BOOK OF ABSTRACTS

August 24-29, 2025

37 YEARS OF TRADITION

- LUMINESCENCE AND LUMINESCENT MATERIALS
- NOVEL FABRICATION TECHNOLOGIES AND TECHNIQUES
- OPTICAL PROPERTIES OF MATERIALS
- SINGLE CRYSTALS, POWDERS, SINTERED CERAMICS, NANOSTRUCTURES
- THEORETICAL, FUNDAMENTAL AND APPLIED RESEARCH

ORGANIZERS

Uniwersytet Wrocławski

INTIBSPAN

UNIWERSYTET EKONOMICZNY
we Wrocławiu

Wrocław-Sosnówka, Poland

Book of abstracts

14th International Conference on Excited States of Transition Elements

ESTE2025

August 24-29, 2025

Conference venue:
Hotel Lake Hill Resort & Spa
Tyrolska St. 2G, 58-564 Sosnówka, Poland

Post address:
ESTE2025 Conference, Faculty of Chemistry, University of Wroclaw
14 F. Joliot-Curie Street, 50-383 Wroclaw, Poland
e-mail:ESTE2025@uwr.edu.pl

Edited by
Joanna Trojan-Piegza and Andrii Shyichuk

Cover design by Justyna Zeler

Printed by
Reprotechnika Wrocław
23 Piłsudskiego Street, 50-044 Wrocław
http://www.reprotechnika.pl

ISBN 978-83-60043-43-1

Chairmen

Eugeniusz Zych, Wiesław Stręk, Dariusz Hreniak

Honorary Chair

Janina Legendziewicz, Renata Reisfeld

International Advisory Committee

Luisa E. Bausá (Spain)
Artur Bednarkiewicz (Poland)
Antonio Benayas (Spain)
Marco Bettinelli (Italy)
Mikhail Brik (Estonia)
Luis Carlos (Portugal)
William Cohen (USA)
Galina Dovbeshko (Ukraine)
Pieter Dorenbos (The Netherlands)
Miroslav Dramićanin (Serbia)
Airton Germano Bispo Jr. (Brazil)
Marek Godlewski (Poland)
Philippe Goldner (France)
Jerzy Hanuza (Poland)
Jorma Hölsä (RSA)
Aivaras Kareiva (Lithuania)
Jiang Li (China)
Stefan Lis (Poland)
Xiaogang Liu (Singapore)
Chong-Geng Ma (China)
Rachid Mahiou (France)
Oscar Malta (Brazil)
Łukasz Marciniak (Poland)
Andries Meijerink (The Netherlands)
Anja-Verena Mudring (Denmark)
Gilles Muller (USA)
Renaldo Tenório Moura Jr. (Brazil)
Marcin Nyk (Poland)
Kazuyoshi Ogasawara (Japan)
Fabio Piccinelli (Italy)
Dirk Poelman (Belgium)
Witold Ryba-Romanowski (Poland)
Marcin Runowski (Poland)
Maria Luisa Saladino (Italy)
Marek Samoć (Poland)
Alok Srivastava (USA)
Andrzej Suchocki (Poland)
Markus Suta (Germany)
Irena Szczygieł (Poland)
Setsuhisa Tanabe (Japan)
Ka-Leung Wong (Hongkong, China)
Tomoyuki Yamamoto (Japan)

Conference Secretaries

Małgorzata Puchalska, Andrii Shyichuk, Joanna Trojan-Piegza, Justyna Zeler

Local Organizing Committee

Vitalii Boiko
Paulina Bukowska
Mykhailo Chaika
Bartłomiej Cichy
Przemysław Dereń
Paulina Gawryszewska-Wilczyńska
Patrycja Godlewska
Marta Gordel-Wójcik
Jerzy Hanuza
Ewa Kasprzycka
Dagmara Kulesza
Aneta Lipa
Anna Łukowiak
Agata Musiałek
Justyna Nasalska
Jerzy Sokolnicki
Dagmara Stefańska
Mariusz Stefański
Robert Tomala
Jakub Tracz
Rafał Wiglusz

Honorary Sponsor

Czesław Zając, Rector of Wrocław University of Economics and Business

Sponsors

ECS The Electrochemical Society
Advancing solid state & electrochemical science & technology

LSI LASER SYSTEMS INTEGRATORS

TH.GEYER

Spectro-Lab®
Laboratoria Przyszłości

EDINBURGH INSTRUMENTS

shim-pol®

intech

Preface

Dear Participants, Colleagues, and Friends,

It is our great pleasure to welcome you to Poland, to the beautiful cities of Wrocław and Sosnówka, for the 14th International Conference on Excited States of Transition Elements – **ESTE2025**.

This conference proudly continues the tradition of the former Rare Earth Spectroscopy (RES) meetings, first held in 1988 at Książ Castle. From its very beginning, this series has brought together leading scientists from around the globe, alongside early-career researchers and students – for many of whom ESTE was their first international scientific conference. ESTE2025 continues this spirit, bringing together almost 140 participants, from distinguished professors to emerging young researchers.

This year's program will explore all aspects of luminescence and luminescent materials, spanning cutting-edge fabrication technologies, innovative characterization techniques, and advanced studies of optical properties in systems such as single crystals, powders, ceramics, nanostructures, glasses, and amorphous materials. The presentations will highlight both fundamental advances and applied breakthroughs, providing a comprehensive picture of the field's current frontiers.

We are confident that ESTE2025 will uphold its tradition of stimulating discussions and inspiring collaborations. With all lectures, poster sessions, and accommodations located in the same venue – the Lake Hill Hotel Resort & Spa – there will be excellent opportunities for interaction and networking. We hope you will find both the conference setting and the surrounding landscapes to be as inspiring for work as they are for relaxation.

We are also pleased to acknowledge the growing engagement of the industry in ESTE. This year, we are grateful for the support of Laser Systems Integrators, Spectro-Lab, TH. Geyer, Edinburgh Instruments, Shim-Pol, Intech, and The Electrochemical Society – one of the world's oldest and most respected international scientific societies, committed to advancing solid-state and electrochemical science and technology.

We wish you an enjoyable and productive conference, with lively discussions, new connections, and collaborations that will extend well beyond this meeting. We also warmly invite you to join us for the next edition of ESTE.

Eugeniusz Zych Wiesław Dariusz Hreniak

Conference Programme

International Conference on Excited States of Transition Elements

24-29 August, 2025

Conference venue: Hotel Lake Hill Resort & Spa in Sosnówka, Poland

Sunday, August 24

Bus from Wroclaw to Sosnówka	**Institut of Low Temperature and Structure Research, Polish Academy of Sciences (INTiBS PAN)**	**Faculty of Chemistry**	**Wroclaw Airport**	**Arrival to Sosnówka**
Bus#1	13:50	14:30	X	~16:30
Bus#2	X	15:00	X	~17:00
Bus#3	X	16:30	17:10	~19:00

Sunday, August 24	**Welcoming participants**	
	16:00 -	Check-in at the hotel possible
	16:00 -	Registration open
	18:00 - 24:00	Welcome reception

Monday, August 25

Monday, August 25	**7:30-9:00**	**BREAKFAST**
	9:00-10:50	**SESSION 1** ***Chair: Dariusz Hreniak***
	9:00-9:30	Welcome talks **Eugeniusz Zych**, **Wiesław Stręk**, **Dariusz Hreniak** ESTE2025 CHAIRS **Christopher Januzzi** EXECUTIVE DIRECTOR & CEO, THE ELECTROCHEMICAL SOCIETY
	9:30-9:55	Invited talk I-1 **Andries Meijerink**, LED IT BE
	9:55-10:20	Invited talk I-2 **William Cohen**, SMALL PARTICLE SIZE $K_2SiF_6:Mn^{4+}$ PHOSPHOR FOR MICRO-LEDS
	10:20-10:35	Oral communication O-1 **Jan Moszczyński**, SUPERSENSITIVE VISUAL PRESSURE SENSOR BASED ON THE EXCITON LUMINESCENCE OF THE Bi^{3+}-DOPED, DOUBLE PEROVSKITE MATERIAL $Cs_2Ag_{0.6}Na_{0.4}InCl_6$
	10:35-10:50	Oral communication O-2 **Lingdong Sun**, LOCAL STRUCTURE ENGINEERING IN RARE EARTH NANOCRYSTALS FOR TUNABLE UPCONVERSION EMISSIONS
	10:50-11:30	**COFFEE BREAK**
	11:30-13:20	**SESSION 2** ***Chair: Pieter Dorenbos***
	11:30-11:55	Invited talk I-3 **Dirk Poelman**, THE COLORFUL WORLD OF MANGANESE: LUMINESCENCE ACROSS OXIDATION STATES
	11:55-12:20	Invited talk I-4 **Jumpei Ueda**, HOLE IONIZATION QUENCHING AND HOLE DETRAPPING PERSISTENT PHOSPHORS
	12:20-12:35	Oral communication O-3 **Łukasz Marciniak**, LUMINESCENCE THERMOMETRY BASED ON FIRST ORDER PHASE TRANSITION
	12:35-12:50	Oral communication O-4 **Patrycja Zdeb-Stańczykowska**, ENHANCING VISIBLE-TO-UVC UPCONVERSION IN Pr^{3+}-DOPED BORATES
	12:50-13:05	Oral communication O-5 **Maria Claudia Felinto**, NEAR-INFRARED NON-GALLATE PERSISTENT PHOSPHORS FUNCTIONALIZED WITH EUROPIUM COMPLEX FOR POTENTIAL OPTICAL IMAGING APPLICATIONS

Monday, August 25		
	13:05-13:20	Oral communication O-6 **Marek Adaszyński**, THE Ce^{3+} AND Sm^{3+}-DOPED PHOSPHATES FOR APPLICATION IN LED LIGHTING
	13:20-14:40	**LUNCH**
	14:40-16:15	**SESSION 3** ***Chair: Marco Bettinelli***
	14:40-15:05	Invited talk I-5 **Chong-Geng Ma**, ADVANCING LUMINESCENT METAL HALIDE PEROVSKITES THROUGH THEORETICAL DEFECT ENGINEERING
	15:05-15:30	Invited talk I-6 **Freddy Rabouw**, SPECTRAL DISTORTIONS IN LUMINESCENCE THERMOMETRY
	15:30-15:45	Oral communication O-7 **Chen Hu**, RECENT PROGRESS ON DEFECT ENGINEERING IN LuAG:Ce CERAMICS TOWARDS ULTRAHIGH FAST SCINTILLATION PROPORTION
	15:45-16:00	Oral communication O-8 **Jiaren Du**, DESIGN OF INORGANIC TRAP-CONTROLLED LUMINESCENT MATERIALS
	16:00-16:15	Oral communication O-9 **Jeffrey Zom**, DEMONSTRATING POLARON MEDIATED PHOTOLUMINESCENCE IN VANADATES BY A COMBINED EXPERIMENTAL AND COMPUTATIONAL STUDY
	16:15-17:10	**COFFEE BREAK**
	17:10-18:30	**SESSION 4 – GEORGES BOULON MEMORIAL SESSION**
	17:10-18:30	Special talk S-1 **Marco Bettinelli**, GEORGES BOULON: A LIFE DEVOTED TO LUMINESCENCE
		Special talk S-2 **Janina Legendziewicz**, HONORING THE MEMORY OF GEORGES BOULON
		Special talk S-3 **Martin Nikl**, CONCLUDING ON GSAG:Ce SINGLE CRYSTAL SCINTILLATOR: MATERIAL OPTIMIZATION AND BOTTLENECKS
		Special talk S-4 **Wiesław Stręk**, LASER DRIVEN LUMINESCENCE OF RARE EARTH COMPOUNDS
	18:30-20:00	**DINNER**

Tuesday, August 26

Tuesday, August 26	**7:30-9:00**	**BREAKFAST**
	9:00-10:50	**SESSION 5** ***Chair: Antonio Benayas***
	9:00-9:25	Invited talk I-7 **Pieter Dorenbos**, CHARGE TRANSITION LEVEL ENERGIES OF THE 3d TRANSITION METALS IN COMPOUNDS
	9:25-9:50	Invited talk I-8 **Oscar Malta**, REVISITING THE MECHANISMS OF NON-RADIATIVE ENERGY TRANSFER IN LANTHANIDE MATERIALS
	9:50-10:05	Oral communication O-10 **Chihaya Fujiwara**, EMISSION PROPERTIES CONTROL BY IODIDE-DOPING EFFECTS IN ZERO-DIMENSIONAL PEROVSKITE CHLORIDE SCINTILLATORS
	10:05-10:20	Oral communication O-11 **Bibo Lou**, STRUCTURE-PROPERTY ANALYSIS AND PERFORMANCE PREDICTION OF ION-DOPED LUMINESCENT MATERIALS VIA HIGH-THROUGHPUT FIRST-PRINCIPLES CALCULATIONS
	10:20-10:35	Oral communication O-12 **Agata Musiałek**, EXTERNAL FIELD CONTROL OF LASER INDUCED WHITE LIGHT EMISSION
	10:35-10:50	Oral communication O-13 **Shunsuke Kurosawa**, EXCITATION AND EMISSION STATES FOR Cr-DOPED GARNET SCINTILLATORS WITH RED AND INFRARED EMISSION
	10:50-11:30	**COFFEE BREAK**
	11:30-13:20	**SESSION 6** ***Chair: Dirk Poelman***
	11:30-11:55	Invited talk I-9 **Jiang Li,** CONTROLLABLE PREPARATION AND PROPERTIES OF ADVANCED LASER CERAMICS
	11:55-12:20	Invited talk I-10 **Greta Inkrataitė**, IMPACT OF BORON CO-DOPING ON THE LUMINESCENCE PROPERTIES OF Pr^{3+} OR Ce^{3+} DOPED YTTRIUM, LUTETIUM, AND GADOLINIUM ALUMINUM GARNETS
	12:20-12:35	Oral communication O-14 **Tingsong Li**, FABRICATION AND CHARACTERIZATIONS OF Eu^{2+}-Dy^{3+} CO-DOPED SrAl$_2$O$_4$ CERAMICS WITH PERSISTENT LUMINESCENCE
	12:35-12:50	Oral communication O-15 **Sandra Witkiewicz-Łukaszek**, SCINTILLATION PROPERTIES OF COMPOSITE SCINTILLATORS BASED ON ORTHOSILICATE COMPUNDS

	12:50-13:05	Oral communication O-16 **Monika Kotykova**, OPTICAL AND SCINTILLATION PROPERTIES OF INDUSTRY-SCALE $(Gd,Y)AlO_3$:Ce SINGLE CRYSTAL
	13:20-14:40	**LUNCH**
	14:40-16:15	**SESSION 7** ***Chair: Jumpei Ueda***
	14:40-15:05	I-11 **Philippe Smet**, REVEALING TRAPPING PROCESSES IN PERSISTENT PHOSPHORS BY TIME-RESOLVED OPTICAL SPECTROSCOPY ON THE PS TO MS TIMESCALE
	15:05-15:30	Invited talk I-12 **Hermi Brito**, LUMINESCENCE PROPERTIES OF RARE EARTH NANOMATERIALS AND COMPLEXES AS LIGHT EMITTERS
	15:30-15:45	Oral communication O-17 **Maxime Delaey**, IMPROVING THE OPTICAL PROPERTIES OF NEAR-INFRARED LUMINESCENT NANOPARTICLES BY PROTECTED CALCINATION
	15:45-16:00	Oral communication O-18 **Przemysław Dereń**, COMPARISON OF UPCONVERSION TO UVC AND UVB IN ABO_3: Pr^{3+} WHERE A = Sc, Y, La, AND Lu
	16:00-16:15	Oral communication O-19 **Yurii Syrotych**, COMPARISON OF STRUCTURAL, LUMINESCENT AND SCINTILLATION PROPERTIES OF $Gd_3Al_xGa_{5-x}O_{12}$:Ce, x=2.3-3 SINGLE CRYSTALS AND SINGLE-CRYSTALLINE FILMS
	16:15-18:30	**POSTER SESSION**
	18:30-20:00	**DINNER**

Wednesday, August 27

Wednesday, August 27	**7:30-9:00**	**BREAKFAST**
	9:00-10:50	**SESSION 8** ***Chair: Hermi Brito***
	9:00-9:25	Invited talk I-13 **Markus Suta,** OUT OF THE COMFORT ZONE – A PARADIGM SHIFT IN LIGAND FIELD TUNING OR NOT?
	9:25-9:50	Invited talk I-14 **Karol Bartosiewicz**, ACHIEVING LONG-PERSISTENT LUMINESCENCE IN Ce^{3+}-DOPED GARNET SINGLE CRYSTALS THROUGH NONSTOICHIOMETRIC ENGINEERING AND CONTROLLED CRYSTALLIZATION KINETICS
	9:50-10:05	Oral communication O-20 **Galyna Dovbeshko / Vitalii Boiko**, WAR-DERIVED CARBON CONTAINING SMOKE NANOPARTICLES WITH HEAVY METALS: PHYSICOCHEMICAL PROPERTY AND TOXICITY
	10:05-10:20	Oral communication O-21 **Nadia Rebrova**, INNOVATIVE Pr^{3+}-ACTIVATED RbCaF$_3$ PHOSPHOR FOR EFFICIENT UVC EMISSION VIA VISIBLE AND X-RAY EXCITATION
	10:20-10:35	Oral communication O-22 **Marta Gordel-Wójcik**, EXPLORING ULTRAFAST DYNAMICS IN HYBRID COLLOIDAL NANOSYSTEMS USING FS TRANSIENT ABSORPTION
	10:35-10:50	Oral communication O-23 **Adam Kabański**, MULTIMODAL TEMPERATURE SENSING IN HYBRID PEROVSKITES DOPED WITH Cr^{3+}
	10:50-11:30	**COFFEE BREAK**
	11:30-13:20	**SESSION 9** ***Chair: Maria Luisa Saladino***
	11:30-11:55	Invited talk I-15 **Jonas Joos**, MULTICONFIGURATIONAL AB INITIO CALCULATIONS AS A TOOL TO REVEAL THE EXCITED STATES OF TRANSITION ELEMENT IMPURITIES IN CRYSTALS
	11:55-12:20	Invited talk I-16 **Sebastian Mahlik,** REVISITING THE SINGLE CONFIGURATIONAL COORDINATE MODEL IN TRANSITION METAL-DOPED PHOSPHORS
	12:20-12:35	Oral communication O-24 **Magdalena Dudek**, OPTICAL COOLING IN CaF$_2$ MICROCRYSTALS DOPED WITH Yb^{3+} IONS
	12:35-12:50	Oral communication O-25 **Andrii Shyichuk**, BROAD BAND EMISSION MODELING WITH AUTOMATED CONSTRUCTION OF CONFIGURATIONAL DIAGRAM

Wednesday, August 27	12:50-13:05	Oral communication O-26 **Adam Watras**, INFLUENCE OF MANGANESE IONS ON Eu^{3+} EMISSION IN Eu^{3+}, Mn^{n+}:YVO_4 NANOPHOSPHOR
	13:20-14:40	**LUNCH**
	14:40-18:30	**EXCURSION**
	20:00-23:00	**DINNER-GRILL-BBQ**

