature-dependent luminescence has been a basis for the thermometric model determination. The obtained results confirm the great potential of the sensing materials based on the hybrid perovskite materials containing Cr^{3+} ions.[3]

The presentation will contain the structural and spectroscopic analysis of the investigated materials, with particular emphasis on their implementation as highly sensitive luminescent thermometers. The influence of the composition on the optical characteristics as well as a determination of the thermometric model will be described in detail.

[1] Kabański A., Ptak M., Stefańska D. (2023) *ACS Appl. Mater. Interfaces*, 15, 7074-7082
[2] Ptak M., Sieradzki A., Simenas M., Mączka M. (2021) *Coord. Chem. Rev*. 448, 213180
[3] Stefańska D., Kabański A., Vu Q., Adaszyński M., (2023) *Sensors*, 15, 6259

[#] corresponding author: a.kabanski@intibs.pl

Photophysical and chiroptical properties of rhenium(I) complex bearing pyrazino-phenanthroline helicene ligand

Dominika Kaczmarczyk#, Monika Srebro-Hooper

Department of Theoretical Chemistry, Faculty of Chemistry, Jagiellonian University,
Gronostajowa 2, 30-387 Kraków, Poland

Organic light-emitting diodes (OLEDs) have gained increasing interest for display and lightening applications. However, the OLED technology still faces some major challenges. Notably, the current portable OLED display devices require the use of anti-glare filters to limit the reflection of external light, which leads to a loss of up to 50% efficiency. In this regard, CP-OLEDs (Circularly Polarized OLEDs) that utilize the circularly polarized luminescence (CPL) emitted by chiral emitters via fluorescence, phosphorescence or thermally activated delayed fluorescence, which could pass the filters with less attenuation [1], offer an attractive alternative.

Metal complexes with helicene ligands such as rhenium(I)-based ones, which have demonstrated a strong chiroptical activity and beneficial CPL characteristics [2], emerge as promising candidates to generate CPL for CP-OLEDS. Recently, a novel Re(I) complex bearing helical π-conjugated pyrazino-phenanthroline ligand has been synthesized (Fig. 1) and its enantiomers have been successfully separated and examined via absorption and emission spectroscopies. To gain comprehensive understanding of experimentally derived photophysical and chiroptical characteristics of both the pristine ligand and the complex, (time-dependent) density functional theory studies have been carried out including simulations of electronic circular dichroism (ECD) spectra and emission features (both non-polarized and CPL) via optimizations of the lowest-energy excited singlet and triplet states and their spin-orbit coupling examinations. The results have been compared with those obtained for the reference non-helicenic systems, highlighting importance of intramolecular charge-transfer states.

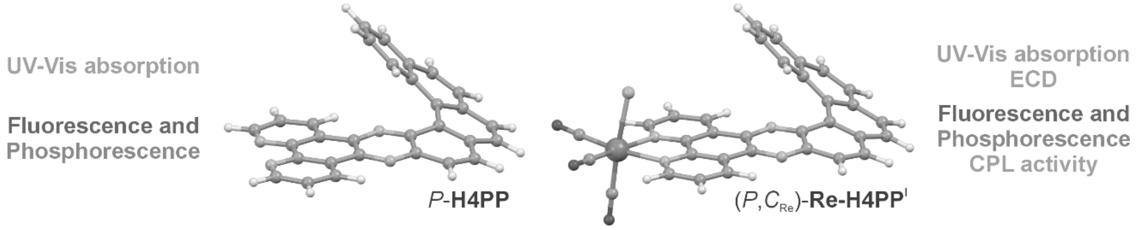


Fig. 1. DFT-optimized structures of the studied ligand and its Re(I) complex.

[1] Dhbaibi K., Abella L., Meunier-Della-Gatta S., Roisnel T., Vanthuyne N., Jamoussi B., Pieters G., Racine B., Quesnel E., Autschbach J., Crassous J., Favereau L. (2021) Chem. Sci. 12, 5522-5533.

[2] Gauthier E. S., Abella L., Hellou N., Darquié B., Caytan E., Roisnel T., Vanthuyne N., Favereau L., Srebro-Hooper M., Williams J. A. G., Autschbach J., Crassous J. (2020) Angew. Chem. Int. Ed. 59, 8394-8400.

\# corresponding author: dominika.kaczmarczyk@doctoral.uj.edu.pl; dominika.jelonek@doctoral.uj.edu.pl; monika.srebro@uj.edu.pl

First-principles calculation of electronic structure of Li^+ co-doped Eu^{3+}-doped ZnO for photodynamic therapy (PDT) application

M. Taibeche[1#], W. Zerman[2], L. Guerbous[1], A. Bouhemadou[3]

[1]Department of radiological and atomic physics, Physics Division/Nuclear Research Center of Algiers,
02 Bd Frantz-Fanon, BP.399, Alger RP, Alger, Algeria,
[2]pthirm Laboratory, Department of physics, Faculty of sciences, Saad Dahleb Blida1 University,
Blida (9000), Algeria.
[3]Laboratory for Developing New Materials and their Characterizations, Department of Physics,
Faculty of Science, University of Ferhat Abbas Setif 1, Setif, Algeria.

Photodynamic therapy or PDT is one promising modality for deep cancer therapy. In fact, the excited adequate scintillator by X-ray radiation can itself excite a photosensitizer to generate reactive oxygen species (ROS), most importantly singlet oxygen (1O2), to damage tumour cells. It has well established that this application cert some properties of scintillators are required such as non-toxicity, high yield of scintillation, nanosized scale and spherical shape. Among ZnO semiconductor scintillator is a promising optical material which is attracting growing interest for PDT application. ZnO non-toxic and stable due to its certain chemical and thermal properties, and specific bandgap energy (3.37 eV), also high binding energy equal to 60 MeV and other advantages. For this purpose, ZnO was activated by some rare earth ion such as Eu^{3+} and co-doped by Li^+ ion to increase its luminescence properties. Using the pseudo-potential plane-wave based on the density functional theory (DFT), the electronic structures and optical properties of ZnO, and co-doped ZnO Li^+ and Eu^{3+} were studied. This work aims to understand the Li^+ ion role in luminescence of ZnO: Eu^{3+} by Using VASP code (Vienna Ab-initio Simulation Packages). Based on the experimental results obtained PL spectra (emission and excitation) at room temperature of the samples: pure ZnO and ZnO–co-doped (Eu^{3+}, Li^+) nanoparticles for various Li concentrations, we calculated the band gap and band structure proprieties. New function was used to be in good agreement with our experimental results such as HSE to properly describe the Bandgap, as well as GGA+U to locate strongly correlated energy levels. In this work we discussed the results obtained by the simulation, thus compared them with our experimental data.

[#] corresponding author: m.taibeche@crna.dz

Engineering atomic size mismatch in La^{3+}, Pr^{3+} codoped $Lu_3Al_5O_{12}$ garnet single crystals for tailored structure and functional properties

Karol Bartosiewicz[1#], Benedetta Albini[2], Damian Szymański[3], Paweł Socha[4], Takahiko Horiai[5], Masao Yoshino[5], Akihiro Yamaji[5], Shunsuke Kurosawa[5,6,7], Romana Kucerkova[8], Pietro Galinetto[2], Akira Yoshikawa[5,6,7]

[1]Faculty of Physics, Kazimierz Wielki University, Powstancow Wielkopolskich 2, 85090, Bydgoszcz, Poland
[2]Department of Physics, University of Pavia, Via Bassi 6, Pavia, Italy
[3]Institute of Low Temperature and Structure Research, PAS, Okolna 2, Wrocław, 50-422, Poland
[4]Faculty of Chemistry, University of Warsaw, Ludwika Pasteura 1, 02-093 Warsaw, Poland
[5]New Industry Creation Hatchery Center, Tohoku University, Sendai 980-8577, Japan
[6]Institute of Laser Engineering, Osaka University, Suita, Osaka 565-0871, Japan
[7]Institute for Materials Research, Tohoku University, Sendai, Miyagi 980-8577, Japan
[8]Institute of Physics, Czech Academy of Sciences, Na Slovance 1999/2, 182 00 Praha, Czechia

This study provided the first in-depth investigation of the effects of large dopant incompatibility (Pr^{3+} and La^{3+} ions) on the small host lattice element (Lu^{3+}) in $Lu_3Al_5O_{12}$ (LuAG) single crystal. The growth of such complex crystals from the melt presented many challenges [1]. By engineering the ionic radius ratio of RE- and M-site cations, a single-crystal phase stabilized by configurational entropy was achieved [2]. This investigation elucidated the crystallization behavior of configurationally disordered rare-earth aluminum garnet oxide $(Lu_{1-x-y}Pr_xLa_y)_3Al_5O_{12}$ from the melt and characterized its functional properties, including microstructural, optical, photoluminescence, and scintillation properties, between 5 and 300 K. Relaxation of the imposed strain energy led to local perturbations and destabilization of the garnet structure [3]. Multielemental EDS mapping, micro-Raman spectroscopy, and thermoluminescence revealed the mechanism by which atomic size mismatch drove a smooth transition from the garnet to the perovskite phase in high entropy garnets. The optical, photoluminescence, and scintillation measurements provided fundamental insights into property changes driven by incompatibility doping. The exploration of atomic incompatibility in oxide materials led to a deeper understanding of the complex processes observed in highly entropic oxide systems, facilitating the development of rational design approaches to enhance functionality.

Acknowledgments:This work was supported by the National Science Centre Poland (NCN) no. 2020/39/D/ST3/02711.

[1] K. Bartosiewicz, V. Babin, K. Kamada, et al., J. Lumin. 216 (2019) 116724.
[2] V. Laguta, M. Buryi, V. Babin, et al., J. Mater. Chem. C 11 (2023) 1346–1359.
[3] K. Bartosiewicz, T. Horiai, A. Yamaji, et al., Mater. Sci. Eng. B 261 (2020) 114677.

[#] corresponding author: karol@ukw.edu.pl

Red-Emitting Tellurite Glasses: A Combined Investigation of Physical, Structural, Optical and Luminescence Properties for Potential Red-Light Source and Scintillation Materials

P. Yasaka[1,2#], W. Wongwan[1,2], K. Boonin[1,2], J. Kaewkhao[1,2]

[1]Physics Program, Faculty of Science and Technology, Nakhon Pathom Rajabhat University,
Nakhon Pathom 73000, Thailand
[2]Center of Excellence in Glass Technology and Materials Science (CEGM),
Nakhon Pathom Rajabhat University, Nakhon Pathom 73000, Thailand

The (35-x)TeO_2: 30ZnO: 30B_2O_3 5BaO: xEu_2O_3 (where x = 0.0, 0.1, 0.5, 1.0, 1.5, 2.0, and 3.0 mol%) glasses were prepared by melt-quenching technique. Their physical, structural optical, and luminescence properties were characterized by density, molar volume, refractive index, absorption spectra, Fourier transform infrared (FTIR), X-ray diffraction analysis (XRD), photoluminescence, Judd-Ofelt (JO) theory, and radioluminescence. The amorphous structure of the samples was confirmed by a Shimadzu XRD–6100 diffractometer. Absorption spectra were evaluated in the wavelength region between 350 - 2300 nm and found five peaks at 394, 465, 533, 2092, and 2207 which corresponded with the energy transitions of Eu^{3+}ion from the ground state of $^5L_6$, $^5D_2$, $^7F_1$, $^7F_6$ and $^7F_1 \rightarrow {}^7F_6$ nm. In the photoluminescence of glass, it was found that glass exhibited the strongest luminescence intensity of Eu^{3+} ion at 613 nm ($^7F_2$) under 394 nm excitation. The overall color of emission is reddish-orange in CIE 1931 chromaticity. The results obtained in photoluminescence properties showed that the glass could be a potential candidate for a red-light source medium in optical materials and scintillation materials.

Keywords: Glass material, Luminescence, Scintillator, Eu^{3+} ions.

[#] corresponding author: pyasaka@webmail.npru.ac.th; pyasaka@hotmali.com

Monolithically integrated Q-switched plasmonic nanolaser

D. Hernández-Pinilla[1#], P. Molina[1], G. López-Polín[1], M. Chhowalla[2], P. Ares[3,4],
J. Gómez-Herrero[3,4], M. O Ramírez[1,4], L. E. Bausá[1,4]

[1]Dept. Física de Materiales, Universidad Autónoma de Madrid, Madrid, Spain
[2]Dept. of Materials Science & Metallurgy, University of Cambridge, Cambridge, UK
[3]Dept. Física de la Materia Condensada, Universidad Autónoma de Madrid, Madrid, Spain
[4]Condensed Matter Physics Center (IFIMAC), Universidad Autónoma de Madrid, Madrid, Spain

The realization of stable coherent nanoscale light sources is of key significance for the development of novel nanoscience and nanophotonic technologies. Here we demonstrate the simultaneous control over temporal and spatial confinement of coherent radiation at subwavelength regions in a monolithically integrated plasmon-assisted nanolaser device. The approach combines a Nd^{3+}-doped Lithium Niobate crystal which provides laser gain in the NIR spectral region, plasmonic chains of Ag nanoparticles that enable subwavelength spatial confinement of laser radiation, and a 2D-monolayer (MoS_2) acting as saturable absorber to achieve a stable temporal confinement of laser radiation [1].

The results establish the basis for the integration of ultra-fast lasers at the nanoscale, in which the synergetic hybridization of the materials involved could benefit applications such as quantum computing, high-speed communications, ultra-sensitive sensing or advanced manufacturing, providing a wealth of opportunities for light manipulation and control at subwavelength scales.

[1] M. O Ramírez, P. Molina, D. Hernández-Pinilla et al. (2023) Laser Photonics Rev, 2300817, 1-7.

corresponding author: david.hernandezp@uam.es

Impact of Side Alkyl Chain Geometry on Diketopyrrolopyrrole Derivatives: Spectroscopic Properties, Aggregation, and Thin Film Organization

Alicja Stachowiak#, Kamil Kędzierski, Karol Rytel, Alina Dudkowiak

Faculty of Materials Engineering and Technical Physics, Poznan University of Technology, Piotrowo 3,
60-965 Poznań, Poland

Diketopyrrolopyrroles (DPP), a family of organic dyes featuring a π-conjugated dilactam core, are known for their rich structural modification capabilities, leading to various property changes. The impact of the spatial structure of side alkyl chains (branched and straight) on the properties of oligothiophene derivatives of DPP in solution and thin layers was explored. In order to control the process of creating thin films at the air-water interface, the Langmuir technique was employed. The process of layer compression was analyzed in detail, where, aside from surface pressure, changes in surface potential and absorption spectra were examined. Thin layers were transferred onto the solid substrate using the Langmuir-Schaefer technique and were studied with confocal microscopy and absorption spectroscopy. Additional conclusions enhancing our understanding of molecular arrangement in thin layers were obtained by combining experimental techniques with DFT calculation results.

Results revealed significant differences in the isotherm during Langmuir layer compression, particularly for the branched alkyl side chain dye, where an additional compression stage was observed. Interestingly, the layer formation process was initiated at a value of 1/3 area per molecule as obtained from DFT geometry optimization calculation, suggesting an elaborate structure of formed layers. It was shown by confocal microscopy that the Langmuir layers transferred onto a solid substrate are not monomolecular but are composed of three different structures. Complexity in the absorption spectra of both materials in solution and significant changes between their spectroscopic properties in the thin film were revealed by spectroscopic study analysis, although minimal differences were observed in their spectra in solution. The appearance of three absorption bands in the red region was revealed by the deconvolution of absorption spectra, in the spectra of the material in every form (solution, In-situ, thin layer). By combining information obtained with Langmuir, spectroscopic and microscopic studies, and DFT calculations, it was concluded that three forms of aggregations - monomer, dimer, and higher aggregation structure (most likely tetramer) - are present already in materials in solution, which translates into their molecular arrangement in thin films. Moreover, the pathways of formation and the ratio of aggregation forms in thin films are influenced by the spatial structure of the side alkyl chain.

---

corresponding author: alicja.stachowiak@put.poznan.pl

Tri-modal optical pressure sensor based on Cr^{3+} ions luminescence

Maja Szymczak[1#], Julia Jaśkielewicz[1], Marcin Runowski[2], Junpeng Xue[3],
Sebastian Mahlik[4], Łukasz Marciniak[1]

[1] Institute of Low Temperature and Structure Research, Polish Academy of Sciences,
Okólna 2, Wroclaw, Poland
[2] Faculty of Chemistry, Adam Mickiewicz University, Uniwersytetu Poznanskiego 8, Poznan, Poland
[3] School of Science Jiangsu University of Science and Technology, Zhenjiang 212100, China
[4] Institute of Experimental Physics, Faculty of Mathematics Physics and Informatics, University of Gdansk,
Wita Stwosza 57,Gdansk, Poland

Preventing disasters resulting from uncontrolled pressure increases constitutes a crucial impetus for investigating novel pressure-sensing methods capable of swiftly and reliably detecting even minute pressure fluctuations, enabling real-time monitoring thereof. One emerging avenue of exploration in this realm involves luminescent manometers, leveraging pressure-induced changes in luminescent characteristics. Recent research in optical pressure sensing underscores the indispensable role of transition metal ions, notably Cr^{3+} ions, owing to their pronounced spectroscopic sensitivity to variations in the crystal field strength. Notably, applied pressure induces shortening of the metal-oxygen distance, affecting the strength of the crystal field which influences their spectroscopic properties [1] and thus affording opportunities for the development of highly sensitive pressure sensors.

Addressing the imperative for dependable real-time measurements with high sensitivity, we proposed a tri-modal luminescent manometer based on Cr^{3+} ions luminescence in doped $Li_3Sc_2(PO_4)_3$ [2]. The innovative approach utilizing the $^4T_2 \rightarrow ^4A_2$ electronic transition of Cr^{3+} integrates three distinct readout modes based on luminescence intensity ratio (LIR), average lifetime of the excited state, and spectral shift of the emission band. Each of these modalities offers exceptional sensitivity of pressure readout, achieving values of 56.86% GPa^{-1}, 93.56% GPa^{-1} and 23.9 nm GPa^{-1}, respectively. Relative to previously reported high-pressure sensors, the $Li_3Sc_2(PO_4)_3:Cr^{3+}$ phosphor emerges as the most sensitive luminescent manometer up to date, operating in average lifetime and spectral shift modes, thereby exhibiting substantial potential for pressure sensing applications, even under harsh conditions.

Acknowledgements: This work was supported by the National Science Center (NCN) Poland under project no. DEC-UMO - 2020/37/B/ST5/00164.

[1] Brik M.G. and Avram N.M. (2009) J. Phys.: Condens. Matter, 21, 155502
[2] Szymczak M., Jaśkielewicz J., Runowski M., Xue J., Mahlik S. and Marciniak L. (2024) Adv. Funct. Mater., 2314068

corresponding author: m.szymczak@intibs.pl

O10 | A. K. Somakumar

Mn^{2+} Luminescence in ZnS Under High Pressure

A. K. Somakumar[1#], Y. Zhydachevskyy[1], D. Wlodarczyk[1], S. S. Haider[1], J. Barzowska[2],
K. R. Bindu[3], Y. K. Edathumkandy[1], T. Zayarniuk[1], Andrzej Szewczyk[1], S. Narayanan[1],
A. Lysak[1], H. Przybylinska[1], E. I Anila[4], A. Suchocki[1]

[1]Institute of Physics, Polish Academy of Sciences, Al. Lotnikow 32/46, 02-668, Warsaw
[2]Institute of Experimental Physics, Faculty of Mathematics, Physics, and Informatics, University of Gdańsk,
Wita Stwosza 57, 80-952 Gdańsk, Poland
[3]SreeSankara Vidyapeetom College, Valayanchirangara, Kerala, 683556, India
[4] CHRIST (Deemed to be University), Bengaluru, Karnataka, 560029, India

Manganese (Mn^{2+}) doped Zinc sulfide(ZnS) sample has potential applications in detectors, display devices and biological fields [1, 2]. In this work, a comprehensive pressure and temperature-dependent luminescence analysis of ZnS:Mn^{2+} nano phosphor with a zinc blende structure is conducted. The nano phosphor was characterized utilizing XRD, SEM, ambient, low temperature and high-pressure luminescence measurements and decay analysis. The high-pressure studies were done at ambient temperature using a diamond anvil cell (DAC) with a pressure-transmitting medium of methanol-ethanol mixture.

The sample was synthesized by a simple chemical precipitation method containing quantum dot-sized nanocrystallites with excellent orange luminescence related to the $^4T_1$-$^6A_1$ transition at ambient conditions. The sample also exhibits stable and identical luminescence behaviour under different types of excitations like UV and X-ray at ambient conditions. The impact-induced mechanoluminescence features of the sample were also investigated and compared with a wurtzite ZnS sample.

The pressure and temperature-induced luminescence mechanism of the phosphor is established via the d^5 Tanabe Sugano diagram. The Mn^{2+} luminescence band shifts with both pressure and temperature and the broad luminescence band of the $^4T_1$-$^6A_1$ transition shifts from the visible to near-infrared range at a rate of - 35.8 meV/GPa with the increase of the pressure. The luminescence subsequently quenched completely at 16.41 GPa due to a pressure induced reversible phase transition from zinc blende ($F\bar{4}3m$) to rocksalt ($Fm\bar{3}m$) structure. The decay kinetics measurements of the sample luminescence with respect to pressure and temperature also established.

Acknowledgements: This work was partially supported by the Polish National Science Center program 2019/33/B/ST8/02142 and SHENG 2 grant number: 2021/40/Q/ST5/00336, ZnS:Mn wurtzite sample was kindly provided by Prof. Dengfeng Peng.

[1] A.K. Somakumar, Y. Zhydachevskyy, D. Wlodarczyk, S.S. Haider, J. Barzowska, K.R. Bindu, Y.K.Edathumkandy, T. Zajarniuk, A. Szewczyk, S. Narayanan, A. Lysak, A.Suchocki, (2024) *Journal of Materials Chemistry C.*

[2] K. R. Bindu, S. A. Kumar, M. Anilkumar, E. I. Anila, (2021) *Solid State Communications*, *323*, 114106

corresponding author: skumar@ifpan.edu.pl

Photoelectrochemically active 2D heterostructure based on MoS_2/Borophene for Hydrogen Evolution

Daria Baranowska[1], Grzegorz Leniec[1], Beata Zielińska[1], Ewa Mijowska[1#]

[1]Department of Nanomaterials Physicochemistry, Faculty of Chemical Technology and Engineering, West Pomeranian University of Technology in Szczecin, 70-311, Szczecin, Poland; Center for Advanced Materials and Manufacturing Process Engineering, West Pomeranian University of Technology in Szczecin, 70-310, Szczecin, Poland

The search for sustainable energy sources has led to increased research into utilizing solar energy for hydrogen production through photoelectrochemical (PEC) processes. Molybdenum disulfide (MoS_2) has attracted considerable attention among the materials studied due to its impressive electronic and catalytic properties. Additionally, the emergence of borophene, a new two-dimensional (2D) material composed of boron atoms, has provided new opportunities for boosting the performance of MoS_2-based catalysts. Borophene possesses outstanding electronic properties and tunable band structures, making it an excellent candidate for enhancing the PEC activity of MoS_2.

In this presentation, I will discuss the fabrication, characterization, and application of MoS2/borophene heterostructures for efficient hydrogen evolution. The investigations involved various applications, including photocatalytic, electrochemical, and photoelectrochemical studies of hydrogen evolution from water-splitting reactions. The structural and electronic properties of MoS2/borophene heterostructures were investigated using advanced characterization techniques, including Transmission Electron Microscopy (TEM), Atomic Force Microscopy (AFM), X-ray Diffraction (XRD), Raman spectroscopy, and Electron Paramagnetic Resonance (EPR).

Evaluation of H_2 generation from MoS_2/borophene under simulated solar irradiation showed enhanced hydrogen evolution rates compared to unmodified MoS_2 in PEC. Ex-situ studies unveiled the synergistic effect between borophene and MoS_2, elucidating the mechanisms behind the enhanced PEC activity. Furthermore, testing the stability and durability of MoS_2/borophene catalysts during prolonged PEC operation demonstrated robust performance over extended periods.

This study highlights the potential of MoS_2/borophene heterostructures as a promising candidate for efficient solar-driven hydrogen evolution, offering insights into the design and advancement of catalytic materials for sustainable energy applications. These findings contribute to the ongoing efforts to advance renewable energy technologies and lay the groundwork for the commercialization of next-generation PEC systems.

---

corresponding author: emijowska@zut.edu.pl

Photophysical properties of Green Fluorescent Protein in solution and polyvinyl alcohol film at room temperature

Beata Wielgus-Kutrowska[1#], Joanna Krasowska[1], Emma Alexander[2],
Zygmunt Gryczyński[2], Ignacy Gryczyński[2]

[1]Division of Biophysics, Institute of Experimental Physics, Faculty of Physics, University of Warsaw,
Pasteura 5, 02-093 Warsaw, Poland.
[2]Department of Physics and Astronomy, Texas Christian University, Fort Worth, TX, 76129,
United States of America.

Fluorescent proteins are now widely used as biological markers for in vitro and in vivo imaging using a variety of spectroscopic methods.

Green Fluorescent Protein has a β-barrel shape, composed of 11 β-bands arranged mainly in an antiparallel manner. The hydrogen bonds between adjacent β-bands allow the form a closed structure with an α-helical segment buried inside the cyllinder. Three residues in this segment (in the wild-type protein they are Ser65, Tyr66 and Gly67) in the presence of molecular oxygen, generates a p-hydroxybenzylidazolidone chromophore, responsible for the visible green fluorescence.

The chromophore is tightly shielded from the solvent molecules and held in the appropriate plane by the hydrogen bonding system inside the protein. This location in the structure ensures efficient fluorescence of the chromophore, protecting it from quenching by molecular oxygen or by radiationless relaxation due to the ring mobility.

Polyvinyl alcohol is a polar, water-soluble compound used i.a. in luminescence studies of organic compounds. As a polar compound, PVA readily forms hydrogen bonds with trapped in it molecules. It causes the stiffening of organic molecules makes it difficult to dispose of their energy in a radiation-free manner. It enables studies of the properties of trapped dyes such as fluorescence, delayed fluorescence and phosphorescence. Anisotropy of fluorescence or phosphorescence is also observed for such molecules, which is not visible in aqueous solutions. PVA-modified materials are used to stabilize biological molecules such as proteins (i.a. lipase, acetylcholinesterase, glucose, oxidase).

In this work, we compare the spectroscopic properties of EGFP entrapped in PVA and in aqueous solution. In addition, we check how such properties change for uranine, an organic molecule for which the excitation and fluorescence emission spectra fall into similar wavelength ranges as for EGFP and an increase in anisotropy and fluorescence intensity is observed after immobilisation in film.

---

corresponding author: Beata.Wielgus-Kutrowska@fuw.edu.pl

Chemical tuning of photo- and persistent luminescence of Cr^{3+}-activated β-Ga_2O_3 by alloying with Al_2O_3 and In_2O_3

V. Stasiv[1#], Y. Zhydachevskyy[1], V. Stadnik[2], V. Hreb[2], V. Mykhaylyk[3], L. Vasylechko[2], A. Luchechko[4], T. Wojciechowski[1], P. Sybilski[1], A. Suchocki[1]

[1]Institute of Physics, Polish Academy of Sciences, aleja Lotników 32/46, Warsaw 02-668, Poland
[2]Lviv Polytechnic National University, S. Bandera Str. 12, Lviv 79013, Ukraine
[3]Diamond Light Source, Harwell Campus, Didcot, OX11 0DE, UK
[4]Ivan Franko National University of Lviv, Tarnavskogo Str. 107, Lviv 79017, Ukraine

This study details the effects of alloying monoclinic β-Ga_2O_3 with Al_2O_3 and In_2O_3 on the photoluminescence, thermoluminescence, and persistent luminescence properties of Cr^{3+} ions. Our investigation provided information on the characteristics and properties of the Cr^{3+} multicentres present in the β-Al_2O_3-Ga_2O_3 and β-Ga_2O_3-In_2O_3 solid solutions. The research results show how the host matrix and Cr3+ ions are related, providing insights for designing and optimizing new materials with specific optical properties, which can be used as long-persistent phosphors or cryogenic luminescent temperature sensors.

To achieve this, we prepared a series of samples using the sol-gel citrate method, with nominal compositions of $(Ga_{1-x}Al_x)_2O_3$:Cr(0.05at.%), Ca(0.5at.%) ($x = 0$; 0.1; 0.2), $(Ga_{1-x}In_x)_2O_3$:Cr(0.05at.%), Ca(0.5at.%) ($x = 0.05$; 0.1; 0.15; 0.2; 0.3; 0.4; 0.5). The samples were calcined at temperatures up to 1500°C.

This work presents a systematic investigation of the photoluminescence (PL) and thermoluminescence (TL) properties of Cr^{3+} in β-Al_2O_3-Ga_2O_3 and β-Ga_2O_3-In_2O_3 solid solutions. We analysed the luminescence properties of the materials at temperatures ranging from 4.4 to 350 K. In particular the PL spectra, PL excitation spectra, diffuse reflection (DR), and PL decay time were examined. We analysed the materials phase composition and crystal structure using powder X-ray diffraction (XRD) data and scanning electron microscope (SEM) to gain a comprehensive understanding.

Obtained results showed that by adjusting the chemical composition of the host lattice, we can fine-tune the thermometric performance of the studied phosphors. This adjustment enables control of the temperature range and the maximal specific sensitivity of the decay time luminescence thermometers based on the studied Cr^{3+}-doped $(Ga\text{-}Al)_2O_3$ and $(Ga\text{-}In)_2O_3$ solid solutions. The studied materials have significant potential for use in cryogenic luminescence thermometry.

Acknowledgements: The work was supported by the Polish National Science Centre (project nos. 2018/31/B/ST8/00774 and 2021/40/Q/ST5/00336) and by the National Research Foundation of Ukraine (grant no. 2020.02/0373).

[#] corresponding author: stasiv@ifpan.edu.pl

Beyond Luminescence to Understand Phosphors. The Case of Ba_2LaNbO_6:Mn and its Derivatives

Dagmara Kulesza[1#], Joanna Jedoń[1,2], Maksym Buryi[3], Mikhail G. Brik[4,5,6,7],
Michał Piasecki[7], Sebastian Mahlik[8], Alok M. Srivastava[9], Eugeniusz Zych[1]

[1]Faculty of Chemistry, University of Wroclaw, 14. F. Joliot-Curie Street, 50-383 Wroclaw, Poland
[2]Department of Chemistry and Chemical Engineering, Chalmers University of Technology, Gothenburg, Sweden
[3]Institute of Plasma Physics of the Czech Academy of Sciences, U Slovanky 2525/1a, 182 00, Prague, Czech Republic
[4]School of Optoelectronic Engineering & CQUPT-BUL Innovation Institute, Chongqing
University of Posts and Telecommunications, Chongqing 400065, PR China
[5]Institute of Physics, University of Tartu, W. Ostwald Str. 1, Tartu 50411, Estonia
[6]Academy of Romanian Scientists, Ilfov Street, no 3, 050044, Bucharest, Romania
[7]Theoretical Physics Department, Jan Dlugosz University, Armii Krajowej 13/15, 42-200 Czestochowa, Poland
[8]Institute of Experimental Physics, Faculty of Mathematics, Physics and Informatics, University of Gdańsk,
Wita Stwosza 57, 80-308, Gdańsk, Poland
[9]Current Lighting Solutions, LLC, 1099 Ivanhoe Road, Cleveland, OH 44110, United States

In recent years, the interest in efficient red light-emitting phosphors, particularly those activated with Eu^{2+} or Mn^{4+} ions, has grown significantly. The focus is on developing narrow and ultra-narrow emitters to advance high-color gamut LED phosphors for various applications. Understanding the interaction between activators and ligands, especially for environmentally sensitive ions like Eu^{2+} or Mn^{4+}, is essential for designing such new phosphors. This presentation shows spectroscopic studies of Mn^{4+}-activated double perovskites Ba_2LaNbO_6, $Ba_2La[Nb_{0.8}Zr_{0.1}W_{0.1}]O_6$, and $Ba_2La[Zr_{0.5}W_{0.5}]O_6$. The main focus was to investigate the impact of chemically-induced structural distortion when Nb was gradually substituted with (Zr,W) pairs, anticipated to increase the Zero-Phonon Line (ZPL) of Mn^{4+} transition probability by disturbing the dopant's octahedral local symmetry [1]. These findings were compared with the EPR spectra. For Ba_2LaNbO_6:Mn and $Ba_2La(Nb_{0.8}$Zr0.1$W_{0.1})O_6$:Mn, only intense lines characteristic of Mn^{2+} were observed, indicating similar Mn^{2+} concentrations in both samples. In contrast, narrow luminescence features from Mn^{4+} could be seen in these phosphors. In $Ba_2La[Zr_{0.5}W_{0.5}]O_6$, both Mn^{2+} and Mn^{4+} were found in the EPR, and the Mn^{4+} emission bands appeared broader, in agreement with the higher concentration of Mn^{4+} as verified by EPR.

The absence of Mn^{2+} luminescence in all three materials will be discussed. We will demonstrate a correlation between the introduced disorder of the cationic subsystem and the experimental and calculated energy of the Mn^{4+} emitting ^2E_g level (R-line) as well as its intensity. The conducted EPR studies indicate the need for further research to comprehend the interplay between different Mn ions in the materials under investigation.

This work was financed by the Polish National Science Centre (NCN), grant OPUS #UMO-2018/31/B/ST4/00924.