Thursday, August 28

Thursday, August 28	**7:30-9:00**	**BREAKFAST**
	9:00-10:50	**SESSION 10** ***Chair: Martin Nikl***
	9:00-9:25	Invited talk I-17 **Marcin Runowski**, COMBINATION OF PHOTOLUMINESCENCE AND MECHANOLUMINESCENCE FOR OPTICAL PRESSURE AND TEMPERATURE MONITORING
	9:25-9:50	Invited talk I-18 **Marco Bettinelli,** $Tb^{3+}\rightarrow Eu^{3+}$ ENERGY TRANSFER IN $Tb_{1-x}Eu_xAl_3(BO_3)_4$ CRYSTALS (x=0.01-0.20)
	9:50-10:05	Oral communication O-27 **Winicjusz Drozdowski**, SCINTILLATION PROPERTIES OF DMAC-TRZ DERIVATIVE CRYSTALS
	10:05-10:20	Oral communication O-28 **Leonardo Ceccon**, CIRCULARLY POLARIZED LUMINESCE FROM PURE AND Eu-DOPED TRIGONAL $TbPO_4\cdot nH_2O$ NANOCRYSTALS COATED WITH DICARBOXYLIC ACID
	10:20-10:35	Oral communication O-29 **Leonardo Saraiva**, DIMENSIONALITY REDUCTION ALGORITHMS AS A PATHWAY TO ENHANCE THE PERFORMANCE OF SINGLE-CENTER Eu^{III} LUMINESCENT THERMOMETER
	10:35-10:50	Oral communication O-30 **Mykhailo Chaika**, THE FEATURE OF Cr^{4+} DOPED $Y_3Al_5O_{12}$ TRANSPARENT CERAMIC SPECTROSCOPIC PROPERTIES
	10:50-11:30	**COFFEE BREAK**
	11:30-13:20	**SESSION 11** ***Chair: Andries Meijerink***
	11:30-11:55	Invited talk I-19 **Riccardo Marin**, A TALE OF REMOTE SENSING: NANOSENSORS, CROSS-SENSITIVITY, AND ARTIFICIAL INTELLIGENCE
	11:55-12:20	Invited talk I-20 **Jörma Hölsä**, PERSISTENT LUMINESCENCE: DOPANTS, DEFECTS AND TRAPS
	12:20-12:35	Oral communication O-31 **Long Yan**, TEMPORAL CONTROL OF DYNAMIC UPCONVERSION MEDIATED BY ENERGY TRANSFER
	12:35-12:50	Oral communication O-32 **Vladimir Pankratov**, NEAR INFRARED SCINTILLATORS BASED ON RARE-EARTH DOPED CsI SINGLE CRYSTALS

Thursday, August 28	12:50-13:05	Oral communication O-33 **Vincent Benning**, PHOTON STATISTICS AS A TOOL TO (DIS)PROVE QUANTUM CUTTING IN NEAR-INFRARED EMITTING MATERIALS
	13:05-13:20	Oral communication O-34 **Wei Hu**, STEPWISE PHOTOCHROMISM REGULATED BY MULTIPLE COLOR CENTERS IN INORGANIC PHOTOCHROMIC MATERIALS
	13:20-14:40	**LUNCH**
	14:40-16:15	**SESSION 12** ***Chair: Markus Suta***
	14:40-15:05	Invited talk I-21 **Antonio Benayas**, HEATING THROUGH OPTICAL EXCITATION ABOVE 1000 nm: SPECTRALLY DECOUPLING THERANOSTICS & ENGINEERING PLASMONIC NANOPARTICLES TO MAXIMIZE HEAT DELIVERY
	15:05-15:30	Invited talk I-22 **Maria Luisa Saladino**, FROM ANCIENT PIGMENTS TO MODERN SECURITY: NOVEL LUMINESCENT FORMULATION FOR ANTI-COUNTERFEITING APPLICATIONS
	15:30-15:45	Oral communication O-35 **Vasilii Khanin**, NANO-ENGINEERED PHOSPHORS FOR WHITE LEDS
	15:45-16:00	Oral communication O-36 **Vojtech Vanecek**, FLUOROPEROVSKITE SOLID SOLUTIONS: A PLATFORM FOR THE STUDY OF 5d → 4f LUMINESCENCE
	16:00-16:15	Oral communication O-37 **Dagmara Stefańska**, THE ROLE OF Eu^{2+} IN PHOSPHORS FOR WHITE AND NEAR-INFRARED LIGHT-EMITTING DIODE APPLICATIONS
	16:15-17:10	**COFFEE BREAK**
	17:10-18:35	**SESSION 13** ***Chair: Marcin Runowski***
	17:10-17:35	Invited talk I-23 **Airton Germano Bispo Junior**, MOLECULAR ENGINEERING OF LANTHANIDE(III) COMPLEXES TOWARDS DUAL-FUNCTION SINGLE MOLECULE MAGNETS DISPLAYING LUMINESCENCE THERMOMETRY
	17:35-18:00	Invited talk I-24 **Yuriy Zorenko**, LUMINESCENCE OF THE ISOELECTRONIC IMPURITIES IN HALIDE AND OXIDE SCINTILLATORS UNDER X-RAYS AND SYNCHROTRON RADIATION EXCITATION
	18:00-18:15	Oral communication O-38 **Oksana Chukova**, THE LUMINESCENCE OF Gd^{3+} AND Ce^{3+} DOPED ZnO NANOPARTICLES
	18:15-18:30	**CLOSING REMARKS**
	20:00-1:00	**BANQUET & DANCING**

Friday, August 29

Friday, August 29	**Check out / Departure**	
	7:30-11:00	BREAKFAST
	Departure from the hotel **Stops at the Wrocław Airport and the Faculty of Chemistry.**	
	9:00	Buses will depart around **9:00, 9:45 and 10:30**. It will take about 1:50 hours to Wrocław Airport, and about 2:30 hours to the city center. **You will have an opportunity to sign up for a specific bus at the conference reception during the conference**.
	9:45	
	10:30	

Abstracts

I-1

LED it be

A. Meijerink[1], **J. de Wit**[1], **A. J. van Bunningen**[1], **S. Wakui**[2], **A. D. Sontakke**[1,3],
M. A. van de Haar[3], **F. T. Rabouw**[1]

[1]*CMI, Debye Institute for Nanomaterials Science, 3584CC Utrecht, The Netherlands*
[2]*Nichia Corporation, 1-19, Tatsumi-Cho, Anan-shi, Tokushima 774-0001, Japan*
[3]*Seaborough Research B.V., Science Park 106, 1098 XG Amsterdam, The Netherlands*
* corresponding author: a.meijerink@uu.nl

Keywords: LED phosphor, Luminescence quenching, KSF:Mn^{4+}, CASN:Eu^{2+}, YAG:Ce^{3+}, Mn^{2+}

The invention of the blue LED has profoundly changed the lighting market. The future is LED lighting. The first success in creating a white light LED relied on YAG:Ce^{3+}, a well-known phosphor that turned out to check all the boxes to survive the extreme conditions (high temperature and light flux) experienced by phosphors in LEDs. To improve the performance of white light LEDs in efficiency, colour rendering and color gamut for displays, many new lanthanide-based phosphors were found such as CASN:Eu^{2+} but also 3d transition metal based phosphors, for example KSF:Mn^{4+}.

In this presentation recent developments in LED phosphor research will be discussed. Many challenges remain, both in developing better phosphors for new applications and understanding issues as luminescence quenching, defects, high power effects, stability, alternative ions. Some 'hot' areas of research include human centric lighting, plant centric lighting (horticulture), narrow band phosphors for high color gamut/efficiency, micro LED phosphors, nanophosphors and high power LEDs and saturation issues. Recent work in our group related to these issues/applications will be discussed followed by an outlook.

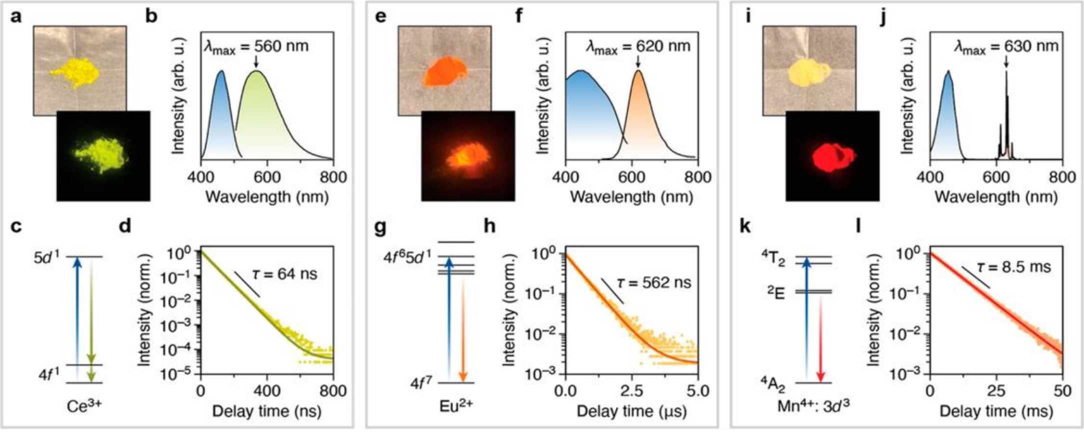


Fig. 1. Characteristics of three phosphor materials studied. (a,b) YAG:Ce^{3+} phosphor powder under ambient illumination (top) and its photoluminescence (bottom). (b) Excitation (blue) and emission spectra of YAG:Ce^{3+}. (c) Energy level scheme of Ce^{3+} in YAG, (d) Photoluminescence decay curve of YAG:Ce^{3+} upon pulsed blue excitation. (e–h) Same as a–d, but for CASN:Eu^{2+}. (i–l) Same as a–d, but for KSF:Mn^{4+}.

[1] M. A. van de Haar, M. Tachikirt, A. C. Berends, M. R. Krames, A. Meijerink, F. T. Rabouw *ACS Photonics* **8** (2021) 1784.
[2] A. J. van Bunningen, J. W. de Wit, S. Wakui, A. Meijerink, *ACS Appl Mater. Interfaces* **16** (2024**)** 1044.
[3] A. J. van Bunningen, A. D. Sontakke, R. van der Vliet, V. G. Spit, A. Meijerink, *Adv. Optical Mater.* **11** (2023) 22022794.

I-2

SMALL PARTICLE SIZE $K_2SiF_6:Mn^{4+}$ PHOSPHOR FOR MICRO-LEDS

W. E. Cohen[1,*], F. Du[1], W. W. Beers[1], C.-Geng Ma[2], M. G. Brik[2,3,4,5,6], A. M. Srivastava[1]

[1]Current Chemicals, 1099 Ivanhoe Road, Cleveland, Ohio 44110, United States of America
[2]School of Optoelectronic Engineering & CQUPT-BUL Innovation Institute, Chongqing University of Posts and Telecommunications, Chongqing, PR China
[3]Center of Excellence for Photoconversion, Vinča Institute of Nuclear Sciences – National Institute of the Republic of Serbia, University of Belgrade, Belgrade, Serbia
[4]Institute of Physics, University of Tartu, W. Ostwald Str. 1, Tartu, Estonia
[5]Faculty of Science and Technology, Jan Długosz University, Częstochowa, Poland
[6]Academy of Romanian Scientists, Ilfov Str. No. 3, Bucharest, Romania

* corresponding author: bill.cohen@currentchemicals.com

Keywords: Red Phosphor, LED, $K_2SiF_6:Mn^{4+}$, Micro-LEDs, Display Devices, Wide Color Gamut

The modern-day pc-LEDs for general illumination are based on a blue-emitting InGaN chip coated with a blend of two phosphors, a green-yellow Cerium-doped garnet phosphor and a red phosphor which is required to induce a “warm-white” color temperature (2700–3500 K). To achieve a preferred color rendering and energy efficiency, a red phosphor with narrow emission is ideal. For display applications with wide-color-gamut performance, white light LEDs composed of narrow emission in blue, green, and red are required and often achieved with pc-LEDs using a blue-emitting InGaN chip coated with a blend of two phosphors, a narrow green Europium-doped phosphor and a narrow red phosphor.

One narrow red phosphor used in white light pc-LEDs that exceeds in the key performance requirements of a red emitter for both general illumination and display application is $K_2SiF_6:Mn^{4+}$ (PFS/KSF) phosphor [1-3]. This is attributable to its unique peak wavelength and narrow emission. Current Chemicals manufactures $K_2SiF_6:Mn^{4+}$ phosphor and sells it under the trade name, TriGain®.

TriGain® phosphor has a typical median particle size of 20-40μm as well as some specialty versions with median particle size of 5-10μm. Recently, we have developed $K_2SiF_6:Mn^{4+}$ phosphor with a smaller particle size (1-3μm), optimized for next generation micro-LED displays such as TV, laptops, mobile phone (Fig. 1). This presentation will focus on the synthesis and optical properties of this new phosphor. We will compare the temperature dependence of the Mn^{4+} luminescence and lifetime with that of the TriGain® phosphor. The thermal quenching behavior is analyzed and discussed. This comparative study highlights the factors influencing non-radiative relaxation processes, which are fundamental to the understanding of phosphor quantum efficiency and performance.

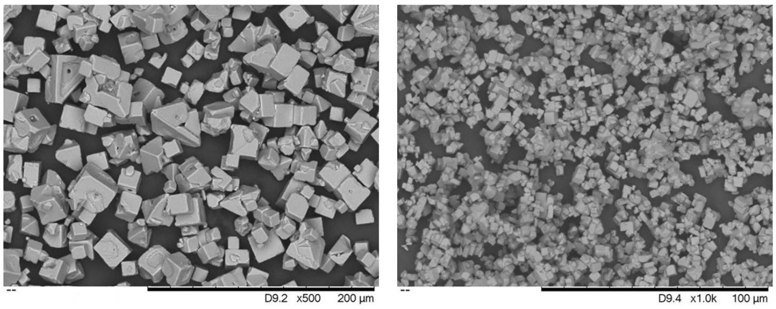


Fig 1: The SEM of TriGain® (left) and small particle size $K_2SiF_6:Mn^{4+}$ (right)

[1] M.G. Brik and A.M. Srivastava, J. Lumin., 133, 69 (2013)
[2] W.E. Cohen, F. Du, W.W. Beers, A.M. Srivastava, ECS J. Solid State Sci. Tech, 12 (2023)
[3] W.W. Beers, W.E. Cohen, A.M. Srivastava, ECS J. Solid State Sci. Technol.,12 (2023)

I-3

The Colorful World of Manganese: Luminescence Across Oxidation States

D. Poelman[1,*], **Q. Zhang**[2], **J. Du**[3]

[1]*LumiLab, Department of Solid-State Science, Ghent University, 9000 Ghent, Belgium*
[2]*School of Integrated Circuits, Southeast University, Nanjing 210096, PR China*
[3] *School of Chemical and Material Engineering, Jiangnan University, 214122, Wuxi, China*

* corresponding author: *Dirk.Poelman@ugent.be*

Keywords: bioimaging, NIR emission, luminescence imaging, energy transfer

Imaging methods play an essential role in medical diagnostics and treatment. In the last years, there has been a strong research interest into the development of optical imaging methods which could replace the current approach based on ionizing radiation, as a safe and cheap alternative. Luminescent nanoparticles could be used as *in vivo* tracers of blood streams, for tracking specific types of cells or for delineating tumors, provided that they emit in one of the so-called optical windows in the near-infrared (NIR), where biological tissues have a low absorption.

Since many years Mn^{2+} has been used as a dopant with tunable broad band emission in the visible range, from green to deep red, depending on the crystal field. To achieve NIR emission, we should turn to one of the (many) other oxidation states of Mn: Mn^{4+} shows narrowband NIR emission at around 700 nm [1], in the first optical window (NIR-I), while Mn^{5+} produces a narrow emission band centered at 1180 nm, in the second optical window (NIR-II) [2].

Next to a general overview of the luminescent characteristics associated with the various oxidation states of Mn ions, we present a phosphate phosphor material where both Mn^{4+} and Mn^{5+} ions can be stabilized [3]. Upon excitation at 365 nm, emission from Mn^{4+} is observed, while excitation at 750 nm (in NIR-I) leads to Mn^{5+} emission. Both emission can be observed simultaneously upon blue light excitation due to energy transfer. The phosphor does not only showcase a highly tunable workhorse NIR emitter, but also has high potential for NIR bioimaging applications.

[1] J. Du, K. Li, R. Van Deun, D. Poelman, H. Lin, *Adv. Opt. Mater.* **10** (2022) 2101714.
[2] Q. Zhang, Z. Yang, X. Zhou, M. Delaey, M. Wang, R. Fu, S. Lei, H. Vrielinck, D. Poelman, *Laser Photonics Rev.* **18** (2024) 2400781.
[3] Q. Zhang, Z. Yang, W. Hu, M. Delaey, L. Yin, Y. Jiang, S. Lei, H. Vrielinck, D. Poelman, *Chem. Eng. J.* **508** (2025) 161131.

This research is funded by FWO (Fund for Scientific Research-Flanders), project G025322N.

I-4

Hole Ionization Quenching and Hole Detrapping Persistent Phosphors

J. Ueda [1]*, A. Hashimoto[1]

[1]*Japan Advanced Institute of Science and Technology, Nomi, 923-1292, Japan*

* corresponding author: *ueda-j@jaist.ac.jp*

Keywords: Luminescence quenching, Persistent phosphor, Ionization

Persistent phosphors, which show continuing luminescence even after the ceasing of excitation light, have been widely used as luminous paint in many products. The persistent luminescence is generally caused by 1. Carrier generation, 2. Carrier trapping, 3. Storage, 4. De-trapping and 5. Luminescence processes.[1] The detrapping carrier is determined by the relationship of trap depths by electron and hole traps. In the condition that the electron trap depth ($E_{\mathrm{e\_trap}}$) is shallower than the hole trap depth ($E_{\mathrm{h\_trap}}$), the electrons are firstly detrapped and the electron detrapping persistent phosphors can be obtained. If $E_{\mathrm{h\_trap}} < E_{\mathrm{e\_trap}}$, the hole can be firstly detrapped and the hole detrapping persistent phosphors can be obtained. Common persistent phosphors like Eu^{2+} and Ce^{3+}-doped materials are classified as the electron detrapping persistent phosphors. On the other hand, it is expected that Eu^{3+}-doped phosphors are caused by the hole trapping and detrappng due to the photo-reduction process ($Eu^{3+} \Leftrightarrow Eu^{2+} + h^+$).

Recently, we successfully demonstrated that the hole-ionization process in Eu^{3+}-doped oxysulfide phosphors using thermoluminescence techniques and developed a new red persistent phosphor of Eu^{3+}-Pr^{3+} co-doped La_2O_2S based on the hole-trapping and detrapping mechanism as shown in Fig. 1 [2]. In the presentation, the design concept of the hole detrapping persistent phosphors will be discussed.

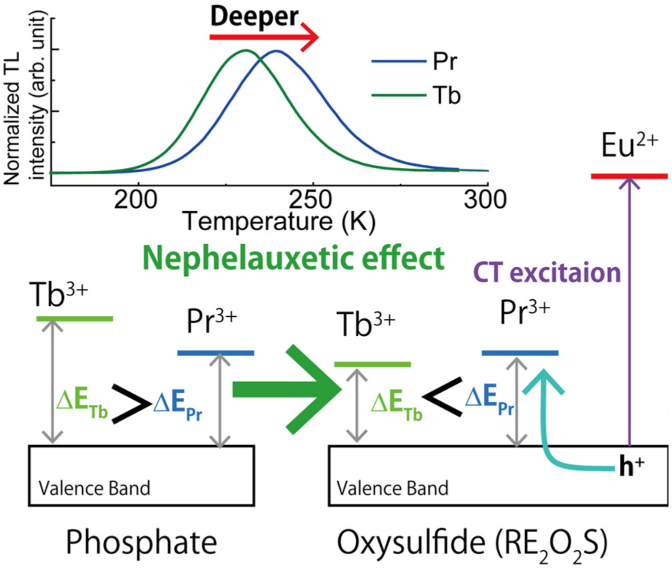


Fig. 1. Energy diagram of Hole detrapping persistent phosphors

References

[1] J. Ueda, Bulletin of the Chemical Society of Japan 94 (2021) 2807

[2] A. Hashimoto, J. Ueda, Y. Aoki, P. Dorenbos, and S. Tanabe, J. Phys. Chem. C 127 (2023) 15611

ADVANCING LUMINESCENT METAL HALIDE PEROVSKITES THROUGH THEORETICAL DEFECT ENGINEERING

C.-G. Ma[1*]

[1]*School of Integrated Circuits & CQUPT-BUL Innovation Institute, Chongqing University of Posts and Telecommunications, Chongqing 400065, China*

* corresponding author: cgma.ustc@gmail.com

Keywords: Metal halide perovskites, Rare-earth, Transition-metal, *ns*^{2}-type ions, First-principles

For over six decades, theoretical spectroscopy has played a pivotal role in defect engineering for luminescent materials, achieving remarkable success in systems involving rare-earth ions, transition metals, and *ns*^{2}-type ions [1]. Despite the recent emergence of metal halide perovskites (MHPs) as highly promising light-emitting materials, the application of these well-established theoretical frameworks to luminescent-ion-doped MHPs remains surprisingly limited. In this work, we introduce a unified first-principles approach capable of not only elucidating but also predicting the fundamental spectroscopic properties of defect-engineered MHPs.