[1] J. Jedoń et al. (2023) J. Alloys Compd. 930, 167435 (1-12).

corresponding author: dagmara.kulesza@uwr.edu.pl

Fluorescence time decay of 1,2-Indanedione-arginine and applications

Ismail Mekkaoui Alaoui#

Physics Department, Cadi Ayyad University, Faculty of Sciences Semlalia
BP 2390 Marrakech 40000, Morocco

The fluorescence spectrum of the reaction product of 1,2-indanedione, a fingerprint reagent [1-3], with amino acid L-arginine (Arg) was measured in water-methanol solutions at room temperature. Dissolved Arg in ultrapure (18.2 MΩ·cm) water was mixed with a methanol (4.10-3M) solution of 1,2-indanedione (50%V/50%V). When the reaction was complete, we measured the excitation, emission and time-resolved fluorescence of the samples at room temperature. The fluorescence of the product is a broadband spectrum having its maximum around 530 nm with a half width of about 50 nm [4]. The fluorescence time decays for the mixture product were calculated using one, two and three exponential fits. The data were analyzed using the linear least squares and logarithmic fit procedures. The best fit was achieved with the three exponential decay law. From the resolution of multi-exponential decay laws, fluorescence decay lifetimes of the fluorescent species were obtained: τ_1 = 0.653 ns with a S.Dev = 0.046 ns; τ_2= 2.962 ns with a S.Dev = 0.011 ns; and τ_3 = 7.100 ns with a S.Dev = 0.168 ns. These results can be used for gender determination from fingerprint residue by comparing the intensities of the fluorescence peaks in the same experimental conditions [4]. For instance, the concentration of amino acids (AAs) in females fingerprints residues is almost the double of the concentration of AAs in males [5] and, consequently, fluorescence peak of 1,2-indanedione-L-arginine in females will be at least two times higher than those from males. In this way, the investigations in a justice case, for example, are reduced by almost 50%.

[1] Ramotowski R. Cantu A.A. Joullié M.M. and Petrovskaia O. (1997) Fingerprint World, 23 (90), 131
[2] Mekkaoui Alaoui I. Menzel E.R. Farag, M. Cheng K.H. and Murdock, R.H. (2005) Forensic Sci. Int., 152, 215-9.
[3] Mekkaoui Alaoui I. Troxler T. and Joullié M.M. (2012) J. Forensic Id., 62, 1-6.
[4] Mekkaoui Alaoui I. and Halamek J. (2019) J. Forensic Sci, 64, 5, 1495-1499
[5] Asano K. G. Bayne C. K. and Buchanan M. V. (2002) J Forensic Sci., 47, 805-7.

corresponding author: mekkaoui@uca.ac.ma

Nanoparticle-Based System of Gold Nanoshells and Silver Sulfide Quantum Dots for Enhancing Optical Response

Marta Gordel-Wójcik[#], Michał Pietrzak, Jakub Tracz,

Faculty of Chemistry, University of Wrocław, 14.p F. Joliot-Curie Street, 50-383, Wrocław, Poland

We aimed to develop a hybrid nanostructure with unconventional optical properties. Hence, we chose gold nanoshells as a base due to their intriguing optical characteristics, particularly their band extinction position in the near-infrared (NIR) range, and their dual contribution to absorption and scattering in the extinction spectrum. In our experiment, we utilized gold nanoshells fabricated onto a silica sphere with a diameter of 120 nm. These nanoshells were meticulously coated with a few nanometers-thick layer of gold. However, to prevent direct adsorption of the fluorescent label onto the metallic surface, it's advisable to incorporate a spacer layer. This may involve a layer of PEG-SH [1] or silica [2]. We opted for the latter due to its relatively easy thickness control, durability, and potential for subsequent surface modifications. In the subsequent step, silver sulfide quantum dots [3] were attached to this structure (Fig.1). This hybrid system exhibits strong mutual interactions, thereby enhancing both linear and nonlinear optical responses.

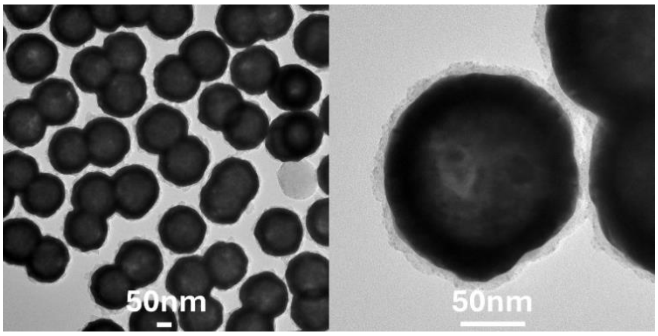


Fig.1 TEM images of gold nanoshells with a silica layer and attached silver sulfide quantum dots.

This work was supported the project No. UMO-2021/43/D/ST5/02249, SONATA 17, funded by National Science Center Poland (NCN).

[1] M. Gordel-Wójcik, K. Piela and R. Kołkowski, Physical Chemistry Chemical Physics, 2022, 24, 5700–5709.
[2] M. Gordel-Wójcik, M. Pietrzak, R. Kołkowski and E. Zych, *J Lumin*, 2024, 270, 120565/1-120565/9
[3] M. Gordel-Wójcik, M. Malik, A. Siomra, M. Samoć and M. Nyk, Journal of Physical Chemistry Letters, 2023, 14, 11117–11124.

[#] corresponding author: marta.gordel-wojcik@uwr.edu.pl

Kinetic of the power-dependent up-conversion luminescence in Er^{3+}/Yb^{3+}-doped single nanocrystal

M. Żebrowski[1], M. Ćwierzona[1], M. Nyk[2], A. Bednarkiewicz[3],
S. Maćkowski[1], D. Piątkowski[1#]

[1] Institute of Physics, Faculty of Physics, Astronomy and Informatics, Nicolaus Copernicus University in Toruń, ul. Grudziądzka 5, 87-100 Toruń, Poland
[2] Advanced Materials Engineering and Modelling Group, Faculty of Chemistry,
Wrocław University of Science and Technology, Wybrzeże Wyspiańskiego 27, 50-370 Wrocław, Poland
[3] Institute of Low Temperature and Structure Research, Polish Academy of Sciences,
Okólna 2, 50-422 Wrocław, Poland

This work analyzes the dynamics of the up-conversion process occurring in the single $NaYF_4$ nanocrystal (NC) doped with Er^{3+} and Yb^{3+} ions under varying excitation laser power. A confocal microscope was used to collect the time-dependent red emission of erbium ($^4F_{9/2}\rightarrow{}^4I_{15/2}$) activated by a laser operating at 980 nm with power changing from hundreds of µW to a few mW. A strong correlation between the laser power and the shape of the decay profile was observed, including changes in both the rising part and the decay tail. Furthermore, we noticed significant decrease in the average decay time with the increasing power of the excitation laser.

In order to explain this phenomenon, observed exclusively for small nanocrystals, we developed a new semi-empirical model of kinetic rate equations of the erbium-ytterbium system. Starting from the standard approach used for bulk crystals, we additionally assumed the presence of two independent erbium populations: internal, simulating ions isolated from the interaction with the environment, and external, attributed to the ions localized close to the NC's surface. For the latter, we introduced an additional nonradiative decay channel depopulating the red-emitting level through the interaction with surfactants. Moreover, an extended $Yb^{3+}\rightarrow Er^{3+}$ energy transfer model, including phonon statistics, was considered.

Eventually, we found that laser radiation prominently changes the temperature of the NC and tunes the up-conversion kinetics. Rising temperature helps to overcome a potential barrier for nonradiative decay and modifies the phonon occupation number in the case of energy transfer. Interestingly, the efficiency of these processes can be reduced by coating NCs with an optically passive shell, insulating external ions from the environment. The proposed kinetic model allowed us to estimate correct fits describing experimental luminescence decay profiles for various excitation powers. We found the presented approach valuable for the analysis of the up-conversion processes within a single nanocrystal and temperature sensing at the nanoscale.

[#] corresponding author: dapi@umk.pl

Magnetoresistance in van der Waals MoS_2/ZnO/VS_2 trilayer heterostructure for spintronics application

Rajalingam Thangavel#, Saurav Lahiri, Manish Kumar

Condensed Matter Physics Laboratory, Department of Physics, IIT (ISM) Dhanbad, Jharkhand,
India, PIN-826004

The van der Waals (vdW) heterostructures based on transition metal dichalcogenides (TMDCs) play a crucial role in next generation spintronics devices. Herein, a trilayer vdW heterostructure comprising MoS_2/ZnO/VS_2 is fabricated using facile drop casting method on a silicon substrate. The corresponding vdW trilayer is then characterized using X-Ray Diffraction (XRD), X-Ray Photoelectron Spectroscopy (XPS) and Raman Spectroscopy. XRD showed the phase formation while the XPS revealed the oxidation state of the constituent elements of the trilayer heterostructure. Raman spectrum of the vdW trilayer showed a blue shift (nearly 6 cm^{-1}) compared to the individual layers due to the mutual interaction between the layers confirming the formation of the heterostructure. Magnetoresistance (MR) measurement with the sample being kept parallel to the external tunable magnetic field revealed a negative MR of 10.2 %. Thus, the magnetoresistive effect of the MoS_2/ZnO/VS_2 vdW trilayer makes it a potential candidate for spin-based devices.

corresponding author: rthangavel@iitism.ac.in

White light generation with high CRI

Dagmara Stefańska[#], Marek Adaszyński, Damian Szymański

Institute of Low Temperature and Structure Research, Polish Academy of Sciences,
Wrocław, 50-422, Poland

White light emitting diodes (WLEDs) are widely used and very important as they significantly reduce global energy demand and contribute to reducing the use of fossil fuels. These products are characterized by high lighting efficiency, low energy consumption, reliability, and are environmentally friendly. Lighting plays an indispensable role in the everyday life of every human being, and electric light sources are responsible for energy consumption of up to 1/5 of the world's electricity production.
LED technology, despite many advantages, also has disadvantages. LED lighting available for sale emits light with an unpleasantly "cold" color. Excessive exposure to blue light disrupts the human circadian cycle, including the production of the sleep hormone melatonin Therefore, the search for artificial light as close as possible to the spectrum of sunlight is one of the most important and urgent challenges faced by advanced science and technology.

During the conference, we will present an innovative method of producing white WLED light with a high color rendering index (CRI) above 90. In our solution, white light is generated by a composite containing two phosphors excited by violet light with CRI 92 and CCT 2550 K. The electroluminescence spectrum covers the entire visible range from 400 nm to 750 nm. The lack of dominance of the blue component and the presence of a band in the red spectral range make this light healthy for the human body. The color of the generated light, the CRI value, and the CCT color temperature can be modified by changing the proportions between the phosphors used. The obtained composites are stable and have successfully passed aging tests that lasted 10,000 hours. It can be used as lighting for home, public, and industrial spaces as well as high-quality specialist lighting, e.g. during surgical procedures. People should realize that good quality light is as important as clean air or a healthy lifestyle.

This research was funded by the National Centre for Research and Development (LIDER/19/0103/L-12/NCBR/2021).

[#] corresponding author: D.Stefanska@intibs.pl

Stokes and anti-Stokes emission of $CaAl_2SiO_6$ polycrystals doped with Pr^{3+} ions

K. Lemański[#], N. Rebrova, P. Zdeb, P. J. Dereń

Institute of Low Temperature and Structure Research, Polish Academy of Sciences,
Okólna 2, 50-422 Wrocław, Poland

Silicates and aluminosilicates belong to a large family of compounds useful in many areas. $CaAl_2SiO_6$ Yoshiokaite mineral structure was first collected from the Moon by the Apollo 14 crew in 1971. In the scientific literature, there are not many papers describing the luminescent properties of $CaAl_2SiO_6$. However, recently manuscripts have been published describing the properties of this aluminosilicate doped with rare earth and transition metal ions [1-3].

The Stokes emission of Pr^{3+} ions is characterized by the blue and red emission, which is mainly from the $^3P_0$ or $^1D_2$ energy levels to the ground state $^3H_4$, respectively. Also, the 5d→4f Stokes and anti-Stokes (see Fig. 1.) emission in the UVC range is observed. The UVC radiation (100-280 nm) is used for disinfection because it successfully destroys viruses and bacteria. Therefore, materials with emissions in the UVC range may find applications that are particularly useful for human health.

The synthesis of $CaAl_2SiO_6$ polycrystals doped with Pr^{3+} ions were carried out with using the solid-state method. The crystalline structures have been confirmed with the XRD measurement. The absorption, excitation, emission spectra, and time decay profiles of the praseodymium(III) ions were measured and analyzed. The studied aluminosilicate phosphors possess characteristics that confirm their potential in luminescent applications.

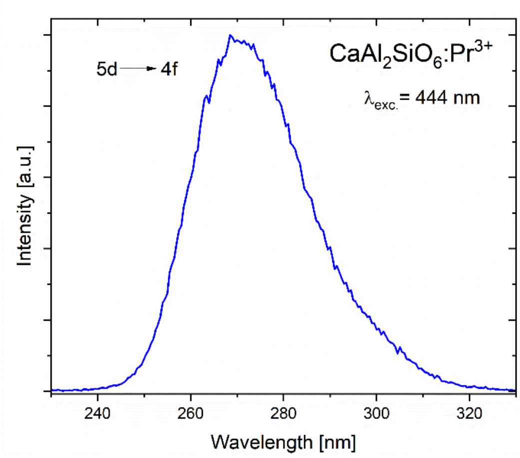


Fig. 1. The upconversion emission in the UVC range.

Acknowledgements: This work was supported by The National Science Centre (NCN) under the OPUS 21 project, grant no. UMO-2021/41/B/ST5/03792, which is gratefully acknowledged.

[1] K. Lemański, W. Walerczyk and P. J. Dereń (2016) J. Alloys Compd., 672, 595–599.
[2] K. Lemański (2023) Solid State Sci., 144, 107300.
[3] K. Lemański (2024) Bull. Mater. Sci., Springer Nature, 47, 70.

[#] corresponding author: K.Lemanski@intibs.pl

Concentration-Dependent Emission Spectra in Cr^{3+}:GGG Transparent Nanoceramics

Mykhailo Chaika[#], Paweł Głuchowski

Institute of Low temperature and Structure Research, Polish Academy of Sciences, Okólna 2,
50 – 422 Wroclaw, Poland

In recent years Cr-doped garnets attracted a lot of attention due to their unique properties. Interpretation of spectroscopic properties of Cr^{3+} ions in garnets is difficult due to the variation of the crystal field strength in a large range resulting in the presence of Cr^{3+} ions in octahedral sites with different local crystal field strengths. This is relevant also for nanostructured materials such as Cr^{3+}-doped nanopowders. Despite the large number of works, a lot of questions remain concerning the luminescence properties of Cr^{3+} ions in nanomaterials.

In the present work we report the studies of optical properties of Cr^{3+}:GGG nanoceramics synthesized by high isostatic pressure (HIP) method at relatively low temperature. Cr:GGG nanoceramics doped with 0.1 at.%, 0.2 at.%, and 0.3 at.% of chromium ions were obtained.

Synthesized nanoceramics consist of crystallites with the average sizes of 17 nm and the average lattice parameters ~12.40 Å. High temperature emission spectra show the presence of at least four different CrO_6 optical active centers in Cr:GGG nanoceramics. The presence of satellites of R-lines confirms uniform distribution of local crystal fields around different chromium ions. The change in the concentration of Cr^{3+} ions do not influence the room temperature optical properties of Cr:GGG nanoceramics. Excitation and emission spectra, and lifetimes were the same for the investigated samples. No difference in the calculated Racah parameters was detected for different Cr^{3+} concentrations.

The low temperature emission spectra depend on the chromium content and the increase in Cr^{3+} concentration caused an increase in the ratio of broadband $^4T_{2g}(^4F)$ emission intensity to overall Cr^{3+} emission. At the same time no difference was detected in the peak position and width of $^4T_{2g}(^4F)\rightarrow{}^4A_{2g}(^4F)$ broadband emission. The difference in the low temperature emission spectra was explained by the energy transfer between chromium ions in the sites with different local crystal field strength. Cr^{3+} ions in the low crystal field site have higher probability of emitting photons rather than transferring the excitation energy to the nearby Cr^{3+} ions. The increase in concentration of Cr^{3+} ions caused an increase in the energy transfer between Cr^{3+} ions thus increasing the ratio of emission intensity of Cr^{3+} ions in low crystal field to the total luminescence.

[#] corresponding author: m.chaika@intibs.pl

O22 N. Rebrova

Upconversion properties of Pr^{3+} doped $A_3Y(PO_4)_3$ (A=Sr, Ba) phosphors

Nadiia Rebrova#, Radosław Lisiecki, Patrycja Zdeb, Przemysław Jacek Dereń

Institute of Low Temperature and Structure Research, Polish Academy of Science,
Okólna Street 2, 50-422 Wrocław, Poland

The significance of ultraviolet (UV) radiation in scientific research and various industries cannot be overstated. UV-C radiation (100–280 nm) is known for its remarkable effectiveness in destroying a variety of microorganisms [1]. This form of radiation is invaluable for applications such as water treatment, air purification, and surface disinfection in various settings, including healthcare facilities, laboratories, and food processing plants. Over the past decades, researchers have studied a number of new phosphors capable of efficiently converting visible light into UV-C radiation. Using Pr^{3+} as an activator is the most efficient option to generate UVC radiation through excitation with visible light using two-photon processes involving emission from the 4f5d band [2]. Despite the high phonon energy, phosphates hold promise for use as UV phosphors due to their small Stokes shift. In addition, they offer photochemical, chemical and, mechanical stability, radiation resistance, as well as a simple preparation process.

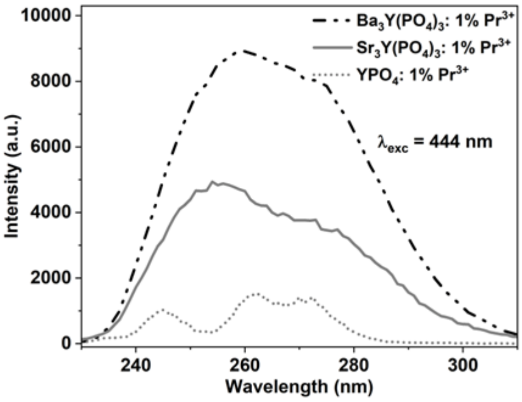


Fig. 1 Upconversion luminescence spectra of $Ba_3Y(PO_4)_3:Pr^{3+}$, $Sr_3Y(PO_4)_3:Pr^{3+}$ and $YPO_4:Pr^{3+}$ crystallites under 444 nm excitation.

In this work, $A_3Y(PO_4)_3:Pr^{3+}$ (A=Ba, Sr) crystallites were synthesized using a solid-state reaction method, and their photoluminescent properties were investigated in detail. Particular emphasis was paid to the study of upconversion in the ultraviolet region using a 444 nm laser as an excitation source. The potential applications of $A_3Y(PO_4)_3:Pr^{3+}$ crystallites as UVC phosphors will be discussed.

Acknowledgments: This work was supported by The National Science Centre (NCN) under the OPUS 21 project, grant no. UMO-2021/41/B/ST5/03792, which is gratefully acknowledged.

[1] Minamikawa T. at all (2021) Sci. Rep., 11, 5070.
[2] Auzel F. (2004) Chem. Rev., 104, 139–173.

---

corresponding author: n.rebrova@intibs.pl

Unlocking the Potential of Pr^{3+}-Doped Borates in the field of Visible to UVC upconversion

Patrycja Zdeb#, Nadiia Rebrova, and Przemysław J. Dereń

Institute of Low Temperature and Structure Research Polish Academy of Science,
Okólna Street 2, 50-422 Wrocław, Poland

The luminophores emitting ultraviolet C (UVC) radiation are intensively studied as a replacement for mercury lamps in germicidal applications or as nanoscintilators in alternative X-ray therapy[1]. Praseodymium (Pr)-doped inorganic matrices stand out as promising candidates for this purpose, thanks to their broad and intense emission bands in the 220–280 nm range corresponding to 4f5d → 4f transitions. However, the fundamental practical limitation of these materials is excitation in the ultraviolet (i.e., in the range 120–200 nm), which leads to their solarization. Since the excitation of a host in the visible never produces such defects, we are looking for new matrices that, doped with Pr^{3+}, can transform visible light into UVC radiation.

The crucial issue in achieving a UVC phosphor lies in the energy of Pr^{3+} 5d levels, a parameter heavily influenced by the composition and crystal structure of the host lattice. These factors impact the crystal field splitting and centroid shift of the 5d levels [2,3]. By carefully selecting the appropriate host for activator ions, it becomes possible to design phosphor with the desired optical properties.

In this study, we introduce a newly obtained phosphor based on a Pr^{3+}-doped borates host. We present its synthesis and optical characterization, with a particular focus on its performance in the UV range. Notably, we observe intense visible-to-UVC upconversion luminescence under 444 nm laser excitation, which we compare to other well-known Vis-to-UVC upconverters. Interestingly, the relative intensity in the 220 – 280 nm range was higher for our material compared to the Y_2SiO_5 host. These findings highlight the potential of Pr^{3+}-doped borates for germicidal applications, particularly in the creation of self-cleaning surfaces.

This work was supported by The National Science Centre (NCN) under the OPUS 21 project, grant no. UMO-2021/41/B/ST5/03792, which is gratefully acknowledged.

[1] Espinoza S.; Müller M.; Jenneboer H.; Peulen L.; Bradley T.; Purschke M.; Haase M.; Rahmanzadeh R.; Jüstel T. (2019) Part. Part. Syst. Charact., 36, 1900280.
[2] Dorenbos P. (2000) J. Lumin, 91, 155-176.
[3] Dorenbos P. (2000) Phys. Rev. B, 62, 15640-15649.

---

corresponding author: p.zdeb@intibs.pl

Investigation of the local environment of luminescent chromium ions in the near-infrared (NIR-I/II) range by electron paramagnetic resonance (EPR) technique

Grzegorz Leniec[1#], Ewa Mijowska[1], Yu-Hsuan Hsiao[2], Ming-Hsuan Huang[2],
Kuan-Chun Chen[2], Chun-Ling Chien[3], Wen-Tse Huang[2], Natalia Majewska[4],
Mikołaj Kamiński[4], Sebastian Mahlik[4], Sheng-Lung Huang[3], Ru-Shi Liu[2]

[1]Department of Nanomaterials Physicochemistry, Faculty of Chemical Technology and Engineering,
West Pomeranian University of Technology in Szczecin, 70-311, Szczecin, Poland; Center for Advanced
Materials and Manufacturing Process Engineering, West Pomeranian University of Technology in Szczecin,
70-310, Szczecin, Poland
[2]Department of Chemistry, National Taiwan University, Taipei 106, Taiwan
[3]Graduate Institute of Photonics and Optoelectronics, National Taiwan University, Taipei 106, Taiwan
[4]Institute of Experimental Physics, Faculty of Mathematics, Physics, and Informatics,
University of Gdansk, Wita Stwosza 57, 80-308 Gdańsk, Poland

The most common and economically viable luminescent ion in the near infrared (NIR) range are chromium ions. The position and shape of the luminescence in the NIR range depend on the local environment of the chromium ions. Single Cr^{3+} ions in an octahedral environment radiate in the 650 - 800 nm range, Cr^{3+}-Cr^{3+} ion pairs in the 750 - 1100 nm range, and single Cr^{4+} ions in a tetrahedral environment in the 1100 - 1600 nm range. Luminescence in the latter range can also be achieved by inter-valence charge transfer between Cr^{3+}-Cr^{2+}/Cr^{4+} pair interactions in an octahedral environment. The exact position of the luminescence maximum and the shape of the luminescence spectrum depend on the crystal field and the distortion of the nearest environment of the luminescent ions. X-ray diffraction (XRD) studies make it possible to determine the structure of the compound matrix, without information on dopants, especially when we have small amounts of doped luminescent ions. Locations of chromium ions are determined based on the ionic radius and valence state of the substituted ions. However, this is an assumption and not scientific information. Scientific information should be confirmed experimentally. The technique that is able to determine the closest environment of luminescence ions (which are usually also paramagnetic ones) is the EPR technique. Even small amounts of doping of luminescent ions make it possible to determine the nearest environment of luminescent ions. In addition, it identifies the symmetry and distortion of this environment. This is the only technique that allows to study the local environment of even a small amount of paramagnetic luminescent ions.

In this presentation, I will focus on the analysis of the near environment of chromium ions in $Y_3Al_5O_{12}$ (YAG) phosphors doped with Cr^{3+} ions and co-doped with Ca^{2+} and Mg^{2+} ions, and the analysis of the local environment of chromium ions for $LiGa_5O_8$ (LGO) phosphors doped with Cr^{3+} ions. All compounds were prepared by the team of Prof. Ru-Shi Liu (NTU) and luminescence studies were performed by the team of Prof. Sebastian Mahlik (UG). EPR studies were performed at the Nanomaterials Physicochemistry Department at the West Pomeranian University of Technology in Szczecin.

[#] corresponding author: gleniec@zut.edu.pl

ELI ERIC: new capabilities for applications in molecular, bio-medical and material science

Mateusz Rebarz#, Shirly Espinoza, Jakob Andreasson

ELI Beamlines Facility, Extreme Light Infrastructure ERIC, 252 41 Dolni Brezany, Czech Republic

Extreme Light Infrastructure (ELI) is a European Project forming a pan-European Laser facility to provide the most intense femtosecond lasers in the world for fundamental and applied research [1]. ELI European Research Infrastructure Consortium (ELI ERIC) was established on 30 April 2021 to jointly manage operations of three facilities: ELI Beamlines in the Czech Republic, ELI-ALPS in Hungary and ELI-NP in Romania. ELI ERIC founding members are the Czech Republic (Host), Hungary (Co-host), Italy, and Lithuania, with founding observers Germany, Bulgaria and Romania.

The scientific activities of all ELI facilities are based on the utilization of ultrashort pulse lasers with a unique combination of pulse profile, repetition rate, and intensity.

One of the important missions of ELI is to develop a new generation of laser-driven sources for ultrashort pulses covering the ultrabroad electromagnetic radiation range (from THz to γ-ray) based on plasma effects in gases, solids as well as relativistic electron acceleration. All sources have the potential to be used in combination with beams split off from their corresponding drive lasers for pump-probe experiments. In contrast to the situation at accelerator base light sources, like synchrotrons and FELs, the fact that the pump pulse can be split off from the same laser pulse that generates the probe pulse provides an intrinsic synchronization and enables monitoring of ultrafast processes from fs to ms.

Here we introduce the experimental research capabilities offered by ELI ERIC to researchers working in molecular, bio-medical and material science. In particular, we highlight unique infrastructure available at ELI Beamlines facility which is focused on developing the complementary capabilities in optical, VUV and X-ray science in one location, with advanced sample preparation abilities [2]. The complex ultrafast phenomena in solids, liquids or gas phase can be studied utilizing pulsed lasers and laser-driven X-ray sources such as a High Harmonics Generation (HHG) source and a Plasma X-ray Source (PXS). The experimental stations include: Atomic, Molecular and Optical (AMO) Science and Coherent Diffractive Imaging (CDI); Soft X-ray Science; Hard X-ray science (diffraction, spectroscopy and pulse radiolysis); Ultrafast UV-VIS-IR spectroscopy (Ellipsometry, Transient Absorption and Stimulated Raman Spectroscopy).

ELI is thought of as a user facility open to all scientists. Details of how to submit a proposal to carry on experiments using ELI ERIC infrastructure will be also provided.

[1] https://eli-laser.eu/
[2] https://www.eli-beams.eu

---

corresponding author: Mateusz.Rebarz@eli-beams.eu

Interlaboratory comparison on absolute photoluminescence quantum yield measurements of scattering luminescent materials

S. Schweizer[1,2#], S. Fiedler[3], F. Frenzel[3], C. Würth[3], I. Tavernaro[3], M. Grüne[1], A. Engel[4], U. Resch-Genger[3]

[1] South Westphalia University of Applied Sciences, Lübecker Ring 2, 59494 Soest, Germany
[2] Fraunhofer Application Center for Inorganic Phosphors, Branch Lab of Fraunhofer Institute for Microstructure of Materials and Systems IMWS, Lübecker Ring 2, 59494 Soest, Germany
[3] Federal Institute for Materials Research and Testing (BAM), Richard-Willstätter-Straße 11, 12489 Berlin, Germany
[4] Schott AG, Hattenbergstraße 10, 55122 Mainz, Germany

An interlaboratory comparison (ILC) of three laboratories from academia and industry is performed to identify and quantify sources of uncertainty of absolute photoluminescence quantum yield (QY) measurements of scattering samples. While the QY of transparent luminescent materials are usually determined relative to a reference dye or standard of known QY [1], the determination of QY of scattering liquid and solid samples such as dispersions of luminescent nanoparticles, solid phosphors, and optoceramics requires, however, absolute measurements with an integrating sphere setup. Although the importance of reliable absolute QY measurements has been recognized, an ILC on suitable measurement geometries and achievable measurement uncertainties have not been reported yet. Such interlaboratory comparisons involving different setups and staff also provide the basis for identifying and quantifying typical instrument- and method-inherent sources of uncertainty.

Two types of commercial stand-alone integrating sphere setups with different illumination and detection geometries are used for measuring QY of transparent and scattering dye solutions as well as solid phosphors. As representative and industrially relevant samples, YAG:Ce optoceramics of varying surface roughness are chosen. These materials are applied, e.g., as converter materials for blue light emitting diodes. Special emphasis is put on the influence of the measurement geometry, the optical properties of the blank (used to determine the number of photons of the incident excitation light absorbed by the sample), and the sample-specific surface roughness. Matching QY values are obtained for transparent dye solutions and scattering dispersions, here utilizing a blank with scattering properties closely matching those of the sample. However, QY measurements of optoceramic samples revealed substantial differences for different blanks with measurement uncertainties of exceeding 20 %. Based on these results, a non-absorbing blank material with a high reflectivity > 95 % such as a 2-mm thick PTFE target placed on the sample holder is recommended. The blank reveals a near-Lambertian light scattering behaviour, yielding a homogeneous light distribution within the integrating sphere.

[1] Pauli, J.; Güttler, A.; Schneider, T.; Würth, C.; Resch-Genger, U. (2023) Analytical Chemistry, 95, 5671-5677.

corresponding author: schweizer.stefan@fh-swf.de

Excitation and emission bands of oxygen vacancies in rare earth bixbyite oxides: experiment and calculations

Andrii Shyichuk[#], Joanna Trojan-Piegza, Eugeniusz Zych

Faculty of Chemistry, University of Wrocław, 14 F. Joliot-Curie, 50-383 Wrocław, Poland

Cubic oxides of Sc, Y and Lu share the same crystal structure of bixbyite. Y_2O_3 and Lu_2O_3 are well known matrices for lanthanide-based phosphors. Lu_2O_3 is also known for a series of thermoluminescence phosphors of different kinds [1]. Lu_2O_3 is prone to oxygen vacancy formation [2,3]. From both chemical and structural similarities, the other two oxides are also expected to form electron-trapping oxygen vacancies.

From computational standpoint, the three oxides indeed exhibit similar electronic properties. Using periodic density functional theory calculations (DFT) for ground state singlets and triplets, and using the respective optimized geometries in multiconfigurational post-Hartree-Fock calculations, it was possible to obtain configuration coordinate diagrams for the excited levels of trapped electron densities at oxygen vacancy sites, in silico and ab initio.

As a parallel experiment, the three oxides where prepared in a form of pressed ceramic pellets and calcined at high temperature in a reducing atmosphere. Such is the typical procedure for a thermoluminescence (energy storage) phosphors preparation [1], although no dopants were now added: the oxides were processed as purchased. Photoluminescence spectroscopy was then applied, with double-grating monochromators at both excitation and emission channels ensuring the lack of stray light artifacts. Albeit not intense, distinct broad excitation and emission bands where observed at energies very close to those obtained in calculations. Discussion of these data will be presented.

[1] Kulesza D., Bolek P., Bos A. J. J. and Zych E. (2016) Coord. Chem. Rev. 325, 29–40, 10.1016/j.ccr.2016.05.006.
[2] Guzik M., Pejchal J., Yoshikawa A., Ito A., Goto T., Siczek M., Lis T. and Boulon G. (2014) Cryst. Growth Des. 14 (7), 3327–3334, 10.1021/cg500225v.
[3] Petermann K., Fornasiero L., Mix E. and Peters V. (2002) Opt. Mater. (Amst). 19 (1), 67–71, 10.1016/S0925-3467(01)00202-6.

corresponding author: andrii.shyichuk@uwr.edu.pl

Optical and EPR spectroscopy of the $Li_2B_4O_7$:Cu,Eu and $Li_2B_4O_7$:Mn,Sm glasses (the review)

B. V. Padlyak[1,2#], I. I. Kindrat[1], A. Drzewiecki[1], V. T. Adamiv[2], I. M. Teslyuk[2]

[1]University of Zielona Góra, Institute of Physics, 4a Szafrana Str., 65-516 Zielona Góra, Poland
[2]Ivan Franko National University of Lviv, Vlokh Institute of Physical Optics, 23 Dragomanov Str., 79005 Lviv, Ukraine

The $Li_2B_4O_7$:Cu,Eu and $Li_2B_4O_7$:Mn,Sm glasses containing 1.0 mol.% CuO and Eu_2O_3 as well as 1.0 mol.% MnO_2 and Sm_2O_3, respectively were obtained and studied in details by XRD, EPR, optical absorption, and photoluminescence methods [1,2]. The studied glasses of high optical quality were obtained by high temperature melting technique. Parameters of the local structure (interatomic distances and coordination numbers) of the studied glasses were derived from XRD data analysis. The EPR and optical spectroscopy show that the Cu impurity is incorporated into the $Li_2B_4O_7$ glass network as Cu^{2+} ($3d^9$) and Cu^+ ($3d^{10}$) ions [1]. The Cu^{2+} ions in $Li_2B_4O_7$:Cu,Eu glass show characteristic EPR and optical absorption spectra. Spin Hamiltonian parameters of the Cu^{2+} EPR spectrum were determined . Optical band gap and Urbach energy of the $Li_2B_4O_7$:Cu,Eu glasses were evaluated. Photoluminescence spectra of the $Li_2B_4O_7$:Cu,Eu glass reveal broad blue emission band of the Cu^+ ($3d^94s^1 \rightarrow 3d^{10}$ transition) and narrow emission bands of the Eu^{3+} ($4f^6$) ions ($^5D_0 \rightarrow {}^7F_J$ (J = 0 – 4)) transitions with characteristic decay kinetics. Energy transfer processes $Eu^{3+} \rightarrow Cu^+$, Cu^{2+} and $Cu^+ \rightarrow Eu^{3+}$ in $Li_2B_4O_7$:Cu,Eu glass are considered.