Our investigation reveals several key advances. In Er^{3+}/Fe^{3+}-codoped $Cs_2NaBiCl_6$ systems, we uncover a novel synergistic charge transfer mechanism between the host lattice and Fe^{3+} dopants, where the optimized energy transfer pathways to Er^{3+} ions combine with a unique Fe^{3+}-induced chemical stress environment to dramatically enhance Er^{3+} NIR-II emission [2]. Furthermore, systematic analysis of $3d^3$ ions in double fluoride perovskites enables us to quantitatively identify the critical electronic structure parameters governing luminescence thermal quenching, providing compelling theoretical evidence that challenges conventional empirical interpretations [3]. Additionally, we demonstrate that strategic *ns*^{2}-type ion doping facilitates precise band alignment engineering, establishing a robust foundation for designing next-generation MHP scintillators with tailored performance characteristics [4].

These findings fundamentally transform our understanding of self-trapped excitons and defect-host interactions in MHPs while creating a powerful predictive framework for the rational design of advanced luminescent materials.

[1] M.G. Brik, C.-G. Ma, Theoretical spectroscopy of transition meatal and rare earth ions: From free state to crystal field. *Jenny Stanford Publishing*, Singapore, 2020.

[2] Y.S. Wang, B.B. Lou, P.P. Dang, G.D. Zhang, Y.J. Wan, L. Tian, H.Z. Lian, Z.Y. Hou, C.-G. Ma, G.G. Li, J. Lin, *Angew. Chem. Int. Ed.* **64** (2025) e202416021.

[3] M.S. Kurboniyon, A.M. Srivastava, B.B. Lou, D.D. Nematov, A. Burhonzoda, T. Yamamoto, C.-G. Ma, M.G. Brik, *Inorg. Chem.* **63** (2024) 21212.

[4] K. Han, J.W. Qiao, S. Zhang, B.B. Su, B.B. Lou, C.-G. Ma, Z.G. Xia, *Laser Photonics Rev.* **17** (2023) 2200458.

Acknowledgments: This work was financially supported by the National Natural Science Foundation of China (Grant Nos. U24A2056, 12274048 and 52161135110).

Spectral distortions in luminescence thermometry

Freddy T. Rabouw[a,b,*], **Sander J.W. Vonk**[a], **Thomas P. van Swieten**[a], **Thimo S. Jacobs**[b],
Robin Vogel[a,b], **Bert M. Weckhuysen**[b], **Andries Meijerink**[a]

[a]*Debye Institute for Nanomaterials Science, Utrecht University, Princetonplein 1,*
3584 CC Utrecht, The Netherlands
[a]*Institute for Sustainable and Circular Chemistry, Utrecht University, Universiteitsweg 99, 3584 CG*
Utrecht, The Netherlands

* *corresponding author: f.t.rabouw@uu.nl*

Intro

Luminescence thermometry has become a popular tool for remote temperature sensing in a variety of environments, ranging from biological samples to microelectronic devices and chemical reactors. A luminescent material with a temperature-dependent emission spectrum is embedded in the sample and the emission is excited and recorded from a distance. However, the optical properties of the sample introduce challenges for luminescence thermometry. Emission spectra are distorted by absorption, scattering, and reflection by the sample. This causes errors in the temperature read-out.

Summary of presentation

This presentation will overview our efforts to understand and handle spectral distortions in luminescence thermometry. Even if the sample is non-absorbing, spectral distortions due to scattering and reflections can cause temperature errors of up to 100°C. We understand this problem using systematic experiments[1] and handle it with local calibration on a device sample.[2] In catalytic-reactor experiments, we encounter spatially[3] or temporally[4] varying optical properties of the sample environments. I will discuss the experiment design allowing for in-situ calibration of the distortions and correction procedures in the data analysis.

References

[1] S.J.W. Vonk *et al.*, *Nano Lett.* **23**, 6560–6566 (2023).
[2] T.P. van Swieten *et al.*, *ACS Appl. Nano Mater.* **4**, 4208–4215 (2021).
[3] T.S. Jacobs *et al.*, *ACS Nano* **17**, 20053–20061 (2023).
[4] R. Vogel *et al.*, *ACS Appl. Mater. Interfaces* **17**, 21215–21222 (2025).

CHARGE TRANSITON LEVEL ENERGIES OF THE 3d TRANSITION METALS IN COMPOUNDS

P. Dorenbos

Delft University of Technology, Delft Reactor Institute, Mekelweg 15, 2629JB Delft, The Netherlands

* corresponding author: *p.dorenbos@tudelft.nl*

Keywords: transition metals, VRBE, defect levels, chemical shift model

The defect levels of the $3d^q$ transition metals (TM) within the bandgap of compounds provide compounds with properties that are utilized in luminescence, lasers, photochromism, batteries, catalysis, semiconductors, and biochemistry. Knowledge of the ground-state level locations, or equivalently the charge transition level (CTL) energies, or equivalently the vacuum-referred binding energies (VRBE), is important to understand or engineer performance. Despite 70 years of interest in the topic, understanding and controlling TM defect levels remains elusive. In this work, experimental data, theories developed, progress over time, and current status are reviewed, and new insights are presented [1].

With the classic theory for the TMs involving the Slater-Condon F^k integrals, the Racah A, B, and C parameters, the crystal field interaction, and the Tanabe-Sugano diagrams, an expression reproducing the CTL energies relative to the vacuum level as a function of the number q of electrons in the $3d^q$ TMs will be presented. The expression contains five parameters that are related to the chemical shift, Racah parameters, the nephelauxetic effect, and the crystal field.

Data on TMs of different valences in 18 chemical environments are collected from the literature. These are inorganic compounds ranging from wide-band-gap halides (F, Cl, Br), chalcogenides (O, S, Se), small-band-gap II-VI and III-V semiconductors, and two TM organic complexes. All provide octahedral or tetrahedral coordinated sites for the TM. Data from luminescence and absorption spectroscopy, deep-level transient spectroscopy, photocurrents, thermoluminescence, and electrochemistry are translated into CTL energies. Next, the derived expression is used to reproduce the CTL energies, providing the values of the five parameters for each compound. The parameters appear strongly related to each other and change predictably with the valence of the TM and the properties of the environment.

All together a broad overview has been obtained and will be presented on how TM defect levels in compounds change with type of TM, with the valence of the TM, and with type of compound.

[1] P. Dorenbos, *Optical Materials*. **164** (2025) 117007.

I-8

REVISITING THE MECHANISMS OF NON-RADIATIVE ENERGY TRANSFER IN LANTHANIDE MATERIALS

Albano N. Carneiro Neto[1], Renaldo T. de Moura Jr.[2], Ricardo L. Longo[3], Oscar L. Malta[3]

[1] Department of Physics, University of Aveiro, Portugal.
[2] Academic Unit of Cabo de Santo Agostinho, Federal Rural University, PE-Brazil
[3] Department of Fundamental Chemistry Federal University of Pernambuco, Brazil

In this lecture three main points will be highlighted: 1) to call attention for shielding effects, produced by the 5s and 5p filled sub-shells, in the multipolar mechanisms (dipole-dipole, dipole-quadrupole and quadrupole-quadrupole) of energy transfer rates between lanthanide ions and ligand-ion [1]. As for the very short-range exchange mechanism, no shielding factors are explicitly necessary, once they are implicitly taken into account in the ion-ion (4f-4f) overlap integrals between their valence shells. 2) to use a new model for treating the Judd-Ofelt Ω_λ intensity parameters by using a thermal root mean squared displacement around each ligating atom (ion) in the analysis of the intensity parameters [2]. This might have an important role for the rationalization of 4f-4f transition intensities and ion-ion energy transfer processes, mainly when the lanthanide ions occupy a center of inversion. 3) to call attention to the fact that the quadrupole-quadrupole mechanism imy be dominant for ion-ion distances as far as 20 Å, provided shielding effects are taken into account. Spectral overlap integrals are evaluated analytically [3]. The mechanisms of intramolecular energy transfer in lanthanide complexes will be discussed.

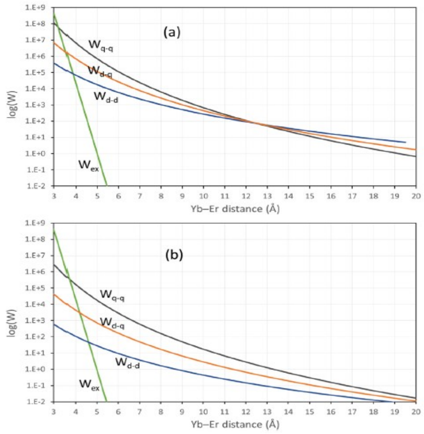


Figure 1. Energy transfer rates for the Step 1: (a) without shielding and (b) with shielding effects.

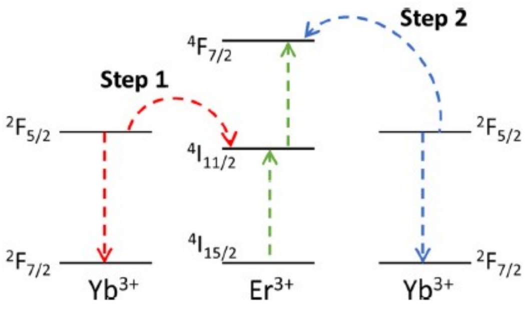


Figure 2. Schematic energy transfer from Yb^{3+} to Er^{3+} ions in the up-conversion process. **Step 1** is considered when the states $^2F_{5/2}$ from Yb^{3+} and $^4I_{11/2}$ of Er^{3+} are involved. **Step 2** involves the higher acceptor (Er^{3+}) level $^4F_{7/2}$.

[1] O.L. Malta, J. Non Cryst. Solids. 354 (2008) 4770–4776. doi:10.1016/j.jnoncrysol.2008.04.023.
[2] A. Shyichuk, R.T. Moura, A.N. Carneiro Neto, M. Runowski, M.S. Zarad, A. Szczeszak, S. Lis, O.L. Malta, J. Phys. Chem. C. 120 (2016) 28497–28508. doi:10.1021/acs.jpcc.6b10778.
[3] A.N. Carneiro Neto, R.T. Moura, O.L. Malta, J. Lumin. 210 (2019) 342–347. doi:10.1016/j.jlumin.2019.02.049.

CNPq , FACEPE

I-9

Controllable preparation and properties of advanced laser ceramics

Jiang Li[a,b*]

[a] Transparent Ceramics Research Center, Shanghai Institute of Ceramics, Chinese Academy of Sciences, Shanghai 201899, China
[b] Center of Materials Science and Optoelectronics Engineering, University of Chinese Academy of Sciences, Beijing 100049, China

E-mail: lijiang@mail.sic.ac.cn

Abstract:

As a new generation of solid-state laser materials, laser ceramics are of great significance to national security and sustainable development of national economy. Laser ceramics have incomparable advantages in physical and chemical properties, and the ceramic preparation technology provides flexibility for laser design. By adjusting the physical and chemical properties of ceramics, it is possible to obtain the characteristics that conventional solid-state lasers do not possess. In this report, rare earth ion doped garnet based transparent ceramics and their composite structures were designed and prepared, and the tailoring and optimization of laser ceramic properties were realized. Then the controllable fabrication and laser properties of sesquioxide transparent ceramics with high thermal conductivity were also studied.

Keywords: Laser ceramics; Controllable preparation; Microstructure; Optical properties

I-10

IMPACT OF BORON CO-DOPING ON THE LUMINESCENCE PROPERTIES OF Pr^{3+} OR Ce^{3+} DOPED YTTRIUM, LUTETIUM, AND GADOLINIUM ALUMINUM GARNETS

Greta Inkrataitė[1*], Nerija Ričkutė[1], Jan-Niklas Keil[2], Thomas Jüstel[2], Ramūnas Skaudžius[1]

[1]*Institute of Chemistry, Faculty of Chemistry and Geosciences, Vilnius University, Naugarduko 24, Vilnius LT-03225, Vilnius, Lithuania*
[2]*Department of Chemical Engineering, FH Münster University of Applied Sciences, Steinfurt, Stegerwaldstrasse 39, Steinfurt D-48565, Germany*

* corresponding author: *greta.inkrataite@chgf.vu.lt*

Keywords: Boron, Garnets, Lanthanide, Luminescence

In order to convert high-energy radiation, such as gamma or X-rays, into visible light scintillating materials are widely applied. Over the years many different candidates to fit the requirements were examined. However, compounds with garnet structures have attracted a particularly large amount of attention. Praseodymium or cerium doped yttrium, lutetium, and gadolinium aluminum garnets have high density, high thermal stability, rather efficient luminescence processes, and thus high quantum efficiency which are needed for a satisfying scintillator performance [1]. However, further optimization and improvement are still required especially w.r.t. a reduced decay time. The duration of the luminescence decay is important because if it is very short then the more signals can be measured within a defined timeframe, resulting in a better resolution and thus higher image quality, for example in CT, SPECT, or PET devices. One way to improve materials properties is to doping the aforementioned compounds with different elements. As such, by doping we could potentially be able to improve key aforementioned parameters: emission intensity, quantum efficiency and decay times [2]. One of these suitableelements is boron. Primarily, it can be used as a flux, and moreover B^{3+} ions have a suitable neutron capture cross section and can also contribute to absorb gamma radiation [3].

In the present work, the effect of boron on the various characteristic of the YAG, LuAG, and GdAG doped by cerium or praseodymium is investigated. Garnets doped with different content of boron were synthesized by the aqueous sol-gel method. Phase purity of all samples was analyzed by means of X-ray diffraction. The morphology of the compounds was evaluated by using scanning electron microscopy. Photoluminescence properties such as emission and excitation spectra, decay curves, quantum efficiency and temperature dependency of the emission and excitation spectra have been investigated. Radioluminescence was also measured in order to determine the scintillation properties. The positive impact of boron addition into the garnet structure on the luminescence properties will be discussed.

[1] I.P. Machado, et. all, *J. Alloys Compd.* **777** (2019) 638–645.

[2] C. Foster, et. all, *J. Cryst. Growth.* **486** (2018) 126–129.

[3] G. Inkrataite, et. all, *J. Alloys Compd.* **875** (2021) 160002.

Acknowledgments: funded by German Academic Exchange Service (DAAD) scholarship.

I-11

Revealing trapping processes in persistent phosphors by time-resolved optical spectroscopy on the ps to ms timescale

P.F. Smet[1], **K. Molkens**[2], **P. Geiregat**[2], **D. Van der Heggen**[1,*]

[1]*LumiLab, Department of Solid State Sciences, Ghent University, 9000 Ghent, Belgium*
[2]*PCN, Department of Chemistry, Ghent University, 9000 Ghent, Belgium*

* corresponding author: David.VanderHeggen@ugent.be

Keywords: Persistent phosphors, strontium aluminate, optical absorption, trapping, energy transfer

Persistent phosphors are luminescent materials that continue to emit light long after the excitation source is removed, finding widespread applications in safety signage, bioimaging, and watch dials. Their long-lasting afterglow is governed by charge trapping and subsequent thermal release, yet a full understanding of the driving mechanisms remains a challenge. To further enhance the performance of persistent phosphors - particularly the total light output after the excitation ended - it is crucial to elucidate the trapping and detrapping processes in detail.

In recent years, significant progress has been made in this area. For example, in $SrAl_2O_4$:Eu,Dy, a redox reaction involving charge trapping at Dy^{3+} ions - resulting in the formation of Dy^{2+} - has been identified as a key element in the final, fully charged state [1,2]. Traditionally, trapping and detrapping *dynamics* are investigated over long timescales (seconds to hours), typically via thermoluminescence glow curve analysis or by looking at steady state conditions. In this work, we explore these processes on much shorter timescales, from picoseconds to milliseconds.

Using transient absorption spectroscopy on $SrAl_2O_4$:Eu,Dy single crystals [3,4], we identify the optical signatures of the excited states associated with both the dopant and the trapping centers. By introducing additional pump sources and varying the temperature, we uncover energy transfer pathways that govern the charge migration and storage. These observations are complemented by measurements of the Eu^{2+} excited state lifetime under both direct excitation of Eu^{2+} and indirectly, via the optical stimulation of trapped charges, as a function of the pumping power. The integration of these multiscale insights enables us to propose a coherent model for the trapping and detrapping mechanisms in this archetypal persistent phosphor system.

[1] P. Dorenbos, *J. Electrochem. Soc.* **152** (2005) H107.

[2] J.J. Joos *et al., Appl. Phys. Letters* **125** (2020) 033001

[3] D. Van der Heggen *et al., Adv. Func. Mater.* **22** (2022) 2208809

[4] D. Van der Heggen *et al., Adv. Opt. Mater.* **13** (2025) 2402153

I-12

Luminescence properties of rare earth nanomaterials and complexes as light emitters

Hermi F. Brito[1]

[1]*Institute of Chemistry, University of São Paulo, São Paulo, 05508-900, Brazil*

*Corresponding author: hefbrito@iq.usp.br

Keywords: BODIPY, lanthanide, luminescence nanomaterials, and complexes

In the last three decades, lanthanide-based materials have been extensively investigated as light-emitter converters (*e.g.*, photoluminescence, electroluminescence, mechanoluminescence, or persistent luminescence). The interest in the luminescence of rare earths is due to a broad emission spectrum ranging from ultraviolet, visible, and near-infrared spectral windows, narrow emission bands, and long (10^{-3} s) emitting level lifetimes. However, the luminescence of most Ln^{3+} ions arises from 4f-4f intraconfigurational electronic transitions, which are forbidden by the Laporte rule. To overcome such outcomes, Ln^{3+} ions are often found as metal centers in coordination compounds or dopants of inorganic networks. Among several classes of coordination compounds, luminescent tetrakis Ln^{3+} complexes formulated as $Q[Ln(L)_4]$ (L: ligand) have garnered attention over the past decade. Tetrakis complexes enable replacing water molecules in the first coordination sphere, which are deleterious to the Ln^{3+} luminescence, and improve the ligand sensitization compared to tris $[Ln(L)_3(H_2O)_x]$ complexes [1]. Our research group focuses on the precise control of structure and energy transfer dynamics to enhance the luminescence of Ln^{3+} tetrakis complexes. For that, several classes of organic ligands (β-diketonates, carbacylamidophosphonates, sulfonylamidophosphonates, alkyldithiocarbamate or carboxylates) and counterions (Q^+: e.g., alkylammonium, imidazolium, and pyridinium derivatives) have been investigated. Besides, we have been dedicated to the preparation of Ln^{3+}-doped luminescent nanomaterials, including inorganic host matrices such as oxides, tungstates, molybdates, fluorides, and selenides. These materials have been prepared using several methods, such as sol-gel, hydrothermal, co-precipitation, combustion, etc., to precisely control the structure, particle size, and luminescence behavior. Moreover, our group is focused on providing further guidance to the luminescence dynamics of Ln^{3+} ions by investigating photophysical parameters such as 4f–4f intensity parameters, radiative and non-radiative spontaneous emission coefficients, emission quantum yields, as well as energy transfer rate studies. These spectroscopic analyses provide tools to optimize the luminescence of Ln^{3+}-doped materials by controlling the doping amount, Ln^{3+} distances in the network, and interactions among the Ln^{3+} dopant ions with the matrices and other codopants.