The EPR and optical spectroscopy show the presence of Mn^{2+}($3d^5$) and Mn^{3+}($3d^4$) impurity ions in the $Li_2B_4O_7$:Mn,Sm glass [2]. By EPR spectroscopy in the studied glass were identified three types of Mn^{2+} centres: single Mn^{2+} (1) centres in the strongly distorted sites; single Mn^{2+} (2) centres in the sites with almost cubic symmetry; Mn^{2+} pairs and small clusters coupled by magnetic dipolar and exchange interactions. The Mn^{2+} EPR spectra parameters in the $Li_2B_4O_7$:Mn,Sm glass have been determined at $T = 295$ K. Optical absorption spectrum of the $Li_2B_4O_7$:Mn,Sm glass contains a very broad intense band peaked at 467 nm belonging to the $^5E_g(D) \rightarrow {}^5T_{2g}(D)$ transition of Mn^{3+} ions and several weak narrow lines corresponding to the $^6H_{5/2} \rightarrow {}^6P_{3/2}$, $^6H_{5/2} \rightarrow {}^6F_{9/2}$, $^6F_{7/2}$, $^6F_{5/2}$ transitions of Sm^{3+} ($4f^5$, $^6H_{5/2}$) ions. Emission spectrum of the $Li_2B_4O_7$:Mn,Sm glass exhibits a broad band corresponding to the $^4T_{1g}(G) \rightarrow {}^6A_{1g}(S)$ transition of Mn^{2+} ions and three characteristic bands in the yellow-orange-red range belonging to the $^4G_{5/2} \rightarrow {}^6H_{5/2}$, $^6H_{7/2}$, $^6H_{9/2}$ transitions of Sm^{3+} ions. Photoluminescence excitation and emission spectra and decay kinetics of Mn^{2+} and Sm^{3+} ions in the $Li_2B_4O_7$:Mn,Sm glass are interpreted. Energy transfer processes $Sm^{3+} \rightarrow Mn^{2+}$, Mn^{3+} and $Mn^{2+} \rightarrow Mn^{3+}$ in the studied glass are proposed.

Acknowledgments: This work was supported by the Ministry of Education and Science of Ukraine (scientific research project No. 0122U001833).

[1] Padlyak B.V., Kindrat I.I., Adamiv V.T., et al. (2023) MRB, 167, 112432.
[2] Padlyak B.V., Kindrat I.I., Adamiv V.T., et al. (2024) MRB, 175, 112788.

---

corresponding author: B.Padlyak@if.u.zgora.pl.

Strategies for increasing Cr^{4+} content in YAG:Cr matrix for laser applications

Romain Thévenet, Audrey Potdevin#, François Réveret, Geneviève Chadeyron

1 Université Clermont Auvergne, Clermont Auvergne INP, CNRS, Institut de Chimie de Clermont-Ferrand, F-63000 Clermont–Ferrand, France.

Chromium-doped crystals are widely used in various domains including optical devices, saturable absorbers for pulsed lasers or thermometry devices[1][2]. Yttrium Aluminum Garnet (YAG) is an excellent matrix to host chromium ions due to its mechanical and optical properties. In this matrix, chromium ions can be found in two crystallographic sites (octahedral and tetrahedral) and under two oxidation states (Cr^{3+} and Cr^{4+}). Depending on the chromium ions oxidation state and on the place they occupy, YAG:Cr compounds are more suitable as phosphor or as saturable absorber. This study presents the synthesis of YAG:Cr powders using the Pechini process. The oxidation of chromium ions in the matrix was achieved by co-doping with a charge-compensating ion and/or the use of an oxidizing agent during synthesis. The structural, morphological and optical properties of the powders were studied. UV-Visible spectroscopy shows the appearance of absorption bands associated with Cr^{4+} ions after optimized synthesis conditions (Figure 1a). Emission spectra confirm the presence of these ions in YAG:Cr produced under oxidizing conditions (Figure 1b). The influence of the synthesis parameters on the optical properties will be discussed

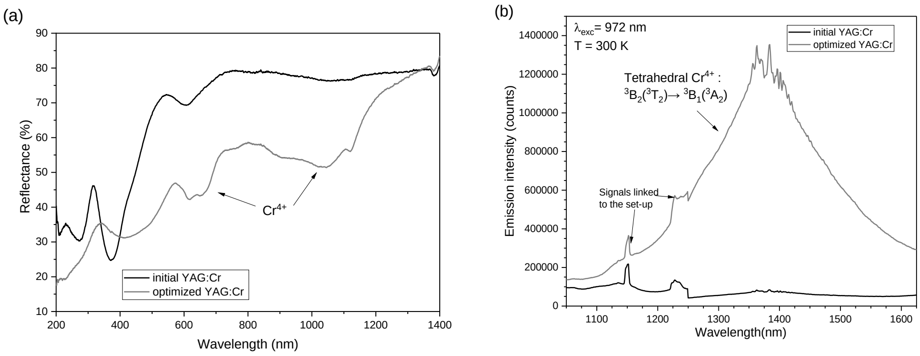


Figure 1: (a) UV-Visible spectra of YAG:Cr powders recorded in diffuse reflection and (b) emission spectra of the same powders excited by a continuous laser source at 972 nm.

Acknowledgment: The authors acknowledge the French Agence Nationale de la Recherche for its financial support in the frame of the ANR CRUMBLE project (ANR-21-CE24-0034-02).

[1] Boulesteix, R; Perrière, C; Maître, A; Chrétien, L ; Brenier, A ; Guyot, Y (2019) Opt. Mater., 96, 109324.
[2] Chen, X; Liu, S; Huang, K; Nie, J; Kang, R; Tian, X; Zhang, S; Li, Y; Qiu, J (2020) Chem. Eng. J., 396.

corresponding author: audrey.potdevin@sigma-clermont.fr

All-Photonic Tunable Molecular Transistor Based on Trivalent Lanthanide Ions Luminescence

Miguel A. Hernández-Rodríguez[1#], Albano N. Carneiro Neto[2], Carlos D.S. Brites[2]

[1]Departamento de Física, Universidad de La Laguna, Apdo. Correos 456,
E-38200 San Cristóbal de La Laguna, Santa Cruz de Tenerife, Spain
[2]Phantom-g, CICECO – Aveiro Institute of Materials, Department of Physics, University of Aveiro,
3810-193 Aveiro, Portugal

Diodes and transistors are without any doubt one of the most impactful innovations that guided the technological advances of computing and every smart device at the present day. However, the rapid technology growth towards the fourth industrial revolution (Industry 4.0) is continuously demanding further computing power [1,2]. Despite the incredible advances that lithography techniques are experiencing during the last decades, they are also about to reach their physical limits, implying that the development of alternative approaches is crucial in order to keep the technological demands,[3–6] as the semiconductor industry has worldwide stated [7]. Here, we describe the proof-of-concept of a tunable all-photonic molecular device based on a Tb^{3+}/Eu^{3+} di-nuclear complex embedded into a di-ureasil hybrid host (dU6EuTb) which responds toward light resembles the conventional electronic transistor. The system permits reversibility, contrasting with the conventional electronic components for which a new function implies a new circuitry. This is to the best of our knowledge the first example of an all-photonic device that mirrors the behaviour of a conventional transistor.

Acknowledgements: MAHR acknowledges the "Beatriz Galindo" program (BG22/00061). MAHR also acknowledges Universidad de La Laguna (ULL) and Consejería de Economía, Conocimiento y Empleo del Gobierno de Canarias for their assistance.

[1] L. Chang, S. Liu, J. E. Bowers, Nature Photonics 2022 16:2 2022, 16, 95.
[2] N. Margalit, C. Xiang, S. M. Bowers, A. Bjorlin, R. Blum, J. E. Bowers, Appl Phys Lett 2021, 118, 220501.
[3] P. Gould, Materials Today 2005, 8, 56.
[4] A. I. Kingon, J. P. Maria, S. K. Streiffer, Nature 2000 406:6799 2000, 406, 1032.
[5] P. Ball, Nature 2000, 406, 118.
[6] A. P. De Silva, S. Uchiyama, Nature Nanotechnology 2007 2:7 2007, 2, 399.
[7] "The chips are down for Moore's law : Nature News & Comment," can be found under https://www.nature.com/news/the-chips-are-down-for-moore-s-law-1.19338, n.d.

corresponding author: mhernanr@ull.edu.es

Cyanobacteria water contaminations. A fluorescence-based method to detect the presence of toxic microcystin molecules in water

Antonio Varriale[1#], Alessandro Capo[1], Angela Pennacchio[2], Concetta Montagnese[2], Antonis Hadjiantonis[3], Panayiota Demosthenous[3], Alessandro Giusti [3], Maria Staiano[2], Sabato D'Auria[4]

[1]Institute of Food Sciences, URT-CNR, 80126 Naples, Italy.
[2]Institute of Food Sciences, CNR, 83100 Avellino, Italy.
[3]CY.R.I.C Cyprus Research and Innovation Center Ltd, Nicosia, Cyprus.
[4]Department of Biology, Agriculture and Food Sciences, CNR, Piazzale Aldo Moro, 7, 00185 Rome, Italy.

For many years water microbiology contaminations have been ruled by a traditional approach due to a limited understanding of the native water bacterial composition and its function. In different areas of the world, water is obtained directly from underground through a borehole. Then it is collected by users and used without prior treatments. This is mainly due to the lack of sensitive, fast methods to detect both the indigenous microbial cells and the presence of relevant pathogens [1].

Cyanobacteria are photosynthetic prokaryotic microorganisms that live in diverse range of environments, from freshwater to marine ecosystems [2]. Cyanobacteria belonging to the genera Microcystis, Anabaena, Planktothrix, and Nostoc produce and release in water harmful toxin molecules, named microcystins. The ingestion or inhalation of microcystins can have severe effects on health [1].

Here, we present a novel analytical method to detect the presence of toxic microcystins in water. The method lays on the use of fluorescence labelled monoclonal antibody to design a competitive resonance energy transfer-based assay for a sensitive and realist detection of the presence of microcystins in water. The assay showed a sensitivity of 0,245 μg/L, that represents a value lower than the limit value set by the World Health Organization.

[1] Mutoti M.I. and Edokpayi J.N. and Mutileni N. and Durowoju O.S. and Munyai F.L. Toxicon. (2023), 226, 107077-107186.
[2] Mehdizadeh Allaf M. and Peerhossaini H. Microorganisms (2022), 24, 10(4), 696-719.

corresponding author: antonio.varriale@cnr.it

Optical properties of Bi_3TeBO_9 crystalline materials doped with rare earth ions

Taras Zhezhera[1#], Pawel Gluchowski[2], Andrzej Miklaszewski[1], Maciej Chrunik[3], Andrzej Majchrowski[3], Dobroslawa Kasprowicz[1]

[1]Faculty of Materials Engineering and Technical Physics, Poznan University of Technology, Piotrowo 3, 60-695 Poznan, Poland
[2]Institute of Low Temperature and Structure Research of Polish Academy of Sciences, Okólna 2, 50-422 Wroclaw, Poland
[3]Institute of Applied Physics, Military University of Technology, Kaliskiego 2, 00-908 Warszawa, Poland

Bi_3TeBO_9 microcrystalline materials doped with selected rare earth ions exhibit a dual nature: they are excellent non-linear optical materials as well efficient phosphors. Pure Bi_3TeBO_9 crystals show high efficiency of second and third harmonic generation; the highest among borate materials (second harmonic generation signal was greater by about 20 times compared to the intensity of that generated in KDP crystal)[1]. Moreover, incorporation of trivalent rare earth ions into Bi_3TeBO_9 matrix induces an effective luminescent response [2-4].

Crystals doped with rare earth ions are commonly known as laser active media [2-4]. Moreover, incorporation of rare earth ions enriches the materials and allows a wide range of applications in optoelectronic systems, phosphors or solar cells [2-4]. The unique properties of rare earth ions are connected with the appearance of luminescence bands that correspond to the *f-f* transitions [2-4].

In this research, we present the results of investigation of luminescent and vibrational properties of Bi_3TeBO_9 materials doped with selected rare earth ions, using Raman and optical spectroscopy methods. The results show that Bi_3TeBO_9 materials doped with selected rare earth ions offer a significant luminescence potential and can be proposed as efficient spectral converters in the new type solar cells enhancing the efficiency of the photovoltaic effect.

Acknowledgements: This work was supported by the Research Project of the Polish Ministry of Higher Education: 0511/SBAD/2451.

[1] M. Xia, X. Jiang, Z. Lin, R. Li, (2016), J. Am. Chem. Soc. 138, 14190.
[2] T. Zhezhera, P. Gluchowski, M. Nowicki, M. Chrunik, A. Majchrowski, K.M. Kosyl, D. Kasprowicz, (2022), J. Mater. Sci. 57, 185 – 203.
[3] T. Zhezhera, P. Gluchowski, M. Nowicki, M. Chrunik, A. Majchrowski, D. Kasprowicz, (2023), J. Lumin. 258, 119774.
[4] T. Zhezhera, P. Gluchowski, M. Nowicki, M. Chrunik, A. Miklaszewski, D. Kasprowicz, (2024), J. Lumin. 268, 120401.

corresponding author: taras.zhezhera@put.poznan.pl

Strategy to probe multimodal light emissions from Eu^{3+}/Yb^{3+} activated garnet nanophosphor for LED device and solar cell applications

Neeraj Kumar Mishra#, Kaushal Kumar

Optical Materials & Bio-imaging Research Laboratory, Department of Physics,
Indian Institute of Technology (Indian School of Mines), Dhanabad-826004, India.

This study investigates multimodal light emission from low temperature solution combustion method synthesized Eu^{3+}/Yb^{3+} activated $Y_3Ga_5O_{12}$ (YGG) nanophosphor. The prepared sample possesses cubic phase having Ia-3d space group and it has been confirmed with the X-ray diffraction and Rietveld refinement analysis. The synthesized sample shows orange-red emission bands owing to the f-f transitions of Eu^{3+} under UV (393 nm) and NIR (980 nm) excitations via downshifting (DS) and upconversion (UC) processes, respectively. On UV (393 nm) excitation of the sample, Eu^{3+} ions absorb this energy and then transfer it to neighboring pair of Yb^{3+} ions giving NIR emission (900 nm-1100 nm) corresponding to $^2F_{5/2}\rightarrow{}^2F_{7/2}$ transition of Yb^{3+}. The energy transfer from single Eu^{3+} ion to a pair of Yb^{3+} ions is possible through the quantum cutting (QC) process and this energy transfer efficiency is found to increase with increasing the concentration of the Yb^{3+}. The quantitative estimation of energy transfer and internal quantum cutting efficiency is measured using decay kinetic measurement. Activation energy of 0.25 eV indicates good thermal stability of the sample. Further, samples are realized for practical application in lighting devices by combining them with the near-ultraviolet (NUV; InGaN) chip. Fabricated LED device shows stability with the driving current values. Studies indicate that present nanophosphor could be useful for display devices and in enhancing the spectral conversion efficiency of the solar cells.

[1] Cheng, X., Zhou, J., Yue, J., Wei, Y., Gao, C., Xie, X. and Huang, L., 2022.*Chemical Reviews*, *122*(21), pp.15998-16050.
[2] Back, M., Xu, J., Ueda, J., Benedetti, A. and Tanabe, S., 2022.*Chemistry of Materials*, *34*(18), pp.8198-8206.
[3] Mishra, N.K., Sarkar, M.I. and Kumar, K., 2023. *Dalton Transactions*, *52*(33), pp.11658-11670.

corresponding author: mneeraj1995@gmail.com

Physical and electrochemical characterization of laser processed anodic semitransparent titania oxide nanotubes formed out of Ti-Au co-sputtered alloy

Saiful Islam Khan, Katarzyna Siuzdak, Katarzyna Grochowska

Centre of Plasma and Laser Engineering, Institute of Fluid-Flow Machinery,
Polish Academy of Sciences, Fiszera 14 st., 80-231 Gdańsk, Poland

Aligned semitransparent oxide nanotube material has been synthesized by anodizing titanium−gold alloy co-sputtered atop indium−tin oxide coated glass substrate. After calcination, the samples were subjected to laser processing (355 nm wavelength, 2 Hz repletion rate, and 6 ns pulse duration) with varying fluence ranging from 20 to 100 mJ/cm^2. Well-defined continuous tubular architecture was observed under the SEM for the untreated sample. However, the laser processed samples show the formation of gold nanoparticles and partial melting as well as agglomeration of the top surface; i.e. for the sample treated with 20 mJ/cm^2 laser fluence, the gold nanoparticles were formed at the crown position of the nanotubes. The energy band-gap reduction was observed in comparison to bare titania reference material and the presence of gold nanoparticles resulted in appearance of characteristic fringes on the UV-VIS spectra that can be attributed to surface plasmon resonance effect, photonic behaviour or constructive and destructive interference of reflected light [1]. Moreover, the electrochemical measurements carried out in appropriate electrolyte with and without the redox species showed pseudo-metallic behaviour exhibiting very low impedance for the prepared oxide materials that can be utilized in sensing applications.

Acknowledgements: This work received financial support from the Polish National Science Centre: grant no 2021/41/B/ST8/01849.

[1] K. Grochowska, N. Nedyalkov, J. Karczewski, Ł. Haryński, G. Śliwiński, K. Siuzdak, Sci. Rep. 10 (2020) 20506

corresponding author: skhan@imp.gda.pl

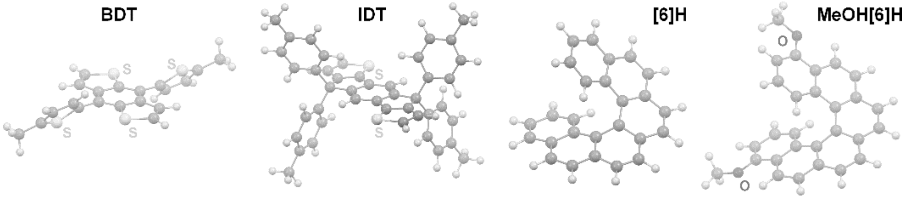
Theoretical spectroscopic studies on [6]helicene-based chiral conjugated oligomers

Joachim Grzybowski#, Dominika Tabor, Monika Srebro-Hooper

Department of Theoretical Chemistry, Faculty of Chemistry, Jagiellonian University,
Gronostajowa 2, 30-387 Kraków, Poland

Conjugated polymers are the object of increasing scientific interest as many of them find applications in areas such as chemical sensing, bio-imaging or optoelectronics including organic light-emitting diodes and photodetectors. One of the most appealing features of chemical systems envisioned as materials for a development of efficient optoelectronic devices is currently the ability to emit circularly polarized light, which in the case of conjugated polymers can be achieved by incorporating a chiral component into their structure. Recently, chiral conjugated oligomers based on benzodithiophene (BDT) and indacenodithiophene (IDT) with (dimethoxy) carbo[6] helicene (see figure below) as a chiral inducer have been obtained and experimentally studied as circularly polarized luminescence (CPL) emitters [1].

The goal of the presented theoretical studies was to create (employing density functional theory and its time-dependent variant calculations) a structural and spectroscopic characterization of the newly synthesized helicene-based conjugated polymers, using model systems with 1:1 and 2:2 BDT/IDT-to-helicene ratio, and thus shed a light on their experimentally observed photophysical and chiroptical properties and identify significant structure-to-property correlations. The research involved a conformational analysis of the proposed motifs, their UV-vis and electronic circular dichroism simulations, and modelling of emission features via S1 excited-state geometry optimizations, showing important role of both building blocks and geometric (rotameric) structure of the model on computed properties.



We gratefully acknowledge Polish high-performance computing infrastructure PLGrid (HPC Centers: ACK Cyfronet AGH, WCSS) for providing computer facilities and support within computational grant no. PLG/2023/016362.

1] Gedeon C., Del Rio N., Furlan F., Taddeucci A., Vanthuyne N., Gregoriou V. G., Fuchter M. J., Siligardi G., Gasparini N., Crassous J. and Chochos C. L. (2024) Adv. Mater., 2314337.

corresponding author: joachim.grzybowski@student.uj.edu.pl; dominika.tabor@student.uj.edu.pl; monika.srebro@uj.edu.pl

O36 K. Orzechowska

Theoretical studies on fluorescence properties of 5-(4-nitrophenyl)-1,3,4-thiadiazol-2-amine

Katarzyna Orzechowska[1#], Arkadiusz Matwijczuk[2], Monika Srebro-Hooper[1]

[1]Department of Theoretical Chemistry, Faculty of Chemistry,
Jagiellonian University,Gronostajowa 2, 30-387 Kraków, Poland
[2]Department of Biophysics, Faculty of Environmental Biology, University of Life Sciences in Lublin,
Akademicka 13, 20-950 Lublin, Poland

1,3,4-thiadiazole derivatives have been shown to reveal a broad spectrum of biological activities such as antitumor, antibacterial and antifungal, along with numerous interesting spectroscopic, crystallographic and biophysical properties [1]. One of their commonly observed feature is a dual fluorescence emission, usually explained in literature by coexistence of multiple emissive states with different electronic and/or molecular structures associated with e.g. excited-state intramolecular proton transfer (ESIPT) or by aggregation effects related to the formation of excimer systems and aggregation-induced emission (AIE) or aggregation-induced emission enhancement (AIEE).

In this contribution, results of (time-dependent) density functional theory ((TD)DFT) calculations are presented aiming at providing a conclusive assignment of dual fluorescence signal that has been recently demonstrated experimentally for 5-(4-nitrophenyl)-1,3,4-thiadiazol-2-amine in foil, gel, and in isopropanol solution upon increasing sample concentration. The (TD)DFT studies included both monomeric and aggregated models built based on the motifs found in the X-ray crystal structure of the compound (Fig. 1), and their computed photophysical properties clearly confirm AIE-origin of the dual emission feature.

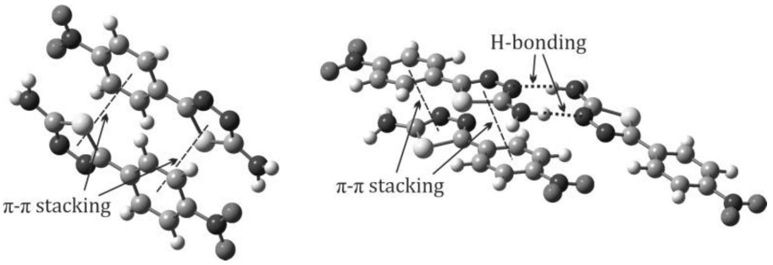


Fig. 1. Selected DFT-optimized dimer and trimer forms of 5-(4-nitrophenyl)-1,3,4-thiadiazol-2-amine.

We gratefully acknowledge Polish high-performance computing infrastructure PLGrid (HPC Centers: ACK Cyfronet AGH, WCSS) for providing computer facilities and support within computational grant no. PLG/2023/016770.

[1] Hu Y., Li C.-Y, Wang X.-M., Yang Y.-H. and Zhu H.-L. (2014) Chem. Rev., 114, 5572–5610.

corresponding author: katarzyna.anna.orzechowska@student.uj.edu.pl; monika.srebro@uj.edu.pl; arkadiusz.matwijczuk@up.lublin.pl

Phosphors for the improvement of silicon solar cell efficiency: general considerations and examples with new materials - $AgIn_5S_8$/ZnS core-shell nanocrystals and $Cs_2Ag_xNa_{1-x}Bi_yIn_{1-y}Cl_6$ powders

Mengqin Kong[1], Oleksandra Raievska[2], Oleksandr Stroyuk[2], Anastasia Barabash[1],
Christof Erban[3], Andres Osvet[1#], Miroslaw Batentschuk[1#], Christoph J. Brabec[1,2]

[1] Institute of Materials for Electronics and Energy Technology (i-MEET),
Department of Materials Science and Engineering, Friedrich-Alexander-Universität Erlangen-Nürnberg,
Martensstrasse 7, Erlangen 91058, Germany
[2] Forschungszentrum Jülich GmbH, Helmholtz Institute Erlangen-Nuremberg for Renewable Energies
(HI ERN), 91058 Erlangen, Germany
[3] Head of Research & Development, Sunovation Produktion GmbH, Glanzstoffstraße 21,
63820 Elsenfeld I Germany

The maximum efficiency of a single-junction solar cell is calculated from the principle of detailed balance, which reaches 33.7 % with a band gap of 1.4 eV (the Shockley-Queisser limit, s., for instance [1]). For multicrystalline Si with a band gap of 1.1 eV, the maximal value of the power conversion efficiency is estimated to be 29 % [2].

To overcome the efficiency limit, the spectral absorption range of the Si cells can be modified by luminescent materials. The detailed balance calculations done by T. Trupke et al. [3,4] show that the power conversion efficiency of Si solar cells can be improved by using down- and/or up-conversion phosphors, to up to 37 %. Previously, we have analyzed the recent progress in the development of phosphors to utilize the infrared region of solar radiation to improve the solar cell performance with the help of rare-earth (RE) ion-doped up-conversion materials [5]. New trends in RE-ion-doped phosphors are briefly discussed in this paper, among them trivalent RE-ion-doped up-conversion materials for organic solar cell applications.

In addition to the analysis of the given concepts and a review of the best achievements, new experimental results using the concept of UV-down-to-Visible light conversion for the PCE improvement of commercial Si solar cells and modules will be presented. These light-conversion layers are based on highly luminescent $AgIn_5S_8$/ZnS core-shell nanocrystals and double-perovskite $Cs_2Ag_xNa_{1-x}Bi_yIn_{1-y}Cl_6$ powders.

[1] S. Rühle. (2016), Solar Energy, 130, 139–147.
[2] C. Strümpel, M. McCann et al., (2007), Sol. En. Mater. & Solar Cells, 91, 238 – 249.
[3] T. Trupke, M. Green, et al. (2002) J. Appl. Phys. 92 (3) 1668 – 1677.
[4] T. Trupke, M. Green, et al. (2002), J. Appl. Phys. 92 (7) 4117 - 4125.
[5] H.-Q. Wang, M. Batentschuk, A. Osvet, L. Pinna, Ch. Brabec (2011), Adv. Mat. 23, 2675 – 2680.

corresponding authors: miroslaw.batentschuk@fau.de, andres.osvet@fau.de

Upconversion nano-particles as photo-acoustic contrast enhancer for OCT imaging

Kaushal Kumar#

Department of Physics, Indian Institute of Technology (ISM), Dhanbad-826004, India

Rare earth (RE) ions doped phosphors have potential applications in optical devices and hence research on RE doped phosphors has attracted much attention. Advent of nano-science has further pushed the research on RE luminescence and now it is prone that nanomaterials possess exotic properties. The rare earth doped nanophosphors have also shown interesting properties despite the atomic transitions of RE ions and thus opened possibilities of newer applications. In this talk chemical synthesis of nano-particles and emission properties of RE ions in regard to photoacoustic signal generation, security printing, temperature sensing, latent fingerprint detection etc. will be presented. In our work thermal decomposition route has resulted well dispersed bare and poly ethylene glycol (PEG) coated nanoparticles of $NaGdF_4$: Ho^{3+}/Yb^{3+} and $NaGdF_4$: Tm^{3+}/Yb^{3+} phosphors. These particles have produced intense green upconversion emission due to the $^5S_2 \rightarrow {}^5I_8$ transition on 980 nm laser excitation. The studies have shown that Yb^{3+}-Ho^{3+} combination also undergoes light-to-heat conversion which could be used as contrast enhancer in optical coherence tomography (OCT) imaging. Prepared samples will also be discussed for security ink and temperature sensing.

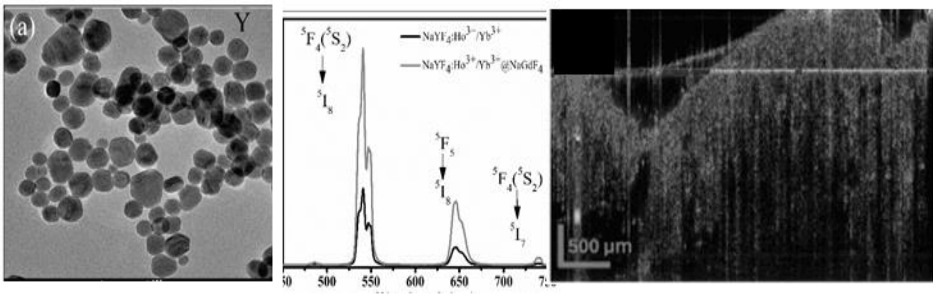


Figure: TEM image $NaGdF_4$: Ho^{3+} /Yb^{3+} colloidal particles (left); Emission spectra (middle); and OCT image of chicken tissue (Right). Green colour represents photo-thermal OCT signal.

corresponding author: kkumar@iitism.ac.in

A new look at the ligand-lanthanide energy transfer pathways

P. Gawryszewska[1], A. N. Carneiro Neto[2], E. Kasprzycka[1], A. Lipa[1], J. Nasalska[1],
V. A. Trush[3], L. Michnik[1], V. M. Amirkhanov[3], O. L. Malta[4], J. Legendziewicz[1]

[1]Faculty of Chemistry, University of Wroclaw, 14 F. Joliot-Curie Str., 50-383 Wroclaw, Poland
[2]Physics Department and CICECO-Aveiro Institute of Materials,
University of Aveiro, Campus Universitário de Santiago, 3810-193 Aveiro, Portugal
[3]Department of Chemistry, Kyiv National Taras Shevchenko University, Volodymyrska str. 64,
Kyiv 01601, Ukraine
[4]Departamento de Química Fundamental, Universidade Federal de Pernambuco, Cidade Universitária,
50740-560 Recife, Brazil

Single Lanthanide (Ln^{3+}) compounds are of great interest due to their special luminescence properties and their various applications for technological purposes. Ln^{3+} luminescence is associated with transitions within the *4f* subshell. Due to the small value of the molar absorption coefficient, Ln^{3+} emission requires sensitization. One way involves the so-called antenna effect, i.e. the use of organic ligands with strong absorption, which transfer excitation energy to the excited levels of Ln^{3+} via intramolecular non-radiative energy transfer (IET).We provide insights into the different pathways and mechanisms of IET for two series of Ln^{3+} coordination compounds with N-phosphorylated sulfonyl- and carboxamides, which were designed as UV to Vis converters. We will show that the pathways and mechanisms of IET are also affected by slight changes in the crystal structure of the chelates in the second coordination sphere, such as counter ions or solvent molecules. We will analyze the influence of the ligand-to-Ln charge transfer state (LMCT), which, by depopulating the ligand singlet state (S_1), dramatically reduces the sensitization efficiency of the Eu^{3+} emission while changing the dominant mechanism of IET. The key role of the $^7F_5$ state of Tb^{3+} in IET will be proved, as well as the dominance of IET through the S_1 state for Tb^{3+} coordination compounds with 2,2'- bipyridine and 1, 10-phenanthroline as the co-ligand. We will also demonstrate how proper ligand design, combined with stiffening of the crystal structure of the coordination compound by introducing alkali metal cations into the first coordination sphere, affects IET efficiency and the intensity of sensitized emission. The above examples provide new insights into the sensitization processes of Tb^{3+} and Eu^{3+} coordination compoundsstyle:

corresponding author: paula.gawryszewska-wilczynska@uwr.edu.pl; albanoneto@ua.pt; ewa.kasprzycka2@uwr.edu.pl; anata.lipa@uwr.edu.pl; justyna.nasalska@uwr.edu.pl; viktor_trush@yahoo.com; lukasz.michnik@chem.uni.wroc.pl; vmamirkhanov@gmail.com; oscar.malta@ufpe.br; janina.legendziewicz@uwr.edu.pl

POSTER PRESENTATIONS

Phase Transition Luminescence Thermometry Based on $LaAlO_3:Eu^{3+}$

Muhammad Tahir Abbas[#], Maja Szymczak, Łukasz Marciniak

Institute of Low Temperature and Structure Research, Polish Academy of Sciences,
Okolna 2, Wroclaw 50-422, Poland

Luminescence thermometry has garnered recently significant research interest due to its straightforward methodology, capacity for remote readout, electrically passive nature, and elevated reliability. Phase transition-based thermometers, renowned for their exceptional sensitivity to temperature fluctuations, have garnered significant attention in recent times [1,2]. Here in, the phase transition – based luminescence thermometry has been studied by utilizing $LaAlO_3:1\%Eu^{3+}$. Even small structural changes such as in $LaAlO_3$ (first order phase transition from rhombohedral to cubic) greatly affected the emission spectra as well as thermometric properties of Eu^{3+}. The phase transition temperature can be changed by modifying both the composition of materials and its morphology. In this work, the size of nanoparticles and the concentration of dopant ions in $LaAlO_3:Eu^{3+}$ on the thermometric properties of the phase transition – based thermometer will be investigated.

Acknowledgements: This work was supported by the National Science Center (NCN) Poland under project no. DEC-UMO- 2022/45/B/ST5/01629.

[1] H. Suo, D. Guo, P. Zhao, X. Zhang, Y. Wang, W. Zheng, P. Li, T. Yin, L. Guan, Z. Wang, F. Wang, *Adv. Sci.* (2024) *11*, 2305241.
[2] L. Marciniak, W. Piotrowski, M. Szalkowski, V. Kinzhybalo, M. Drozd, M. Dramicanin, A. Bednarkiewicz, *Chem. Eng. J.* (2022**)**, *427*, 131941.

[#] corresponding author: m.abbas@intibs.pl

Luminescence properties of Eu^{3+} and Dy^{3+} ions in germanate ceramics Li_2AGeO_4 (A = Zn, Mg)

Nikola Bednarska-Adam[#], Marta Kuwik, Wojciech A. Pisarski, Joanna Pisarska

University of Silesia, Institute of Chemistry, Szkolna 9, 40-007 Katowice, Poland

Inorganic systems have played a crucial role in technology, especially in advanced materials like color display devices and optoelectronic devices [1]. Optical hosts doped with lanthanide ions (Ln^{3+}) have garnered significant attention due to their luminescent properties [2]. Among these ions, Eu^{3+} and Dy^{3+} have emerged as prominent dopants for visible light emitters [2, 3]. Materials doped with Eu^{3+} exhibit orange-red luminescence, while Dy^{3+} ions contribute to visible emission in the blue and yellow spectral regions. Optical hosts containing Eu^{3+} and Dy^{3+} exhibit distinctive emission intensity variations due to their site-selective nature and local environment symmetry, analyzed using the red-to-orange luminescence intensity ratio R/O (Eu^{3+}) and yellow-to-blue luminescence intensity ratio Y/B (Dy^{3+}), respectively [4]. Among others, germanate ceramics with olivine structure are promising hosts for Ln^{3+} ions. Recent studies by Misevicius et al [5] showed intense yellow emission in $LiYGeO_4$ doped with Dy^{3+} ions, while Dai et al [6] observed long-lasting red persistent luminescence in $LiYGeO_4{:}Eu^{3+}$ phosphors. Although some research has explored Ln^{3+}-doped $LiYGeO_4$ materials, luminescent investigations on Li_2MgGeO_4 and Li_2ZnGeO_4 doped with Eu^{3+} and Dy^{3+} have not been yet conducted.

In this study, luminescence properties of Li_2MgGeO_4 and Li_2ZnGeO_4 doped with Eu^{3+} and Dy^{3+} ions are presented and discussed. Based on emission spectra and their decays some spectroscopic parameters for Ln^{3+} were determined. Our results reveal promising optical properties, indicating their potential as inorganic visible emitters.

Acknowledgment: This research was funded by National Science Centre (Poland), grant number 2019/35/B/ST5/01924.

[1] Damodaraiah S., Reddy Prasad V., Vijaya Lakshmi R. P., Ratnakaram Y.C. (2019) Opt. Mater. 92, 352-358
[2] Chemingui S., Ferhi M., Horhcani-Naifer K., Ferid M. (2015) J. Lumin, 166, 82-87
[3] Andresen Ä., Bahar A., Conradi D., Oprea I., Pankrath R., Voelker U., Betzler K., Wöhlecke M. (2008) Phys. Rev. B., 77, 21410
[4] Han Q., Gao W., Qi J., Zhao X., Zhang J., Wang Y., Dong S., Liu W., Hao A., Dong J. (2019) J. Lumin 212, 227-232
[5] Misevicius M., Griniuk E., Ramanauskas R. (2023) Mater. Chem. Phys. 306, 128082
[6] Dai T., Ju G., Jin Y., Wu H., Hu Y. (2021) J. Lumin 237

[#] corresponding author: nikola.bednarska@us.edu.pl

Optical properties of double perovskite $Cs_2Ag_{0.2}Na_{0.4}In_{0.6}Si_{0.4}Cl_6$

G. Beketova[1#], T. Leśniewski[2], N. Górecka[2], K. Szczodrowski[2], S. Mahlik[2], N. Zhanturina[1]

[1]K. Zhubanov Aktobe Regional University, Aktobe, Kazakhstan
[2] University of Gdansk, Gdansk, Poland

Recently, a lot of research has been carried out in the field of optical properties of perovskites. The step in improving materials for electroplating, electronics, solar cells and other applications is the study of the properties of double halide perovskites.

Double halide perovskites are a class of crystalline materials that have a structure similar to perovskite (ABX_3), but with one or more ions replacing other ions in that structure, and contain halides (F-, Cl-, Br-, I-) in as anions X. Since the double halide perovskites are ionic crystals, their charge carriers in the form of electron-phonon coupling are strongly related to lattice vibrations. And this interactions helps to understand electrical and optical properties of double perovskites. Also of great interest in the study of double halide perovskites are mixed perovskites with three cations, which can significantly expand the absorption spectrum and increase the quantum yield of luminescence due to synergistic effects. Our research is about the mixed double perovskite $Cs_2Ag_{0.2}Na_{0.4}In_{0.6}Si_{0.4}Cl_6$.

Double halide perovskites synthesis is based on dissolved poly-crystalline powder of starting material in hydrohalic (HX, X = Cl or Br)/hypophosphorous acid mixed solvent [1]. After heating to 100-200 K, it should be slowly cooled at a rate 0.5 Celcius degrees in an hour [2]. The XRD pattern recorded for $Cs_2Ag_{0.2}Na_{0.4}In_{0.6}Si_{0.4}Cl_6$ shows that the collected pattern matches very well to the desired phase attributed to the 04-007-2290 powder diffraction file. The main peak of the material structure is centered at 2= 24°. The lattice constant is 10.51 A. Some other XRD diffraction lines, located at 14.5°, 28°, 34°, 42°, 48.96°, and others.

We registered the optical properties of $Cs_2Ag_{0.2}Na_{0.4}In_{0.6}Si_{0.4}Cl_{6.}$ Photoluminescence excitation spectra has only one maximum at 259 nm at observation 600 nm. After 340 nm no signal is registered. The luminescence band of perovskite was obtained at an excitation wavelength of 300 nm and is located in the region of 601 nm (orange-red). In $Cs_2AgInCl_6$ crystal, the emission band is observed at 630 nm [3]. The incorporation of Na and Si ions leads to the shift of photoluminescence band to shorter wavelength part.

It can be noted that alloyed perovskites with different ratio of Ag, Na, In, Si have an exhibit larger photoluminescence intensity, broad absorption spectrum compared to their single-component counterparts due to enhanced defect tolerance, and synergistic effects.

[1] Igbari F.; et al. (2019) Adv. Energy Mater., 9,12, 1803150.
[2] Zelewski S.J. et al. (2019) J.Mater.Chem.C., 7, 8350.
[3] Jackson D. Majher et al. (2019) Chem.Mater., 31, 1738-1744.

corresponding author: diko_2006@mail.ru

Innovative luminescent materials for lighting and sensory applications

Oskar Bogucki[1,2], Marcin Kaczkan[1], Anna Kozłowska[2]

[1] Warsaw University of Technology, Institute of Microelectronics and Optoelectronics,
Koszykowa 75, Warsaw, 00-662, Poland
[2] Łukasiewicz Research Network Institute of Microelectronics and Photonics,
al. Lotników 32/46, Warsaw 02-668, Poland

Since the invention of blue light-emitting diodes, the development of LED lighting and various types of phosphor materials has been observed. Most studies concern powder phosphors embedded in resin, whose significant drawback is low resistance to high temperatures, leading to rapid degradation when operating in unfavourable conditions (e.g. during high-energy excitation). In this work, phosphor powders based on yttrium-aluminium garnet crystallites activated with rare earth ions, suspended in binders based on silica with the addition of magnesium oxide, lithium, and potassium are analysed. Such materials are characterized by good resistance to high temperatures [1,2]. A process has been developed for the synthesis of YAG powders with dopant of rare earth ions with optimal grain sizes, i.e. those that are best suspended in binders, which allows for deposition of homogeneous luminescent layers using an airbrush. Thanks to the spraying technique of applying luminescent layers, it is possible to create phosphors composed of many layers with different dopants. This significantly facilitates the manipulation of the optical parameters of the light source and the sensitivity of the temperature sensor. In this work, spectroscopic and photometric analysis of luminescent layers will be shown. In particular, emission and excitation spectra as well as chromatic coordinates will be presented. The microstructure of powders and layers made will be analysed. Exemplary application of luminescence layers as remotely illuminated phosphors using a 'blue' laser diode will be demonstrated.

[1] W.A. Hollerman, R.F. Guidry, F.N. Womack, and N.P. Bergeron, S.W. Allison, D.L. Beshears, M.R. Cates, and S.M. Goedeke, T.J. Bencic, and C.R. Mercer, J.I. Eldridge. (2003) Use of phosphor coatings for high temperature aerospace applications, 39th AIAA/ASME/SAE/ASEE Joint Propulsion Conference and Exhibit 20-23 July 2003, Huntsville, Alabama

[2] S. W. Allison, D. L. Beshears, Thomas Gadfort, T. Bencic, J. Eldridge, W. A. Hollerman and P. Boudreaux. (2001), High temperature surface measurements using lifetime imaging of thermographic phosphors: Bonding tests, 19th International Congress on ICIASF 200

corresponding author: oskar.bogucki@imif.lukasiewicz.gov.pl; marcin.kaczkan@pw.edu.pl; anna.kozlowska@imif.lukasiewicz.gov.pl

Examining the Impact of Samarium Doping on the Properties of Boro-Tellurite Glass for optical applications

K. Boonin[1,2#] , P. Yasaka[1,2], J. Kaewkhao[1,2]

[1]Physics Program, Faculty of Science and Technology, Nakhon Pathom Rajabhat University, Nakhon Pathom 73000, Thailand
[2]Center of Excellence in Glass Technology and Materials Science (CEGM), Nakhon Pathom Rajabhat University, Nakhon Pathom 73000, Thailand

The glass composition (30-x)TeO_2 - 30B_2O_3 - 10ZnO - 20BaO - 5TiO_2 - 5GdF_3 : xSm_2O_3 represents a tailored blend designed to exhibit unique physical, structural, optical, and luminescence properties. This study explores the impact of varying concentrations of Sm_2O_3 (Samarium oxide) dopant (x) on the overall characteristics of the glass matrix. The base composition is composed of TeO_2, B_2O_3, ZnO, BaO, TiO_2, and GdF_3, carefully balanced to achieve desired attributes. The incorporation of Sm^{3+} introduces intriguing possibilities for optical applications due to its distinctive spectral properties. The investigation delves into the structural modifications, and luminescence behavior induced by Sm_2O_3 doping. The synergy of TeO_2, B_2O_3, ZnO, BaO, TiO_2, and GdF_3, combined with the introduction of Sm^{3+}, results in a glass matrix with tunable optical characteristics. The study employs a comprehensive set of analytical techniques, including X-ray diffraction, FTIR, and Judd-Ofelt, to elucidate the crystalline and amorphous phases, as well as the vibration bonding of the glass. Varying Samarium concentrations systematically affect the glass's luminescence in ${}^4G_{5/2} \rightarrow {}^6H_s$ transitions (s = 5/2, 7/2, 9/2, 11/2), with manifestations at 566 nm, 602 nm, 649 nm, and 708 nm, respectively. Understanding the interplay between the constituents in this glass system opens avenues for applications in lasers, optical amplifiers, and other photonics devices. The findings presented in this abstract contribute to the evolving field of glass science and its diverse applications, offering insights into the development of advanced materials for optical technologies.

Keywords: Glass, Luminescence, Optical, Sm^{3+} ions.

[#] corresponding author: kboonin@webmail.npru.ac.th; kboonin@hotmali.com

Implementation of a genetic algorithm concept in an open source software for the ellipsometric data evaluation

Jakub Bożek#, Krzysztof Dorywalski

Institute of Experimental Physics, Faculty of Mathematics, Physics and Informatics,
University of Gdansk, Wita Stwosza 57, 80-308 Gdansk, Poland

Ellipsometry has traditionally relied on a limited range of applications developed by a select few companies. However, during work at the university the necessity of a more inclusive approach crystallized. The tool would assist researchers in expanding the capabilities of their ellipsometry studies without additional cash contribution. In this regard, we present open-source software written in Python, a programming language well-known among scientists.

Our software offers the capability to simulate data such as psi, delta on thickness/wavelength spectra, reflectance plots, determination of Brewster's angle and more. Additionally, it provides the means to analyze experimental data, whether or not prior knowledge of sample properties is available.

One of the major benefits of our solution is an easy-to-use graphical interface, designed to streamline the user experience and facilitate intuitive navigation. The interface allows researchers to interact with the software seamlessly, providing a visual representation of the simulated or analyzed data. Through this graphical interface, users can easily manipulate input parameters, visualize results, and explore various analysis options.

A notable feature of our software is its reliance on Dr Eng Krzysztof Dorywalski's concept of utilizing a genetic algorithm (GA) to identify an optimal starting point for the gradient-based Levenberg-Marquardt algorithm (LMA). This concept has been further developed into a multilayer GA, where each iteration progressively narrows down the search range, resulting in accurate and rapid determination of essential parameters such as thickness, refractive index (plot), extinction coefficient (plot), or layer roughness.

By offering an open-source solution with an intuitive graphical interface, our software aims to empower researchers and practitioners in the field of ellipsometry. It ensures a user-friendly experience, making the software accessible to a broader community which provides possibility of rapid development.

corresponding author:j.m.m.bozek@gmail.com

Estimation of the degree of surface defectiveness of the $Ti_3C_2T_x$ films

K. Chernyakova[1#], R. Karpicz[1], M. Ivanovskaya[2], E. Ovodok[2], I. Azarko[3], I. Audzeichyk[2,3]

[1]Center for Physical Science and Technology, Sauletekio av. 3, LT-10257 Vilnius, Lithuania
[2]Research Institute for Physical Chemical Problems of the Belarusian State University,
Leningradskaya str. 14, 220006, Minsk, Belarus
[3]Belarusian State University, Nezavisimosti av. 4, 220030, Minsk, Belarus

Two-dimensional (2D) nanomaterials with chemical and structural diversity have attracted research interest due to their unique photonic, mechanical, electrical, magnetic, and catalytic properties that distinguish them from bulk materials [1]. Among them, 2D titanium carbide with the following chemical formula $Ti_3C_2T_x$ (T can be O, OH, or F), known as MXene, is being intensively researched for various applications. The properties of MXene $Ti_3C_2T_x$ can vary depending on the synthesis methods. The work aims to compare the surface defects of MXenes $Ti_3C_2T_x$ obtained from Ti_3AlC_2 after an aggressive dissolution of aluminum in HF and a milder treatment in LiF/HCl [2]. A convenient method for monitoring the concentration of defects – carbon and titanium vacancies – is electron spin resonance (ESR) spectroscopy. In the Mxene $Ti_3C_2T_x$ samples, spin-localized states related to the MXene $Ti_3C_2T_x$ surface were detected: carbon vacancies with a captured electron (V_C) and Ti^{3+} ions in coordination with the cation vacancy (Ti^{3+}–V_{Ti}). It is shown that a wide signal with g_{iso} = 1.94–1.95 form Ti^{3+}–V_{Ti} centers can indicate the presence of titanium vacancies, and ESR spectroscopy can be a tool for assessing the defectiveness of the surface of MXenes $Ti_3C_2T_x$. The concentration of centers (Ti^{3+}–V_{Ti}) is an order of magnitude higher in the sample after treatment in HF than in LiF/HCl, which is experimental evidence of higher defectiveness and heterogeneity of the chemical composition and surface structure of MXenes $Ti_3C_2T_x$ obtained by treating Ti_3AlC_2 in an HF solution in comparison with LiF/HCl. For applying MXenes in various fields, controlling the concentration of surface vacancies in these materials is important. The presence of vacancies is an advantage of these materials when used in adsorption and photocatalysis, but vacancies are undesirable for use, for example, in optics. The ability to quantitatively monitor the concentration of titanium vacancies and carbon in MXenes $Ti_3C_2T_x$ using ESR spectroscopy is an important result of this study.

Acknowledgment: Himreagent 2021–2025 № 2.1.04.02

[1] Anasori B., Lukatskaya M. R., Gogotsi Y. (2017) Materials, 2, 16098–16.
[2] Wei, Y.; Zhang, P.; Soomro, R.A.; Zhu, Q.; Xu, B. (2021) Adv. Mater., 33, 2103148.

corresponding author: katsiaryna.charniakova@ftmc.lt

Properties of "phosphate-tungstate glass - $K_2Eu(PO_4)(WO_4)$ crystalline phosphor" glass-ceramics

V. Chornii[1,2#], S. G. Nedilko[1], V. Sheludko[3], K. Voynalovych[1], V. Stasiv[4], K. Terebilenko[1]

[1]Taras Shevchenko National University of Kyiv, 64/13 Volodymyrska st., Kyiv, Ukraine
[2]National University of Life and Environmental Sciences of Ukraine, 15 Geroiv Oborony st., Kyiv, Ukraine
[3]Oleksandr Dovzhenko Hlukhiv National Pedagogical University,
24, Kyivska str., Hlukhiv, Ukraine
[4]Institute of Physics Polish Academy of Sciences, al. Lotników 32/46 Warsaw, Poland

Luminescent glass-ceramics (GCs) are actively elaborated as alterative to phosphor-in-silicone/resin composites for light emitting diodes (LEDs). In comparison to polymers, which are used in commercial LEDs, the GCs demonstrate better stability of optical characteristics under the action of heat and powerful light fluxes, as well as lower degradability (aging) due to higher thermal conductivity. To achieve a high intensity of emission it is desirable to decrease light scattering in GCs that appears due to mismatch between refraction indices of glass and crystalline components. It was assumed that the similarity of the chemical compositions of the glass host and crystalline phosphor should result in better homogeneity of the optical glass-ceramics.

Here, the optical properties of the samples that consist of $K_2Eu(PO_4)(WO_4)$ red phosphor incorporated into phosphate-tungstate glass host have been studied. The glass of xK_2O-yP_2O_5-zWO_3-$(1-x-y-z)Bi_2O_3$ system (x = 27 – 51 mol %, y = 19 – 41 mol %, z = 16 – 41 mol %) has been synthesized by melt quenching technique. It was found from differential thermal analysis that the glass transition temperature was in 380 - 500 °C range for all of the samples. The GC were made by adding the $K_2Eu(PO_4)(WO_4)$ micro/nanocrystals into previously melted glass at 800 °C. The content of crystalline component in glass-ceramics was chosen to be 1 % mas. The X-ray diffraction patterns of the glasses and GC were very similar each to other with wide bands peaking at 29°, 45°, and 55° of 2Θ, but no narrow peaks have been found due to low content of crystalline component. At the same time, the crystallites and their agglomerations are clearly distinguished on optical microscopy images in the case of GC under white and UV light illumination. The photoluminescence spectra of the glass ceramics depend on the excitation wavelength and consist either with wide band of glass emission in 400 – 800 nm range or additionally with narrow lines of Eu^{3+} emission typical for $K_2Eu(PO_4)(WO_4)$ crystals.

This work was supported by EURIZON FELLOWSHIP PROGRAMME "Remote Research Grants" (Grant Agreement EU #3010-A-EURIZON) with funding provided by the European Union (through EURIZON H2020 project, grant agreement 871072).

[#] corresponding author: vchornii@gmail.com; vchornii@nubip.edu.ua

Practical application of fluorescent dyes in forensic science

Martyna Czarnomska[1#], Emilia Gruszczyńska[1], Lewkowicz Aneta[1], Piotr Bojarski[1],
Sławomir Steinborn[2], Łukasz Balwicki[3]

[1]Faculty of Mathematics, Physics and Informatics, University of Gdansk
[2]Faculty of Law and Administration of the University of Gdansk
[3]Faculty of Health Sciences with the Institute of Maritime and Tropical Medicine,
Medical University of Gdansk

The research aims to improve various areas of analysis of dactyloscopic and DNA evidence by introducing innovative physicochemical methods based on the fluorescence phenomenon, while preserving the evidentiary function of the material examined, verifying existing procedures, and maintaining the reliability of the evidence in a procedural sense. Any method used in forensic science and admitted as evidence in court must have a diagnostic value that is known and described in the professional and recognized literature on the subject, as we are talking about scientific evidence. Empirical studies will allow the description and evaluation of the photophysical and structural properties of luminescent materials. Luminescent probes such as DFO, Diamond™ Nucleic Acid Dye, SYBR® Green I Nucleic Acid, and Acridine Orange will allow the development of applications in forensic science. Research into spectroscopic techniques, such as the analysis of absorption, emission spectra, or fluorescence lifetimes, enables the development of a method or the improvement of an existing method for the examination of evidence. Ongoing research has resulted in a new method for the visualization of dactyloscopic traces and the proposal of a method combining two currently used methods - 2-in-1 analysis.

This research was supported by a National Science Centre, Poland grant 2021/41/B/HS5/03250 (A.L., M.Cz., E.G.).

corresponding author: martyna.czarnomska@phdstud.ug.edu.pl

Molecular Spectroscopy in Time of Death Estimation

Emilia Gruszczyńska[1], Marta Starost[2], Martyna Czarnomska[1], Aneta Lewkowicz[1],
Piotr Bojarski[1], Łukasz Balwicki[3]

[1]Faculty of Mathematics, Physics and Informatics, University of Gdansk
[2]Faculty of Law and Administration of the University of Gdansk
[3]Faculty of Health Sciences with the Institute of Maritime and Tropical Medicine,
Medical University of Gdansk

The estimation of the time of death is a highly complex and challenging task in forensic medicine and science. The methodologies currently employed to determine the postmortem interval (PMI) are demonstrably inaccurate, primarily due to the significant influence of external environmental conditions [1]. Therefore, there is a pressing need among forensic experts for the improvement of current methods and the development of new, more accurate and non-invasive techniques. This includes the exploration of physicochemical methods and the identification of new markers that can enhance the precision of the determination of time of death and reduce the risk of error.

The present study introduces an innovative non-invasive approach to estimating time of death based on spectroscopic analysis of free tryptophan present on the skin surface. Using spectroscopic techniques, we confirmed that tryptophan is a promising marker for this purpose. The spectroscopic methods will permit the detection of changes in the concentration of free tryptophan over time, thereby offering a potential new approach for forensic investigations.

This research was supported by a grant National Science Centre, Poland 2021/41/B/HS5/03250 (E.G., M.Cz., A.L.)

[1] Sutton, L.; Byrd, J. An Introduction to Postmortem Interval Estimation in Medicolegal Death Investigations. WIREs Forensic Science 2020, 2 (5). https://doi.org/10.1002/wfs2.1373.

corresponding author: emilia.gruszczynska@phdstud.ug.edu.pl

Effect of growth conditions on the optical properties of In_2S_3 thin films in the broad FIR–DUV spectral range

Krzysztof Dorywalski[1#], Leszek Bychto[2], Bohdan Andriyevsky[2]

[1]Institute of Experimental Physics, Faculty of Mathematics, Physics and Informatics, University of Gdańsk,
Wita Stwosza 57, 80-308 Gdańsk, Poland
[2]Faculty of Electronics and Computer Sciences, Koszalin University of Technology,
Śniadeckich str. 2, PL-75-453, Koszalin, Poland

Indium sulfide In_2S_3 semiconductor compound is being considered as a replacement for the CdS buffer layer in the next generation $Cu(In,Ga)Se_2$ (CIGS) thin film solar cells. In addition to its non-toxicity, one of its main advantages is its ability to deposit good quality thin films by a relatively simple and therefore inexpensive method of Vacuum Thermal Evaporation, which predestines it for industrial applications. Determining the influence of different deposition techniques and conditions on the optical properties of In_2S_3 films is a key factor for their optoelectronic applications.

Here we focus on the studying of the effect of deposition conditions on the structural and hence optical properties of In_2S_3 thin films grown by the above motioned method. The complex dielectric function ε(E) of the films deposited on glass substrates has been determined in the broad spectral range from the far-infrared FIR to the deep-ultraviolet DUV based on infrared spectroscopy using the synchrotron radiation (IR) and spectroscopic ellipsometry (VIS–DUV). The strong impact of the substrate and post-annealing temperatures on the optical properties is discussed in relation to the structural changes.

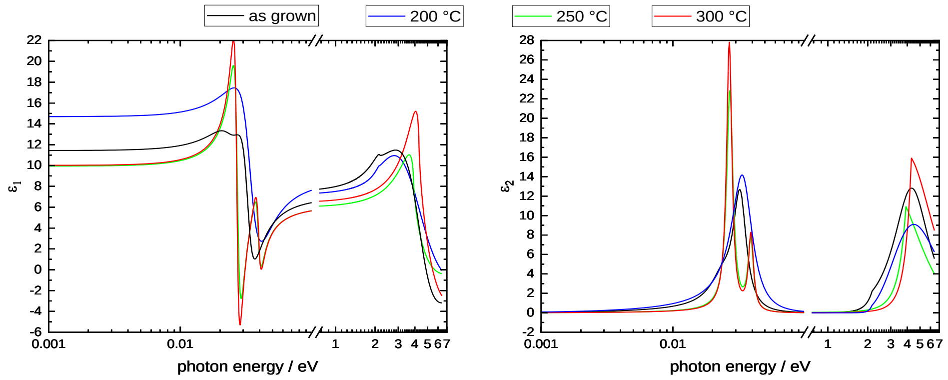


Fig. 1. Real ε_1 and imaginary ε_2 parts of the complex dielectric function for In_2S_3 thin films annealed at different temperatures (substrate temperature 250 °C)

[1] Andriyevsky B., Bychto L., Dorywalski K., et. al. (2023) Infrared Phys Technol, 131, 104662.

corresponding author: krzysztof.dorywalski@ug.edu.pl

Scintillation properties of GOS and GYAGG ceramics activated with cerium and praseodymium ions

Konrad. J. Drozdowski[1#], Marcin E. Witkowski[1], Winicjusz Drozdowski[1],
Lukasz Swiderski[2], Weerapong Chewpraditkul[3], Dong Huang[4], Danyang Zhu[4], Jiang Li[4]

[1]Institute of Physics, Faculty of Physics, Astronomy and Informatics, Nicolaus Copernicus
University in Toruń, ul. Grudziądzka 5, 87-100 Toruń, Poland
[2]National Centre for Nuclear Research, ul, Andrzeja Soltana 7, 05-400 Swierk-Otwock, Poland
[3]Department of Physics, Faculty of Science, King Mongkut's University of Technology Thonburi,
Bangkok, 10140, Thailand
[4]Transparent Ceramics Research Center, Shanghai Institute of Ceramics, Chinese Academy of Sciences,
Shanghai 201899, China

In this Communication we present a broader characterization of two different Gd-based ceramics from the point of view of their potential scintillator applications. The Gd_2O_2S (GOS) samples were doubly activated with Ce (0.003 mol%) and Pr (0.1 mol%) ions, whereas the GYAGG samples with Ce ions only, forming two compositions: $Ce_{0.006}Gd_{1.996}Y_{0.998}(Y_{0.02}Ga_{0.98})_2GaAl_2O_{12}$ and $Ce_{0.006}Gd_{1.996}Y_{0.998}(Y_{0.04}Ga_{0.96})_2GaAl_2O_{12}$. The following studies were performed: *i)* pulse height spectra as the basic measurement used to determine the values of scintillation light yield and energy resolution, *ii)* scintillation time profiles recorded to observe the kinetics of scintillation, *iii)* radioluminescence as a function of temperature to recognize the emission bands and their thermal dependences, *iv)* thermoluminescence to investigate the distribution of charge traps in the ceramics. We show that the GOS ceramics display reasonably high scintillation yields close to 30000 ph/MeV, but their scintillation is slow (a few μs), which is related to the intraconfigurational emission of Pr^{3+} ions. The strong point of the GOS ceramics is their thermal dependence of radioluminescence, since there is only a small thermal quenching at room temperature. Thermoluminescence shows distinct glow peaks and about 1/5 of charge carriers generated during X-ray excitation are captured by various kinds of traps. The GYAGG ceramics offer somewhat lower yields compared to GOS, but their scintillation, as based on the interconfigurational Ce^{3+} emission, is much faster. Unfortunately, as indicated by radioluminescence measurements, there is a relatively strong thermal quenching at room temperature. The glow curves of GYAGG are formed by less peaks than GOS, but still a similar amount of carriers is captured by traps. Summarizing, both ceramics have promising properties and could replace monocrystals in some applications related to radiation detection. Moreover, there is possibly plenty of room for improvement, therefore a further development of these ceramics is thinkable.

corresponding author: 503545@doktorant.umk.pl

Exploring lead-free liquid-ionic perovskite crystals as novel scintillators

Mohanad S. Eid[1#], Konrad. J. Drozdowski[1], Marcin E. Witkowski[1], Ricky Subagyo[2], Arramel[3], Yuly Kusumawati[2], Dominik Kowal[4], Michal Makowski[4], M. Danang Birowosuto[4], Winicjusz Drozdowski[1]

[1]Institute of Physics, Faculty of Physics, Astronomy and Informatics, Nicolaus Copernicus University in Toruń, ul. Grudziądzka 5, 87-100 Toruń, Poland
[2]Department of Chemistry, Faculty of Science and Data Analytics, Institut Teknologi Sepuluh Nopember, Kampus ITS Keputih, 60111 Sukolilo, Surabaya, Indonesia
[3]Nano Center Indonesia, Jl PUSPIPTEK, South Tangerang, Banten 15314, Indonesia
[4]Łukasiewicz Research Network-PORT Polish Center for Technology Development, ul. Stabłowicka 147, 54-066 Wrocław, Poland

The exploration of hybrid organic-inorganic perovskites (HOIPs) within the context of scintillator materials presents a novel avenue in materials science. In addition, by combining the unique properties of ionic liquid (IL)-based organic cations with lead-free perovskite we can leverage the unique properties of these compounds such as tunable bandgaps and large stokes shift with a small probability of reabsorption of scintillation light since the overlap absorption and emission spectral area is smaller.

In this study we aimed to investigate the potential of ionic liquid lead-free perovskite embedded within PDMS (polydimethylsiloxane) matrix as promising candidates for scintillator applications. The samples under investigation included a variety of compositions: *a)* $BMPBiBr_4$, *b)* $APIBiBr_5$, *c)* $APIBiSnBr_5$, *d)* $BMIBiBr_4$, and *e)* $APISn_2Br_{10}$. The primary motivation behind this investigation arises from their lead-free nature, which addresses environmental concerns of using lead-based materials. Additionally, these perovskite microcrystals exhibit a substantial Stokes shift of approximately 0.8 eV, indicating potential for efficient light emission and detection.

By characterization and evaluation of the scintillation properties of these materials, using such techniques as pulse height spectra, scintillation time profiles, radio- and thermoluminescence measurements, our findings may lead the way for the development of next-generation radiation detection systems with improved performance and reduced environmental impact, marking a significant step forward in the field of radiation detection.

[#] corresponding author: mohanadeid@doktorant.umk.pl

Ellagic acid thin films studied by time-resolved ellipsometry

Shirly Espinoza[1#], Marieta Levichkova[2], Eva Bittrich[3]

[1]ELI Beamlines, ERIC, Za Radnicí 835, 252 41 Dolní Břežany, Czech Republic
[2]Heliatek GmbH, Treidlerstr. 3, 01139 Dresden, Germany
[3]Leibniz-Institut für Polymerforschung Dresden e.V., Hohe Str. 6, 01069 Dresden, Germany

Ellagic acid (EA) is a plant-based polyphenol, which has been recently explored for the creation of functional materials [1-3]. In this work, we present the analysis of the transient changes of the optical properties of thin films of EA induced by a pump pulse. By femtosecond pump-probe spectroscopic ellipsometry technique [4-5] we followed photo-induced changes in the dielectric constant of two samples of EA prepared according to Bittrich et al.[6]: 75 nm EA film deposited via thermal evaporation on a substrate of an opaque 80 nm thick gold layer on quartz glass, and a 30 nm EA film deposited on Silicon [(100), native SiOx]

The transient Ψ and Δ spectra, taken at different time delays between the 3.1 eV pump and the probe pulses, were modelled through a uniaxial optical dispersion using an effective medium approximation. Transient effects, caused by the incidence of the pump pulse on the different substrates, were recorded by measuring pump-probe ellipsometry spectra on the substrates alone, and were used for the modelling. Effects on the near-UV range previously assigned to aromatic π−π* transitions [6] were observed.

Support by the project Advanced research using high intensity laser produced photons and particles (CZ.02.1.01/0.0/0.0/16-019/0000789) from the European Regional Development Fund is gratefully acknowledged.

[1] Bittrich E., Domke J., Levichkova M., et al. (2021) ACS Appl. Energy Mater, 4, 12, 14273–14286.
[2] Sahu T.K., Gupta A., Agarwal V., et al. (2023) ACS Appl. Eng. Mater, 1, 12, 3194–3204
[3] Feng Y., Li P., Wei J. (2022) Coordination Chemistry Reviews, 468, 214649
[4] Espinoza S., Richter S., Rebarz M., et al. (2019) Appl. Phys. Lett. 115, 052105
[5] Richter S., Rebarz M., Herrfurth O., et al. (2021) Rev. Sci. Instrum. 92, 033104
[6] Bittrich E., Domke J., Jehnichen D., et al. (2020) J. Phys. Chem. C, 124, 30, 16381–16390

corresponding author: shirly.espinoza@eli-beams.eu

LPE growth and investigation of optical and photoelectrical properties of Ce^{3+} and Ce^{3+},Mg^{2+} doped $Gd_3Sc_2Al_3O_{12}$ and $Gd_{1.5}Lu_{1.5}Sc_2Al_3O_{12}$ single crystalline films

Vitalii Gorbenko[1#], Tetiana Zorenko[1], Sandra Witkiewicz-Łukaszek[1], Mikołaj Kaminski[2], Sebastian Mahlik[2], Artur Majewski-Napierkowski[1], Yuriy Zorenko[1]

[1]Faculty of Physics of Kazimierz Wielki University in Bydgoszcz, 85-090 Bydgoszcz, Poland
[2]Institute of Experimental Physics, Faculty of Mathematics, Physics and Informatics, University of Gdansk, 80-308 Gdansk, Poland

In this work, we present the results of crystallization and investigation of the optical and photoelectrical properties of the single crystalline films (SCFs) of singly Ce^{3+} and doubly Ce^{3+}, Mg^{2+} doped $Gd_3Sc_2Al_3O_{12}$ and $Gd_{1.5}Lu_{1.5}Sc_2Al_3O_{12}$ garnets. The SCF samples were grown by the liquid phase epitaxy (LPE) method onto $Gd_3Ga_5O_{12}$ (GGG) and $Gd_3Ga_{2.5}Al_{2.5}O_{12}$ (GAGG) substrates, respectively, from the super-cooling melt–solution based on the PbO-B_2O_3 flux. The absorption, luminescence, scintillation, and photoelectrical properties of $Gd_3Sc_2Al_3O_{12}$:Ce and $Gd_{1.5}Lu_{1.5}Sc_2Al_3O_{12}$:Ce SCFs, as well as $Gd_3Sc_2Al_3O_{12}$:Ce,Mg and $Gd_{1.5}Lu_{1.5}Sc_2Al_3O_{12}$:Ce,Mg SCFs with two different Mg concentration were investigated using conventional spectral methods and compared with the properties of the reference YAG:Ce and $Gd_{1.5}Lu_{1.5}Al_5O_{12}$:Ce SCF samples.