[1] Costa, I.F.; Blois, L.; Paolini, T.B.; Assunção, I.P.; Teotonio, E.E.S.; Felinto, M.C.F.C.; Moura Jr. R.T., Longo, R.L.; Faustino, W.M.; Carlos, L.D.; Malta, O.L.; Carneiro Neto, A.N.; Brito, H.F. Luminescence properties of lanthanide tetrakis complexes as molecular light emitters. *Coordination Chemistry Review*, 502, 2115590 (2024)

The authors thank FAPESP (Thematic Project 2021/08111-2), CNPq (308872/2022-3), and CAPES for financial support.

I-13

Out of the comfort zone – A paradigm shift in ligand field tuning or not?

M. Suta[1,*]

[1]*Inorganic Photoactive Materials, Institute of Inorganic Chemistry, Heinrich Heine University Düsseldorf, 40225 Düsseldorf, Germany*

* corresponding author: markus.suta@hhu.de

Keywords: transition metals, angular overlap model, electronic effects

Many 3d transition metal ions such as the $3d^3$ ions Cr^{3+} and Mn^{4+}, or the $3d^5$ high spin (HS) ion Mn^{2+} are known to give rise to luminescence competitive to those of the lanthanoid ions with their 4f and 5d valence orbitals. Usually, their luminescence spectra are interpreted based on the assumptions of the theory by Tanabe and Sugano [1] basically separating the contributions of the crystal field (parametrized by $10Dq$ in cubic fields) and the Racah parameters B and C for the interelectronic repulsion [2]. Most commonly, the ligand field is tuned by means of the ratio of $10Dq/B$: The crystal field splitting can be varied by the metal-ligand distance or variation of the oxidation state of the transition metal activator according to Bethe's original theory [3], while covalency effects are usually implemented by a reduction of the interelectronic repulsion lowering the Racah parameters. Many effects such as the broad-banded nature of the luminescence of Cr^{3+} in elpasolite-type fluorides compared to the well-known narrow-line red emission of Mn^{4+} in cubic $K_2[SiF_6]$ (KSF:Mn^{4+}) are explicable with that approach.

In this lecture, we will look at the limits of this conceptual approach and I will demonstrate that a molecular orbital approach treating $10Dq$ and the Racah parameters on a common level is sometimes unavoidable. In fact, using the concept of the angular overlap model by Schäffer and Jørgensen [4] can offer an equivalent explanation of the previously mentioned aspects but allows to widen the horizon to reach spectral ranges with the luminescence of selected transition metal ions that may not have been conceived possible. Among these are compounds that give rise to narrow-line emission of Cr^{3+} with an even stronger ligand fields than in ruby [5], deep NIR emission ($\lambda_{em} > 850$ nm) of Cr^{3+} in selected oxometallates [6], broad-band emission of Mn^{4+} [7], and efficient NIR emission of Mn^{2+} [8]. All of them have in common that their luminescence has been tuned by electronic orbital effects, sometimes even including the second coordination sphere. Although this may appear like a paradigm shift, we will discuss whether this is in fact the case or simply a change in the perspective on a concept.

[1] a) Y. Tanabe, S. Sugano, *J. Phys. Soc. Jpn.* **9** (1954) 753; b) Y. Tanabe, S. Sugano, *J. Phys. Soc. Jpn.* **9** (1954) 766.

[2] G. Racah, *Phys. Rev.* **62** (1942) 438.

[3] H. Bethe, *Ann. Phys.* **395** (1929) 133.

[4] C. E. Schäffer, C. K. Jørgensen, *Mol. Phys.* **9** (1965) 401.

[5] a) I. Widmann, M. Suta, H. Huppertz *et al.*, *Adv. Funct. Mater.* **34** (2024) 2400054; b) G. Kinik, I. Widmann, B. Bendel, H. Huppertz, A. Meijerink, M. Suta *et al.*, *under review* (2025).

[6] G. Kinik, M. Suta *et al.*, *in finalization* (2025).

[7] a) M. Möbs, A. J. Karttunen, K. O. Christe, F. Kraus, *Inorg. Chem.* **63** (2024) 7105; b) M. Stremel, F. Kraus, M. Suta *et al.*, *in finalization* (2025).

[8] L. M. Träger, A. Shagova, B. J. Schöpper, G. J. Reiß, H. Huppertz, M. Suta, *under review* (2025).

Acknowledgments: Funding by the German Research Foundation (project SU 1156/5-1, project no. 554302036) is gratefully acknowledged.

I-14

ACHIEVING LONG-PERSISTENT LUMINESCENCE IN Ce^{3+}-DOPED GARNET SINGLE CRYSTALS THROUGH NONSTOICHIOMETRIC ENGINEERING AND CONTROLLED CRYSTALLIZATION KINETICS

K. Bartosiewicz[1*], V. Fritz[2], D. Van der Heggen[2], R. Tomala[3], J. Zeler[4], D. Szymanski[3], M. Yoshino[5], T. Horiai[5], R. Kral[1], S. Kurosawa[5,6,], E. Zych[4], P. F. Smet[2], A. Yoshikawa[5,6]

[1]*Institute of Physics, Academy of Sciences of the Czech Republic, Na Slovance 1999/2, 18200, Praha, Czechia*
[2]*LumiLab, Department of Solid State Sciences, Ghent University, Krijgslaan 281/S1, Ghent, 9000, Belgium*
[3]*Institute of Low Temperature and Structure Research, Polish Academy of Sciences, Okolna 2, Wrocław, 50422, Poland*
[4]*University of Wrocław, Faculty of Chemistry, F. Joliot-Curie 14, Wrocław 50383, Poland*
[5]*New Industry Creation Hatchery Center, Tohoku University, 2-1-1 Katahira Aoba-ku, Sendai, Miyagi 980-8577, Japan*
[6]*Institute for Materials Research, Tohoku University, 2-1-1 Katahira Aoba-ku, Sendai, 9808577, Japan*
*corresponding author: bartosiewicz@fzu.cz

Keywords: persistent luminescence, single crystal, garnets, charge traps, thermoluminescence

Commercially available $SrAl_2O_4:Eu^{2+},Dy^{3+}$ phosphors show intense and long-lasting persistent luminescence or afterglow, persisting for several hours after excitation. However, in the current era of white LEDs-based lighting technologies, their practical relevance has diminished [1,2]. The limitation arises from their absorption edge, which extends only up to approximately 450 nm, thereby reducing their efficiency for excitation by the lower-energy region of the blue light emitted by standard white LEDs. Ongoing research is focused on the development of persistent phosphors that exhibit efficient excitation under white LEDs with extended absorption over 450 nm range, enhancing compatibility with white LEDs. Previous studies demonstrated that Cr^{3+}/Yb^{3+} co-doped $Y_3Al_2Ga_3O_{12}:Ce^{3+}$ garnets in the form of transparent ceramics and powders are promising candidates for the next generation of white-LEDs-chargeable persistent phosphors. In the case of $Y_3(Al,Ga)_5O_{12}:Ce^{3+}$ single crystals, persistent luminescence under UV excitation has been observed, with emission durations lasting several seconds [3]. Since these initial findings, no significant studies have been reported on persistent luminescence in $Y_3(Al,Ga)_5O_{12}:Ce^{3+}$ single crystals, leaving this area of research relatively unexplored. This study addresses the challenge of the negligible afterglow observed in $Y_3(Al,Ga)_5O_{12}:Ce^{3+}$ single crystals. Introducing 3-6% nonstoichiometric Y_2O_3 excess into $Y_3Al_{1.75}Ga_{3.25}O_{12}:Ce$ single crystals prolonged afterglow duration by a few hours. To further prolong afterglow, the crystallization process and kinetics were adjusted to allow for immediate crystallization of the entire melt out of the crucible, while preserving the structural integrity of the single crystal. This approach further increased the afterglow to several hours. Applying the same methodology to the $Lu_3Al_2Ga_3O_{12}:Ce^{3+}$ system yielded consistent results, thereby validating this novel strategy for achieving long afterglow in garnet single crystals.

[1] J. Ueda et al., *Appl. Phys. Lett.* **104** (2014) 101904. [2] J. Ueda et al., *Appl. Mater. Interfaces* **10** (2018) 20652. [3] W. Holloway et al., *J. Opt. Soc. Am* **59** (1969) 60.

Acknowledgment: European Union's Horizon Europe research and innovation programme under the Marie Skłodowska-Curie Actions COFUND, Physics for Future, grant agreement No 101081515 and OP JAC project LASCIMAT – CZ.02.01.01/00/23_020/0008525.

I-15

Multiconfigurational *ab initio* calculations as a tool to reveal the excited states of transition element impurities in crystals

J. J. Joos[1*]

[1]*LumiLab, Department of Solid State Sciences, Ghent University, Gent, Belgium*
Faculty of Sciences, Antwerp Maritime Academy, Antwerp, Belgium

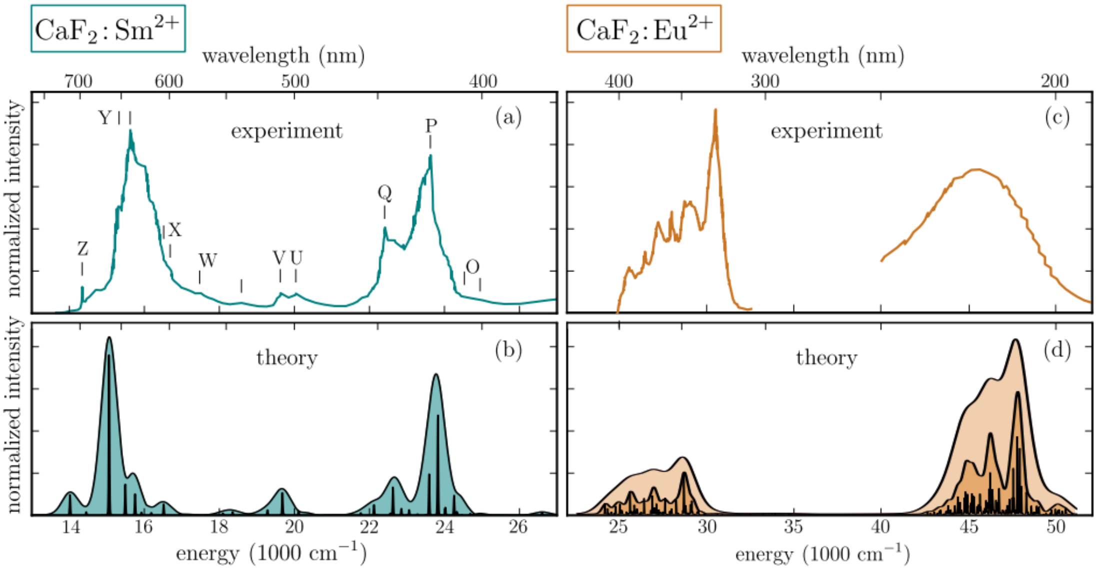
* corresponding author: *jonas.joos@ugent.be*

Keywords: quantum chemistry, cluster embedding, spin-orbit coupling, theoretical spectroscopy

In contrast to their high application potential, *e.g.* in wavelength conversion, scintillation or quantum technology, transition elements are notoriously difficult study cases for first principles methods. The incompletely filled *d* (or *f*) shell gives rise to strong electron correlation effects, *i.e.* the electronic states are poorly described by a single Slater determinant. This is however an important requirement to justify the use of single-reference methods such as density-functional theory.

Wave-function-based quantum chemistry is presented as an alternative to study solid state systems. While such methods suffer from the exponential scaling of the wave function, it is shown that insightful and accurate results can nevertheless be obtained by adopting well-considered approximations, in particular by exploiting embedded cluster methods. An additional advantage is that spin-orbit relativistic effects are efficiently incorporated in this methodology, allowing to obtain electronic absorption and emission spectra that can be immediately compared to experiments, also for compounds that contain heavier elements.

After a short overview of the methodology, several recent use cases will be demonstrated, highlighting the potential of quantum chemical methods to support the development of novel optical materials.



Comparison of calculated (SA-RASSCF/MS-RASPT2/RASSI-SO) with experimental spectra of lanthanide impurities in a fluorite crystal.

[1] Z. Barandiarán, J. Joos, L. Seijo, Luminescent Materials – A Quantum Chemical Approach for Computer-Aided Discovery and Design, Springer, 978-3-030-94983-9 (2022).

REVISITING THE SINGLE CONFIGURATIONAL COORDINATE MODEL IN TRANSITION METAL-DOPED PHOSPHORS

S. Mahlik[1,*]

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

* corresponding author: sebastian.mahlik@ug.edu.pl

Keywords: configurational coordinate diagram, electron–lattice coupling, non-radiative relaxation

The single configurational coordinate diagram (SCCD) is a foundational model for understanding luminescence and non-radiative relaxation processes in transition metal-doped phosphors. Despite its widespread use, a comprehensive comparison with experimental data across various host lattices reveals notable discrepancies between observed activation energies and those predicted by the SCCD model, indicating limitations in its underlying assumptions. This study critically examines the SCCD framework by analyzing factors such as the displacement between ground and excited state potential energy surfaces, differences in their curvature, and the nature of electron–lattice coupling. Experimental data obtained from luminescence and excitation (absorption) spectra are used to parameterize the one-dimensional SCCD within the harmonic approximation. Key physical quantities, including the configurational shift, the strength of electron–lattice interaction, and the probability of non-radiative transition, are discussed in detail. Possible anharmonic contributions to the potential energy surfaces are also considered, along with the interpretation and plausible values of the non-radiative transition probability and frequency factor. Correlations between fitted physical parameters, particularly between the electron-lattice coupling energy and the activation energy for non-radiative transitions, highlight the complex interplay between electronic structure and lattice dynamics in thermally activated luminescence quenching.

I-17

COMBINATION OF PHOTOLUMINESCENCE AND MECHANOLUMINESCENCE FOR OPTICAL PRESSURE AND TEMPERATURE MONITORING

M. Runowski[1,*], T. Zheng[2], P. Woźny[1], K. Soler-Carracedo[1], J. Moszczyński[1],
S. Mahlik[3], D. Peng[4]

[1]Adam Mickiewicz University, Faculty of Chemistry, Uniwersytetu Poznańskiego 8, 61-614, Poznań, Poland
[2]Hangzhou City University, School of Information and Electrical Engineering, Hangzhou 310015, China
[3]University of Gdansk, Faculty of Mathematics, Physics and Informatics, Gdansk 80-308, Poland
[4] Key Laboratory of Optoelectronic Devices, College of Physics and Optoelectronic Engineering, Shenzhen University, Shenzhen 518060, China

* corresponding author: *runowski@amu.edu.pl*

Keywords: Optical sensors; force, pressure & temperature sensing; sound-to-light conversion

Mechanoluminescence (ML) is a powerful phenomenon that enables light generation induced with mechanical or acoustic waves.[1] Whereas, photoluminescence (PL) thermometry is a modern technique for remote, non-invasive temperature detection. However, the efficient combination of both approaches is a challenge, where the low signal intensity limits their simultaneous use in real-world applications.

Here, we show the first utilization of ML-based thermometry for online temperature monitoring in working electro-mechanical devices, accompanied with force and sound visualization, using Er^{3+}-Mn^{2+} co-doped ZnS/CaZnOS heterojunction as ML-active materials. The materials exhibit alike characteristic PL and bright green, yellow or orange ML, depending on the chemical composition and stimuli used. Temperature-dependent PL is utilized to calibrate luminescence thermometry response, allowing further use of the friction- and sound-induced ML signal for temperature sensing and visualization in heated, sonicated or motorized systems. This approach demonstrates excellent application potential of sound-to-light conversion for remote monitoring, and excitation-light-free temperature probing.

We also show the development of the highly sensitive pressure and temperature gauge based on the $Sr_2MgSi_2O_7$:Eu^{2+}/Dy^{3+} material, exhibiting persistent photoluminescence (PersL) and mechanoluminescence. Notably, anti-counterfeiting, night-vision safety-sign, 8-bit optical-coding, and QR-code applications that exhibit intense PersL were demonstrated by 3D-printing the studied material in combination with a polymer.[2]

[1] T. Zheng, M. Runowski, I. R. Martín, K. Soler-Carracedo, L. Peng, M. Skwierczyńska, M. Sójka, J. Barzowska, S. Mahlik, H. Hemmerich, et al., *Adv. Mater.* **2023**, *35*, 2304140.
[2] T. Zheng, J. Luo, D. Peng, L. Peng, P. Woźny, J. Barzowska, M. Kamiński, S. Mahlik, J. Moszczyński, K. Soler-Carracedo, F. Rivera-López, H. Hemmerich, M. Runowski, *Adv. Sci.* **2024**, *11*, 2408686.

Acknowledgments: Work supported by the National Science Center (2023/50/E/ST5/00021).

I-18

Tb^{3+}→Eu^{3+} ENERGY TRANSFER IN Tb$_{1-x}$Eu$_x$Al$_3$(BO$_3$)$_4$ CRYSTALS (x=0.01-0.20)

L. Ceccon[1], **S. Ruggieri**[1], **M. Bettinelli**[1,*], **A. N. Carneiro Neto**[2], **L. D. Carlos**[2] **and F. Piccinelli**[1]

[1]Luminescent Materials Laboratory, University of Verona, 37128 Verona, Italy
[2]Physics Department and CICECO – Aveiro Institute of Materials, University of Aveiro, 3810-193 Aveiro, Portugal

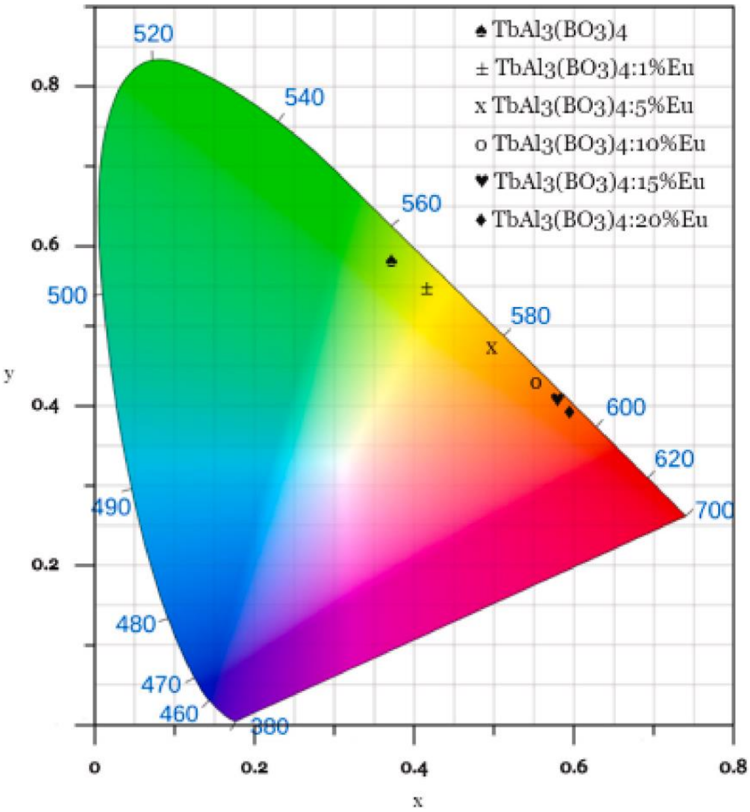
* corresponding author: *marco.bettinelli@univr.it*

Keywords: Eu^{3+}, Tb^{3+}, energy transfer, borate crystalline materials

This work focuses on energy transfer processes involving trivalent lanthanide ions (Ln^{3+}) in materials fully concentrated with respect to the Tb^{3+} sensitizer ion and containing relatively small amounts of the activator ion Eu^{3+}. One class of inorganic crystal hosts will be considered, namely the trigonal huntite borates LnAl$_3$(BO$_3$)$_4$, which finds applications in the field of luminescent materials and devices. The optical spectroscopy and excited state dynamics as a function of the temperature of the materials under investigation will be presented, and the characteristics of the energy transfer process will be identified and discussed.