The differences in the optical, scintillation, and photoelectronic properties as well as energy transfer processes from garnet hosts to Ce^{3+} activators in Ce^{3+} and Ce^{3+},Mg^{2+} doped SCF samples were observed and explained in the context of creation of creation of Ce^{3+}, Ce^{4+}-Mg^{2+} and Ce^{3+}-Mg^{2+}-2V_O centers (V_O -oxygen vacancy).

Furthermore, the luminescent properties of the mentioned film samples were investigated under excitation by synchrotron radiation at Superlumi station at P66 line at PETRA 3 storage range at DESY, Hamburg, with energy in the 3.7-12.5 eV range at 10 K. Based on this results, the energy levels of Ce^{3+} ions in both garnet host were elucidated with respect band gap extrema, contributing valuable insights into the luminescence behaviour of these materials. The energy creation of excitons bound with Ce^{3+} ions in $Gd_3Sc_2Al_3O_{12}$:Ce and $Gd_{1.5}Lu_{1.5}Sc_2Al_3O_{12}Al_2O_3$:Ce hosts was determined to be equal to 6.335 eV and 6.45 eV, respectively.

Acknowledgements: The work was performed in the frame of NCN 2019/33/B/ST3/ 00406 project and partly in the frame of Regional Excellence Initiative nr RID/SP/0048/ 2024/01 project. Investigation with synchrotron radiation at DESY were performed in the frame of I-20210147 EC and I-20220864 projects.

[#] corresponding author e-mail: gorbenko@ukw.edu.pl

Controlling Europium Oxidation State in Diopside Through Flux Concentration

N. Górecka[1#], T. Leśniewski[1], M. Łapiński[2], Y.-T. Tsai[3], S. Mahlik[1], A. Bielicka-Giełdoń[4], K. Szczodrowski[1]

[1]Institute of Experimental Physics, Faculty of Mathematics, Physics, and Informatics, University of Gdańsk,
Wita Stwosza 57, 80-308 Gdańsk, Poland,
[2]Institute of Nanotechnology and Materials Engineering, Gdansk University of Technology,
Gabriela Narutowicza 11/12, 80-233 Gdansk, Poland,
[3]Research Center for Applied Sciences, Academia Sinica, Taipei 11529, Taiwan,
[4]Faculty of Chemistry, University of Gdansk, Wita Stwosza 63, 80-308 Gdansk, Poland.

This explores the connection between the H_3BO_3 flux concentration and the coexistence of Eu^{2+} and Eu^{3+} dopants within $CaMgSi_2O_6$ crystals (diopside). The samples were synthesised using a solid-state synthesis method under varying atmospheric conditions, including oxidative (air), neutral (N_2), and reductive (H_2/N_2 mixture) environments. Additionally, some materials underwent chemical modification by partially substituting Si^{4+} with Al^{3+} ions. Depending on the specific synthesis conditions, the materials predominantly displayed either the orange-red luminescence of Eu^{3+} (under oxidising conditions) or the blue luminescence of Eu^{2+}. However, the comprehensive results confirmed the co-existence of Eu^{3+}/Eu^{2+} luminescence in both cases. In the case of materials obtained under oxidazing atmosphere the intensity of the trace Eu^{2+} emission increased with increasing of flux concentration independently on the materials modification, while in the case of materials obtained under reductive atmosphere the changes of Eu^{3+} emission intensity depended on the presence or absence of Al^{3+} ions (the intensity increased in the case of unmodified materials and decreased in the modified ones with increasing of concentration of flux). The emission of the materials obtained under neutral atmosphere was characterized by the Eu^{3+} and Eu^{2+} luminescence and the evolution of the Eu^{2+} emission intensity, with increasing of flux concentration, was similar behavior as in the case of samples obtained in air. All these effects were qualitatively explained considering the double role of the flux in the studied system: as an agent that facilitate the diffusion of chemical species during solid state process and as a charge compensating agent.

Acknowledgements: This work was supported by the National Science Center (NCN) Poland under project PRELUDIUM-17, no. UMO-2019/33/N/ST4/00425.

corresponding author: natalia.gorecka@ug.edu.pl

Properties of ultrasound induced luminescence of $LiTaO_3$:Pr at kHz and MHz frequency ranges

Syed Shabhi Haider[1#], Justyna Barzowska[2], Philippe F. Smet[3], Andrzej Suchocki[1]

[1]Institute of Physics, Polish Academy of Sciences, Al. Lotników 32/46, Warsaw 02-668, Poland.
[2]Institute of Experimental Physics, Faculty of Mathematics, Physics and Informatics, University of Gdańsk, Wita Stwosza 57, 80-308, Gdańsk, Poland.
[3]Department of Solid State Sciences, LumiLab, Ghent University, Krijgslaan 281-S1, 9000 Ghent, Belgium.

Light emission from LiTaO3:Pr during exposure of low (20 kHz) and high (3.3 MHz) frequency ultrasonic waves are presented. After being charged at ~270 nm, the phosphor emits light with three prominent peak bands at 511 nm, 618 nm, and 892 nm, as observed in both photoluminescence and mechanoluminescence spectra. The unlike acoustic phenomena at low (acoustic cavity) and high (acoustic streaming) frequency pointed at a distinct mechanism for the light emission: i) ML-driven and ii) TL-driven for low and high frequency, respectively. Moreover, the activation energy of the traps (i.e. the trap depth) are modulated by tuning the praseodymium concentration (1% (sample S1), 3% (S2) and 3% (S4)). We used this to demonstrate diverse behavior of ultrasound induced light emission at various thermal conditions. Aimed at application purpose, S1 is advantageous for high-intensity emission and long distance detection, S2 is suitable for scenarios demanding good reproducibility, and S3 proves to be valuable for fast response to ultrasound. Additionally, the presented study offers a comprehensive roadmap for understanding of the correlation between ultrasound induced luminescence and the energy distribution of trap depths.

corresponding author: shabhi@ifpan.edu.pl

P18 **I. Halimski**

Trans-stilbene aggregates and crystallites in polystyrene films: microscopy and spectroscopy

Ivan Halimski[1#], Renata Karpicz[1], Andrej Dementjev[1], Marija Jankunec[2],
Jevgenij Chmeliov[1,3], Mindaugas Macernis[3], Darius Abramavicius[3], Leonas Valkunas[1,3]

[1] Department of Molecular Compound Physics, Center for Physical Sciences and Technology, Lithuania
[2] Institute of Biochemistry, Life Sciences Center, Vilnius University, Lithuania
[3] Institute of Chemical Physics, Faculty of Physics, Vilnius University, Lithuania

Stilbene is a typical molecule to demonstrate photoisomerization, playing a vital role in a variety of processes ranging from photochemistry to biology. *Trans-Cis* photoisomerization happens with liquid stilbene under UV irradiation, while its solid *trans*-isomer can remain stable. *Trans*-stilbene (TS) itself seems to be very promising material for, e.g., ionizing radiation detection [1]. *Trans*-stilbene could be prepared as a thin film in polystyrene (PS) matrix [2,3], and previous studies reveled unusual temperature dependence [2] as well as concentration effect [3] on spectral properties of such TS-containing thin polystyrene films.

In this work we provide a deep analysis of optical properties (absorbance, steady-state and time-resolved fluorescence as well as florescence excitation) of TS film, prepared in PS matrix, dependent on its structure (applying Atomic Force Microscopy and Coherent-Anti-Stokes Raman Scattering), varying both TS concentration and the film thickness. With the microscopy concentration/thickness-dependent formation of TS aggregates and crystallites is observed. One of the most inspiring results is that both concentration- and thickness-dependent fluorescence spectra and kinetics can be expressed as a linear combination of pure molecular and higher aggregates contributions. This means it is possible to control the properties of the prepared sample by adjusting film properties such as concertation and thickness. For instance, the solubility threshold of TS in the PS matrix can be found, above which aggregates start to form.

A more detailed discussion will be provided in the conference.

[1] Budakovsky S. V., Galunov N. Z., Rybalkooleg A. Y., Tarasenko A., Yarychkin V. V. (2002) Mol. Cryst. Liq. Cryst., 385, 71–77.
[2] Karpicz R., Ostapenko N., Ostapenko Y., Polupan Y., Lazarev I., Galunov N., Macernis M., Abramavicius D., Valkunas L. (2021) Phys. Chem. Chem. Phys., 23, 3447–3454.
[3] Karpicz R., Kareivaite G., Macernis M., Abramavicius D., Valkunas L. (2023) Phys. Chem. Chem. Phys., 25, 21183–21190.

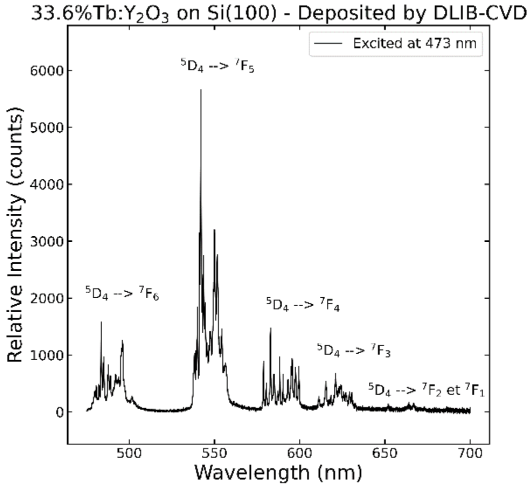
corresponding author: ivan.halimski@ftmc.lt

Optimizing Luminescence of Terbium doped Y_2O_3 Thin-Films Grown by CVD and Spin-Coating Methods

Alexandre Hebbrecht#, Maria Alejandra Arranz-Martinez, Alexandre Tallaire,
Philippe Goldner

Chimie Paris Tech, PSL University, CNRS, Institut de Recherche de Chimie Pairs, Paris, 75005, France.

Rare-earth doped oxides are promising materials for a broad range of applications from light sources to quantum technologies. They can be obtained in different forms, among which thin films can offer a well-controlled growth process at wafer scales. In this work, we investigated Spin-Coating (SC) deposition and Liquid Injection Chemical Vapor Deposition (DLI-CVD) techniques for obtaining terbium (Tb) doped Y_2O_3 films [1].



Among rare earth ions, Tb^{3+} can show ms excited state lifetime even at high doping concentrations thanks to a favorable energy level scheme, leading to phenomena such as efficient Interparticle Förster Resonance Energy Transfer (IFRET) [2]. However, Tb can also be found as a tetravalent ion, Tb^{4+} [3]. This is not desirable since Tb^{4+} is not emitting and moreover can quench Tb^{3+} luminescence. As the formation of an oxide is classically performed under oxidizing atmosphere, the management of the valence of Tb may be challenging.

Here, we present the optimization of $Tb:Y_2O_3$ optical properties at a high doping concentration. We especially studied the influence of growth and post-annealing atmospheres and succeeded to prevent the oxidation of Tb^{3+} to Tb^{4+}. As a result, good optical properties, as well well-crystallized films, were obtained at high Tb concentration.

These results open the way to the development of high-quality rare earth doped thin films in which compositions and structures like buffer and caping layers can be efficiently tuned.

[1] Harada et al. (2022), Mater. Adv., 3, 1, 300-311.
[2] Henderson et al. (2006), Oxford University Press, Chapter 10, 455-504.
[3] Belaya et al. (2013), Inorg Mater, 50, 4, 379-386.

corresponding author: alexandre.hebbrecht@chimieparistech.psl.eu

Novel photoacoustic spectroscopy methodology for biosensing of complex environmental water contamination: Baltic sea studies

P. Janowicz[1#], S. Pogorzelski[1], P. Rochowski[1], K. Boniewicz-Szmyt[2]

[1]Institute of Experimental Physics, Faculty of Mathematics, Physics and Informatics, University of Gdańsk,
Wita Stwosza 57, 80-308 Gdańsk, Poland
[2]Faculty of Marine Engineering, Gdynia Maritime University, Morska 81-83, 81-225 Gdynia, Poland

The aim of the presentation is to demonstrate the potential of novel photoacoustic (PA) spectroscopy techniques for bioassessment of Baltic sea water complex pollution i.e., chemical, plastics and biofilm-forming, photosynthetically active contamination species residing at submerged solid substrata [1]. In particular, applicable to particular contamination systems (opaque and scattering samples) unavailable for standard spectroscopic analyses. Two kinds of spectroscopic modalities were tested: a standard and diffusive reflectance (DR) together with photoacoustics depth-profiling technique. As model contaminants, three: chemical (paracetamol), biological (green algae), and microplastics samples were selected. Photosynthetic signatures such as photosynthetic energy storage, photoacoustic spectra as well as geometric and structural biogeography of microbial colonies (via confocal microscopy) were correlated to the water trophic state and organic matter transformation routes [2]. It turned out, that both PA and DR techniques provided similar results for the model microplastics-contaminated water. However, due to various efficiency of specific light-matter interactions, these two modalities demonstrated different spectral signatures. Both techniques were effectively applied to monitoring of seawater microscopic (> 0.5 μm) particles and, covering submerged solid substrata, photosynthetically-active biofilms [3]. Particularly, DR data revealed higher sensitivity to the microplastics particle presence. The PA solid state species data demonstrate, that the technique could be utilized for opaque, like sediments, sample identification. In the light of self-coincidence between the results derived by PA and DR modalities, the methodology can be useful to create a novel concept of water pollution sensing.

[1] Grzegorczyk M. Pogorzelski S. and Rochowski P. (2022) J. Environ. Chem.Eng., 10, 107983.
[2] Grzegorczyk M. Pogorzelski S. Janowicz P. Boniewicz-Szmyt, K. and Rochowski P., (2022) Materials, 15, 6351.
[3] Boniewicz-Szmyt K. Grzegorczyk M. Pogorzelski S. and Rochowski P. (2023) Oceanologia, 65,194-201.

---

corresponding author: p.janowicz.558@studms.ug.edu.pl

Phase Transition Based Luminescence Thermometry of $ZnP_2O_7:Eu^{3+}$

Anam Javaid[1#], Maja Szymczak[1], Malgorzata Kubicka[1], Łukasz Marciniak[1]

[1]Institute of Low Temperature and Structure Research, Polish Academy of Sciences, Okolna 2, 50-422 Wroclaw, Poland.

After experiencing remarkable growth over the past decade, the field of luminescence thermometry has now matured into a well-established technology. Luminescence thermometry has emerged as an effective way to implement remote thermal reading and finds promising applications in many fields. Although many different mechanisms have already been used in thermometry, new ones are still being sought to improve the thermometric properties. A recently proposed, very promising approach is phase transition based luminescence thermometry[1,2]. In this work, we investigate the spectroscopic properties of $ZnP_2O_7:Eu^{3+}$ for which a first order phase transition from the *I2/c* to *C2/m* structures around 400 K was observed. The described phase transition modifies the shape of the Eu^{3+} ion emission spectrum, enabling this effect to be implemented for temperature sensing. The influence of dopant ion concentration and synthesis method on the thermometric properties of $ZnP_2O_7:Eu^{3+}$ will be investigated.

Acknowledgements: This work was supported by the National Science Center (NCN) Poland under project no. DEC-UMO- 2022/45/B/ST5/01629.

[1] M. Back, J. Ueda, J. Xu, D. Murata, M. G. Brik, S. Tanabe, *ACS Appl. Mater. Interfaces* (2019**)**, *11*, 38937.
[2] L. Marciniak, W. Piotrowski, M. Szalkowski, V. Kinzhybalo, M. Drozd, M. Dramicanin, A. Bednarkiewicz, *Chem. Eng. J.* (2022**)**, *427*, 131941.

corresponding author: a.javaid@intibs.pl

Optical properties of Ni^{2+} Short-Wave Infrared emission under extreme conditions

Mikołaj Kamiński[1#], Ru-Shi Liu[2], Sebastian Mahlik[1]

[1]Institute of Experimental Physics, Faculty of Mathematics, Physics and Informatics, University of Gdansk,
Wita Stwosza 57, 80-308 Gdansk, Poland
[2]Department of Chemistry, National Taiwan University, Taipei 106, Taiwan

Phosphor-converted infrared light-emitting diodes (pc-LEDs) mark a promising departure from conventional semiconductor LEDs based on InGaAs and GaAs, as well as traditional infrared light sources like tungsten halogen lamps and laser diodes. They offer improved versatility and temperature stability. As a result, there is a growing demand for pc-LED light sources capable of emitting broadband SWIR light within the 900–1700 nm range. These advancements would open up exciting possibilities in spectroscopy, optical coherence tomography, optical communication, and noninvasive medical imaging applications. Therefore, the quest for the most efficient phosphor is paramount.

Among the ions investigated for these applications, Ni^{2+} stands out as exceptionally promising, thanks to its wide emission range spanning from 1000 to 1700 nm. Significantly, systems combining both Cr^{3+} and Ni^{2+}, utilizing energy transfer between them, have showcased improved overall luminescence.[1,2] Achieving optimal phosphor efficiency necessitates a deeper understanding of the optical properties of Ni^{2+}.

In this study, we present an investigation focused on $MgGa_2O_4$:Cr^{3+}, Ni^{2+} with Al^{3+} and Sn^{4+} cation dopants. Our research integrates high-pressure measurements with temperature-dependent analyses and luminescence kinetic measurements. The objective is to elucidate how the crystal field strength influences optical properties and to explore the mechanisms behind thermal quenching. Moreover, we change the chemical pressure by incorporating smaller Al or larger Sn ions or into the crystal lattice and compare this process with externally applied pressure using the Diamond Anvil Cell. As both the concentration of Al^{3+} and mechanical pressure increase, a noticeable blueshift of the $^3T_2 \rightarrow {}^3A_2$ transition emerges, while the incorporation of Sn^{4+} results in opposite effect i.e. the redshift of the Ni^{2+} emission. Finally, we present a comparison between the temperature-dependent total integrated intensity and calculated decay times, considering their implications for thermal quenching.

[1] Y.-T. Tsai, P.-X. Chen, M. Kamiński, N. Majewska, S. Mahlik and M.-H. Fang, *ACS Appl. Opt. Mater.*, , DOI:10.1021/acsaom.3c00464.
[2] C.-Y. Chang, M.-H. Huang, K.-C. Chen, W.-T. Huang, M. Kamiński, N. Majewska, T. Klimczuk, J.-H. Chen, D.-H. Cherng, K.-M. Lu, W. K. Pang, V. K. Peterson, S. Mahlik, G. Leniec and R.-S. Liu, *Chem. Mater.*, 2024, 36, 3941–3948.

corresponding author: mikolaj.kaminski@phdstud.ug.edu.pl

Optical properties of lead-free $Cs_2Na_{0.6}Ag_{0.4}InCl_6:Bi^{3+}$ double perovskite.

Paulina Kapuśniak[1#], Emeric C. C. Kiss[1], Andrzej Suchocki[2], Yaroslav Zhydachevskyy[2],
Jing Wang[3], Chong-Geng Ma[4], Mikhail G. Brik[1], Piotr Brągiel[1], Michał Piasecki[1]

[1]Institute of Physics, Jan Dlugosz University in Czestochowa, Poland
[2]Institute of Physics, Polish Academy of Science, Warsaw, Poland
[3]State Key Laboratory of Optoelectronic Materials and Technologies, Sun Yat-sen University, China
[4]Chongqing University of Posts and Telecommunications, Chongqing, China

Perovskite materials have emerged as a focal point in materials science owing to their exceptional optical and electronic attributes. Metal-halide double perovskite (MHDPs) are recently booming as promising alternatives for Pb-based halide-perovskite for their non-toxicity and significantly enhanced chemical and thermodynamic stability[1]. Alloyed lead-free double perovskite display intense photoluminescence are environmentally friendly and their devices show long-term operation. Among these perovskites $Cs_2Na_{0.6}Ag_{0.4}InCl_6:Bi^{3+}$ has emerged as a particularly promising candidate. This specific composition offers unique opportunities for exploration, especially in the realm of photovoltaics and LED technology[2]. Luo et al. found that the cation exchange reaction i.e., the partial exchange of Ag^+ with Na^+ cations, results into the break of the parity-forbidden transition. Adding Na^+ alloy and incorporating Bi^{3+} into the perovskite network improves the intense warm white emission of $Cs_2Na_{0.6}Ag_{0.4}InCl_6$ originating from sells-trapped exciting. Investigating the properties and behaviour of $Cs_2Na_{0.6}Ag_{0.4}InCl_6:Bi^{3+}$ is thus essential for advancing our understanding of perovskite materials and unlocking their full potential for practical applications in renewable energy and LED technology[3].

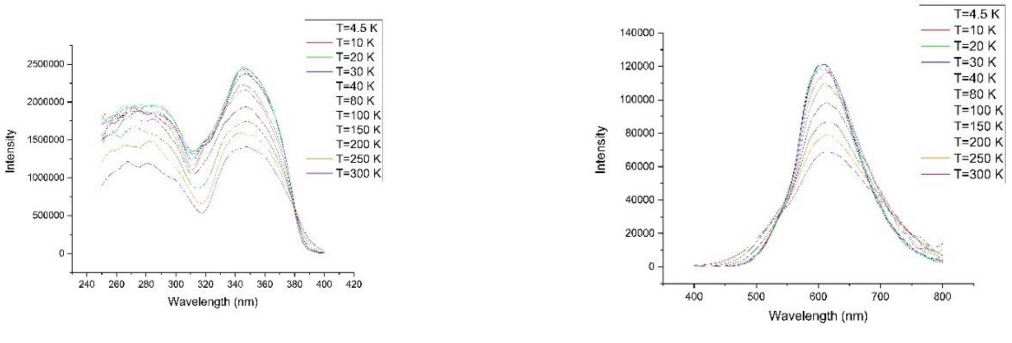


Figure 1. PLE and PL spectra of different temperatures for $Cs_2Na_{0.6}Ag_{0.4}InCl_6:Bi^{3+}$.

Acknowledgments: This work was partially supported by Polish National Science Center program SHENG2 of Poland-China cooperation, project number: 2021/40/Q/ST5/00336.

[1] L. Wang, C. Running et al., (2022), AFM, 32(22), 211338.
[2] R.S. Liu, K. Dave et al., (2022), Nanoscale, 14(47), 17735-117742.
[3] S. Xu, B. Chen et al., (2023), SAA, 288, 122181.

corresponding author: paulina.kapusniak@doktorant.ujd.edu.pl

Structure and photocatalytic properties of black titania nanotubes

R. Karpicz[1#], M. Ivanovskaya[2], S. Poznyak[2], E. Ovodok[2], D. Kotsikau[3]

[1]Center for Physical Science and Technology, Savanorių pr. 231, LT-02300 Vilnius, Lithuania
[2]Research Institute for Physical Chemical Problems of the Belarusian State University,
Leningradskaya str. 14, 220006, Minsk, Belarus
[3]Belarusian State University, Nezavisimosti av. 4, 220030, Minsk, Belarus

The structural features of white, blue-gray, and black titanium dioxide nanotubes (TiO_2NTs) obtained under different heat treatment conditions [1] were studied to establish the reason for their different photo- and electrocatalytic activity in the oxygen reduction reaction. Changes in color and photo- and photoelectrocatalytic properties of colored TiO_2 nanomaterials are associated with the presence of oxygen vacancies, Ti^{3+} ions, surface Ti–OH groups, and (or) Ti–H groups, impurities (such as N, C, F), or a combined effect of all of these factors. As a rule, electrochemical oxygen reduction in alkaline solutions on TiO_2 electrodes occurs directly through one reduction peak at potentials of about −0.8 V. On black TiO_2NTs obtained by heating in H_2, oxygen reduction occurs at −0.5 V and −0.8 V. A decrease in the potential for electrocatalytic reduction of oxygen, a change in the mechanism of the process, and an increase in current density take place at about −0.8 V. An increase in the photocurrent is also observed upon irradiation with $\lambda > 420$ nm [2]. The peculiarities of its surface structure cause the change in the mechanism of oxygen reduction on black TiO_2NTs. The influence of the structural rearrangement of the TiO_2 surface and carbon impurities on the color and properties of black TiO_2NTs is considered, and the participation of carbon itself in the catalytic reaction is also discussed. Carbon is included in the composition of TiO_2NTs during their formation in an ethylene glycol electrolyte.

Acknowledgment: Himreagent 2021–2025 No. 2.1.04.02; Horizon Europe FLORIN No. 101086142.

[1] Ivanovskaya M., Chernyakova K., Ovodok E., Poznyak S., Kotsikau D., Micusik M. (2023) Mater. Chem. Phys, 297, 127416–10.

[2] Maltanava H. M., Konakov A. O., Gaevskaya T. V., Belko N. V., Samtsov M. P., Poznyak S. K. (2023) J. Appl. Spectr., 90, 882–896.

[#] corresponding author: renata.karpicz@ftmc.lt

Carbon states in the anodic alumina films formed in electrolytes containing formic acid

Katsiaryna Chernyakova, Ieva Matulaitienė, Giedre Grincienė, Arūnas Jagminas,
Renata Karpicz[#]

Centre for Physical Sciences and Technology, Sauletekio av. 3, LT-10257 Vilnius, Lithuania

The carbon obtained during the aluminum anodic oxidation in formic acid with ammonium heptamolybdate or oxalic acid additives and embedded in the oxide matrix exists as luminescent and biocompatible carbon nanoparticles with a diameter of 20–25 nm that can be extracted from the initial films. The films have a wide blue fluorescence in the wavelength range of 350–700 nm with a maximum at ca. 460 nm. The fluorescence decay is non-exponential and has an average lifetime of 1.54 and 1.59 ns for ammonium heptamolybdate and oxalic acid, respectively. The fluorescence spectrum is a superposition of several decay components. Besides oxygen vacancies, these are hydroxyl, carbonyl, and carboxylate groups. Carbon nanoparticle solutions also exhibit an excitation-dependent emission behavior at 280–450 nm excitation wavelengths with average lifetimes of 7.25–8.04 ns, depending on the composition of the initial film. Since the carbon nanoparticles were obtained by the dissolution of anodic alumina films without additional treatment, such as ultrasonication, we can conclude that carbon is obtained during the anodic oxidation of formate ions and is incorporated in the alumina in the form of amorphous carbon that can be extracted from the initial films. The alumina matrix significantly quenches the fluorescence of the embedded carbon.

Acknowledgment: the Research Council of Lithuania (Grant No. S-MIP-23-70).

[#] corresponding author: renata.karpicz@ftmc.lt

Luminescence of $Bi_3TeBO_9:Yb^{3+}$ phosphors

Dobrosława Kasprowicz[1#], Taras Zhezhera[1], Paweł Głuchowski[2], Marek Nowicki[1,3],
Maciej Chrunik[4], Barbara Szczęśniak[5], Andrzej Majchrowski[4]

[1]Faculty of Materials Engineering and Technical Physics, Poznan University of Technology, Poznan, Poland
[2]Institute of Low Temperature and Structure Research of Polish Academy of Sciences, Wroclaw, Poland
[3]Center for Advanced Technology, Adam Mickiewicz University, Poznan, Poland
[4]Institute of Applied Physics, Military University of Technology, Warsaw, Poland
[5]Institute of Chemistry, Military University of Technology, Warsaw, Poland

Investigated series of $Bi_3TeBO_9:Yb^{3+}$ μ-crystalline powders are bifunctional materials, exhibiting nonlinear optical properties of Bi_3TeBO_9 matrix [1] and effective luminescence of active Bi^{3+} and Yb^{3+} ions. $Bi_3TeBO_9:Yb^{3+}$ μ-crystalline powders were prepared using modified Pechini method. The hexagonal structure of $P6_3$ space group of Bi_3TeBO_9 μ-crystalline powders was confirmed using XRD measurements [2]. In this paper, we present the results of investigation of luminescence of $Bi_3TeBO_9:Yb^{3+}$ μ-crystalline powders studied by optical spectroscopy methods. The vibrational properties of investigated samples were studied using μ-Raman spectroscopy. The results indicate a potential use of $Bi_3TeBO_9:Yb^{3+}$ as spectral converters in new generation photovoltaic devices.

Acknowledgement: This work was supported by the Research Project of the Ministry of Higher Education of the Republic of Poland: 0511/SBAD/2451.

[1] Xia M, Jiang X, Lin Z and Li R, (2016), J. Am. Chem. Soc., 138(43), 14190–14193.
[2] Kasprowicz D, Zhezhera T, Lapinski A, Chrunik M, Majchrowski A, Kityk A V and Shchur Ya, (2019), J. Alloys Comp., 782, 488–495.

corresponding author: dobroslawa.kasprowicz@put.poznan.pl

Effect of Ag co-doping on Pr^{3+} luminescence in lithium tetraborate glasses

I. I. Kindrat[1#], B. V. Padlyak[1,2], R. Lisiecki[3], A. Drzewiecki[1], V. T. Adamiv[2]

1 University of Zielona Góra, Institute of Physics, 4a Szafrana Str., 65-516 Zielona Góra, Poland
2 Ivan Franko National University of Lviv, Vlokh Institute of Physical Optics,
23 Dragomanov Str., 79-005 Lviv, Ukraine
3 Institute of Low Temperature and Structure Research of the Polish Academy of Sciences,
Division of Optical Spectroscopy, 2 Okólna Str., 50-422 Wrocław, Poland

The spectroscopic and luminescent properties of the Pr-doped and Pr-Ag co-doped lithium tetraborate ($Li_2B_4O_7$ or $Li_2O–2B_2O_3$) glasses have been detailed studied using electron paramagnetic resonance (EPR), optical absorption, photoluminescence (emission, excitation, decay kinetics) and Judd–Ofelt analysis [1]. The optical absorption spectra of the investigated glasses show several $4f – 4f$ absorption bands related to Pr^{3+} ($4f^2$, $^3H_4$) ions. Co-doping with Ag leads to a significant increase of optical absorption in the visible and partly in the near infrared (NIR) regions due to effects of light scattering and surface plasmon resonance (SPR) absorption induced by silver nanoparticles.

The orange-red Pr^{3+} emission band with a maximum at 601 nm ($^1D_2 \rightarrow {}^3H_4$ transition) and a lifetime of 22 μs dominates in the luminescence spectra. An increase in the intensity of the Pr^{3+} luminescence in 40 % and 3 – 4 times upon excitation at 445 nm ($^3H_4 \rightarrow {}^3P_2$ transition) and at different photoexcitations in the UV region was observed in the $Li_2B_4O_7$:Pr,Ag glass in comparison with the $Li_2B_4O_7$:Pr glass. Based on the obtained experimental results and Judd–Ofelt theory, the experimental and theoretical oscillator strengths (f_{exp} and f_{theor}), phenomenological parameters (Ω_2, Ω_4, Ω_6), radiative properties (A_{rad}, β, τ_{rad}) and quantum efficiencies (η) of the Pr^{3+} luminescence were calculated.

The presence of isolated Ag^+ ($4d^{10}$, $^1S_0$) ions, small non-plasmonic Ag aggregates (Ag_m^{n+} nanoclusters) and plasmonic Ag metallic nanoparticles in the $Li_2B_4O_7$:Pr,Ag glass was proposed based on detailed analysis of optical absorption, photoluminescence spectra and decay curves. The observed enhancement of luminescence intensity as well as increase of stimulated emission cross-section and quantum efficiency of luminescence in the $Li_2B_4O_7$:Pr,Ag glass are explained by excitation energy transfer from Ag^+ ions and Ag aggregates to Pr^{3+} ions as well as local-field effect induced by Ag metallic nanoparticles. Silver co-doping is a promising approach to improve the luminescent properties of Pr^{3+} ions in borate glasses.

Acknowledgements. This work is supported by the Ministry of Education and Science of Ukraine (project number 0122U001833) and the National Science Centre of Poland (project number DEC-2023/07/X/ST3/00737).

[1] Kindrat I.I., Padlyak B.V., Lisiecki R., Drzewiecki A., Adamiv V.T. (2022) J. Lumin., 241, 118468.

corresponding author: igor.k.physics@gmail.com, I.Kindrat@if.uz.zgora.pl

Luminescence properties of $Rb_2SnCl_6:Te^{4+}$ at high pressures

Emeric. C. C. Kiss[1], Paulina K. Kapusniak[1], Andrzej Suchocki[2], Yaroslav Zhydachevskyy[2], Jing Wang[3], Chong-Geng Ma[4], Michał Piasecki[1], Mikhail G. Brik[5], Calin Avram[6]

[1]Institute of Physics, Jan Dlugosz University Czestochowa, Czestochowa, Poland
[2]Institute of Physics, Polish Academy of Sciences, Warsaw, Poland
[3]State Key Laboratory of Optoelectronic Materials and Technologies, School of Chemistry,
Sun Yat-sen University, Guangzhou, China
[4]Chongqing University of Posts and Telecommunications, Chongqing, P. R. China
[5]Institute of Physics, University of Tartu, Tartu, Estonia
[6]Department of Physics, West University of Timisoara, Timisoara, Romania

Prior research by S. Si et al. [1] has proven the efficacy of these materials as laser-active media for high-power lasers, attributable to their 70% PLQY. In this study, we investigated the luminescence properties of $Rb_2SnCl_6:Te^{4+}$ under varying conditions. We conducted a comprehensive analysis of the PL emission over a range of pressures and temperatures. The objective was to determine if the luminescence intensity of $Rb_2SnCl_6:Te^{4+}$ could be enhanced under these conditions. Figure 1a illustrates the PL spectra measured at 10 K across pressures from 0.09 to 4.64 GPa. We observed a consistent blue shift in the emission wavelength as pressure increased. Initially, there was a quenching of luminescence up to 2 GPa, beyond which the intensity of the emission began to rise with increasing pressure. In contrast, the temperature-dependent PL spectra (Figure 1b) were measured from 4.5 to 300 K with an excitation wavelength of 385 nm. The maximum intensity was observed at 20 K with a peak emission at 575 nm. As the temperature increased, the emission intensity decreased, with the peak shifting to 580 nm at 300 K. These findings indicate that pressure can influence the luminescence properties of $Rb_2SnCl_6:Te^{4+}$, potentially enhancing its intensity under specific conditions.

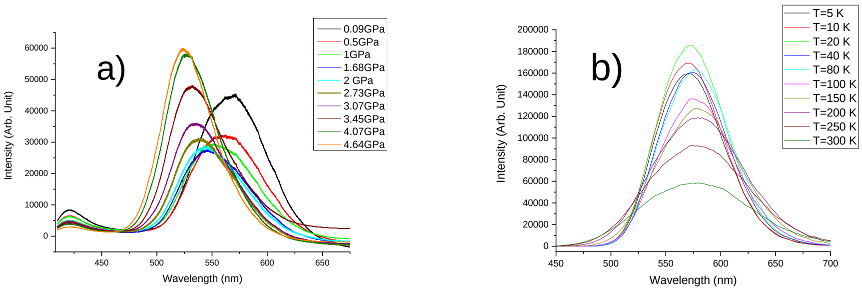


Figure 1. Photoluminescence spectra under pressure (a) and temperature (b).

Acknowledgments: This work was partially supported by the Polish National Science Center program SHENG2 of Poland-China cooperation, project number: 2021/40/Q/ST5/00336.

[1] S. Si et al., (2022), Journal of Luminescence, 251, 119212.

corresponding author: emeric.kiss98@e-uvt.ro, kiss.emeric@doktorant.ujd.edu.pl

Magnetite electronic structure from multi-configurational ab-initio calculation

Kamil Nalikowski[1], Jakub Kłos[2], Wit Krośnicki[3], Valera Veryazov[4], Marek Krośnicki[1#]

[1]Institute of Theoretical Physics and Astrophysics, Faculty of Mathematics, Physics and Informatics,
University of Gdańsk, ul. Wita Stwosza 57, 80-308 Gdańsk, Poland
[2]I Liceum Ogólnokształcące im. Mikołaja Kopernika w Gdańsku, ul. Wały Piastowskie 6
[3]X Liceum Ogólnokształcące im. Gdyńskich Nauczycieli Bohaterów II Wojny Światowej w Gdyni,
ul. Władysława IV 58
[4]Division of Theoretical Chemistry, Chemical Centre, Lund University, P. O. Box 124,
SE-22100 Lund, Sweden

Magnetite's structure (Fe_3O_4) has been known since 1915 [1]. It is assumed to form an inverse spinel structure which is usually represented as $B^{III}(A^{II}B^{III})O_4$. Trivalent iron ions completely occupy the tetrahedral sites, while the octahedral sites are randomly populated by both trivalent and divalent ions. In our study, we have examined one of the possible configurations for the distribution of these multivalent ions. In this work ground state energy is calculated for different spin multiplicity available for a given size cluster. It is shown that there exists an optimal high spin multiplicity for which the electronic energy of the system is the lowest. Excited state calculations show a very dense state population, resulting in a narrow band gap close to the experimental result.

The problem of valency and oxidation state of an atom in a crystal is discussed in context of quantum chemical calculations [2] of bulk Fe_3O_4 in embedded cluster approach. Results of the calculations for high spin ground state support experimental valency. We employed the MOLCAS software package [3] for our calculations, particularly the recent implementation of the SCEPIC (Self-Consistent Embedded Potential for Ionic Calculation) program [4].

[1] Bragg W. H. (1915) Nature, 95, 561
[2] Veryazov V., Everestov R. A. (1991) Theor. Chim. Acta, 81, 95-103
[3] Manni G. L. et al. (2023) J. Chem. Theory Comput 19, 20, 6933-6991
[4] Larsson E. D. , Krośnicki M. , Veryazov V. (2022), A program system for self-consistent embedded potentials for ionic crystals, Chem. Phys. 562, 111549

corresponding author: marek.krosnicki@ug.edu.pl

New core-shell nanocomposites - synthesis, characterization, and fluorescence properties

Agata Kowalska[1], Elżbieta Adamska[1], Piotr Bojarski[2], Beata Grobelna[1], Anna Synak[2#]

[1]Faculty of Chemistry, University of Gdansk, Wita Stwosza 63, 80-309 Gdańsk, Poland
[2]Faculty of Mathematics, Physics, and Informatics, University of Gdansk, Wita Stwosza 57, 80-308 Gdańsk, Poland

Core-shell nanostructures described in this work can be specially designed for fluorescence application e.g. for excitation energy transfer studies [1]. They are made of two or more materials, with the inner material acting as the core and the outer material acting as the shell. The role of the core is most often played by metallic nanoparticles such as Ag or Au, while the shell may be inorganic metal oxides or organic polymers coats. [2]. In this work, we present the synthesis and characterization of new Au@SiO_2 nanocomposites as a base for modification by strongly fluorescent compounds to use as a part of probes in the fields of bioassays and bioimaging shortly.

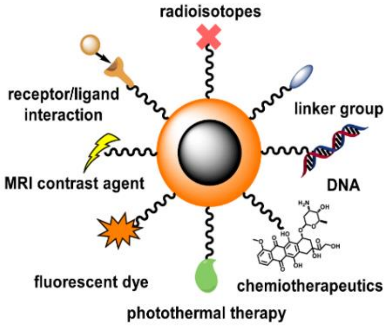


Figure 1. Examples of possibilities for modifying core-shell nanostructures [1].

This material was prepared by the sol-gel method and was characterized by TEM microscopy, UV-Vis, and infrared spectroscopy (IR). Moreover, we conducted the angle measurements due to the strong relationship between the level of surface wettability and cell adhesion efficiency. In addition, the main characteristics of luminescence provide information on their behavior in new environments.

[1] Synak A.; Adamska E.; Kułak, L.; Grobelna, B.; Niedziałkowski P., and Bojarski P. New core-shell nanostructures for FRET studies: synthesis, characterization, and quantitative analysis, International Journal of Molecular Sciences 23 (2022) 1-13
[2] Kowalska, A.; Adamska, E.; Grobelna, B. "Medical Applications of Silver and Gold Nanoparticles and Core-shell Nanostructures Based on Silver or Gold Core: Recent Progress and Innovations" (2024) ChemMedChem e202300672.

corresponding author: anna.synak@ug.edu.pl

Titanate-germanate glasses doped with rare earth ions for infrared photonics

Karolina Kowalska#, Marta Kuwik, Joanna Pisarska, Wojciech A. Pisarski

University of Silesia, Institute of Chemistry, Szkolna 9 Street, 40-007 Katowice, Poland

The family of low phonon barium gallo-germanate glasses (GBG) [1] has been chosen in this study due to the possibility of substituting GeO_2 by TiO_2, playing the role of network-modifier or network-former, depending on its concentration [2, 3]. The optical results confirmed significantly enhanced the near-IR emission bands located at 1.06 μm (Nd^{3+}: $^4F_{3/2} \rightarrow {}^4I_{11/2}$), 1.53 μm ($Er^{3+}$: $^4I_{13/2} \rightarrow {}^4I_{15/2}$), 1.80 μm ($Tm^{3+}$: $^3F_4 \rightarrow {}^3H_6$) and 2 μm ($Ho^{3+}$: $^5I_7 \rightarrow {}^7I_8$) in the function of TiO_2 in GBG system. Several spectroscopic and laser parameters for rare earth ions were determined. Discussed phenomena are important from scientific and technological points of view, contributing to the development of scientific research in glass science and modern photonics. The studies confirmed that rare earth-doped titanate-germanate glasses offer excellent near-IR luminescence properties and could be successfully applied to laser technology.

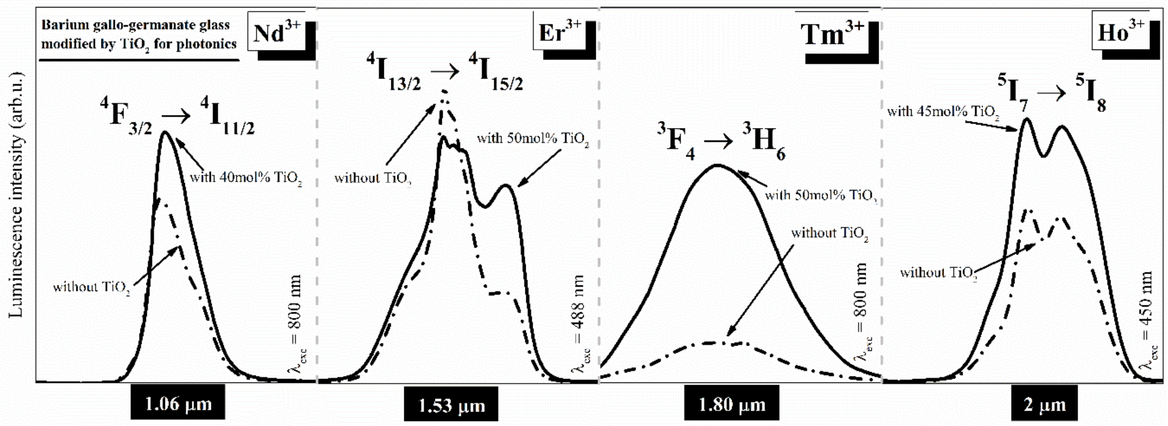


Fig. Near-IR luminescence spectra due to main laser transition of Nd^{3+}, Er^{3+}, Tm^{3+} and Ho^{3+} ions in novel titanate-germanate glasses.

Acknowledgment: This research was funded by National Science Centre (Poland), grant number 2018/31/B/ST8/00166.

[1] Pisarska J., Sołtys M., Górny A., Kochanowicz M., Zmojda J., Dorosz J., Dorosz D., Sitarz M., Pisarski W.A. (2018) Spectrochim. Acta, Part A 201, 362-366
[2] Pisarski W.A., Kowalska K., Kuwik M., Polak J., Pietrasik E., Goryczka T., Pisarska J. (2020) Materials, 13, 4422.
[3] Toloman D., Suciu R., Leostean C., Regos A., Ardelean I. (2014) Phys. B 438, 84–87

corresponding author: karolina.kowalska@us.edu.pl

Examining Ambipolar, Nitrogen-Doped Polycyclic Aromatic Hydrocarbons for Enhanced Efficiency in TADF OLED Emission

Dharmendra Kumar[1], Marcin Lindner[2], Przemyslaw Data[1]

[1]Department of Molecular Physics, Faculty of Chemistry, Lodz University of Technology,
Stefana Zeromskiego 114, Lodz 90-543, Poland.
[2] Institute of Organic Chemistry, Polish Academy of Sciences, Kasprzaka 44/52, Warsaw 01-224, Poland.

Recently, researchers have shown increasing interest in thermally activated delayed fluorescence (TADF) materials, especially for their potential in advancing organic light-emitting diodes (OLEDs) [1]. These materials utilise electrically generated triplet excitons, converting them into emissive singlet excitons through reverse intersystem crossing (rISC) and receiving IQE of up to 100%. Our investigation explores how the electron-donating capabilities of a novel class of emitters, nitrogen-doped polycyclic aromatic hydrocarbons (PAHs), affect their photophysical properties. These molecules aim to narrow the gap between the highest occupied (HOMO) and lowest unoccupied molecular (LUMO) orbitals, resulting in minimal singlet-triplet gaps (ΔE_{ST}), crucial for efficient rISC operations [2]. All compounds examined displayed small ΔE_{ST} values ranging from 0.03 to 0.37 eV, indicating favourable TADF properties. To characterise these nitrogen-doped PAHs, we conducted comprehensive analyses, including electrochemistry, photophysical, and device fabrication. By modifying the molecular structure with various electron-donating groups, we could control the luminescence mechanism, shifting between TADF and room-temperature phosphorescence (RTP) and enhancing photoluminescence quantum yields (PLQY) up to 96% in solid thin film matrices such as Zeonex® and CBP. Time-resolved spectroscopy performed on these matrices revealed detailed emission properties of the compounds. To demonstrate feasibility, we constructed solid-state OLED devices using CBP as the host material. We achieved a turn-on voltage of around 4.0 V and reached a maximum external quantum efficiency (EQE) of up to 21.9% by incorporating phenothiazine as the donor component.

[1] Xian-Kai Chen, Dongwook Kim, and Jean-Luc Brédas, 2018 51 (9), 2215-2224
[2] Jakub Wagner, Paola Zimmermann Crocomo, Michal Andrzej Kochman, Adam Kubas, Przemyslaw Data, Marcin Lindner, 2022, 61, e 202202232

corresponding author: dharmendra.kumar@dokt.p.lodz.pl; przemyslaw.data@p.lodz.pl; marcin.lindner@icho.edu.pl

Dual role of oxygen-related defects in luminescence kinetics of AlN:Mn^{2+}

Agata Lazarowska[1#], Mikołaj Kamiński[1], Nerine J. Cherepy[2], Sebastian Mahlik[1],
Ru-Shi Liu[3]

[1]Institute of Experimental Physics, University of Gdansk, Wita Stwosza 57, 80-308 Gdansk
[2]Lawrence Livermore National Laboratory, Livermore, CA, 94550, United States
[3]Department of Chemistry, National Taiwan University, Taipei 106, Taiwan

This study presents the impact of temperature and pressure on AlN:Mn^{2+} luminescence kinetics. Unusual behaviour of Mn^{2+} optical properties during UV excitation is observed, where a strong afterglow luminescence of Mn^{2+} occurs even at low temperatures. When the temperature increases, the contribution of afterglow luminescence is further enhanced, causing a significant increase in the luminescence intensity. The observed phenomena may be explained by an energy diagram in which O_N -V_{Al} complex in AlN:Mn^{2+} plays a key role. Hence the O_N -V_{Al} complex defect in AlN:Mn^{2+} plays a double function. When the O_N -V_{Al} defect is located close to Mn^{2+} ion, it is responsible for transferring excitation energy directly to Mn^{2+} ions. However, when the O_N -V_{Al} defect complex is located far from Mn^{2+} ions, its excited state level acts as an electron trap responsible for afterglow luminescence. Additionally, three models have been tested to explain the structure of the emission spectrum and the strong asymmetry between excitation and emission spectra. From the most straightforward configuration coordinate diagram through the configuration coordinate diagram model assuming different elastic constants in the excited and ground-state ending by a model based on Jahn –Teller effect. We proved that only the Jahn–Teller effect in the excited $^4T_1$ electronic state with spin-orbit coupling could fully explain the observed phenomena. Finally, high-pressure spectroscopic results complemented by the calculation of Racah parameters and the Tanabe-Sugano diagram are presented.

[#] corresponding author: agata.lazarowska@ug.edu.pl

Full energy structure of the Cr^{3+} activator in $Cs_2NaInCl_6$ double halide perovskite host under pressure

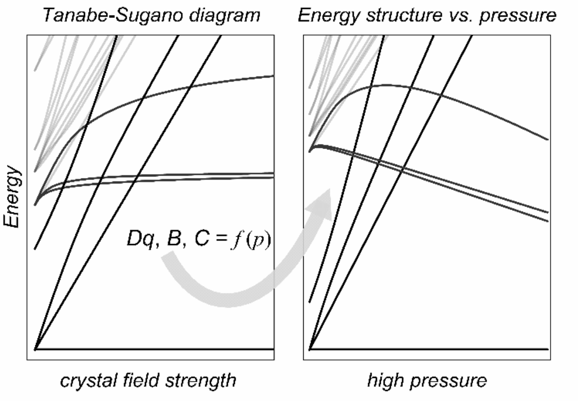
T. Leśniewski[1,2], M. Mazurek[2], N. Górecka[2], K. Szczodrowski[2], S. Mahlik[2]

[1]Faculty of Physics, Kazimierz Wielki University in Bydgoszcz, Powstańców Wielkopolskich 2,
85-090, Bydgoszcz, Poland
[2]Institute of Experimental Physics, Faculty of Mathematics, Physics and Informatics, University of Gdansk,
Wita Stwosza 57, 80-308 Gdansk, Poland

Applying pressure is one of the methods to alter the spectroscopic properties of optical materials activated with transition metal (TM) ions. The energies of electronic transitions of a d^n TM ion are described by an appropriate Tanabe-Sugano (TS) diagram, and the effect of pressure can be superficially understood as increasing the crystal field strength (Dq), i.e. moving right on the TS diagram. The reality is more complex since pressure also affects the mutual electrostatic iteration of the d^n electrons in the TM ion (nephelauxetic effect). This is described by Racah parameters B and C, which can be obtained experimentally.

In this work I report the effect of pressure on radiative transitions in double halide perovskites $Cs_2NaInCl_6$ activated with Cr^{3+} (d^3), by means of high-pressure photoluminescence (PL) and photoluminescence excitation (PLE) spectroscopy. In these materials, a spectacular change between broadband to narrow line emission in the PL spectrum occurs at elevated pressure, resulting from crossover between the $^4T_2$ and ^2E states in the TS diagram.

In this research I am going one step further – utilizing high pressure PLE spectroscopy ton access some of the higher excited states of the system. This allows me to determine all three parameters: crystal field strength Dq, Racah parameters B and C, relevant to the energetic structure of the system. Finally, based on pressure dependence of the parameters, the pressure evolution of all energy levels of the Cr^{3+} dopant is determined, following the approach described in my previous work [1]. In effect an energy diagram of all the crystal field levels of Cr^{3+} dopant in halide perovskite matrix is constructed, which can be understood as the *true* TS diagram of the system, where abstract parameter Dq is replaced by pressure.



[1] Leśniewski T. (2023) Phys. Chem. Chem. Phys., 25, 14449–14462.

corresponding author: tadeusz.lesniewski@ug.edu.pl

Temperature Dependent Luminescence of $SrAl_{12}O_{19}:Eu^{2+},Eu^{3+},Cr^{3+}$ Thermometric Phosphors

Pola Łukaszczuk[1], Justyna Zeler[1], Małgorzata Sójka[1], Tadeusz Leśniewski,
Sebastian Mahlik[2], Mikhail Brik[3], Michał Piasecki[3], Eugeniusz Zych[1#]

[1]University of Wrocław, Faculty of Chemistry, 50-383 Wrocław, 14 F. Joliot-Curies Street, Poland
[2]Institute of Experimental Physics, Faculty of Mathematics, Physics and Informatics, University of Gdańsk,
Wita Stwosza 57, 80-308, Gdańsk, Poland
[3]Theoretical Physics Department, Jan Dlugosz University, Armii Krajowej 13/15,
42-200 Czestochowa, Poland

This research on inorganic phosphor $SrAl_{12}O_{19}$ doped with Eu^{2+}, Eu^{3+}, and Cr^{3+} presents exciting findings that could impact luminescent thermometry technology. This phosphor was characterized through photoluminescent measurements at temperatures from 12 – 1000 K, as well as at elevated pressures up to 30 GPa. The results revealed that Eu^{2+} and Eu^{3+} contributed to luminescence, and only the former's emission strongly depended on temperature. Cr^{3+} ions generated emission around 700 nm, and detailed studies at 12 K proved the presence of at least three sites of different symmetries. Figure 1 shows that their emissions differed in decay kinetics. The efficient $4f \rightarrow 5d$ absorption transition and energy transfer from Eu^{2+} to Cr^{3+} allow for effective excitation of their emissions, making the $SrAl_{12}O_{19}$ doped with Eu^{2+}, Eu^{3+}, and Cr^{3+} an attractive material for luminescent thermometer applications. High-pressure spectroscopy has demonstrated a negligible shift in the emission of Eu^{2+} and Eu^{3+}, indicating that the material could be used as a pressure-invariant luminescence temperature sensor in high-pressure environments. This research could have a significant impact on the field of luminescent thermometry, and the findings presented in this study will be discussed in detail to identify the most promising thermometric parameters available.

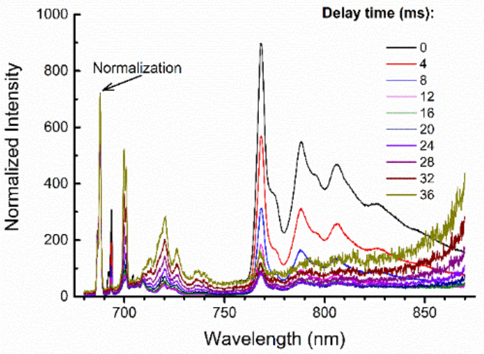


Figure 1. Time-resolved luminescence spectra of $SrAl_{12}O_{19}$ doped with Eu^{2+}, Eu^{3+}, and Cr^{3+} in the range of Cr^{3+} luminescence.

This research was financed by the Polish National Science Centre (NCN) under OPUS grant #2018/31/B/ST4/00924.

corresponding author: eugeniusz.zych@uwr.edu.pl

Spectroscopic and Photoelectric studies: Insights into Quenching Phenomena of NIR materials

Natalia Majewska, Sebastian Mahlik

Institute of Experimental Physics, Faculty of Mathematic, Physics, and Informatics, University of Gdańsk,
Wita Stwosza 57, 80-308 Gdańsk, Poland

Due to their potential applications in biology, Cr^{3+}-activated luminescent materials have recently gained significant attention worldwide. These materials, capable of producing either sharp-line or broadband spectra, are promising candidates for phosphor-converted infrared light-emitting diodes (pc-NIR LEDs) and have found use in food freshness, quality, and composition analysis. One of the primary objectives is to identify materials exhibiting efficient broadband near-infrared (NIR) luminescence. Understanding the quenching phenomena, which may be related to the crossing point between the ground state and excited state or to autoionization, is crucial for designing efficient NIR materials.

Ga_2O_3 activated by Cr^{3+} ions are promising material for NIR sources, characterized by efficient NIR luminescence in the 650–900 nm range, peaking at 740 nm. Here, luminescence and photoelectric studies are presented for Cr^{3+}-activated Ga_2O_3 modified with In^{3+}. Incorporating In^{3+} into the Ga_2O_3 matrix, with its larger ion radius, has enabled us to shift the maximum emission to 850 nm. In the excitation spectra, three bands were observed in the UV-Vis range. The band at 250-300 nm likely arises from overlapping emissions associated with band-to-band transitions, charge transfer (CT), and transitions to the higher state Cr^{3+} $^4T_1(4P)$ from the ground state $^4A_2$. Two additional bands in the visible range correspond to transitions $^4A_2 \rightarrow {}^4T_2$ and $^4A_2 \rightarrow {}^4T_1$ of Cr^{3+}. Similar transitions were observed in the photoconductivity spectrum, indicating the role of Cr^{3+} dopants in photocurrent generation. Furthermore, a shift towards longer wavelengths in the broad band between 250-300 nm was observed, indicating that as the In^{3+} concentration increases, the energy bandgap decreases.

Luminescence intensity measurements at different temperatures revealed that $Ga_2O_3:Cr^{3+}$ luminescence remains stable within the temperature range of 100-400 K but begins to decrease at higher temperatures. With increasing In^{3+} concentration, luminescence intensity starts to decrease even at lower temperatures, indicating earlier quenching of the sample. Analysis of temperature-dependent decay times confirms this trend, indicating non-radiative quenching of luminescence. Conversely, a reverse trend was observed in the photocurrent measurements, where the excitation spectrum intensity increases with temperature. Significant differences were also observed in the behavior of photocurrent intensity depending on In^{3+} content. Specifically, for materials with indium doping, photocurrent intensity increases significantly faster with temperature compared to $Ga_2O_3:Cr^{3+}$. These findings suggest that thermal quenching in these materials is not solely related to the crossing of the ground and excited state parabolas but is also associated with autoionization processes.

corresponding author: natalia.majewska@ug.edu.pl

Luminescence of the Sc^{3+} isoelectronic impurities and antisite defects in $(Y,Lu,Gd)_3Al_5O_{12}$ garnets

Artur Majewski-Napierkowski[1#], Jan Pejchal[2], Martin Nikl[2], Karol Bartosiewicz[1], Yuriy Zorenko[1]

[1]Faculty of Physics of Kazimierz Wielki University, 85-090 Bydgoszcz, Poland
[2]Institute of Physics, Czech Academy of Sciences, 16200 Prague, Czech Republic

The isoelectonic impuries (*IsIm*) can serve as very effective emission centers in UV range in semiconductors [1] and dielectrics [2]. Generaly, the ability of *IsIm* for the creation of emission centers is defined by the value of non-Coulomb potential (NCP) which appears due to the substitution of core ions by the *IsIm* in dodecahedral and octahedral positions of the garnet lattice. The value and sign of NCP depends on: i) ability of *IsIm* for the substitution of core cations in their regular positions of garnet host; ii) difference ΔR of ionic radii for *IsIm* and core cation and iii) variance between the core and electronic shell of *IsIm* and host cations [3]. Namely, at the reaching of critical value of NCP, the *IsIm* and aniti-site defects (ADs) such as Y_{Al}, Lu_{Al}, Sc_{Al}, Sc_Y or Sc_{Lu} cause the formation of separated levels in forbidden gap of the garnet host acting as centers for localization of host excitons and localization of the electrons or holes. The recombination of free carriers from the conduction and valence bands with the electrons or holes, localized at the mentioned centers leads to radiative annihilation of excitons *localized* and *bound* with *IsIm* and ADs and the appearance of the additional emission bands in UV range [4].

This work is the continuation of the previous studies [3, 4] on the regularities of the luminescence centers formation by the ADs and Sc^{3+} *IsIm* in the $(Y,Lu,Gd)_3Al_5O_{12}$ garnet compounds. Such regularities have been revealed also for the ADs (Y_{Al} , Lu_{Al} and Gd_{Al} in (Y,Lu,Gd)AG hosts), *as special kinds of IsIm* [3]. Creation of such type of ADs in the concentration even up to 0.25-0.3 at.% is the irrevocable consequence of the single crystals (SC) growth of these garnets from high-temperature melt at 1800-2000°C. Conversely, the single crystalline films (SCF) of these garnets grown by the liquid hase epitaxy (LPE) method are free from ADs due to low (~1000°C) temperature of their crystallization. Therefore, the SC and SCF of (Y,Lu,Gd)AG garnets are the convenient objects for the investigation of radiative relaxation of low-energy excitations in garnet compounds, in particular exciton luminescence, connected with *IsIm* and AD centers [3, 4].

Peculiarities of the luminescence and excitation energy transfer from the garnet host to the emission centers formed by Sc^{3+} *IsIm* and ADs have been studied in SCs and SCFs of undoped and Sc^{3+} doped (Y,Lu,Gd)AG garnets using convetional spectral methods as well as the luminescent spectroscopy under excitation by pulsed synchrotron radiation (SR) with energy in the 3.7-12.5 eV range at new Superlumi stations at P66 line at Pertra III storage rings at DESY, Germany.

Acknowledgement: This work was performed in the frame NCN OPUS 24 LAP 2022/47/I/ST8/ 02600 project and partly in the frame of MNSW Poland Regional Excellence Initiative RID/SP/0048/2024/01 project. The investigation at DESY was performed in the frame I-20220044 and I-20220864 EC proposals.

[1] S. E. Derenzo, E. Bourret-Courchesne, G. Bizarri, A. Canning, Bright and ultra-fast scintillation from a semiconductor?, NIM A805 (2016) 36–40.

[2] K.Shakhova, A. Panova, V.Goriletsky, Ya. Prikhod'ko, V. Gavrylyuk, S.. Korsunova, N.Kosinov, Luminescence and scintillation properties of Na-activated CsI–CsBr crystals. Radiation Measurements, 33 (2001) 769–771.

[3] Yu. Zorenko. Luminescence of isoelectronic impurities and antisite defects in garnets. Phys. Stat. Sol. (c), 2 (2005) 375-379

[4] Yu. V. Zorenko. Luminescence of La^{3+} and Sc^{3+} Isoelectronic Impurities in $Lu_3Al_5O_{12}$ Single Crystalline Films. Optics and Spectroscopy 100 (2006) 572-580.

corresponding author: arthur@ukw.edu.pl

Optical properties of $Cs_2NaInCl_6:Cr^{3+}$ for application in pc-LED infrared emitters

Michał Mazurek[#], Tadeusz Leśniewski, Natalia Górecka, Karol Szczodrowski,
Sebastian Mahlik

Institute of Experimental Physics, Faculty of Mathematics, Physics and Informatics, University of Gdansk,
Wita Stwosza 57, 80-308 Gdansk, Poland

In recent years, the materials development community has devoted considerable attention to the broad class of materials known as perovskites, notable for their distinctive crystal structure. To date, the perovskite-structured materials researched in both industry and academia have been primarily inorganic or hybrid organic-inorganic lead halides. These materials are highly promising for applications in the photovoltaic and lighting industries, such as light-emitting quantum dots. However, their potential is significantly limited by the presence of toxic elements, as well as their poor mechanical strength and chemical stability.

Another emerging class of perovskite materials, free of many of the aforementioned disadvantages, is the halide double perovskites. These materials hold great potential for use in the photonics industry due to their favorable optical properties, including a direct bandgap and efficient excitonic emission. Additionally, these materials can be doped with lanthanides or transition metals, further enhancing their potential applications.

In this study, we present the optical properties of $Cs_2NaInCl_6:Cr^{3+}$ synthesized using the hydrothermal method. The material exhibits broadband and efficient emission in the near-infrared range around 950 nm when excited by ultraviolet light around 325 nm, visible light around 560 nm, or near-infrared light around 800 nm. The research focused on determining the spectroscopic properties of $Cs_2NaInCl_6:Cr^{3+}$, including the temperature dependence of luminescence intensity and decay time. Additionally, the study examined show luminescence emission and excitation spectra vary with pressure. The investigated compound is suitable for use in phosphor-converted infrared LEDs (pc-LEDs), where the phosphor emits broadband infrared light when excited by a LED, typically InGaN. Such infrared emitters offer a promising alternative to traditional infrared LEDs based on InGaAs or GaAs and infrared light sources like tungsten halogen lamps in many branches of industry.

[#] corresponding author: michal.mazurek@phdstud.ug.edu.pl

Structure and luminescent properties of Dy^{3+}- doped $Ca_{10-2x}Dy_xLi_x(PO_4)_6O_2$ (0 ≤x≤1) oxyapatites for white LEDs application

M. Mehnaoui[1#], G. Yannick[2], G. Panczer[2], G. Boulon[2], R. Ternane[1]

[1]Laboratoire d'Application de la Chimie aux Ressources et Substances Naturelles et à l'Environnement (LACReSNE-LR05ES09), Université de Carthage, Faculté des Sciences de Bizerte,
7021 Zarzouna, Bizerte, Tunisia
[2]Institut Lumière Matière (ILM), UMR-CNRS 5306, Université Lyon1, F-69622 Villeurbanne Cedex, France.

Apatites with the general formula $M_{10}(PO_4)_6X_2$(M is a divalent cation and X is a halide) havea considerable flexibility in their elemental composition. The apatite lattice has two sites Ca(I) and Ca(II) available for cations localized in the 4(f) and 6(h) positions, respectively. This study describes the structure and luminescent properties of Dy^{3+}doped $Ca_{10-2x}Dy_xLi_x(PO_4)_6O_2$ (0 ≤ x ≤ 1)(CDLPO).The materials were prepared via conventional solid state reaction. The effects of synthesis parameters, Dy^{3+}concentration and charge compensator Li^+ co-doping on the structural and vibrational properties of samples were investigated.

The structural and morphological studies of the CDLPO phosphors were carried out by X-ray diffraction (XRD), Infrared spectroscopy, Raman scattering spectroscopyand Scanning Electron Microscopy (SEM). Calcium-oxyapatite system shows a common apatite structure and occurs as a continuous solid solution.

According to the Dy^{3+}emission spectra, two different cation sites have been identified in this apatite structure. Two emission bands of the Dy^{3+} ion are observed, the blue band (460–500 nm) corresponding to the $^4F_{9/2} \rightarrow {}^6H_{15/2}$ transition and the yellow band (550–600 nm) due to the $^4F^{9/2} \rightarrow {}^6H_{13/2}$ transition. The overlap between the emission band of one site and the excitation band of the other site corresponds to an energy transfer phenomenon.

The intense emission at 572 nm could be potentially used in apatites as a white emitting phosphor. Both blue and yellow emissions would constitute the white light [1]. Correlations between the luminescence results and the structural data are discussed.

[1] Wentao Zhang, Meng Yul, Zhongqi Wu, Yiqun Wang, Peicong Zhang. Journal of Materials Science: Materials in Electronics (2018) 29:8224-8233

corresponding author: mohamed.mehnaoui@fsb.ucar.tn

P40 **M. Mirczak**

Usage of deep learning in FTIR spectra analysis of functional groups

Szymon Mirczak[1], Jakub Bożek[1], Cezary Muszalski[1], Tomasz Urbańczyk[2],
Marek Krośnicki[1#]

[1] Institute of Theoretical Physics and Astrophysics, Faculty of Mathematics, Physics and Informatics,
University of Gdansk, st. Wita Stwosza 57, 80-308 Gdańsk, Poland
[2] Smoluchowski Institute of Physics, Jagiellonian University, ul. Prof. Stanisława Łojasiewicza 11,
30-348 Kraków, Poland

The Fourier transform in infrared spectroscopy (FTIR) stands as a common spectroscopic technique. Spectral interpretation, while it takes a lot of time, gives crucial insights into the functional groups existing within compounds and intricate substances. Our endeavour involves the development of distinct neural network models to examine their effectiveness in classification of FTIR spectra's affiliation with individual functional groups. These ML models allow us to reduce time of functional group analysis and foster the elucidation of FTIR spectra.

In our research we used 8728 gas-phase spectra from the NIST database[1], interpreting them as one-dimensional vectors. Successfully, we train models of CNN and DNN for the most prevalent functional groups, subsequently deducing their presence in the spectra, which were not used in the training process (we are comparing our results with this publication[2]). Such models serve to broaden the scope of FTIR measurements for facile analysis of organic.