In all cases the Tb^{3+}→Eu^{3+} transfer of excitation occurs in the presence of fast energy migration among the Tb^{3+} donor ions, making the overall process highly efficient. By progressively changing the Eu^{3+} concentration, it is possible to obtain, upon excitation in the near UV, light emission that is finely tunable from the green to the orange and finally to the red spectral region (Fig. 1) [1].

[1] L. Ceccon et al., Ceramics International, 51 (2025) 16471-16474.



CIE color space chromaticity diagram of the TbAl$_3$(BO$_3$)$_4$ and TbAl$_3$(BO$_3$)$_4$:x%Eu^{3+} (x = 1, 5, 10, 15 and 20) family of compounds. λ_{exc}=374 nm.

I-19

A Tale of Remote Sensing: Nanosensors, Cross-Sensitivity, and Artificial Intelligence

E. Andreato[1], N. Panov[1], L. Ming[1], I. Pessotto[2], P. Canton[2], D. Jaque[1],
E. Ximendes[1], R. Marin[1,2*]

[1]*Universidad Autónoma de Madrid, Madrid, 28049, Spain*
[2]*Università Ca' Foscari of Venice, Mestre-Venice, 30170, Italy*

* corresponding author: *riccardo.marin@unive.it*

Luminescence sensing, thermometry, machine learning, chromium, cross-sensitivity.

Luminescence sensing continues to attract the attention of several scientific communities: Materials scientists, optical spectroscopists, biologists, environmental scientists, and signal processing experts are just some of the researchers involved in this fast-paced field. A holistic approach to the development of a luminescence sensing approach entails the design and preparation of the most appropriate luminescent sensor, followed by careful calibration and attentive analysis of the luminescence signal. Properly performed, this process yields a sensor capable of providing reliable and precise readouts of a measurand of interest. In many cases, this is easier said than done.

In this talk, we will touch upon our latest research achievements and challenges we encountered in the development of luminescence sensing approaches, focusing on temperature and pressure sensing as case studies. Novel nanoparticles and staple luminescent materials will be discussed in the context of luminescence sensing, introducing the concept of cross-sensitivity and its quantitative description. This discussion will segue into a somewhat unexpected eulogy of this phenomenon, which provides fertile ground to augment the functionalities of a luminescence sensing approach.

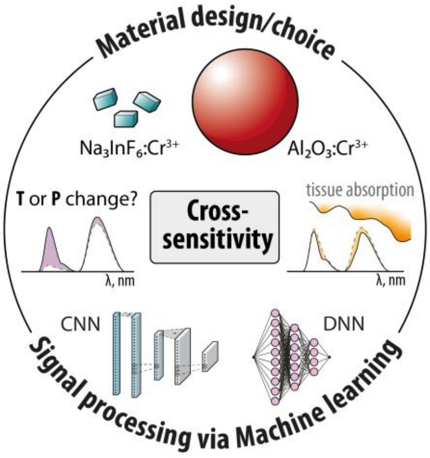


Fig. 1. Elements at the base of our recent contributions to luminescence sensing.

[1] C. Brites et al., *Adv. Mater.* **35** (2023) 2302749.

[2] E. Andreato et al., *Chem. Mater.* (2025) DOI: 10.1021/acs.chemmater.4c03335.

[3] E. Ortiz-Rivero et al., *Small Methods* **9** (2024) 2400718.

[4] L. Aldaz-Caballero et al., *Adv. Sensor Res.* **2** (2023) 2300078.

[5] L. Ming et al., *Nat. Commun.* (2025) DOI: 10.1038/s41467-025-59681-7.

Acknowledgments: R.M. and E.X acknowledge the financial support of Spanish Ministerio de Ciencia, Innovación y Universidades for support to research through Project PID2022-14210NA-I00 (NAMSTEPS) funded by MICIU/AEI/10.13039/501100011033 and by FEDER, EU. This work is supported by ERC grant MAtCHLESS, 101162875.

Persistent Luminescence: Dopants, Defects and Traps

D. Hreniak[1], L.C.V. Rodrigues[2], H.F. Brito[2], J. Hölsä[1,2,3,*],

[1]Institute of Low Temperature and Structure Research, PAN, PL-50-422 Wrocław, Poland
[2]Institute of Chemistry, University of São Paulo, SP-05508-000, São Paulo – SP, Brazil
[3]Department of Physics, University of the Free State, ZA-9301 Bloemfontein, South Africa

* corresponding author: *jholsa@utu.fi*

Keywords: Persistent, Luminescence, Composition, Structure, Defects, Traps

The narrative of **Persistent Luminescence** (PersLum) **(not phosphorescence)** **may extend 2000+ years from now**) when the Chinese and Japanese Emperors exchanged gifts – including a painting of a cow eating grass (day) or musing (night). At the time, paint colour/emission was obtained using only a few pigments (**seashells $CaCO_3$**). In hindsight, at high hydrostatic pressures, metals may well diffuse from the **Mn, Ni, Co, Cu** deposits to form **doped** $CaCO_3$ pigments. Much later, in early 1600s, **alchemists** reduced $BaSO_4$ to **Bologna stone (BaS:Cu$^{1/2/3+}$)** with golden lust. However, Ba was discovered only later (1808) and detailed structural and spectral studies had to wait till early 2010s.

After WWII distinct rare earths became commercially available and a few rare earths ($Eu^{2/3+}$, Tb^{3+}) were found as potential dopants for (any kind) phosphors. However, the rush on new phosphors went too viral and too prompt, **losing all rational** when the **catastrophic blunder (Eu^+) was suggested** to be part of the PersLum mechanism ($Eu^{2+} + R^{2+} \leftrightarrow$ **Eu^+** $+ R^{3+}$). **No more than two oxidation states** for any rare earth have ever been found: +III for all and +II for Sm, Eu, Tm, Yb as well as +IV for Ce, Pr, Tb. The REDOX processes have now lost all credibility – also because of huge energies required in the charge-decharge-recharge steps.

Evolution from natural hosts & impurities to new host materials was inevitable due to the scarcity of the rare earths (especially Eu). R^{3+} based hosts (as R_2O_3) can enjoy the chemical similarity with Ca^{2+}/Sr^{2+} based host – with the problem of **incompatible charges between R^{3+} and Ca^{2+}/Sr^{2+}**. This said, the **Vegard's three rules** concerning the **same charge**, **similar size** and **similar crystal structures** of the dopant and host compounds have to be respected. The last one is often impossible and is thus neglected but unexpected problems may arise. The requirement of the similar size can be easily checked giving the acceptable solid solubility limits (±5 %) for Ca^{2+} & R^{3+}: all R^{3+} though heavier than Gd^{3+} are substantially smaller than Ca^{2+} is compatible with all R^{3+}. For the Sr^{2+} hosts the heavier R^{3+} are really too small. The forced $Ca^{2+} \leftrightarrow R^{3+}$ substitution leads to **uncontrollable non-stoichiometry, defect formation and eventually loss of luminescence**.

An intelligent alternative to the **incompatible charges between R^{3+} and Sr^{2+}/Ca^{2+}** is to replace "**the same charge**" with the "**same average charge**". This **R^{3+} - Na^+ - Ca^{2+} (2+2 = 1+3)** change works very well in avoiding the compatibility problems though reduced solid dopant – host solubility can still persist.

The use of the average charges (above) leads to the unexpected **finding of traps** leading to the long sought charge carriers (now confirmed to be electrons and holes) with very **low charge** and no mass. R^{3+} attracts and Na^+ holes, respectively. The close proximity of the defects helps to keep **strong bonding** between them and efficient charging and decharging the defects.

HEATING THROUGH OPTICAL EXCITATION ABOVE 1000 nm: SPECTRALLY DECOUPLING THERANOSTICS & ENGINEERING PLASMONIC NANOPARTICLES TO MAXIMIZE HEAT DELIVERY

N. Caetano-Zeballos[1,2], **L. Aldaz-Caballero**[1,2], **J. Giráldez-Martínez**[3], **A. Casillas**[4], **A. I. Fernández-Domínguez**[5,6], **O. G. Calderón**[4], **S. Melle**[4], **L.V. Besteiro**[3,7], **R. Marin**[1,2,8], **M. Quintanilla**[9,10], **A. Benayas***[1,2,10]

[1]*Nanomaterials for BioImaging Group (nanoBIG), Departamento de Física de Materiales, Universidad Autónoma de Madrid (UAM), Madrid 28049, Spain.*
[2]*Nanomaterials for BioImaging Group (nanoBIG), Instituto Ramón y Cajal de Investigación Sanitaria (IRYCIS), Hospital Ramón y Cajal, Madrid 28034, Spain*
[3]*CINBIO, Universidade de Vigo, 36310 Vigo, Spain*
[4]*Dpto. Óptica, Facultad de Ciencias Físicas, Universidad Complutense de Madrid, Ciudad Universitaria, 28040 Madrid, Spain*
[5]*Departamento de Física Teórica de la Materia Condensada, (UAM), E- 28049 Madrid, Spain*
[6]*Condensed Matter Physics Center (IFIMAC), (UAM), E- 28049 Madrid, Spain*
[7]*Departamento de Física Aplicada, Universidade de Vigo, 36310 Vigo, Spain*
[8]*Institute for Advanced Research in Chemical Sciences (IAdChem) Universidad Autónoma de Madrid, Madrid 28049, Spain*
[9]*Departamento de Física de Materiales, (UAM),Madrid 28049, Spain*
[10]*Nicolás Cabrera University Institute of Materials Science, (UAM), Madrid 28049, Spain*

* corresponding author: *antonio.benayas@uam.es*

Keywords: heat conversion efficiency, plasmonics, gold nanostars, indium-tin oxide nanoparticles

Within the biomedical context, light-to-heat conversion is used for applications such as photoacoustic imaging (PAI), - based on periodic heat generated upon pulsed optical excitationto create acoustic waves via the thermoelastic effect- [1] photothermal therapy (PTT) -eradicating malignancies (e.g. tumors) or being an adjuvant factor, following a controlled local temperature increase [2]. Light-to-heat conversion is frequently performed by plasmonic nanoparticles (P-NPs), featuring high molar extinction coefficient, which can efficiently release heat upon optical excitation resonant with their surface plasmon [3].

In this work we explore two different routes for spectral tunability of P-NPs: geometry -gold nanostars (GNSts)-, and composition -indium tin oxide (ITO) NPs. GNSTs allows to increase the penetration depth and spatial resolution of the light-to-heat conversion by moving optical excitation into the 2nd biological window (BW-II, 1000 to 1350 nm). Engineering the “spiky” configuration of this nanomaterial also increases the absorption vs. scattering ratio, thus favouring heat generation. On the other hand, the proof-of-concept on ITO NPs showcases the concept of all-optical (spectrally) decoupled theranostics, owing to a localized surface plasmon resonance almost exclusively located within NIR-III (>1500 nm), as they can adequately team up with luminescent NPs currently applied in biomedicine without detrimental spectral overlapping. Moreover, heat conversion efficiency (HCE) methodology is thoroughly explained as a pathway to quantify the heat delivery for the studied P-NPs, and to corroborate the absorption percentage value obtained by integrating sphere measurements.

[1] I.-C. Sun et al *ACS Nano*, 2024, 18, 3575–3582
[2] X. Cui et al *Chem. Rev*., 2023, 123, 6891–6952.
[3] Z. He et al *Mater. Today*, 2023, 62, 168–189.

I-22

From Ancient Pigments to Modern Security: Novel Luminescent Formulation for Anti-Counterfeiting Applications

M.L. Saladino[1]

[1]*Dipartimento di Scienze e Tecnologie Biologiche Chimiche e Farmaceutiche (STEBICEF),*
Università degli studi di Palermo, Viale delle Scienze, Ed.17, I-90128 Palermo, Italy
[2] *IPCF-CNR, Istituto per i Processi Chimico Fisici, V.le F. S. d'Alcontres 37, I- 98158*
Messina, Italy

* corresponding author: *marialuisa.saladino@unipa.it*

Keywords: Egyptian Blu, Han Blu, clays, Infrared emission

Egyptian Blue (EB, $CaCuSi_4O_{10}$) and Han Blue (HB, $BaCuSi_4O_{10}$) are two blue ancient pigments known for their efficient conversion of red light into infrared emission.

Here, their use in the luminescent formulations, able of emitting distinct signals depending on the excitation wavelength used for illumination is reported. The present study focused on developing luminescent multi-component composites capable of emitting in the red and near-infrared (NIR) spectral regions, depending on the excitation source, while incorporating at least three levels of security [1]. By combining various luminescent materials with different chemical natures and physical properties, synergistic effects can be achieved.

In addition, the possibility of using them as marker to evaluate the consolidation of lime and mortars will be reported.

The formulation preparation included systematic studies to synthesize the blue pigments in a cheap way using microwave irradiation and to obtain stable colloidal systems investigating the role of parameters such as concentration, pH and the presence of any additives affecting stability, transparency and optical properties. The kind of interactions responsible for the stability of formulation was also investigated.

References:

[1] F. Armetta, et al. *J. of Material Chemistry C*, **13**, (2025) 1188 - 1197, DOI: 10.1039/D4TC04228J

Acknowledgments: MLS Thank the Join Chairs Project "Innovative Nanostructured Materials with Luminescent Properties for Cultural Heritage (NanoLuBC)"- Prot 73332 del 06-05-2025. Rep contratti convenzioni 2175/2025.

I-23

Molecular Engineering of Lanthanide(III) Complexes Towards Dual-Function Single-Molecule Magnets Displaying Luminescence Thermometry

Airton G. Bispo-Jr,[1*] **Diogo A. Gálico,**[2] **Fernando A. Sigoli,**[3] **Muralee Murugesu**[2]

[1]Department of Fundamental Chemistry, University of São Paulo (USP), Institute of Chemistry, São Paulo, São Paulo, 05508-900, Brazil.
[2] Department of Chemistry and Biomolecular Sciences, University of Ottawa, Ottawa, Ontario, K1N6N5, Canada.
[3] Department of Inorganic Chemistry, Institute of Chemistry, University of Campinas, Josué de Castro Street, Campinas, São Paulo, 13083-970, Brazil.

* corresponding author: airton.bispo.junior@iq.usp.br

Keywords: Rare earths, single-molecule magnets, luminescence thermometry, quantum computing.

Lanthanide(III) (Ln^{III}) coordination compounds lead the field of single-molecule magnets (SMMs), offering promise for application in high-density data storage molecular devices. In these SMMs, luminescence provides additional insight into magnetic dynamics and enables molecular-level temperature sensing. However, enhancing both luminescence and magnetic properties remains a key challenge. Herein, mononuclear and dinuclear Ln^{III} species are presented to investigate how the precise structural control affects magnetic and luminescent properties through magneto- and opto-structural correlations. These complexes include $[Nd_2(valdien)_2(acac)_2]$ (1) (N^1,N^3-bis(3-methoxysalicylidene)diethylenetriamine, $acac^-$ = acetylacetonate), $[Nd_2(valdien)_2(NO_3)_2]$ (2), [Dy(acac)$_3$(bpm)] (3) (bpm = 2,20-bipyrimidine), $[Dy_2(bpm)(hexd)_6]$ (4) (hexd = 2,4-hexanedione), and $[Dy_2(bpm)(hpd)_6]$ (5) (hpd = 3,5-heptanedione). The Nd^{III} complexes show field-induced slow magnetic relaxation, with temperature-dependent dynamics linked to QTM and Raman processes due to a distorted D_{2d} coordination environment. The Dy^{III} species exhibit zero-field SMM behavior with effective barrier to the reversal of magnetization reaching up to 290 K (3), attributed to a slightly distorted D_{4d} coordination environment. Complexes 1 and 2 display Nd^{III} near-infrared luminescence, and the crystal field band components in the emission spectra enabled temperature sensing with a maximum relative thermal sensitivity (S_r) reaching 0.5% K^{-1} at 50 K. 3 – 5, in their turn, presented the typical Dy^{III} luminescence within the visible spectral range. This was also used to probe the temperature, achieving a maximum S_r of 1.5% K^{-1} at 70 K (3). The maximum S_r in these complexes is governed by ligand triplet state energy and local symmetry, tuned via electronic/steric effects. This investigation offers guidance for mapping structural parameters to design dual-functional magnetic–luminescent materials.

[1] A. G. Bispo-Jr, D. A. Gálico, R. M. Diaz-Rodriguez, J. S. Ovens, F. A. Sigoli, M. Murugesu, *Inorg. Chem. Front.* **10** (2023) 3929.

[2] A. G. Bispo-Jr, L. Yeh, D. Errulat, D. A. Galico, F. A. Sigoli, M. Murugesu, *Chem. Commun.* **59** (2023) 8723.

[3] A. G. Bispo-Jr, D. A. Galico, F. A. Sigoli, M. Murugesu, Dalton Trans. **54** (2025) 4876.

Acknowledgments: FAPESP (Process number: 2021/09755-0 and 2019/23763-6)

LUMINESCENCE OF THE ISOELEKTRONIC IMPURITIES IN HALIDE AND OXIDE SCINTILLATORS UNDER X- RAYS AND SYNCHROTRON RADIATION EXCITATION

[1,2]Yu. Zorenko, [1]V. Gorbenko, [1]S. Witkiewicz-Lukaszek, [1]Yu. Syrotych, [1]T. Zorenko,
[2]K. Shunkeyev, [2]Sh. Sagimbayeva, [2]A. Kenzhebayeva

[1]K. Zhubanov Aktobe Regional University, 030000 Aktobe, Kazakhstan
[2]Department of Physics of Kazimierz Wielki University,85-090 Bydgoszcz, Poland

* corresponding author: zorenko@ukw.edu.pl

Keywords: garnets, alkali-halide compounds, isoelectronic dopants, luminescence, synchrotron radiation

In general, any dopant **A**, acting as cation isoelectronic impurities (CII) relative to a core cation **B** with the same charge state, can effectively localize low-energy excitations (electrons, holes, or excitons) by creating a non-Coulombic potential at the substitution site. For this reason, CIIs are widely exploited for the development of luminescent and scintillation materials that operate in the UV and blue ranges and offer good thermal stability at room temperature (RT).

This work is dedicated to the consideration of the regularities in the formation of luminescence centers by CIIs in alkali halide compounds (AHCs) using CsI and KCl crystals doped with Na^+ ions as examples, as well as in complex oxides with a garnet structure $A_3Al_5O_{12}$ (A=Y, Lu) doped with La^{3+} and Sc^{3+} ions. Similar consideration have also been applied to antisite defects (ADs) in garnets (Y^{3+} on Al^{3+} sites in YAG and Lu^{3+} on Al^{3+} sites in LuAG), which can be considered as a special kinds of CIIs [1]. These ADs typically form in concentrations of 0.05–0.25 at.% as a result of growing garnet single crystals (SCs) at high temperatures (1900–2000 °C) from a melt. In contrast, single crystalline films (SCFs) of these garnets grown by the liquid-phase epitaxy method are free of ADs due to the significantly lower crystallization temperature (~1000 °C). As a result, both SCs and SCFs of (Y, Lu)AG garnets serve as suitable model systems for investigating the radiative relaxation of low-energy excitations, particularly exciton luminescence associated with CII and AD centers.