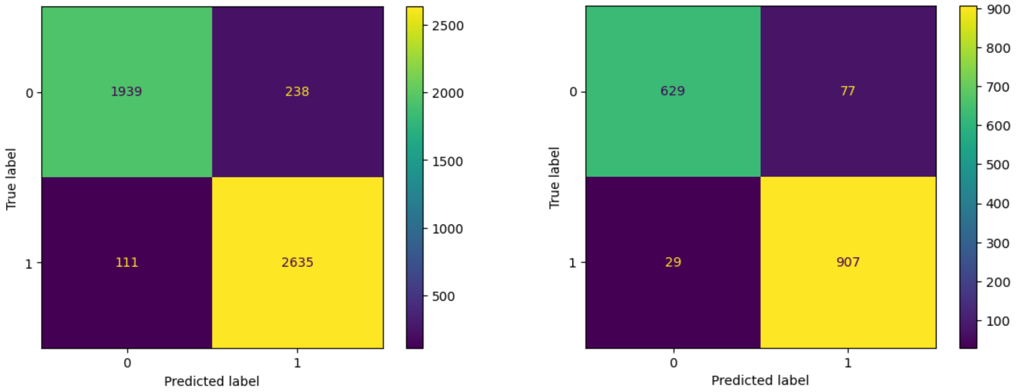


Figure 1 Accuracy of CNN model on training (left, ~96% success rate) and test (right, ~97% success rate) sets for aromatic compounds.

[1]: https://webbook.nist.gov/chemistry/
[2]: A. A. Enders et. al. Anal. Chem. 2021, 93, 28, 9711–9718

[#] corresponding author: marek.krosnicki@ug.edu.pl

Simultaneous generation of higher harmonics and upconversion luminescence in lanthanide-doped nanoparticles for optical coding and anti-counterfeiting applications

Jan Moszczyński[1#], Marcin Runowski[1], Przemysław Woźny[1], Inocencio R. Martín[2],
Kevin Soler-Carracedo[1,2], Teng Zheng[3], Sascha Feldmann[4]

1. Faculty of Chemistry, Adam Mickiewicz University, Uniwersytetu Poznańskiego 8,
Poznań 61-614, Poland
2. Departamento de Fisica, IUdEA, IMNand MALTA Consolider Team, Universidad de La Laguna,
San Cristobal de La Laguna, Santa Cruz de Tenerife E-38200, Spain
3. School of Information and Electrical Engineering, Hangzhou City University, Hangzhou 310015, China
4. Rowland Institute, Harvard University, 100 Edwin H. Land Boulevard, Cambridge, MA 02142, USA

Nonlinear optical materials currently play very crucial role in various fields like nanophotonics, optical information processing, biomedical imaging, and anti-counterfeiting. However, the presently used nanomaterials for these applications are effective only for a single type of nonlinear optical activity. Here, we report for the first time a new type of materials based on the $LiNbO_3:Ln^{3+}$–doped nanoparticles [1]. Our nanoparticles exhibit multiple efficient nonlinear optical activities, including SHG and THG, along with up-conversion photoluminescence at the same time. They maintain high efficiency optical activity independently if they are in the form of powder or in the form of the aqueous colloidal solution. Their high stability allows for the formation of optically active biocompatible fibers, polymer-based 3D-printed objects, and fingerprint detection. Additionally, we demonstrate the first 8-bit coding platform solely relying on the multimodal nonlinear optical activities from various processes. Furthermore this lanthanide-doped nanomaterial platform represents a significant advancement in the field of photonics and materials engineering. It has high potential usage in such areas like biomedicine, anti-counterfeiting, and optical information processing.

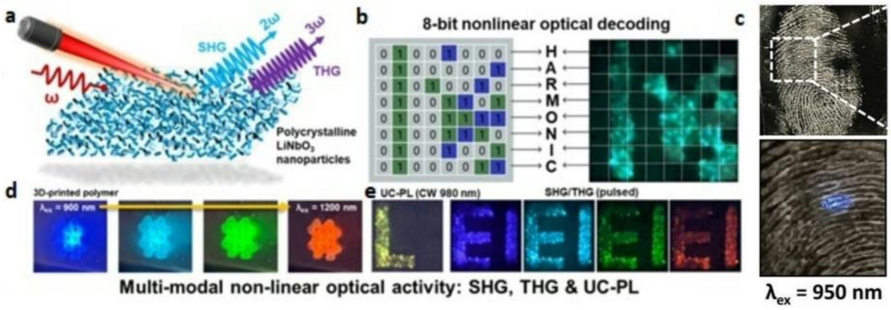


Fig. a. Generating Second and third Harmonic by LiNbO3 nanoparticles, b. 8-bit optical coding and decoding, c. Fingerprint disclosing d. 3D-printed polymer e. Up-conversion photoluminescence and SHG/THG encoding

[1] Runowski M., Woźny P., Martín I. R., Soler-Carracedo K., Zheng T., Hemmerich H., Rivera-López F, Moszczyński J., Kulpiński P., Feldmann S. (2024) Adv. Func. Mat., 34, 2307791

corresponding author: janmos1@st.amu.edu.pl

Ab-initio study of Thorium activator in CaF_2 crystal an outlook for electron-nuclear bridge process.

Kamil Nalikowski[1], Valera Veryazov[2], Marek Krośnicki[1#]

[1]Institute of Theoretical Physics and Astrophysics, Faculty of Mathematics, Physics and Informatics,
University of Gdańsk, ul. Wita Stwosza 57, 80-308 Gdańsk, Poland
[2]Division of Theoretical Chemistry, Chemical Centre, Lund University,
P. O. Box 124, SE-22100 Lund, Sweden

Thorium doped CaF_2 crystal has been recently heavily studied due to its possible application as a new time standard based on nuclear excitation of radioactive ^{229}Th isotope. Enhancing probability of excitation of nuclear isomer ^{229}Th (recently measured to be 8.35 eV [1]) requires resonance transmission of energy from electronic structure to nuclear hyperfine structure (electron bridge process). The process in theory allows for selective manipulation of hyperfine states via coupling with local electronic states induced by thorium activator in solid CaF_2 crystal. The process of doping thorium atom into the crystal matrix produces many defects which influence the absorption and emission spectra in UV and VUV spectrum. In our theoretical approach, a quantum cluster containing Th defect is being embedded into the pure CaF_2 crystal environment using ab-initio model potentials (AIMP). Electronic states are calculated utilizing multi-configurational wave function methods. In this work we discuss results of different charge compensation schemas of Thorium located in the cation site of CaF2 in the context of spectroscopic experimental data A special attention is paid to the valence of an activator located in CaF_2 lattice [2]. For the calculation we used MOLCAS software package [3], in particular the recent implementation of SCEPIC (Self-Consistent Embedded Potential for Ionic Calculation) program [4].

[1] Tiedau J. et. al. (2024) Phys. Rev. Lett. 132, 182501
[2] Veryazov V., Everestov R. A. (1991) Theor. Chim. Acta, 81, 95-103
[3] Manni G. L. et al. (2023) J. Chem. Theory Comput 19, 20, 6933-6991
[4] Larsson E. D. , Krośnicki M. , Veryazov V. (2022), A program system for self-consistent embedded potentials for ionic crystals, Chem. Phys. 562, 111549

corresponding author: marek.krosnicki@ug.edu.pl

Pressure-induced luminescence study of $MAPbBr_3$: Mn perovskites

S. Narayanan[1#], Ya. Zhydachevskyy[1], C. G. Ma[2], J. Wang[3], A. Suchocki[1]

[1] Institute of Physics, Polish Academy of Sciences, Al. Lotnikow 32/46, 02-668, Warsaw, Poland
[2] Chongqing University of Posts and Telecommunications,No. 2 Chongwen Road, Nan'an District, Chongqing 400065, P.R. China
[3] State Key Laboratory of Optoelectronic Materials and Technologies, School of Chemistry, Sun Yat-sen University, Guangzhou 510275, China

The excellent light-absorbing properties of hybrid organic-inorganic perovskites have been the subject of fundamental investigation in various research fields. Amongst these materials, $MAPbBr_3$ perovskite materials are significantly more stable. Doping Mn^{2+} into hybrid halide perovskites has attracted much attention since it makes it easier for energy to move from the host material to the dopants, producing interesting photophysical properties. This work explores the behavior of Mn-doped methylammonium lead bromide ($MAPbBr_3$) under stress using photoluminescence. Temperature-dependent luminescence study of $MAPbBr_3$: Mn exhibited main peaks ~ 389 nm, 402 nm associated with low intense peaks with high energy. Effects of hydrostatic pressure on photoluminescence characteristics were investigated by diamond anvil cells to achieve pressure as high as 10 GPa, providing insight into any possible phase transitions, and the pressure coefficient was found to be -0.012±0.001 eV/GPa. Origin of the various luminescence peaks and detailed analysis of the observed pressure dependence will be presented.

Acknowledgments: This work was partially supported by the Polish National Science Center program SHENG2 of Poland-China cooperation, project number: 2021/40/Q/ST5/00336.

[#] corresponding author: saranya@ifpan.edu.pl

Optical and luminescent properties of the paper filled with $SrAl_2O_4$:Eu,Dy oxide and carbon nanotubes

S. Nedilko[1#], V. Chornii[1,2], V. Barbash[3], O. Yashchenko[3],
V. Scherbatskyy[1], S. Haider[4], A. Suchocki[4]

[1]Faculty of Physics, Taras Shevchenko National University of Kyiv, Kyiv, Ukraine
[2]National University of Life and Environmental Sciences of Ukraine, Kyiv, Ukraine
[3]National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute"
Kyiv, Ukraine
[4]Institute of Physics, Polish Academy of Sciences, Warsaw, Poland

Today, the field of the flexible electronics devices production not only occupies a significant place in electronic instrumentation, but it also continues activ developping. The development of new materials for the specified industry is an important task. The demand for environmentally safe materials for flexible electronics is particularly relevant, including cellulose materials for "paper" electronics.

It should be noted that cellulose paper is used as a substrate in most developments for enhancing the urface properties, flexible and transparent films suitable for applying elements of opto-electronic circuits. Those can be thin film transistors, solar cells, energy storage devices, batteries, sensors, etc.

At the same time, in recent years, studies of mixed composites have been actively conducted, where the matrix is paper, and the fillers are electrically conductive, magnetic, thermoelectrical, light-sensitive, etc. components. Their choice determines the functional orientation of the paper composite.

In this work, we investigated the paper, where the luminescent conversion of ultraviolet radiation into long-lasting photo- and mechanoluminescent visible light was the main function of that. For this purpose, the luminescent oxide $SrAl_2O_4$:Eu,Dy was introduced into the composition of the paper. The engineering of the mechanical (density, tensile strength, hardness, flexibility), optical (whiteness, transparency, gloss and dullness) and luminescent characteristics (spectrum and intensity of light) of the paper was carried out by changing the oxide content and introducing another component into the composition of the paper - multi-walled carbon nanotubes (MWCNT).

To obtain the hybrid nanocomposite material, sulfated coniferous bleached cellulose was used as a basis, which was previously ground in a laboratory grinding complex, and first, a suspension of nanocellulose from non-wood plant material and alkyl ketene dimer was added to the fibrous mass, and then luminescent oxide and/or MWCNT were added.

The mechanical, optical/luminescent properties mentioned above were studied in relation with changes in the structure and morphology of the produced materials. For this purpose, the results of XRD, optical and electron microscopy, Raman and infrared spectroscopy were used.

Acknowledgements. The work was financed by National Research Foundation of Ukraine (project № 2022.01/0168) and supported by the Institute of Physics of Polish Academy of Sciences (Warsaw).

[#] Corresponding author: SGNedilko@gmail.com

Luminescent properties of Pr^{3+} doped $LiBaF_3$ crystallites

Patrycja Zdeb[1], Alexander Grippa[2], Przemysław Jacek Dereń[1], Nadiia Rebrova[1#]

[1] Institute of Low Temperature and Structure Research, Polish Academy of Science,
Okólna Street 2, 50-422 Wrocław, Poland
[2] Institute for Scintillation Materials, National Academy of Sciences of Ukraine, Nauky Avenue 60,
61072 Kharkov, Ukraine

Over the past decades, considerable progress has been made in the research of luminescent materials. This progress encompasses the discovery of new phosphors as well as deeper investigations into existing ones. Additionally, significant advances in characterization methods have led to a refined understanding of luminescence mechanisms. Numerous new luminescent materials have been created that emit across the spectrum from ultraviolet to infrared. Praseodymium is a unique activator that, depending on the matrix, can emit throughout this range due to the interaction between its abundant 4f energy levels and the 4f5d state. Particularly intriguing is that the optical properties of materials activated by Pr^{3+} in the UV range can be modulated by altering the crystallographic environment of the activator ion. Among the variety of matrices, fluoride matrices are most often studied due to their low phonon energy, high optical transparency, good chemical and photochemical stability.

In this study, crystallites $LiBaF_3$ with different concentration of Pr^{3+} were obtained by the solid state method. The structure, luminescence properties in UV-vis range and X-ray excited luminescence are investigated. Particular attention was paid to providing information on the possible use of $LiBaF_3$:Pr^{3+} as a scintilators and optical-thermometer.

no.

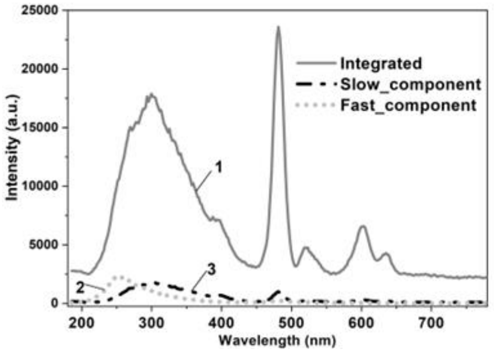


Fig. Time-resolved X-ray excited luminescence spectra of $LiBaF_3$:Pr^{3+} at 295 K: (1) integrated spectrum, (2) fast component, (3) slow component.

Acknowledgments: This work was supported by The National Science Centre (NCN) under the Miniatura 7 project, grant 2023/07/X/ST5/00965, which is gratefully acknowledged. A. Grippa (Oleksandr Gryppa) is supported by Visegrad Fellowship #62410067.

[#] corresponding author: n.rebrova@intibs.pl

Luminescence properties of $ACaF_3$ (A=K, Rb, Cs) doped with Pr^{3+} ions

Alexander Grippa[1], Patrycja Zdeb[2], Anatoliy Voloshinovskii[3], Andriy Pushak[4]
Przemysław Jacek Dereń[2], Nadiia Rebrova[2#]

[1] Institute for Scintillation Materials, National Academy of Sciences of Ukraine,
Nauky Avenue 60, 61072 Kharkov, Ukraine
[2] Institute of Low Temperature and Structure Research, Polish Academy of Science,
Okólna Street 2, 50-422 Wrocław, Poland
[3] Ivan Franko National University of Lviv, 8 Kyryla i Mefodiya St, 79000, Lviv, Ukraine
[4] Ukrainian Academy of Printing, Pidholosko st., 19, Lviv, Ukraine

Research continues to develop new phosphors capable of emitting light across a broad spectrum, from ultraviolet (UV) to infrared, with potential applications in a variety of fields. In this context, praseodymium has garnered attention for its ability to emit across the entire spectrum, influenced by the interaction between the lattice host and Pr^{3+} ions. This interaction results in desirable optical properties due to the energy configuration of the $4f^15d^1$ state in relation to the $4f^2$ levels and the conduction band's ground states. For example, materials where E(4f5d) is lower than $E(^1S_0)$ and only 4f5d-4f interconfiguration transitions are observed can be utilized as ultraviolet phosphors, scintillators, and light upconverters. In contrast, materials where E(4f5d) is higher than $E(^1S_0)$ and only the 4f-4f transition occurs can be used as photon cascade emitters.

The luminescent properties of $ACaF_3$ (A=K, Rb, Cs) perovskites doped with various rare earth metals, such as Eu^{2+}, Yb^{3+}, Gd^{3+}, Nd^{3+}, Dy^{3+}, Sm^{3+}, and Ce^{3+}, were intensively studied. Almost no attention was paid to Pr^{3+} activated $ACaF_3$ (A=K, Rb, Cs) hosts. In this work, the new phosphors $ACaF_3$:Pr^{3+} (A=K, Rb, Cs) were synthesized using solid state reactions. Luminescent properties in ultraviolet and visible ranges were investigated. Information on the prospects for using $ACaF_3$ Pr^{3+} (A=K, Rb, Cs) as scintillators will be discussed.

Acknowledgments: This work was supported by The National Science Centre (NCN) under the Miniatura 7 project, grant no. 2023/07/X/ST5/00965, which is gratefully acknowledged. A. Grippa (Oleksandr Gryppa) is supported by Visegrad Fellowship #62410067.

corresponding author: n.rebrova@intibs.pl

The benefits of photoacoustic methods applied to membrane transport studies

P. Rochowski[1#], S. Pogorzelski[1], P. Niedziałkowski[2]

[1]Institute of Experimental Physics, Faculty of Mathematics, Physics and Informatics, University of Gdańsk,
Wita Stwosza 57, 80-308 Gdańsk, Poland
[1]Department of Analytical Chemistry, Faculty of Chemistry, University of Gdańsk,
Wita Stwosza 63, 80-308 Gdańsk, Poland

The presentation focuses on the Gdansk's group recent advancements in the field of membrane transport studies as needed for transdermal delivery systems, greatly fueled by unique type of noninvasive photoacoustics-based measurements performed. In general, the photoacoustics modalities are based upon the detection of acoustic response of a sample following the absorption of modulated energy flux. A unique feature of the methods is related to a correspondence between the adjustable incident light modulation frequency f, and the sample depth contributing to the photoacoustic response. As such, the measurements can be performed in two configurations, i.e. for constant f and variable incident light wavelength λ (spectroscopy mode), and for variable f and constant λ (depth-profiling mode). The latter one offers the acquisition of the pigment concentration distribution within a system under study, or the evolutions of the concentration profiles if the measurements are performed in a cyclic manner. In the case considered here, the transdermal delivery-mimicking system consisted of a cellulose membrane in a one-side contact with a model drug. A broad photoacoustic characterization of the system, involving spectroscopy-based stationary measurements and sorption/desorption experiments, along with the time-resolved spectroscopy and depth-profiling for the dynamic system (a direct observation of the membrane transport process) allowed for the development and validation of a novel mathematical approaches to the membrane transport processes quantification, and highlighted the impact of the interfacial mass transfers on the overall membrane sorption kinetics. This, in fact, puts into question one of the longstanding paradigms of the passive membrane transport, i.e. the diffusion-controlled character of the membrane sorption processes [1,2].

[1] Rochowski P., Niedziałkowski P. and Pogorzelski S. (2020) IJP, 580, 119233.
[2] Rochowski P. (2023) IJP, 580, 123452.

corresponding author: pawel.rochowski@ug.edu.pl

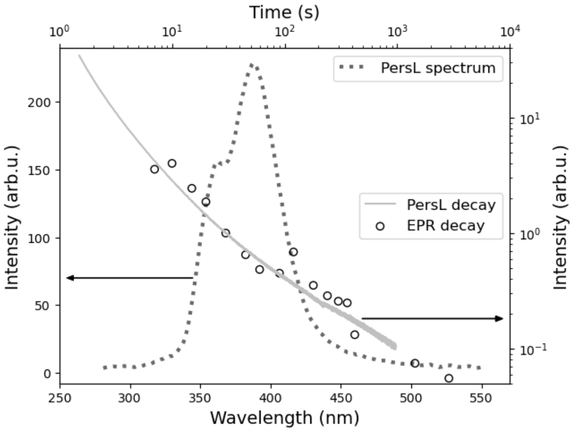
P48 | P. Rodionovs

Long persistent UV-A luminescence in $Sr_3MgSi_2O_8$:Ce^{3+}

Pavels Rodionovs#, Guna Doke, Guna Krieke, Dace Nilova, Andris Antuzevics

Institute of Solid State Physics, University of Latvia, 8 Kengaraga Str., LV-1063, Riga, Latvia

In recent years, there has been increasing interest in UV-emitting persistent phosphors. These materials have numerous potential applications such as photocatalysis, sterilization, and anti-counterfeiting. Herein, we report on the X-ray and UV-activated UV-A long PersL Ce^{3+}-doped $Sr_3MgSi_2O_8$ phosphor. Samples with different Ce concentration were prepared via high temperature solid state reaction method. Obtained materials were investigated using photoluminescence (PL), electron paramagnetic resonance (EPR), and thermally stimulated luminescence (TSL) spectroscopy methods. Our experiments demonstrate that the Ce^{3+} PersL emission in the 300 - 450 nm range remains detectable for a minimum of 16 hours after X-ray or UV irradiation. The TSL analysis identified several discrete charge traps, exhibiting activation energies ranging from 0.5 to 1.7 eV. Subsequent EPR measurements confirm the existence of four paramagnetic centers. Investigation into the thermal stability of paramagnetic centers reveals that one of them (g_1 = 2.0056, g_2 = 1.9981, and g_3 = 1.9926) gradually decays at room temperature and is correlated with PersL processes [1].



PersL spectrum of $Sr_3MgSi_2O_8$:Ce^{3+} and comparison of paramagnetic center signal time-derivative decay with PersL kinetics.

Latvian Council of Science, project “Defect engineering of novel UV-C persistent phosphor materials”, project No. LZP-2021/1-0118 is gratefully acknowledged.

[1] Doke G., Krieke G., Rodionovs P., Nilova D., Antuzevics A. Trap properties of novel UV-A persistent phosphor $Sr_3MgSi_2O_8$:Ce^{3+} (2024) J RARE EARTH.

corresponding author: Pavels.Rodionovs@cfi.lu.lv

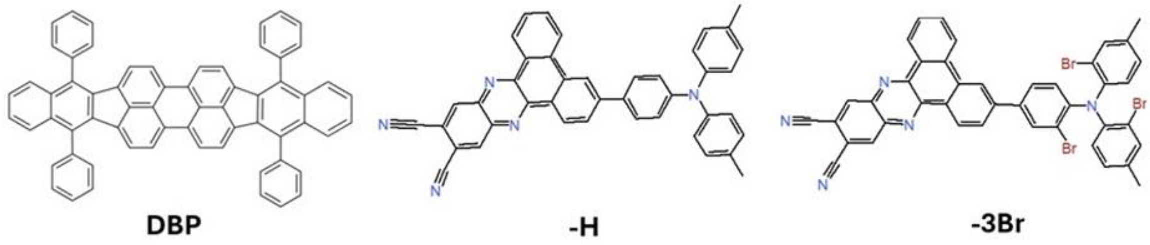
Near-infrared thermally activated delayed fluorescence and heavy-atom effect in organic exciplexes

Radosław Rogowski[1], Illia E. Serdiuk[1], Michał Mońka[1], Daria Grzywacz[1,2],
Beata Liberek[2], Piotr Bojarski[1]

[1]Faculty of Mathematics, Physics and Informatics, University of Gdańsk,
Wita Stwosza 57, 80-308 Gdańsk, Poland
[2] Faculty of Chemistry, University of Gdańsk, Wita Stwosza 63, 80-308 Gdańsk, Poland

The described research concerns the spectral studies of novel exciplex emitters for near-infrared (NIR) OLED (Organic Light Emitting Diode). Through the mechanism of thermally activated delayed fluorescence (TADF) emitters can effectively utilize both singlet and triplet excitons formed in a 1:3 ratio due to the spin statistics during electrical excitation. Exciplex TADF systems offer higher stability and efficiency, but their examples with high quantum yields in NIR range are very scarce. Even more challenging is to achieve high reverse intersystem crossing rate (rISC) in this range, which is the key to fast TADF and high OLED stability.

The aim of this research is to explore the photophysical properties of an exciplex system comprising DBP fluorophore as a donor and dicyanophenazine-based TADF emitter as an acceptor (Figure 1). In our previous studies we have shown that rISC in such a TADF emitter can be finely enhanced by the heavy atom effect. Therefore, we further explore the effect of bromine substitution on the discovered exciplexes.



DBP -H -3Br

Figure 1. Structures of DBP and TADF emitters -H and -3Br.

Our results provide experimental and theoretical (via DFT calcucations) proof of the exciplex formation. Studied systems show emission maximum in the 704 nm range with the PLQY of 25% Both systems show TADF in the 10-1000 μs time region. The studied photophysical constants and the emission characteristics of the exciplexes aim to determine their good potential for OLED applications, whilst DFT predicted electronic features shed the light on the TADF mechanism.

Acknowledgements: Financial support from the National Centre for Research and Development (NCBR) within the LIDER XI grant LIDER/47/0190/L-11/19/NCBR/2020 is gratefully acknowledged. Quantum chemical calculations were performed on the computers of the Wroclaw Centre for Networking and Supercomputing (WCSS), Poland.

corresponding author: r.rogowski.765@studms.ug.edu.pl

High-pressure luminescence and Raman spectroscopy of the single crystalline films of $Ca_3Sc_2Si_3O_{12}$:Ce and $Ca_2YMgScSi_3O_{12}$:Ce garnets

Anna Shakhno[1,2#], Mikołaj Kamiński[3], Sebastian Mahlik[3], Tomasz Runka[4],
Vitalii Gorbenko[1], Tetiana Zorenko[1], Sandra Witkiewicz-Lukaszek[1], Yuriy Zorenko[1]

[1]Department of Physics, ul. Powstańców Wielkopolskich 2, Bydgoszcz, 85090, Poland
[2]Mechantronics Department, Kazimierz Wielki University in Bydgoszcz, 85-074 Bydgoszcz, Poland
[3]Institute of Experimental Physics, Faculty of Mathematics, Physics and Informatics, University of Gdansk, Wita Stwosza 57, 80-308 Gdansk, Poland
[4]Faculty of Materials Engineering and Technical Physics, Poznan University of Technology, Piotrowo 3, 60-965 Poznań, Poland

The phosphors based on single crystalline films (SCF) of Ce-doped Ca-Si-based mixed garnets, namely $Ca_3Sc_2Si_3O_{12}$:Ce (CSSG:Ce) and $Ca_2YMgScSi_3O_{12}$:Ce (CYMSSG:Ce) attract attention due their potential applications in various optoelectronic devices, particularly at the development of film and film-crystal phosphor converter for WLED [1, 2].

Using the liquid phase epitaxy (LPE) method, the CSSG:Ce and CYMSSG:Ce SCFs were grown onto GAGG and YAG single crystal (SC) substrates, respectively, with SCF/substrate misfit values of 0.25% and 2% [3]. The substantial difference in lattice constants between the films and substrates induces significant internal mechanical stresses, which could significantly affect the optical characteristics of the film phosphors. However, the impact of mechanical stress on the properties of SCFs, grown on different substrates, remains unexplored. By applying additional high external pressure to these epitaxial structures, it is possible to investigate the mechanical-optical coupling effects in SCF of LPE grown garnet compounds [4]. For this reason, in this work we focus on analyzing the luminescent properties of CSSG:Ce SCF/GAGG SC and CYMSSG:Ce SCF/YAG SC epitaxial structures at high-pressure range up to 16 GPa, using diamond anvil cells.
A critical aspect of the characterization of such composite materials is the description of the properties of the transition layer that forms between the SCF and the substrate during the LPE growth process. Anticipating the occurrence of high mechanical stresses in this area, it is worth examining their impact on the vibration and optical properties of the film materials. This study also used confocal Raman spectroscopy, analyzing the CSSG:Ce SCF/GAGG SC and CYMSSG:Ce SCF/YAG SC epitaxial structures from the surface of the SCF through the transition layer to the substrate, providing insight into the mechanical-optical interactions in these systems.

Acknowledgment. The work is performed in the frame of Polish NCN 2019/33/B/ST3/ 200406 and 2022/45/B/ST8/01757 projects and partly in the frame of Regional Excellence Initiative nr RID/SP/0048/2024/01project.

[1] V. Gorbenko et al. Journal of Luminescence 199 (2018) 245–250.
[2] N. Wei et al. Appl. Phys. Lett. 101 (2012) 061902.
[3] A.A. Setlur et al. ECS J. Solid State Sci. Technol. 2 (2012) R3059–R3070.
[4] L.-I. Bulyk et al. Journal of Luminescence 252 (2022) 119276.

[#] corresponding author: shakhno.ukw.edu.pl

Excitation and emission bands of oxygen vacancies in rare earth bixbyite oxides: technical details

Andrii Shyichuk#, Joanna Trojan-Piegza, Eugeniusz Zych

Faculty of Chemistry, University of Wrocław, 14 F. Joliot-Curie, 50-383 Wrocław, Poland

The computational model for an oxygen vacancy in a bixbyite oxide was developed as follows. The experimental crystal structure was used to prepare ab initio model potentials (AIMPs) for RE and O in a pure RE_2O_3 crystal (RE = Sc, Y, Lu), as described in [1]. These AIMPs represent the "non-chemical" part of the system and surround the embedded cluster. The cluster is constructed from the RE_4O17 moiety of the crystal, which includes the four Lu atoms surrounding an oxygen site and the oxygen atoms surrounding those four Lu atoms. The central oxygen atom is replaced by a ghost atom with a modified, more spatially extended basis set. The total charge of this cluster is 22, corresponding to two trapped electrons at the ghost atom (vacancy) site. The system is then subjected to multiconfigurational calculations for singlets using DFT, RASSCF, CASPT2, and RASSI-SO methods in a sequence.

To achieve the experimentally observed broad spectroscopic bands, a (pseudo)vibrational deformation must be applied to the cluster. In this study, it was assumed that the system "slowly" oscillates between two geometries corresponding to singlet and triplet states of the vacancy's two-electron density. These geometries were obtained using DFT PAW calculations on a single $RE_{32}O_{47}$ cell, with the cell size fixed to the experimental value while optimizing the atomic positions. Interpolating between the two cluster geometries resulted in a set of cluster geometries. The respective clusters were placed in the pristine-crystal embedding lattice, the calculations described above followed.

The calculations produced a set of energy levels that were interpolated to achieve smooth E(R) curves, where E represents energy and R represents the average bond length of the ghost atom. Using these interpolation curves, absorption and emission spectra were simulated. Notably, this methodology can also be applied in experimental spectra analysis: a novel band shape is proposed, allowing for the modeling of an arbitrary Gaussian-like asymmetric band with as few as four parameters plus temperature. This approach assumes that the initial and final level energies are described by E(R) parabolas and that the initial level populations follow a Boltzmann distribution.

[1] L. Seijo, Z. Barandiaran, J. Math. Chem. 10 (1992) 41–56. https://doi.org/10.1007/ BF01169170

corresponding author: andrii.shyichuk@uwr.edu.pl

Lanthanide ions (Eu^{3+}, Er^{3+}, Pr^{3+}) as luminescence and charge carrier centers in Sr_2TiO_4

K. Szczodrowski[1#], M. Behrendt[1], J. Barzowska[1], N. Górecka[1], N. Majewska[1],
T. Leśniewski[1], M. Łapiński[2], S. Mahlik[1]

[1]Institute of Experimental Physics, Faculty of Mathematics, Physics, and Informatics, University of Gdańsk,
Wita Stwosza 57, 80-308 Gdańsk, Poland,
[2]Institute of Nanotechnology and Materials Engineering, Gdansk University of Technology,
Gabriela Narutowicza 11/12, 80-233 Gdansk, Poland,

A series of strontium orthotitanate (Sr_2TiO_4) samples doped with 2% of a mole of europium, praseodymium, and erbium were obtained using the solid-state synthesis method. The X-ray diffraction (XRD) technique confirms the phase purity of all samples and the lack of the influence of dopants at a given concentration on the structure of materials. The optical properties indicate, in the case of Sr_2TiO_4:Eu^{3+}, two independent emission (PL) and excitation (PLE) spectra attributed to the Eu^{3+} ions at sites with different symmetries: low – excited at 360 nm and high – excited at 325 nm, while, for Sr_2TiO_4:Er^{3+} and Sr_2TiO_4:Pr^{3+}, the emission spectra do not depend on the excitation wavelength. The measurements of X-ray photoemission spectroscopy (XPS) indicate the presence of only one type of charge compensation mechanism, which is based on the creation of strontium vacancies (V_{Sr}'') in all cases. This suggests that the different charge compensation mechanisms cannot easily explain the presence of Eu^{3+} at two nonequivalent crystal sites. The photocurrent excitation (PCE) spectroscopy investigations, that have not been reported in the literature so far, show that among all the studied dopants, only Pr^{3+} can promote the electrons to the conduction band and give rise to electron conductivity. The results collected from the PLE and PCE spectra allowed us to find the location of the ground states of lanthanides(II)/(III) in the studied matrix.

corresponding author: karol.szczodrowski@ug.edu.pl

Efficient NIR emission in SiO_2-LaF_3:Nd^{3+} sol-gel nano-glass-ceramics

Joanna Śmiarowska[1#], Natalia Pawlik[1], Tomasz Goryczka[2], Wojciech A. Pisarski[1]

[1] University of Silesia, Institute of Chemistry, Szkolna 9 Street, 40-007 Katowice, Poland
[2] University of Silesia, Institute of Materials Science, 75. Pułku Piechoty 1A Street,
41-500 Chorzów, Poland

Optical properties of Nd^{3+} ions have been widely investigated due to the efficient emission in the near-infrared spectral range. Indeed, the NIR emissions (~1.06 μm and ~1.3 μm) have proved to be used in solid-state lasers or O-band amplifiers. However, the luminescent performance of the Nd^{3+} ions is strongly dependent on the type of host material; therefore, it is crucial to find a suitable matrix to enhance the resultant luminescence. Among many host systems, oxyfluoride sol-gel nano-glass-ceramics (nGCs) present unique advantages due to the combination of the high chemical and mechanical stability of the oxide host with the low phonon energy of the fluoride framework. Efficient incorporation of the dopant ions into low-phonon energy fluoride crystal lattice may significantly reduce the probability of multiphonon relaxation and consequently enhance their luminescence [1,2].

In this work, the series of sol-gel materials doped with Nd^{3+} ions were synthesized and further transformed into nano-glass-ceramics containing LaF_3:Nd^{3+} nanocrystals via controlled heat treatment, carried out at 700^0C and 900^0C. The structural characterization of obtained materials was performed using X-ray diffraction (XRD), revealing the crystallization of the fluoride nanophase. The examination of luminescent properties included analysis of PLE (λ_{em}=1063 nm) as well as the PL spectra recorded using different excitation wavelengths (λ_{exc}=521 nm, 579 nm, and 793 nm). Furthermore, the luminescence decay curves of the $^4F_{3/2}$ excited state of Nd^{3+} were registered. Additionally, the influence of the temperature of controlled heat treatment on the luminescence of Nd^{3+} ions was studied. The characteristic emissions of Nd^{3+} ions were observed in all fabricated samples. The results indicate the obtained materials are promising candidates for the NIR luminescence applications.

[1] D. Rajesh, A.S.S. de Camargo (2019) J. Lumin. 207, 469-476.
[2] M. E. Cruz, J. Fernandez, A. Duran, R. Balda, Y. Castro (2023) J. Non-Cryst. Solids 601, 122050-122059.

corresponding author: joanna.smiarowska@us.edu.pl

Raman and luminescent spectroscopy of Ce^{3+} doped $Tb_3Al_5O_{12}$ single crystalline film phosphors grown onto $Gd_3Al_{2.5}Ga_{2.5}O_{12}$ and $Y_3Al_5O_{12}$ substrates

Yurii Syrotych[1,2#], V. Gorbenko[1], Piotr Radomski[3], Tomasz Runka[3], Yuriy Zorenko[1]

[1]Department of Physics, Kazimierz Wielki University, Bydgoszcz, Poland
[2]Department of Mechatronics, Kazimierz Wielki University, Bydgoszcz, Poland
[3]Faculty of Materials Engineering and Technical Physics, Poznan University of Technology, Poznań, Poland

Nowadays the luminescent materials in form of single crystalline film (SCF) based on various oxide compounds are mainly produced by the liquid phase epitaxy growth method [1]. Furthermore, novel composite scintillators and white LED converters based on SCFs and single crystal (SC) substrates with the same crystalline structure (homoepitaxy) or a near crystalline structure (quasi-homoepitaxy) are also made using LPE technology [2]. The examples of such efficient luminescence materials are SCF of Tb3Al5O12:Ce (TbAG:Ce) garnet, grown onto undoped Gd3Al2.5Ga2.5O12 (GAGG) and Y3Al5O12 (YAG) SCs substrates [3]. This work represents our last investigation of the cross-section of TbAG:Ce SCF/GAGG SC and TbAG:Ce SCF/ YAG SC epitaxial structures, using the Raman spectroscopy. For both quasi-homoepitaxy grown composites, a clear distinction between SCF and the substrate was achieved using Raman spectroscopy. The interaction of TbAG.Ce films and different GAGG and YAG substrates can lead to changes in the optical properties of the films caused by significant mechanical stresses at the SC/SCF interface due to various differences in the lattice constants for SC YAG and GAGG. Additionally, the presence of transition layer (TL) between TbAG:Ce SCF, and YAG, and GAGG substrates was found. It can be assumed that the chemical composition of the solution is in the TL range can be considered as (Tb3-xGdx)3Al5O12 and (Tb3-xYx)3Al5O12 solid solutions for TbAG:Ce/GAGG and TbAG:Ce/YAG structures, respectively, where x values was changed from 0 in SCF and 3 in the substrates. Evaluation of the TL from the Ce-doped film to the undoped substrate is also possible with the measurements of the Ce3+ high-precision luminescence along the cross-section of epitaxial structures. It is noticeable that the intensity of Ce3+ ion luminescence changes with the measurement position and is completely attenuated upon passing through the transition layer.

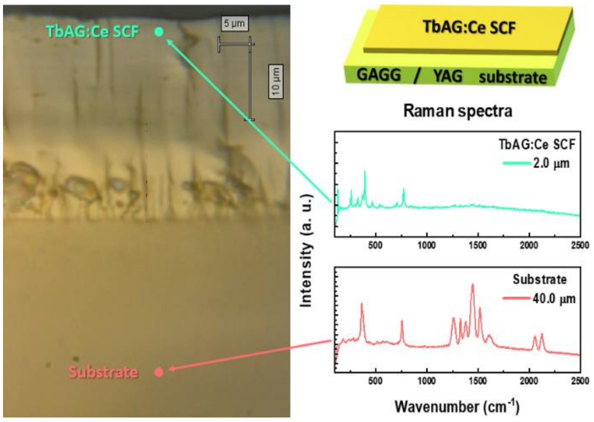


Fig. 1. Microphoto of the epitaxial structure, as well as its scheme, with indicated initial and ending point of Raman spectra

Acknowledgements: The work was performed in the frame of Polish NCN OPUS 24 LAP 2022/47/I/ST8/02600 and 2022/45/B/ST8/01757 projects and partly in frame of Regional Excellence Initiative nr RID/SP/0048/2024/01 project.

[1] Nanocomposite, Ceramic, and Thin Film Scintillators, Pan Stanford Publ. Ltd.; Nov.11, 2016.
[2] S. Witkiewicz-Lukaszek, V. Gorbenko, et all, Crystal Growth@ Design 18 (2018) 1834
[3] S. Witkiewicz-Lukaszek, et all, CrystEngComm 20 (2018) 3994–4002.

corresponding author: syr@ukw.edu.pl

Electronic structure of Mn^{2+}-doped phosphors

Zafari Umar[1,2], Oleg Khyzhun[1,3], Tomoyuki Yamamoto[4], Mikhail G. Brik[1,5], Mega Novita[1],
Michal Piasecki[1#]

[1]Faculty of Science and Technology, Jan Długosz University,
Armii Krajowej 13/15, PL-42200 Czestochowa, Poland
[2]Center of Innovative Development of Science and New Technologies,
National Academy of Sciences of Tajikistan, Dushanbe 734025, Tajikistan
[3]Frantsevych Institute for Problems of Materials Science, NAS of Ukraine, UA-03142 Kyiv, Ukraine
[4]Faculty of Science and Engineering, Waseda University, Tokyo 169-8555, Japan
[5]Center of Excellence for Photoconversion, Vinča Institute of Nuclear Sciences –
National Institute of the Republic of Serbia, University of Belgrade, Belgrade, Serbia

Nanocrystalline materials doped with transition metal ions (Mn^{4+}, Cr^{3+}, Mn^{2+}, Ni^{2+}) are promising materials due to their potential application in many fields. In particular, nanocrystalline materials doped with Mn^{2+} ions have become the object of intensive research due to their practical application as a source of NIR phosphors. In the present work we report on results of a density functional theory study of geometric and electronic structures and optical transition energy of Mn^{2+}-doped phosphors using various methods of calculations, in particular GGA-PBE, SCAN, HSE06. The geometric and electronic structures and optical transitions of the Mn^{2+} ion being in tetrahedral and octahedral environments are analyzed following the technique [1,2]. As an example, Figure 1 presents the results of GGA-PBE calculations of DOS of Mn^{2+}-doped $KMgF_3$.

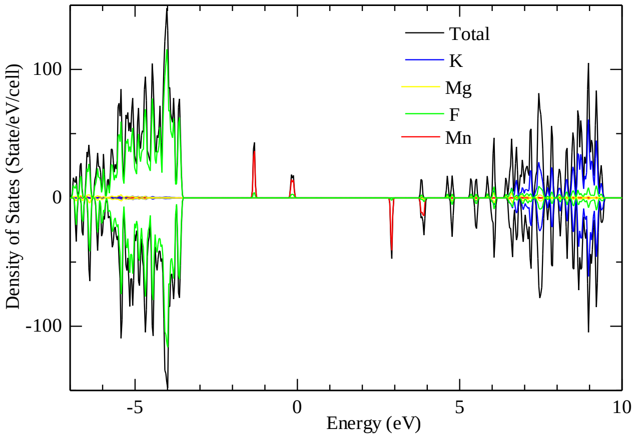


Figure 1. Density of states (DOS) of Mn^{2+} -doped $KMgF_3$.

[1] Umar Z., Khyzhun O., Yamamoto T., Brągiel P. (2024) Opt. Mater., 149, 115057.
[2] Umar Z., Kurboniyon M.S., et al. (2024) J. Lumin., 266, 120278.

LIF emission spectra of CdAr molecule

Tomasz Urbańczyk#, Jarosław Koperski

Smoluchowski Institute of Physics, Jagiellonian University, Łojasiewicza 11, 30-348 Kraków, Poland

In laser spectroscopy of diatomic molecules, measurements of LIF emission spectra provide valuable information on both, the electronic energy-state potential to which the emission occurs (*bound* → *bound* spectra) as well as the shape of the emitting excited-state wave function (*bound* → *free* spectra).

Recently, our research group, as part of the ATOMIN 2.0[1] project, acquired a SpectraPro HRS 750 grating spectrometer (Teledyne Princeton Instruments). Using an image intensifier, this device can efficiently detect signals coming from single photons. The poster will present the latest results obtained, for example, in the measurement and interpretation of the LIF dispersed emission spectra associated with the de-excitation of CdAr molecule following excitation to different vibrational υ' levels of the $B^3\Sigma_1^+$ (5^3P_1) state, as shown in Fig. 1.

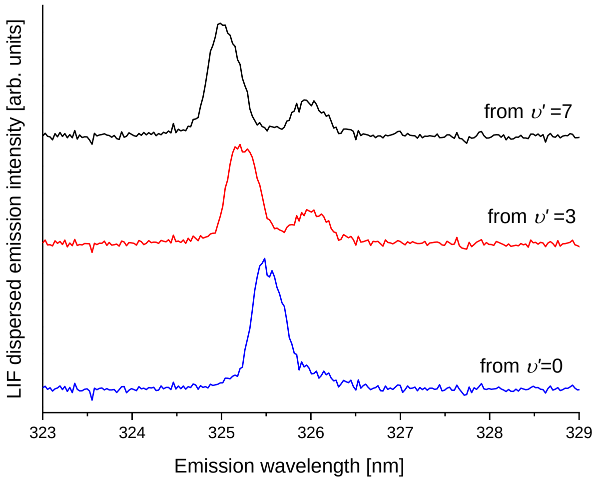


Fig.1. LIF dispersed emission signal observed in de-excitation of CdAr molecule from three selected υ' vibrational levels of the $B^3\Sigma_1^+$ (5^3P_1) state.

[1] ATOMIN 2.0 – ATOM-scale material research centre for the INnovative economy.

corresponding author: tomek.urbanczyk@uj.edu.pl

A new approach to analyzing the results of basic thermoluminescence methods

Marcin E. Witkowski[#], Alicja Chruścińska

Institute of Physics, Faculty of Physics, Astronomy and Informatics,
Nicolaus Copernicus University in Toruń, ul. Grudziądzka 5, 87-100 Toruń, Poland

The probability per unit time of release of an electron from a trap is assumed to be described by the well-known Arrhenius equation:

$$p = sexp\left(-\frac{E}{k_B T}\right)$$

where s is called the frequency factor or attempt-to-escape factor, E is the thermal trap depth, i.e. the thermal activation energy needed to release an electron from the trap to the conduction band, k_B is the Boltzmann constant, and T is the absolute temperature. The reciprocal of this probability is interpreted as the lifetime of traps at temperature T, which is a critical parameter used to characterize scintillator and dosimetric materials.

The Variable Heating Rate (VHR) method, also known as the Hoogenstraaten's method [1], as well as the Isothermal Decay (ID) of thermoluminescence (TL) or optically stimulated luminescence (OSL) signal [2,3], are two fundamental methods that allow the determination of trap parameters. The typical approach to interpretation of the results of these methods, which one has traditionally been used for many decades, is based on linear regression. Unfortunately, while the precision of the energy determined in this way is relatively good, the uncertainty of the frequency factor is significant, typically larger than the value of determined parameter, thus resulting in a huge error in lifetime estimation.
In this communication, we present the results of non-linear regression applied to VHR and ID measurement data. The analysis using the presently available numerical tools enables the fitting of trap parameters with much better precision than the linear regression, resulting in more accurate lifetime estimation.

[1] Hoogenstraaten W. (1958), Philips Res. Rep.,**13**, 515-693.
[2] McKeever S.W.S. (1985), "Thermoluminescence of Solids", Cambridge University Press.
[3] Chen R. and McKeever S.W.S. (1997), "Theory of Thermoluminscence and Related Phenomena", World Scientific.

[#] corresponding author: mwit@fizyka.umk.pl

Excitation mechanisms of Mn-related luminescence in $YAlO_3$:Mn crystals

Ya. Zhydachevskyy[1#], Yu. Hizhnyi[2], I. Romet[1,3], I. Kudryavtseva[3], V. Stasiv[1], Xinyu Zhang[4],
S. Nedilko[2], A. Lushchik[3], A. Suchocki[1]

[1] Institute of Physics, Polish Academy of Sciences, Warsaw 02-668, Poland
[2] Taras Shevchenko National University of Kyiv, Kyiv 01033, Ukraine
[3] Institute of Physics, University of Tartu, Tartu 50411, Estonia
[4] Department of Physics, Southern University of Science and Technology, Shenzhen 518055, China

The Mn-doped yttrium aluminum perovskite $YAlO_3$ has been intensively studied as a material for holographic recording, optical data storage and dosimetry of ionizing radiation with the use of thermally (TSL) or optically stimulated (OSL) luminescence [1, 2]. Manganese ions in $YAlO_3$:Mn crystals can be present in the form of Mn^{4+} ions in octahedral coordination (Al^{3+} sites) as well as Mn^{2+} ions in strongly distorted dodecahedral coordination (Y^{3+} sites). Despite a large volume of accumulated experimental data on optical and TSL properties, the excitation mechanisms and the energy transfer processes in $YAlO_3$:Mn crystals still require clarification as there were no direct results, neither theoretical nor experimental, regarding the positions of Mn energy states with respect to conduction or valence band of the $YAlO_3$ host.

The work presents experimental data measured in the VUV range of photoluminescence excitation (PLE), TSL creation, and optical absorption spectra of the $YAlO_3$:Mn crystals studied earlier in [2], as well as theoretical results on the electronic properties of a relevant set of Mn-relared point defects in $YAlO_3$ crystals. The geometry-optimized spin-polarized calculations of the electronic structures with use of DFT-based Plane-Wave Pseudopotential method and GGA-PBE exchange-correlation functionals were carried out in the super-cells approach. Various Mn-related point defects were modelled in the super-cells: single Mn_{Al} and Mn_Y substitutions, pair defect combinations of Mn_{Al} or Mn_Y with Hf_Y, Si_{Al}, Y_{Al} or V_O, as well as some triple-site defects like Mn_{Al}-Mn_Y-V_O, Mn_Y-V_O-Y_{Al} etc. Populations of Mn *d* defect levels in the particular defect complexes are analysed in order to understand the effect of charge trapping on the formation of Mn-related luminescence centers.

Results of the calculations are analysed together with the experimental data on PL, PLE, TSL creation, and optical absorption of $YAlO_3$:Mn crystals. On the basis of the made analyses the excitation mechanisms and the energy transfer processes involving Mn ions and intrinsic charge traps are discussed.

Acknowledgements: The work was supported by the Polish National Science Centre (project no. 2018/31/B/ST8/00774).

[1] Ya. Zhydachevskyy, Yu. Hizhnyi, S.G. Nedilko *et al.* J. Phys. Chem. C 125 (2021) 26698-26710.
[2] H. Przybylińska, Ya. Zhydachevskyy, A. Grochot *et al.* J. Phys. Chem. C 126 (2022) 743-753.

corresponding author: zhydach@ifpan.edu.pl

Excited states of luminescence centers in “KBi(MoO$_4$)$_2$ @phosphate-molybdate glass” ceramics

V. Borysiuk[1#], A. Oliynyk[1], Yu. Hizhnyi[1], S. Nedilko[1], Ya. Zhydachevskyy[2]

[1]Faculty of Physics, Taras Shevchenko National University of Kyiv, Kyiv, 01601, Ukraine
[2]Institute of Physics, Polish Academy of Sciences, Warsaw, 02-668, Poland

Theoretical modeling of the electronic structure of interphases in heterostructure composites is powerful tool in elaboration of novel technologically perspective optical materials [1]. This report presents results of the excited electronic states and optical spectra calculations of molybdate groups MoO$_4$ and Bi ions, which are currently considered as possible centers of luminescence of glass-ceramic composite material “KBi(MoO$_4$)$_2$ crystal@phosphate-molybdate glass of K$_2$O-P$_2$O$_5$-MoO$_3$-Bi$_2$O$_3$ system”. The atomic and electronic structures of the crystal, glass and interphase layers of composites were obtained in earlier studies using molecular dynamics and band-periodic DFT methods.

The calculations were carried out at the Time-Dependent Density Functional Theory (TD-DFT) within molecular cluster approach. The geometry-optimized calculations were carried out using Gaussian software package [2]. Excited electronic states of molybdate groups MoO$_4$ or Bi ions in crystal, glass and interphase layers were calculated using the two-level ONIOM-2 approach. The quantum mechanical (QM) region comprised the atoms of molybdate groups MoO$_4$ or Bi ions, while the mechanical (MM) region comprised all atoms of crystal, glass and interphase layers (~2500 atoms). The electronic embedding was used in order to take into account electrostatic interaction between the QM and MM regions, i.e., the atoms of the QM region were treated by TD-DFT calculations, while the atoms of the MM region were treated as partial charges contributing to the quantum-mechanical Hamiltonian.

Calculations were carried out for 10 structures of glass and interphace regions of the composite and then averaged to obtain statistically valuable results. The excited states of the MoO$_4$ groups and Bi ions in KBi(MoO$_4$)$_2$ crystal were also calculated using the same approach, method and approximations.

Results on the optical spectra for three different components of composite material (crystal, glass and interphase) are compared with experimental data in order to outline the properties inherent to each component. The origin of intrinsic luminescence in phosphate-molybdate glass-ceramics is discussed.

[1] P. López-Caballero, J. M. Ramallo-López, L. J. Giovanetti, et al., J. Mater. Chem. A, vol. 8, pp. 6842-6853, 2020.
[2] M. J. Frisch, G. W. Trucks, H. B. Schlegel, et al, Gaussian 09, Gaussian: Wallingford, CT, 2009.

corresponding author: viktor.borysiuk@knu.ua

Optical properties of $K_3Tb(PO_4)_2$ green phosphor

V. Chornii[1,2#], S. G. Nedilko[1], K. Terebilenko[1], V. Zozulia[1], V. Boyko[2], Ya. Zhydachevskyy[3]

[1]Taras Shevchenko National University of Kyiv, 64/13 Volodymyrska st., Kyiv, Ukraine
[2]National University of Life and Environmental Sciences of Ukraine, 15 Geroiv Oborony st., Kyiv, Ukraine
[3]Institute of Physics Polish Academy of Sciences, al. Lotników 32/46 Warsaw, Poland

Rare-earth (RE) doped phosphates are considered as perfect materials for elaboration of phosphors for lighting applications [1]. Among them the terbium-containing compounds have been studied as green phosphors as well as hosts for some other RE ions. In particular, energy level schemes of Tb^{3+} and Eu^{3+} ions support energy transfer from former to latter resulting in sensitization of orange-red light emission of europium. It was shown earlier that $K_3Tb_{1-x}Eu_x(PO_4)_2$ reveals intensive visible luminescence under excitation in a wide range from vacuum ultraviolet up to visible light [2]. At the same time optical properties of $K_3Tb(PO_4)_2$ host attracted little attention so far. It is worth considering the structure and properties of undoped host in order to find ways for improvement of luminescence characteristics (e.g. intensity, quantum yield, lifetime, etc.) of the $K_3Tb_{1-x}RE_x(PO_4)_2$ compounds.

The title compound has been synthesized by fluoride-assisted flux method. The diffuse reflectance, IR transmittance, photoluminescence (PL) emission and excitation spectra as well as PL decay kinetics have been measured and analyzed. It was found that the samples reveal absorption bands in 280-400 nm which were ascribed to defects in $K_3Tb(PO_4)_2$ crystals, namely to formation of Tb^{4+} ions and oxygen vacancies. The Tb^{3+} ions green luminescence dominates in spectra when PL excitation takes place in 110 – 480 nm spectral range. This PL is characterized by lifetime 2.6 ms regardless of the excitation wavelength. In addition, for the first time, the violet PL with a band maximum at 410 nm was found under excitation in the 270-325 nm range. The PL kinetics measurements have showed this violet luminescence reveals two components with lifetimes below 20 ns. The peculiarities of optical properties of the $K_3Tb(PO_4)_2$, in particular, quantum yield dependence on excitation wavelength, have been explained by impact of Tb^{4+} ions formed in the compound under study.

Acknowledgements: Funding for this research was provided by National Research Foundation of Ukraine (grant No. 2022.01/0168).

[1] Mehare M. D., et al. (2023) Progr. Mater. Sci., 133, 101067.
[2] Mikhailik V. B., Kraus H., and Dorenbos P. (2009) Phys. Stat. Sol. RRL, 3, 13–15.

corresponding author: vchornii@gmail.com, vchornii@nubip.edu.ua

Atomic and electronic structures of interfaces in oxide glass-ceramic composites

Yu. Hizhnyi[1#], V. Chornii[1,2], Ya. Zhydachevskyy[3], S. G. Nedilko[1]

[1]Taras Shevchenko National University of Kyiv, 64/13 Volodymyrska st., Kyiv, Ukraine
[2]National University of Life and Environmental Sciences of Ukraine, 15 Geroiv Oborony st., Kyiv, Ukraine
[3]Institute of Physics Polish Academy of Sciences, al. Lotników 32/46 Warsaw, Poland

Oxide glass ceramics are composite materials in which oxide micro/nano crystallites are incorporated into matrix of oxide glass. The interest in studying of such kind of materials is related to wide prospects of their potential applications, in particular, in electronics, optical thermometry, biomedicine, etc [1]. The physical properties of glass-ceramic materials are largely determined by electronic properties of the "interphase region", which has an atomic structure different from the structure of both crystalline and glass components. The physical characteristics of interphase regions of composite materials are difficult to predict using only general ideas about atoms, ions or molecules interactions. However, the mutual diffusion of component atoms can be effectively modeled in calculations using the molecular dynamics (MD) methods. Further application of the electronic structure calculation methods to the obtained atomic structures allows to calculate the most important micro- and macro-characteristics of the interphase layers and thus to explain the experimentally observed properties of glass-ceramic composites.

This work presents results of complex computational and experimental studies of the atomic and electronic structures of interphases of oxide glass-ceramic composite materials of two different types: a) $K_2Bi(PO_4)(WO_4)$ crystal in K_2O-P_2O_5-WO_3-V_2O_5 phosphate-tungstate glass system; b) $LaVO_4$ crystal in $(1-x)B_2O_3$-xV_2O_5 and xLi_2O-$2V_2O_5$-$(98-x)B_2O_3$ borate glass systems. The atomic structures of interface layers of composites were calculated by MD methods implemented in Amorphous Cell and Forcite programs of Materials Studio software package [2]. The electronic structure calculations were performed in the DFT approximation using the band-periodic plane wave pseudopotential method CASTEP.

Obtained computational results are compared with experimental data on structural analysis, optical and luminescence spectroscopy of pure and RE-doped samples of glass-ceramic composite materials. A relationship between atomic and electronic structures of interface (interphases) layers and optical characteristics of studied composites is analyzed. The possibility of tuning of the optical properties of studied oxide glass-ceramic composite materials is discussed.

[1] Nedilko, S. G. (2023). Interphases in luminescent oxide nanostructured glass-ceramics. Journal of Materials Science: Materials in Electronics, 34(11), 998.
[2] BIOVIA, Dassault Systèmes, Materials Studio 2019 (version 19.1.0.5), San Diego: Dassault Systèmes, 2018.

corresponding author: e-mail yuriy.hizhnyi@knu.ua

P62 **T. Zorenko**

Optical and photoelectrical properties of Ce^{3+} and Mg^{2+}-Si^{4+} co-doped $Gd_3Ga_5O_{12}$ and $Gd_3Ga_3Al_2O_{12}$ single crystalline films

Tetiana Zorenko[1#], Vitalii Gorbenko, Sandra Witkiewicz-Łukaszek[1],
Artur Majewski-Napierkowski[1], Mikołaj Kaminski[2], Sebastian Mahlik[2],
Tadeusz Leśniewski[2], Yuriy Zorenko[1]

[1]Faculty of Physics of Kazimierz Wielki University in Bydgoszcz, 85-090 Bydgoszcz, Poland
[2]Institute of Experimental Physics of Faculty of Mathematics, Physics and Informatics,
University of Gdansk, 80-308 Gdansk, Poland

In this work, we present the results of crystallization and investigation of the optical and photoelectrical properties singly Ce^{3+}, doubly Ce^{3} -Mg^{2+}, and triply Ce^{3+}-Mg^{2+}-Si^{4+} doped of $Gd_3Ga_5O_{12}$ and $Gd_3Ga_3Al_2O_{12}$ single crystalline films (SCF). These garnets possess a relatively low band gap E_g =6.2-6.4 eV compared to well-known YAG and LuAG garnets with Eg =7.8-8 eV and can be suitable for the creation of photo-sensitive e/h trapping levels in the case of Mg^{2+}-Si^{4+} donor-acceptor doping.

The SCF samples were grown by the liquid phase epitaxy (LPE) method onto $Gd_3Ga_5O_{12}$ (GGG) and $Gd_3Ga_{2.5}Al_{2.5}O_{12}$ (GAGG) substrates, respectively, from the melt–solution based on the PbO-B_2O_3 flux. The absorption, luminescence, and photoelectrical properties of Ce^{3+} doped and Mg^{2+}-Si^{4+} codoped SCFs of GGG and GAGG garnets were investigated using conventional spectral methods and compared with the properties of the reference GGG:Ce and GAGG:Ce crystal and ceramic samples. In addition, the influence of the thermal annealing at 1300 ^{o}C in air and in 95% N_2 - 5% H_2 reducing atmosphere on the optical and photoelectrical properties of both types of SCFs was investigated.

Moreover, the luminescent properties of selected SCF samples were studied at 10 K under excitation by synchrotron radiation (SR) with energy in the 3.5-12.0 eV range at P66 Superlumi station at PETRA 3 storage range at DESY, Germany. Based on these results, the energy structure of different Ce^{3+} related centers in Mg^{2+}-Si^{4+} codoped SCF samples were compared with respect to the band structure of these garnets.

The results of this complex study are helpful for the development of luminescent materials for composite photovoltaic screens as well as for the creation of the composite thermoluminescent and optically-stimulated detectors based on the epitaxial structures of Ce^{3+} doped and Mg^{2+}-Si^{4+} codoped garnets, producing by LPE growth method.

Acknowledgements: The work was performed in the frame of NCN Poland no 2019/33/B/ST3/00406 project and partly in the frame of MNSW Poland Regional Excellence Initiative nr RID/SP/0048/2024/01 project. An investigation with SR at Superlumi station at DESY was performed in the frame of I-20210147 EC, I-20220044, and I-20220864 projects.

[#] corresponding author: tzorenko@ukw.edu.pl

IWASOM 2024 Participants List

Presenting author	**lecture/ oral presentation**	**poster presentation**
Muhammad Tahir Abbas		**P1**
Michele Back	**TL1**	
Anna Baran		
Karol Bartosiewicz	**O5**	
Justyna Barzowska	O10	P17, P52
Miroslaw Batentschuk	**O37**	
Luisa Bausa	**TL3**, O7	
Nikola Bednarska-Adam		**P2**
Gulnara Beketova		**P3**
Oskar Bogucki		**P4**
Piotr Bojarski		P9, P10, P30, P49
Kitipun Boonin	O6	**P5**
Viktor Borysiuk		**P59**
Jakub Bożek		**P6**, P40
Albano Carneiro Neto	**TL7**, O30, O39	
Mykhailo Chaika	**O21**	
Katsiaryna Chernyakova		**P7**, P25
Vitalii Chornii		**P8**, P44, **P60**, P61
Martyna Czarnomska		**P9**, P10
Sabato D'Auria	**IL16**, O31	
Przemysław Jacek Dereń	**TL9**, O20, O22, O23	P45, P46
Krzysztof Dorywalski		P6, **P11**

Konrad Drozdowski		**P12**, P13
Winicjusz Drozdowski	**TL10**	P12, P13
Mohanad Eid		**P13**
Shirly Espinoza	O25	**P14**
Mu-Huai Fang	**IL11**	
Yinnan Feng		
Paula Gawryszewska	**O39**	
Marek Godlewski	**TL11**	
Philippe Goldner	**IL12**	P19
Vitaliy Gorbenko	IL3	**P15**, P50, P54, P62
Marta Gordel-Wójcik	**O16**	
Natalia Górecka		P3, **P16**, P34, P38, P52
Emilia Gruszczyńska		**P9**, **P10**
Ignacy Gryczyński	**TL5**, O12	
Maciej Grzegorczyk		
Joachim Grzybowski	**O35**	
Syed Shabhi Haider	O10	**P17**, P44
Ivan Halimski		**P18**
Alexandre Hebbrecht		**P19**
David Hernández Pinilla	**O7**	
Miguel Hernández-Rodríguez	**O30**	
Yuriy Hizhnyi		P58, P59, **P61**
Paulina Janowicz		**P20**
Daniel Jaque	**TL2**	
Anam Javaid		**P21**
Adam Kabański	**O2**	

Dominika Jelonek (Kaczmarczyk)	**O3**	
Mikołaj Kamiński	O24	P15, **P22**, P33, P50, P62
Paulina Kapuśniak		**P23**, P28
Renata Karpicz		**P7**, P18, **P24**, **P25**
Dobroslawa Kasprowicz	O32	**P26**
Saiful Islam Khan	**O34**	
Ihor Kindrat	O28	**P27**
Emeric Claudiu Kiss		P23, **P28**
Jakub Kłos		**P29**
Shohei Kodama	**IL2**	
Agata Kowalska		**P30**
Karolina Kowalska		**P31**
Marek Krośnicki	**IL5**	P29, P40, P42
Wit Krośnicki		**P29**
Konrad Krysiak		
Dagmara Kulesza	**O14**	
Dharmendra Kumar		**P32**
Kaushal Kumar	O33, **O38**	
Shunsuke Kurosawa	**IL6**, O5	
Agata Lazarowska		**P33**
Karol Lemański	**O20**	
Grzegorz Leniec	O11, **O24**	
Tadeusz Leśniewski		P3, P16, **P34**, P35, P38, P52, P62
Aneta Lewkowicz		P9, P10
Ewelina Lipiec	**IL13**	

Ru-Shi Liu	**IL1**, O24	P22, P33
Pola Łukaszczuk	IL3	**P35**
Sebastian Maćkowski	**IL8**	
Sebastian Mahlik	IL9, IL10, O9, O14, O24	P3, P15, P16, P22, P33, P34, P35, P36, P38, P50, P52, P62
Natalia Majewska	O24	**P36**, P52
Artur Majewski- Napierkowski		P15, **P37**, P62
Łukasz Marciniak	**IL10**, O9	P1, P21
Michał Mazurek		P34, **P38**
Mohamed Mehnaoui		**P39**
Andries Meijerink	**TL4**	
Ismail Mekkaoui Alaoui	**O15**	
Ewa Mijowska	**O11**, O24	
Szymon Mirczak		**P40**
Neeraj Mishra	**O33**	
Jan Moszczyński	IL9	**P41**
Kamil Nalikowski		P29, **P42**
Saranya Narayanan	O10	**P43**
Marcin Nyk	**O1**, O17	
Katarzyna Orzechowska	**O36**	
Bohdan Padlyak	**O28**	P27
Michał Piasecki	**IL14**, O14	P23, P28, P35, P55
Joanna Pisarska		P2, P31
Wojciech Pisarski		P2, P31, P53
Audrey Potdevin	**O29**	
Mateusz Rebarz	**O25**	

Nadiia Rebrova	O20, **O22**, O23	**P45**, **P46**
Pawel Rochowski		P20, **P47**
Pavels Rodionovs		**P48**
Radosław Rogowski		**P49**
Marcin Runowski	**IL9**, IL10, O9	P41
Stefan Schweizer	**O26**	
Anna Shakhno		**P50**
Andrii Shyichuk	**O27**	**P51**
Philippe Smet	**TL8**	P17
Roman Sobolewski	**IL15**	
Ajeesh Kumar Somakumar	**O10**	
Alicja Stachowiak	**O8**	
Marta Starost		**P10**
Vasyl Stasiv	**O13**	P8, P58
Dagmara Stefańska	O2, **O19**	
Andrzej Suchocki	**TL12**, O10, O13	P17, P23, P28, P43, P44, P58
Markus Suta	**TL6**	
Anna Synak		P30
Yurii Syrotych		**P54**
Karol Szczodrowski		P3, P16, P34, P38, **P52**
Jan Szumilas		
Maja Szymczak	IL10, **O9**	P1, P21
Joanna Śmiarowska		**P53**
Mohamed Taibeche	**O4**	
Rajalingam Thangavel	**O18**	

Zafari Umar		**P55**
Tomasz Urbańczyk		P40, **P56**
Antonio Varriale	**O31**	
Valera Veryazo	**IL4**	P29, P42
Feng-e Wang		
Beata Wielgus-Kutrowska	**O12**	
Marcin E. Witkowski		P12, P13, **P57**
Patarawagee Yasaka	**O6**	P5
Patrycja Zdeb	O20, O22, **O23**	P45, P46
Justyna Zeler	**IL3**	P35
Taras Zhezhera	**O32**	P26
Yaroslav Zhydachevskyy	O10, O13	P23, P28, P43, **P58**, P59, P60, P61
Tetiana Zorenko		P15, P50, **P62**
Yuriy Zorenko	IL3, **IL7**,	P15, P37, P50, P54, P62
Eugeniusz Zych	IL3, O14, O27	P35, P51
Michał Żebrowski	**O17**	

Notes