However, studying the luminescent properties and electronic structure of CIIs in dielectric matrices remains challenging, since these dopants typically do not exhibit internal transitions in the UV and visible ranges that are detectable by conventional absorption or luminescence spectroscopy. A promising solution is the use of luminescence spectroscopy in the VUV range under excitation by synchrotron radiation (SR), which has proven effective in this work.

The luminescence characteristics and excitation energy transfer from CsI and KCl matrices, as well as from YAG and LuAG garnet hosts to emission centers formed by CII and ADs, were studied in this work using conventional spectral methods such as cathodoluminescence at RT, X-ray excited luminescence, thermoluminescence, and thermally-stimulated luminescence spectra and glow curves in the 80–600 K range. Furthermore, time-resolved luminescence investigations of CsI:Na [2] and KCl:Na crystals and SCs and SCFs of undoped, La^{3+}-doped, and Sc^{3+}-doped YAG and LuAG garnets were conducted at the Superlumi station at the PETRA III storage ring at DESY, Germany, under excitation by pulsed SR in the 3.7–12.5 eV range. This energy range covers part of the transmittance window, the exciton absorption region, and the onset of interband transitions of the respective AHC and garnet hosts.

1. Y. Zorenko. *Phys. Stat. Sol. (c)*, 2 (2005) 375-379.
2. K. Shunkeyev, A. Kenzhebayeva, S. Sagimbayeva, Y. Zorenko, J. Luminescence, 2025, submitted.

Acknowledgments: The work is performed in the frame of Polish NCN No 2022/47/I/ST8/02600 *project and also funded by Science Committee of the Ministry of Science and Higher Education of the Republic of Kazakhstan (Grant No. AP26100001).*

CONCLUDING ON GSAG:Ce SINGLE CRYSTAL SCINTILLATOR: MATERIAL OPTIMIZATION AND BOTTLENECKS

[1]M. Nikl*, [1]J. Pejchal, [2]J. Ježek, [2]D. Sedmidubský, [1]V. Laguta, [1]O. Zapadlík, [1]V. Babin
[1]Institute of Physics of the Czech Academy of Sciences, Prague, 182 00 Czech Republic
[2]University of Chemistry and Technology, Prague, 166 28, Czech Republic

* corresponding author: nikl@fzu.cz

Keywords: scintillator, single crystal, luminescence, energy transfer, traps

The discovery of multicomponent garnet single crystal scintillators in 2011 [1] started a new period in R&D of scintillating oxides. Due to band-gap engineering, the $Gd_3Al_{5-x}Ga_xO_{12}$:Ce, $2<x\leq3$, (GAGG:Ce) single crystals became the most efficient bulk single crystal scintillator within oxide materials with further practical advantages of mechanical and chemical stability and stable crystal growth in industrial conditions. Because of Ga presence in the chemical formula, there is an unavoidable need for the usage of iridium crucible [2], which makes their production very expensive. Thus, the question arose, if the electronic band structure of such a multicomponent garnet can be shaped and electronic traps suppressed in a similar way as in GAGG:Ce, but with a chemical formula of a material which would enable using a cheaper technology, based e.g. on molybdenum crucibles used for industrial production of classical YAG:Ce or LuAG:Ce single crystals [3].

Such a choice includes the Sc-admixed garnets of the general formula $(Gd,Sc)_3(Al,Sc)_2Al_3O_{12}$, doped by Ce^{3+} (GSAG:Ce), which were revisited in recent literature [4]. The micropulling-down (mPD) and Bridgman crystal growth methods have verified this possibility [5,6] with the achieved LY up to about 10000 ph/MeV, more than four times lower compared to GAGG:Ce grown with mPD technique [1].

In this contribution, we will report the conclusive results of composition tuning and postgrowth thermal annealing to increase scintillation efficiency and LY of GSAG:Ce. LY value in the optimized crystal exceeded 17 000 ph/MeV. With the help of correlated usage of TSL and EPR (performed at the Gd-free YSAG crystals) experiments, completed further with the electronic band structure calculations, we have revealed the origin of lower performance of GSAG:Ce compared to GAGG:Ce.

(1) K. Kamada et al, *Crystal Growth & Design* **11** (2011) 4484.
(2) K. Kamada et al, *J. Cryst.Growth* **535** (2020) 125510.
(3) Ji. Kvapil et al, *J. Cryst. Growth* **52,** 542 (1981).
(4) D. Spassky et al, *CrystEngComm* **22** (2020) 2621.
(5) O. Zapadlík et al, *Crystal Growth & Design* **21** (2021) 7139.
(6) K. L. Hovhannesyan et al, *CrystEngcomm* **26** (2024) 4812.

Acknowledgments: This research was supported by Czech Science Foundation project no. 21-17731S and by OP JAC financed by ESIF and MEYS (Project LASCIMAT – CZ.02.01.01/00/23_020/0008525). Computational resources were provided by the e-INFRA CZ project (Project ID No.: 90254), supported by MEYS of the Czech Republic.

S-4

LASER DRIVEN LUMINESCENCE OF RARE EARTH COMPOUNDS

W. Strek, D. Hreniak, M. Stefański, R. Tomala

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

* corresponding author: w.strek@intibs.pl

Keywords: rare earths, luminescence, optical properties, laser-induced white emission

The unique properties of lanthanides, the first of which were discovered as late as the 18th century, and which result from their electronic structure, are the subject of increasingly intensive research, the results of which are leading to their growing importance in science and also in the global economy. One of the most important applications of materials based on lanthanide compounds is undoubtedly their use in optical light sources. Research on such applications was also conducted by my research group in cooperation with Prof. Georges Boulon and his collaborators [1-7]. Many of the results of this joint work inspired research into new luminescent applications of nanomaterials doped with lanthanide ions. In the present lecture, the development of research on laser-driven luminescence of such materials is presented and discussed in view of potential new applications, not only in the field of optics.

[1] D. Hreniak, W. Strek, A. Speghini, M. Bettinelli, G. Boulon, Y. Guyot, *Appl. Phys. Lett.* **88(16)** (2006) 161118 (3pp).

[2] J. Amami, D. Hreniak, Y. Guyot, R. Pazik, C. Goutaudier, G. Boulon, M. Ayadi, W. Strek, *J. Lumin.* **119-120** (2006) 383.

[3] J. Amami, D. Hreniak, Y. Guyot, R. Pazik, W. Strek, C. Goutaudier, G. Boulon, *J. Phys.: Condens. Matter.* **19(9)** (2007) 096204 (14pp).

[4] W. Zhao, D. Hreniak, G. Boulon, W. Strek, A. Brenier, M. Yin, P. Gluchowski, A. Lukowiak, R. Wiglusz, T. Epicier, *Radiat. Meas.* **45(3-6)** (2010) 304.

[5] J. Amami, D. Hreniak, Y. Guyot, W. Zhao, G. Boulon, *J. Lumin.* **130(4)** (2010) 603.

[6] L. Marciniak, W. Strek, Y. Guyot, D. Hreniak, G. Boulon, *J. Phys. Chem. C* **119(9)** (2015) 5160.

[7] L. Marciniak, W. Strek, D. Hreniak, Y. Guyot, *Appl. Phys. Lett.* **105(17)** (2014) 173113 (4pp).

Supersensitive Visual Pressure Sensor Based on the Exciton Luminescence of the Bi^{3+}-doped, double perovskitematerial $Cs_2Ag_{0.6}Na_{0.4}InCl_6$.

J. Moszczyński[1,*], M. Runowski[1], P. Woźny[1], K. Soler-Carracedo[1], A. Lazarowska[2], M. Kamiński[2], N. Majewska[2], A. Muñoz[3], S. Sobczak[1], K. Dave[4], W.-T. Huang[4], R.-S. Liu[4], S. Mahlik[2]

[1]Faculty of Chemistry, Adam Mickiewicz University, Uniwersytetu Poznańskiego 8, Poznań 61-614, Poland
[2]Institute of Experimental Physics, Faculty of Mathematics, Physics and Informatics, University of Gdańsk, Wita Stwosza 57, 80-308 Gdańsk
[3]Departamento de Física, IUdEA, IMN & MALTA Consolider Team, Universidad de La Laguna, Apdo. Correos 456, E-38200 San Cristóbal de La Laguna, Santa Cruz de Tenerife, Spain
[4]Department of Chemistry, National Taiwan University, Taipei 106, Taiwan

*corresponding author: *jan.moszczynski@amu.edu.pl*

Keywords: Pressure sensor, High-Pressure, Perovskite materials, Luminescence

Accurate, rapid, and remote detection of pressure, one of the fundamental physical parameters, is vital for scientific, industrial, and daily life purposes. However, due to the limited sensitivity of luminescent manometers, the optical pressure monitoring has been applied mainly in scientific studies. Here, we developed the first supersensitive optical pressure sensor based on the exciton-type luminescence of the Bi^{3+}-doped, double perovskite material $Cs_2Ag_{0.6}Na_{0.4}InCl_6$. The designed luminescent manometer exhibits an extremely high sensitivity, *i.e.* $d\lambda/dp = 112$ nm GPa^{-1}. It also allows multi-parameter sensing, using both blue-shift and rarely observed band narrowing with pressure. Importantly, this material has small temperature dependence for the manometric parameter used, *i.e.* spectral shift, allowing detection under extreme pressure and temperature conditions. The developed sensor operates in the visible range, and its emission shifts from orange to blue with pressure. This properties allowed us to demonstrate the real-world application of this sensor in detecting small changes in pressure with a designed uniaxial pressure device, with unprecedented resolution of the order of a few bars, demonstrating the technological potential of this sensor for remote, online monitoring of cracks and strains in heavy construction facilities [1,2].

[1] M. Runowski; P. Woźny; K. Soler-Carracedo; A. Lazarowska; M. Kamiński; N. Majewska; A. Muñoz; J. Moszczyński; S. Sobczak; K. Dave; W.-T. Huang; R.-S. Liu; S. Mahlik *Mater. Horiz.*, 2024, **11**, 4911-4924

[2] T. Zheng; M. Runowski; J. Xue; L. Luo; U. R. Rodríguez-Mendoza; V. Lavín; I. R. Martín; P. Rodríguez- Hernández; A. Muñoz; P. Du, *Adv. Funct. Mater.*, 2023, **33**, 2214663.

Acknowledgments:
Work supported by the National Science Center (grant 2023/50/E/ST5/00021)

O-2

Local Structure Engineering in Rare Earth Nanocrystals for Tunable Upconversion Emissions

L. Sun*, H. Dong, J. Zhang, Y. Liang, Z. Deng, C. Yan

College of Chemistry and Molecular Engineering, Peking University, Beijing, 100871, China

* corresponding author: *sun@pku.edu.cn*

Keywords: keyword 1, rare earth 2, nanoparticles 3, upconversion emission

Upconversion emissions from rare earth-doped nanocrystals have sparked extensive research interests in nanophotonics, biomedicine, photovoltaics, pressure sensing, etc. Rational modulation of upconversion emissions is highly desirable to meet specific application requirements. Among the diverse attempts, local structure engineering is fundamentally feasible, through which the upconversion emission intensity, selectivity, and lifetime can be tuned effectively. The underlying mechanism of the local structure dependent upconversion emissions lies in the degree of parity hybridization and energy level splitting of lanthanide ions as well as interionic energy transfer efficiency. Ionic exchange method had been developed to apply tensile stress and compressive stress to luminescent centers which alter the local structure, as the core/shell structure. Recent achievements on host composition modification, external field regulation, and interfacial strain management have been proved as efficient ways in tuning local structure as well as f-f transitions. It is expected to deepen the understanding of local structure dependent upconversion emissions and arouse adequate attention to desired optical properties of rare earth nanocrystals.

[1] Z. Lyu, H. Dong, X. Yang, L. Huang, Y. Xu, K. Wu, L. D. Sun, C. H. Yan, *JACS Au*, **3**(2023) 860.

[2] H. Dong, L.D. Sun, C. H. Yan, *J. Am. Chem. Soc.* **143**(2021), 20546.

Acknowledgments: This work was supported by National Natural Science Foundation of China (22031002) and Ministry of Science and Technology of the People's Republic of China (2022YFF0710001).

LUMINESCENCE THERMOMETRY BASED ON FIRST ORDER PHASE TRANSITION

L. Marcinik[1*], **M. Szymczak**[1], **A. Javaid**[1], **M. Abbas**[1], **M. Kubicka**[1]

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

* corresponding author: *l.marciniak@intibs.pl*

Keywords: luminescence thermometry, lanthanide ions, phase transition, high sensitivity

While luminescence thermometry based on the intensity ratio of emissions from two thermally coupled excited states offers several advantages, such as straightforward implementation and robust performance, it is inherently constrained by relatively low relative sensitivity. This limitation arises from the fact that the sensitivity of such systems is directly proportional to the energy gap between the two thermally coupled levels.

To overcome this constraint, a novel approach has recently emerged, leveraging thermally induced structural phase transitions in the host material to modulate the spectroscopic behavior of lanthanide ions[1,2]. These first-order phase transitions, alter the local symmetry around the dopant ions, leading to modifications in the number and intensity of Stark components in the emission spectrum, as well as changes in the probability of radiative depopulation of excited states. Exploiting these effects enables the development of luminescent thermometers with exceptionally high relative sensitivity.

Despite these advantages, two primary challenges remain: (i) the relatively narrow thermal operating range, and (ii) hysteresis of the thermometric parameters between heating and cooling cycles, which can compromise measurement reliability.

This lecture will present the fundamental principles of luminescent thermometry based on structural phase transitions, with particular focus on both ratiometric and lifetime-based approaches. Strategies to mitigate the aforementioned limitations will be discussed in detail, including compositional tuning and thermal cycling stabilization. Moreover, the influence of material morphology on the thermometric performance, especially relative sensitivity, will be examined to highlight design considerations for practical sensor development.

[1] L. Marciniak, W. Piotrowski, M. Szalkowski, V. Kinzhybalo, M. Drozd, M. Dramicanin, A. Bednarkiewicz*, Chem. Eng. J.* **427** (2022) 131941.

[2] L. Marciniak, W. Piotrowski, M. Szymczak, C. D. S. Brites, V. Kinzhybalo, H. Suo, L.D. Carlos, F. Wang, *ACS Appl. Mater. & Interf.* **16** (2024) 26439

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

O-4

Enhancing Visible-to-UVC upconversion in Pr^{3+}-Doped Borates

P. Zdeb-Stańczykowska[1,*], **N. Rebrova**[1], **P.J. Dereń**[1]

[1]Institute of Low Temperature and Structure Research, Polish Academy of Science, ul. Okólna 2, 50-422 Wrocław, Poland.

* corresponding author: p.zdeb@intibs.pl

Keywords: UVC radiation, upconversion, Pr^{3+}-doped phosphors, charge compensation, clusters

Upconversion materials form a broad and impactful class of luminophores, with those capable of converting visible light into UVC radiation gaining particular attention. The germicidal effectiveness of UVC [1] makes these materials highly valuable for applications such as purification and surface decontamination. Among them, Pr^{3+}-doped compounds with wide band gaps are especially promising, as they can absorb two blue photons and emit a single UVC photon [2-5], positioning them as strong candidates for next-generation light sources.

In this work, we investigate the visible-to-UVC upconversion process in $A_3(BO_3)_2:Pr^{3+}$ (A = Sr, Ca) compounds, with particular emphasis on the role of Li^+ and Na^+ co-doping for charge compensation. Our results demonstrate that Na^+ co-doping significantly enhances upconversion luminescence in both materials—not only in comparison to the uncompensated samples but also relative to the well-established $Y_2SiO_5:Pr^{3+}$ upconverter.

We also examined the decay kinetics of the $^3P_0$ and $^1D_2$ energy levels, noting the absence of concentration quenching in the $^1D_2$ decay time. To better understand this phenomenon, we conducted numerical simulations using a multi-level energy model, which indicated the potential formation of Pr^{3+} ion clusters. Co-doping with Na^+ or Li^+ ions effectively suppressed ion pair formation, thereby contributing to the observed enhancement in upconversion efficiency.

This study provides valuable insights into the role of charge compensation and cluster formation in Vis-to-UVC upconverting materials, an area that remains largely unexplored.

[1] N.G. Reed, *Public Health Rep.* **125** (2010) 15.
[2] N. Rebrova *et al.*, *Inorg. Chem.* **63** (2024) 3028.
[3] E.L. Cates *et al.*, *Technol.* **45** (2011) 3680.
[4] Y Du *et al.*, *Adv. Opt. Mater.* **12** (2024) 2400971.
[5] P. Zdeb *et al.*, *J. Phys. Chem. Lett.* **15** (2024) 9356.

This work was supported by a grant from the Polish National Science Centre, no. 2021/41/B/ST5/03792, for which we are very grateful.

O-5

Near-infrared non-gallate persistent phosphors functionalized with europium complex for potential optical imaging applications

L.H.C Francisco[1], R.P. Moreira[1], H.F. Brito[2], O.L. Malta[3],
E. E. S. Teotonio[4], M.C.F.C. Felinto[1*]

[1]Nuclear and Energy Research Institute, Sao Paulo, 05508-000, Brazil
[2]Institute of Chemistry, University of Sao Paulo, Sao Paulo, 05508-900, Brazil
[3]Department of Chemistry, Federal University of Pernambuco, 50.740-560, Brazil
4Department of Chemistry, Federal University of Paraíba, João Pessoa, PB, Brazil

* corresponding author: *mcfelinto2014@gmail.com*

Keywords: Persistent phosphors, Near-infrared, Europium complex, Optical imaging.

Recently, Cr^{3+}-activated non-gallate persistent phosphors have been studied to achieve long near-infrared (NIR) lasting persistent luminescence (PersL), particularly through introducing defects and engineering the local structure with the substitution of different ions (e.g. Mg^{2+}, Al^{3+}) into Cr^{3+}-doped $ZnSnO_4$ hosts [1]. These materials are potential candidates for optical imaging applications due to their bright PersL in the first NIR biological window. Hence, in this scenario, we prepared mixed oxide $Zn_{2-x}Mg_xSnO_4{:}Cr^{3+}$ phosphors by the ceramic method and microwave-assisted solid-state method, and further functionalized these materials with an $Eu(tta)_3(H_2O)_2$ complex by microwave-assisted silanization, utilizing APTMS as a precursor [2]. XRD experiments indicate that the inverse-spinel structure of the host matrix is preserved after functionalization. At the same time, TEM results show a polymeric silica shell with 10-20 nm size in coated phosphors. Interestingly, by combining standard luminescence spectroscopy with synchrotron techniques such as XRF, XANES and XEOL, Eu^{3+} to Cr^{3+} energy-transfer is observed, suggesting that the europium complex is an efficient sensitizer for Cr^{3+} emission under UV and X-ray excitation, outlining a novel strategy to achieve bright NIR luminescence in persistent phosphors for optical imaging applications.

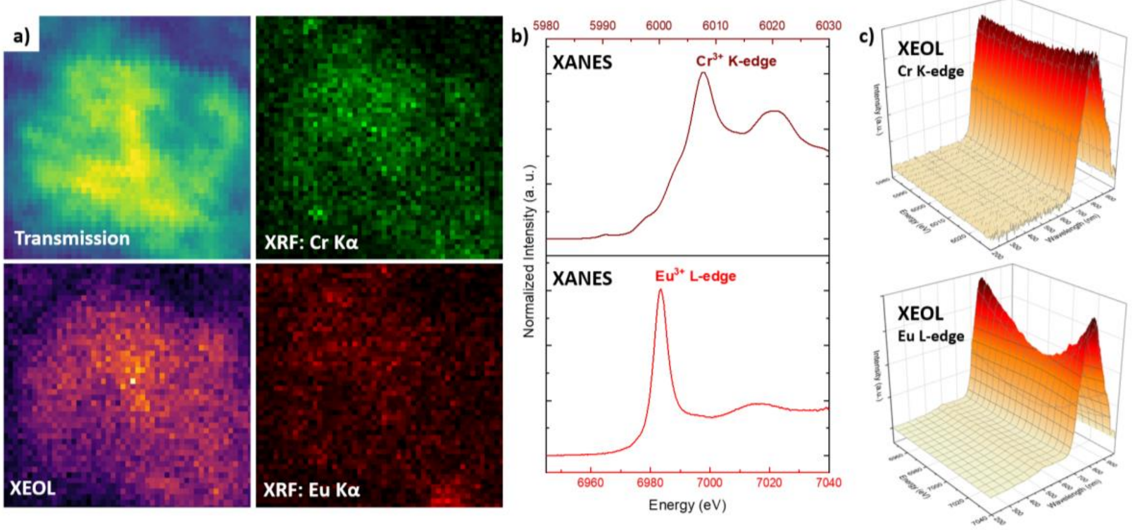


Fig. 1: a) Transmission, XEOL and XRF maps (10 µm × 10 µm), b) XANES spectra and c) 3D XEOL emission spectra recorded under Cr^{3+} K-edge and Eu^{3+} L-edge for a functionalized phosphor.

[1] L. Lin et al., *Chem. Matter*. **36** (2024) 10895-10901.
[2] L.H.C. Francisco et al, *J. Alloys Compd*. **882** (2021) 160608.

Acknowledgments: FAPESP (Grant 2021/08111-2), CNPq, and IPEN-CNEN.

The Ce^{3+} and Sm^{3+}-doped phosphates for application in LED lighting

M. Adaszyński, **D. Stefańska**[*]

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

* corresponding author: *d.stefanska@intibs.pl*

Keywords: lanthanides, Ce^{3+} and Sm^{3+}-doped phosphors, phosphates, LEDs, plant growth stimulation

The optimization of light condition is a key factor in modern agriculture, especially in controlled environments such as greenhouses. Light exposure is one of the most critical environmental parameters for plants, as it regulates numerous physiological processes - most notably photosynthesis, which enables the conversion of photons into biochemical energy [1]. There are different classes of photoactive plant pigments. The most important among them are chlorophylls, which are essential for the photosynthesis process. These pigments absorb light most efficiently in blue (430-470 nm) and red (640-670 nm) light ranges. Another class of pigments are carotenoids, which assist in light harvesting by transferring the energy to chlorophylls and also protect the chloroplasts from photooxidative stress by quenching reactive oxygen species [1, 2]. In addition to photosynthesis, light is as well controlling other physiological plant function by phytochromes, which are red/NIR sensitive photoreceptors. They regulate various processes such as photoperiodism and growth responses [1]. By engineering luminescent materials with emission spectra that align with the absorption characteristics of these pigments, it is possible to enhance plant growth more efficiently [3].

In this work, a phosphate $Ca_2Sr(PO_4)_2$ doped with Ce^{3+} and Sm^{3+} ions was synthetized using simple solid-state reaction method and crystalizes in the *R3cH* space group. No additional phases was detected as confirmed by powder XRD analysis. A broad excitation band from 250 nm to 350 nm was observed, which corresponds to 4f → 5d transition of Ce^{3+} ions. Furthermore, multiple narrow excitation lines were observed for Sm^{3+} ions with the most intensive one at around 403 nm, corresponding to $^6H_{5/2} \rightarrow {}^6P_{3/2}$ transition. The emission spectra under 320 nm consist of a broad band for 5d → 4f transition of Ce^{3+} ions with maximum at around 370 nm. Furthermore a multiple peaks in the red/NIR range are observed, corresponding to the Sm^{3+}ions with the highest intensity at around 600 nm corresponding to $^4G_{5/2} \rightarrow {}^6H_{7/2}$ transition. To summarize, the spectral match between the emission of the examined material and plant pigments, make this compound promising in the application for stimulating plant growth LED lighting.

[1] A. Pirson, M.H. Gottingen, H. Zimmermann, *Encyclopedia of Plant Physiology*, Springer, Berlin **12A** (1981).

[2] C. Triantaphylidès, M. Krischke, F. A. Hoeberichts, B. Ksas, G. Gresser, M. Havaux, F. Van Breusegem, M. J. Mueller, *Plant Physiol.* **148** (2008) 960.

[3] J. Chen, C. Guo, Z. Yang, T. Li, J. Zhao, *J. Am. Ceram. Soc.* **99** (2016) 218.

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

Recent progress on defect engineering in LuAG:Ce ceramics towards ultrahigh fast scintillation proportion

Chen Hu[a,b], Danyang Zhu[a,b], Yanbin Wang[a,b], Romana Kucerkova[c], Alena Beitlerova[c], Martin Nikl[c], Jiang Li[a,b*]

[a] Transparent Ceramics Research Center, Shanghai Institute of Ceramics, Chinese Academy of Sciences, Shanghai 201899, China
[b] Center of Materials Science and Optoelectronics Engineering, University of Chinese Academy of Sciences, Beijing 100049, China
[c] Institute of Physics of the Czech Academy of Sciences, Cukrovarnicka 10, Prague 16200, Czech

Abstract:

Future high energy physics (HEP) experiments at the energy and intensity frontiers present stringent challenges to inorganic scintillators in radiation hardness, fast time response and cost. Inorganic scintillators in ceramic form have attracted a broad interest due to its lower fabrication temperature, effective usage of raw material, and no need for aftergrowth mechanical processing. In this paper, recent progress on defect engineering in radiation hard, fast, and cost-effective LuAG:Ce transparent ceramic scintillators for future HEP experiments was reported. Co-dopants, such as Ca^{2+} and Mg^{2+}, were used to improve fast scintillation proportion of LuAG:Ce ceramics. Results of their optical and scintillation performance will be presented. The improvement on fast scintillation proportion was further confirmed by thermoluminescence results. The different behavior of Ca^{2+} and Mg^{2+} co-doping was explained by the density functional theory (DFT) calculations. As a consequence, both Ca^{2+} and Mg^{2+} co-doped ceramic samples show a fast-total ratio above 98%. Future plan concerning other garnet scintillators will also be presented.

Keywords: LuAG:Ce; transparent ceramics; scintillators; thermoluminescence; first-principles calculations

O-8

Design of Inorganic Trap-Controlled Luminescent Materials

<u>Jiaren Du*[1]</u>, Wei Hu[2], Jingxuan Zhang[1], Hengwei Lin[1], Dirk Poelman[2]

[1] *International Joint Research Center for Photo-responsive Molecules and Materials, School of Chemical and Material Engineering, Jiangnan University, 214122, Wuxi, China*
[2] *LumiLab, Department of Solid-State Science, Ghent University, 9000 Ghent, Belgium*

* corresponding author: *jiaren.du@jiangnan.edu.cn*

Keywords: traps, persistent luminescence, photochromism, microwave-assisted synthesis

Inorganic responsive materials have attracted a lot of attention in fields from temperature indicators, smart displays, thermometry and optoelectronic devices, to high-security anti-counterfeiting [1]. Despite the substantial progress made, it is still a major challenge to obtain more robust and efficient materials that can be applied in a wider temperature range to meet the demand of science and industry. Moreover, the responsiveness reaction of multi-responsive materials upon various external fields is still restricted to monochromatic visualization with single-wavelength light emission, which limits the wide application of responsive materials for cutting-edge technologies. This talk will present new perspectives on their wide applications in terms of designing and screening inorganic trap-controlled responsive materials for various ambient conditions, and beyond [2,3].

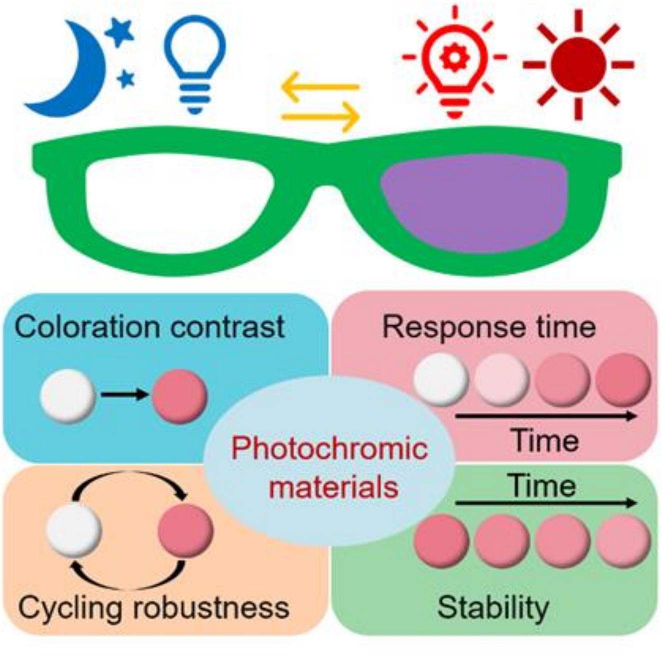


Fig. 1. Design of Inorganic Trap-Controlled Materials

Reference:
[1] J. Du, Z. Yang, H. Lin, D. Poelman. ***Responsive Mater.*** 2024, 2, e20240004.

[2] W. Hu et al., ***ACS Energy Lett.*** 2024, 9, 2145.

[3] J. Du et al., ***Adv. Mater.*** 2024, 36, 2314083.

O-9

Demonstrating Polaron Mediated Photoluminescence in Vanadates by a Combined Experimental and Computational Study

J. Zom[1*], **A. Vasileiadis**[2], **S. Yuan**[3], **E. van der Kolk**[1]

[1] *Luminescence Materials, Delft University of Technology, Mekelweg 15, 2629 JB, Delft, The Netherlands*
[2] *Storage of Electrochemical Energy, Delft University of Technology, Mekelweg 15, 2629 JB, Delft, The Netherlands*
[3] *Department of Physics, McGill University, Sherbrooke Street West 845, QC H3A 0G4, Montréal, Canada*

*corresponding author: j.zom@tudelft.nl

Keywords: Vanadate, Luminescence, Charge Transfer, Polaron, Self-trapped Exciton

The luminescence in vanadates is commonly attributed to charge-transfer excitations based on the molecular-orbital theory applied on isolated VO_4 tetrahedra. In this study, we demonstrate that in a series of alkali vanadates (MVO_3, M=Li, Na, K, Rb, Cs) such luminescence can better be explained by their ability to self-trap electrons, forming electron polarons, and to subsequently form self-trapped excitons. We show that the energy of their bandgaps, electron polarons (see Figure 1), and self-trapped excitons, predicted by Density Functional Theory, are in line with their experimentally obtained optical properties. Furthermore, by measuring the temperature-dependent and time-dependent intensity of their luminescence, we find that internal quenching does not appear to determine their luminescence efficiency, in contrast to earlier hypotheses. Instead, their efficiency seems determined by the rate at which self-trapping occurs. These new insights provide a way to rationally design efficient vanadium-based phosphors and sets the groundwork for further theoretical understanding.

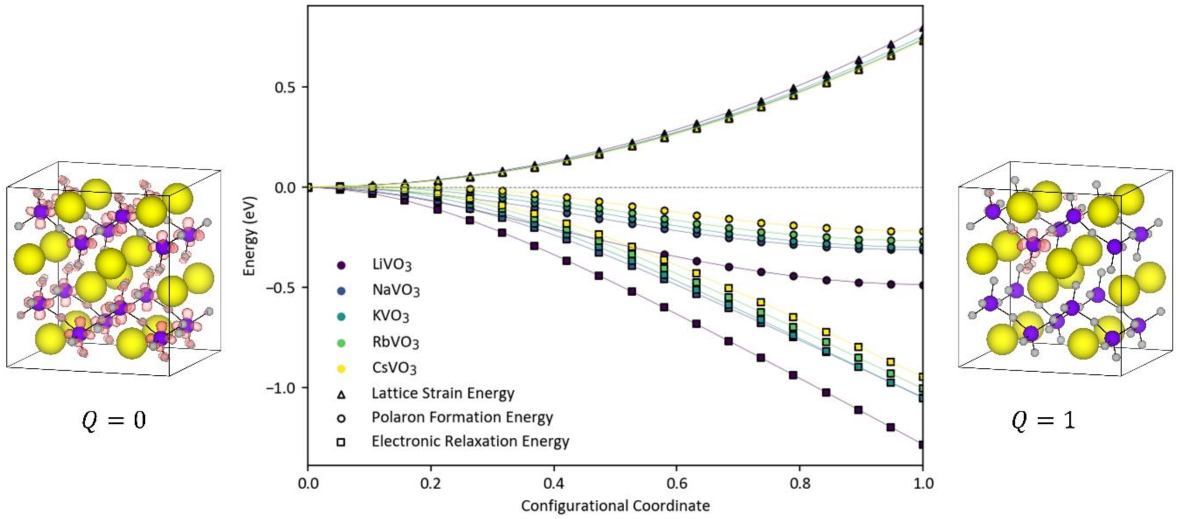


Fig. 1. Energy (y-axis) of an excited electron as function of the configuration coordinate (x-axis), which can be viewed as the degree of distortion of the initial ionic configuration, for the alkali vanadates (MVO_3, M=Li, Na, K, Rb, Cs). Barrierless self-trapping of the electrons can occur in all 5 materials, their only difference being a shift in their relative energy. The polaron formation energy is mostly demined by their electronic relaxation, whereas the lattice strain is similar for all materials. The figures on the sides show isosurface plots of the electron-density (indicated in red) of the excited electron at the initial and final configuration, for $CsVO_3$.

O-10

Emission Properteis Control by Iodide-Doping Effects in Zero-Dimensional Perovskite Chloride Scintillators

Chihaya Fujiwara[1,2] *, Shunsuke Kurosawa[1,3,4,5], Akihiro Yamaji[1,3], Akira Yoshikawa[1,3]

[1]Institute for Materials Research, Tohoku University, Sendai, 980-8577, Japan
[2] Department of Materials Science, Graduate School of Engineering, Tohoku University, Sendai, 980-8579, Japan
[3] New Industry Creation Hatchery Center, Tohoku University, Sendai, 980-8579, Japan
[4] Institute of Laser Engineering, Osaka University, Osaka, 565-0871, Japan
[5] Institute for Integrated Radiation and Nuclear Science, Kyoto University, Osaka, 590-0494, Japan

* corresponding author: *fujiwara.chihaya.p8@dc.tohoku.ac.jp*

Keywords: Zero-Dimensional Perovskite, Halide Phosphor, Scintillator, First principal calculation

Scintillator materials with a structure of zero-dimensional perovskite A_2BX_6 (A=Cs, B=Hf,Zr, X=Cl,Br,I) such as Cs_2ZrCl_6 have high attention due to their high luminescence efficiency originating from self-trapped exciton (STE)[1]. Since light output (L) is generally inversely proportional to the band gap (E_{gap}), target materials for improvement of L are smaller bandgap materials such as iodide compounds. Indeed, we also have investigated and succeeded in discovering novel and high light-output iodide materials [2]. However, we reveal that the effective mass of electrons and holes decreases in iodide compounds like Cs_2ZrI_6 by Density Functional Theory (DFT) calculations, and this result suggested an emission efficiency of STE decrease. This means iodides are not expected to be a suitable material to improve the L, and this result (concept) is against conventional wisdom. Thus, we optimized the balance between the bandgap and these effective masses, and we focused on Cs_2ZrCl_6 doped with iodide. In this paper, we propose a new material concept to improve L.

All crystals were grown by the Bridgman-Stockberger method. The internal quantum yield (PLQY) of Cs_2ZrI_6 is 6%, which was consistent with the result of low luminescence efficiency suggested by the DFT results. On the other hand, the PLQY of I-doped Cs_2ZrCl_6 was approximately 60-70% which was comparable to or higher than that of Cs_2ZrCl_6. This result indicated that high quantum efficiency can be maintained with slight I substitution. On the other hand, E_{gap} for I-doped Cs_2ZrCl_6 was found to be as smaller as 3.66 eV, while that of Cs_2ZrCl_6.was 4.95 eV As shown in Figure 1, the light output of I-doped Cs_2ZrCl_6 was 55,000 photons/MeV which is higher than that of non-doped Cs_2ZrCl_6 due to the lower E_{gap} of I doped Cs_2ZrCl_6.

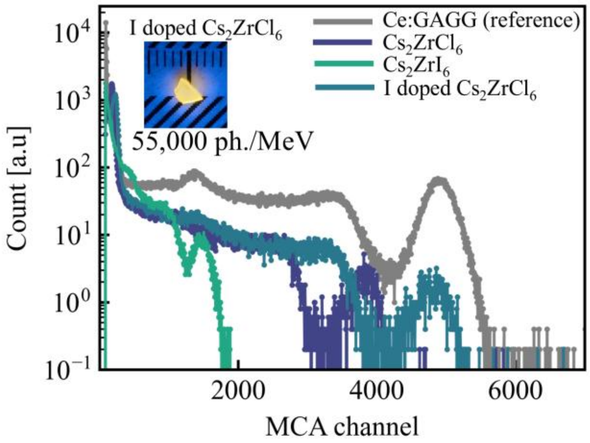


Figure 1. The pulse height spectra of Cs_2ZrX_6 (X-Cl, I) compounds

[1] Y. Tang *et al.*, *Coord. Chem. Rev.*, vol. 499, p. 215490, Jan. 2024.
[2] S. Kodama *et al.*, *Radiat. Meas.*, vol. 124, pp. 54–58, 2019.

O-11

Structure-Property Analysis and Performance Prediction of Ion-Doped Luminescent Materials via High-Throughput First-Principles Calculations

B. Lou[1*]

[1] *School of Integrated Circuits, Chongqing University of Posts and Telecommunications, Chongqing, China*

* corresponding author: *loubb@cqupt.edu.cn*

Keywords: luminescence, first-principles calculation, high-throughput

Ion-doped luminescent materials are attracting widespread interest in the optoelectronics field, ranging from solid-state lighting, displays, and multifunctional applications. Effective first-principles calculation methods have been explored in geometric and electronic structures of rare earth ions, transition metal ions, and ns^2 ions. Those methods can approximate the excited state properties and provide reasonable prediction of excitation emission energies. Recently, we combine high-throughput with established first-principles luminescence calculation methods: 1) batch acquisition of material structures from the Materials Project and preparation for luminescence calculations; 2) batch calculation of ground and excited state structures to obtain data such as defect energy levels of dopant ions and excitation/emission energies; 3) analysis of high-throughput calculation results to predict structure-property relationships for luminescence. It demonstrates significant potential for predicting and designing luminescent materials.

Here, we briefly introduce the existing first-principles calculation methods for ion-doped luminescent materials, and elaborate on the positive roles of calculations in explaining luminescence mechanisms and constructing luminescence models in combination with experimental research. In addition, taking the Sb^{3+}-doped halide series as an example, we introduce the research work related to high-throughput calculations.

[1] B. Lou, J. Wen, L.X. Ning, M. Yin, C.-G. Ma, C.-K. Duan*, *Phys. Rev. B* **104** (2021) 115101.

[2] L. Cao, X. Jia, W. Gan, C.-G. Ma, J. Zhang, B. Lou*, J. Wang, Advanced Functional Materials, **33** (2023) 2212135.

Acknowledgments: This work was financially supported by the National Natural Science Foundation of China (Grant Nos. 12304439), the China Postdoctoral Science Foundation (Grant No. 2023MD744135) and the Scientific and Technological Research Program of Chongqing Municipal Education Commission (Grant No. KJQN202200629).

O-12

EXTERNAL FIELD CONTROL OF LASER INDUCED WHITE LIGHT EMISSION

A. Musialek*, R. Tomala, M. Oleszko and W. Stręk

Institute of Low Temperature and Structural Research, PAS, Wroclaw, 50422, Poland

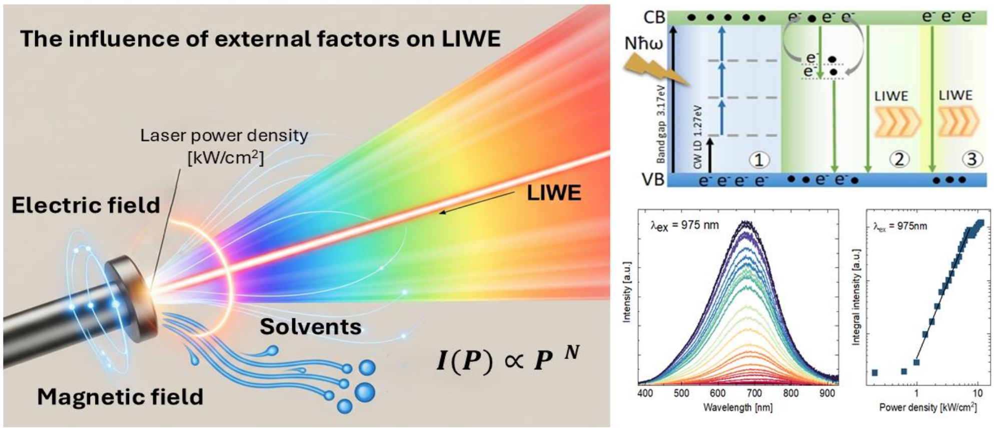
* corresponding author: *a.musialek@intibs.pl*

Keywords: luminescence, LIWE, photocurrent, magnetic field, solvents

The generation of broadband, sunlight-like emission (LIWE) from a single-component material under intense laser irradiation is a phenomenon of significant scientific interest. It is a unique physical process that opens the way for advanced applications, including lighting and optical data storage. It is primarily characterized by its nonlinear nature and threshold behavior. The process is described by the power law:

$$I(P) \propto P^N$$

where $I(P)$ is the emission intensity, P is the excitation laser power, and N is related to the number of photons. A deeper understanding of this process requires the analysis of its fundamental properties, such as the excitation threshold, dependence on laser power density, the influence of conditions (pressure, atmosphere, temperature), the characteristics of the accompanying photocurrent [1], and the effect of a magnetic field [2].



Our research addresses the key challenge of modulating LIWE properties and developing methods for the active control of the aforementioned characteristics. Beyond the classical characterization of the phenomenon, the influence of external electric and magnetic fields is being investigated as an effective tool for controlling the properties of LIWE.

[2] M. Stefanski, P. Głuchowski, W. Strek, Ceram. Int. **46** (2020) 18.

[2] M. Oleszko, R. Tomala, A. Musiałek, P. Wiewiórski, M. Kowol, and W. Strek, *Low Temp. Phys*. **51** (2025) 9.

Acknowledgments:

This work was supported by the National Centre for Research and Development, Poland under grant no. SHENG2021/40/Q/ST5/00220.

O-13

EXCITASTION AND EMISSION STATES FOR CR-DOPED GARNET SCINTILLATORS WITH RED AND INFRARED EMISSION

S. Kurosawa[1, 2], **C. Fujiwara**[1], **Y. Urano**[1], **A. Yamaji**[1]

[1] *Tohoku University, Sendai, 980-8577, Japan*
[2] *Osaka University, Suita, 565-0871, Japan*

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

Scintillator, Red and Infrared

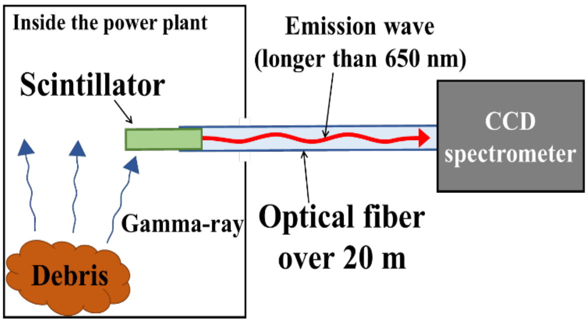
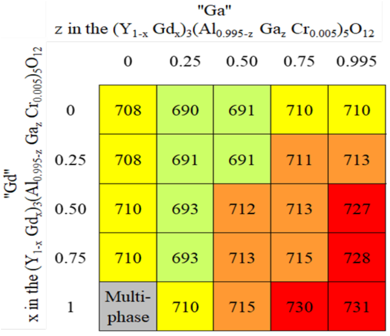


Fig. 1 Schematic view of the radiation dose monitoring system

Real-time dose rate monitors under the high dose-rate condition are required for the decommissioning step of the Fukushima Daiichi Nuclear Power Station, and we have proposed a dose monitor consisting of a scintillator, optical fiber and CCD spectrometer as shown in Fig.1 [1]. Since the scintillator is coupled with an over-20-m long optical fiber, (a) the long emission wavelength (longer than 650 nm) and (b) high light output are required for the scintillator to suppress the photon loss through the fiber, and to discriminate the noise in the below 550-nm region originating from the scintillation photons and/or Cherenkov photons in the optical fiber itself, here we describe this noise as "blue noise". We focused on Cr-doped garnet crystals, because these materials were expected to have red and infrared emission originating from $^4T_2 \rightarrow A_2$ (d-d) transition of Cr^{3+} [2].

We prepared sintered powder pellets of $(Y_{1-x}Gd_x)_3(Al_{0.995-z}Ga_zCr_{0.005})_5O_{12}$ (x = 0, 0.25, 0.50, 0.75, 1, z = 0, 0.25, 0.50, 0.75, 0.995) were prepared as pellets by powder sintering method to pre-evaluate their luminescence properties. Finally, we determined compositions with emission wavelength of over 650 nm or much longer. Figure 2 show the results of emission wavelength for these samples.



"Gd" x in the $(Y_{1-x}Gd_x)_3(Al_{0.995-z}Ga_zCr_{0.005})_5O_{12}$	"Ga" z in the $(Y_{1-x}Gd_x)_3(Al_{0.995-z}Ga_zCr_{0.005})_5O_{12}$				
	0	0.25	0.50	0.75	0.995
0	708	690	691	710	710
0.25	708	691	691	711	713
0.50	710	693	712	713	727
0.75	710	693	713	715	728
1	Multi-phase	710	715	730	731

Fig. 2 Maximum peak of emission wavelength [nm] and composition of $(Y_{1-x}Gd_x)_3(Al_{0.995-z}Ga_zCr_{0.005})_5O_{12}$

After this selection, $Gd_3(Ga_{0.995}Cr_{0.005})_5O_{12}$ (Cr:GGG) was found to be suitable for our application, so that a Cr:GGG single crystal was grown the micro-pulling-down method. Compared to the emission wavelength of Cr:YAG, that of Cr:GGG was red-shifted; the emission wavelengths were 707 and 731 nm for Cr:YAG and Cr:GGG, respectively.

Moreover, we evaluated the emission intensity with 20-m long optical fiber under the high-dose-rate condition up to 1 kGv/h using ~70-Tb ^{60}Co source at Kyoto University. The result shows we succeeded in wide dose-rate dynamic rage detector (a dozen mGy/h to a few kGy/h). Here, some samples had afterglow (over 1 min.) after gamma-ray irradiation, and we evaluated the trap sites and energy transfer to reveal the mechanism of such afterglow. We report details of these results in the conference.

[1] S. Kodama, S. Kurosawa *et al., Applied Physics Express,* **13** (2020) 047002
[2] S. Kurosawa *et al, J. Cryst. Growth.* **452** (2016) 95.

O-14

Fabrication and characterizations of Eu^{2+}-Dy^{3+} co-doped $SrAl_2O_4$ ceramics with persistent luminescence

Tingsong Li[1,2], **Jiang Li**[1,2,*]

[1] *Transparent Ceramics Research Center, Shanghai Institute of Ceramics, Chinese Academy of Sciences, Shanghai, 201899, China*

[2] *Center of Materials Science and Optoelectronics Engineering, University of Chinese Academy of Sciences, Beijing, 100049, China*

* corresponding author: *lijiang@mail.sic.ac.cn*

Keywords: persistent luminescence, $(Sr_{0.97}Eu_{0.01}Dy_{0.02})Al_2O_4$ ceramics, vacuum pre-sintering, hot isostatic pressing

Persistent luminescent material is a kind of photoluminescent material, which absorbs and stores light energy under the irradiation of external light source, and still emits luminescent material with a human eye recognizable and lasting longer than zero point one seconds after the excitation light source is withdrawn. It can be applied to lighting. $SrAl_2O_4$ is a very popular material system, showing very competitive properties and being a kind of benchmark for new materials. In our study, $(Sr_{0.97}Eu_{0.01}Dy_{0.02})Al_2O_4$ persistent luminescence (PersL) ceramics were fabricated by solid-state reactive sintering in vacuum combined with hot isostatic pressing (HIP) using H_3BO_3 as sintering additive. The phase composition, microstructure, luminescence properties, trap state, and PersL performance of HIP post-treated $(Sr_{0.97}Eu_{0.01}Dy_{0.02})Al_2O_4$ PersL ceramics were discussed. For the $(Sr_{0.97}Eu_{0.01}Dy_{0.02})Al_2O_4$ PersL ceramics after HIP post-treatment, the initial luminescence intensity of the ceramics reached over 6400 mcd/m^2 with a simulated daylight irradiation of 1000 lx for 5 min, and the persistent emission decay time > 17 h. This is much better than the $SrAl_2O_4:Eu^{2+},Dy^{3+}$ PersL powders and the other luminescent ceramics. In addition, this method is a solid-state reactive sintering method for synthesizing ceramics, which has the advantages of low cost and simple operation, and is suitable for large-scale, high-volume industrial production.

[1] Tingsong Li, Qiang Liu, Danyang Zhu, Penghui Chen, Yanqiu Jing, Junlin Wu, Haohong Chen, Dariusz Hreniak, Martin Nikl, Jiang Li*. Fabrication and characterizations of Eu^{2+}-Dy^{3+} co-doped $SrAl_2O_4$ ceramics with persistent luminescence. *J. Am. Ceram. Soc.* **106** (2023) 10: 5877-5886.

Acknowledgments: National Key R&D Program of China, Grant/Award Number: 2021YFE0104800; International Partnership Program of Chinese Academy of Sciences, Grant/Award Number: 121631KYSB20200039; International Cooperation Project of Shanghai Science and Technology Commission, Grant/Award Number: 20520750200.

O-15

SCINTILLATION PROPERTIES OF COMPOSITE SCINTILLATORS BASED ON ORTHOSILICATE COMPUNDS

S. Witkiewicz-Lukaszek[1], **V. Gorbenko**[1], **T. Zorenko**[1], **J. A. Mares**[2], **R. Kucerkova**[2],
M. Nikl[2], **O. Sidletskiy**[3], **Yu. Zorenko**[1]

[1]*Physics Department, Kazimierz Wielki University, Bydgoszcz, 85090, Poland*
[2]*Institute of Physics, Academy of Science of Czech Republic, Prague, 182 00, Czech Republic*
[3]*Institute of Scintillation Material, National Academy of Science of Ukraine 69000 Kharkiv Ukraine*

* corresponding author: *s-witkiewicz@wp.pl*

Keywords: orthosilicates, LPE, Bi and Ce dopants, crystals, films, composite scintillators, ionizing radiation

In this work, we analyzed two different approaches for development of the composite scintillators (CS) on the base of (Y,Lu)$_2$SiO$_5$ (YLSO) orthosilicate compounds using the Liquid Phase Epitaxy (LPE) method. In the first concept (Fig.1a), we employed the same scintillation material (Y$_{1.5}$Lu$_{0.5}$)SO with different dopants (Bi, Ce) for producing SCF and SC parts of CS using homoepitaxial growth mode with neglectable film/substrate lattice misfit **m**. In the second concept (Fig.1b), the CS were produced on the base of different scintillation materials and same activator (Ce) in the SCF and SC parts using quasi-homoepitaxial growth mode with a lattice misfit between the substrate and film in the range of 0.05–0.15%.

The optical and scintillation properties of the SCF and bulk parts of the CSs producing both approaches were characterized using absorption and cathodoluminescence spectra, pulse height spectra, and scintillation decay kinetics under α- and β-particles, and γ-rays excitation. Furthermore, we show the possibility of the simultaneous registration of these types of ionization radiation by the way of separation of the scintillation decay kinetics of SCF and SC parts of composite scintillators (Fig.1a, 1b). Namely, the (Y$_{0.75}$Lu$_{0.25}$)SO:Bi SCF/LYSO:Ce SC type of CS are characterized by high LY of their film and bulk crystal parts and suitable Figure of Merit (FOM) under simultaneous registration of mentioned types of radiation (Fig. 1c).

However, although promising growth results, the obtained FOM values for the developed CS were not sufficiently high (FOM<0.2 (Fig.1c) as we need for certain practical applications requiring enhanced discrimination capability and radiation sensitivity. Therefore, to improve the performance metrics of the developed CSs, the potential application of thermo-luminescence (TL) and optically stimulated luminescence (OSL) techniques was considered. The integration of TL/OSL techniques in composite epitaxial structures could significantly increase their applicability for dosimetry and radiation imaging, where precise radiation type discrimination is essential.

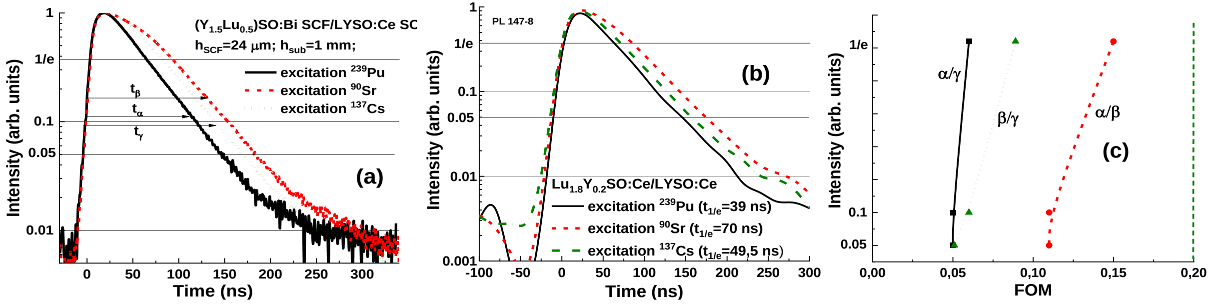


Fig. 1. Separation of the scintillation decay curves of (Y$_{1.5}$Lu$_{0.5}$)SO:Bi SCF/LYSO:Ce SC (a) and (Lu,Y)$_2$SO:Ce/LYSO:Ce (b) composite scintillators under excitation by α- (^{241}Am) and β- (^{90}Sr) particles and γ-quanta (^{123}Cs).

[1] W. Chewpraditkul, e.a. Optical Materials **35** (2013) 1679-1684.
[2] T. Martin, e. a. IEEE Trans. Nucl. Sci., **56** (2009) 1412-1418.
[3] J.A. Mares, S. Witkiewicz-Lukaszek, e. a. Optical Materials **96** (2019) 109268.

Acknowledgments: This work was supported by the Polish National Centre (NCN) OPUS 24 LAP No 2022/47/I/ST8/02600 project and in part by the Ministry of Science and High Education of Poland in frame of Regional Excellence Initiative nr RID/SP/0048/2024/01 project.

O-16

Optical and Scintillation Properties of Industry-Scale (Gd,Y)AlO$_3$:Ce Single Crystal

M. Kotyková[1,2,3] *, J. Touš[3], K. Blažek[3], T. Marek[3], J. Polák[3], R. Kučerková[1], P. Průša[2], M. Nikl[1]

[1]*Institute of Physics of the Czech Academy of Sciences, Prague, 182 00, Czechia*
[2]*Czech Technical University in Prague, Faculty of Nuclear Sciences and Physical Engineering, Prague, 115 19, Czechia*

[3]*CRYTUR, spol. s r.o., Turnov, 511 01, Czechia*

* corresponding author: kotykova@fzu.cz

Keywords: (Gd,Y)AlO$_3$:Ce, heavy perovskite, single crystal, scintillator, thermoluminescence

The (Gd,Y)AlO$_3$:Ce system is a heavy perovskite material that combines high density with efficient scintillation. Unlike other heavy perovskites, (Gd,Y)AlO$_3$:Ce exhibits limited backward energy transfer from Ce^{3+} to Gd^{3+} ions and fast energy migration in Gd-sublattice, resulting in enhanced scintillation intensity and LY [1, 2]. Remarkably, it significantly outperforms those of widely used scintillators such as the BGO and even YAP:Ce.

In this work, we present a large single crystal of (Gd,Y)AlO$_3$:Ce grown by the Czochralski method, with dimensions suitable for industrial applications. The crystal exhibits a diameter exceeding 40 mm and a usable length of more than 70 mm. To evaluate the homogeneity of the crystal, we prepared plate-shaped samples (1 mm thick) from both the beginning and the end of the crystal. These samples were subjected to a comprehensive set of measurements, including light yield, photoluminescence spectra, scintillation and photoluminescence decay time, and afterglow.

Our results indicate minimal differences between the samples taken from different crystal sections, confirming excellent optical and scintillation homogeneity throughout the crystal volume. Additionally, thermoluminescence measurements were performed on a sample from the end of the crystal. The obtained glow curve was compared with that of a reference YAP:Ce sample. The initial rise method was applied to determine the activation energies of the dominant trapping states, providing further insight into the defect structure of the material. This study confirms the potential of large Czochralski-grown (Gd,Y)AlO$_3$:Ce crystals for high-performance scintillation applications.

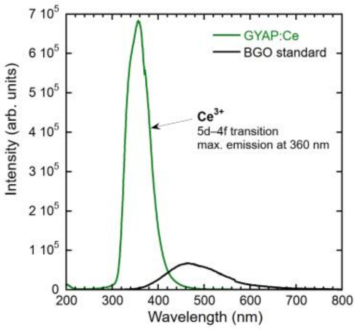


Fig. 1: *A radioluminescence spectrum of (Gd,Y)AlO$_3$:Ce and a reference BGO sample*

[1] M. Kucera et al., *IEEE T. Nucl. Sci.* **67** (2020) 1049.

[2] M. Kotykova et al., *Mater. Adv.* **5** (2024) 9774.

Acknowledgments: This work was supported by Technology Agency of the Czech Republic, project No. FW06010047 and Operation Programme Johannes Amos Comenius, project LASCIMAT – CZ.02.01.01/00/23_020/0008525.

Improving the optical properties of near-infrared luminescent nanoparticles by protected calcination.

M. Delaey[1], **D. Poelman**[2,*]

[1]*Lumilab, Department of Solid State Sciences, Ghent University, Ghent, 9000, Belgium*

* corresponding author: *dirk.poelman@ugent.be*

Keywords: luminescence, near-infrared, nanomaterials, neodymium, bio-imaging

Near-infrared (NIR) active materials hold considerable significance in the field of bio-imaging research. Biological tissues exhibit minimal attenuation within specific wavelength regions of the NIR spectrum, commonly referred to as biological windows, thereby underscoring the potential of NIR-emissive optical probes [1].

Neodymium ions possess advantageous optical characteristics, including appropriate excitation and emission wavelengths as well as extended luminescent lifetimes. These properties enable excitation within the biological windows and facilitate time-gated imaging techniques, which effectively remove background signals arising from tissue autofluorescence. Consequently, neodymium-doped nanoparticles emerge as promising candidates for optical probes [2].

Distinct synthetic methodologies for these neodymium-doped nanoparticles result in varying sizes, shapes and morphologies, which dictate the pharmacokinetics of the optical probes [3]. Furthermore, they may greatly impact the optical properties as well [4]. The presence of defects may induce non-radiative radiative relaxation pathways, causing a decrease in luminescence intensity and lifetime.

Herein, the optical properties of $GdVO_4:Nd^{3+}$ nanoparticles are greatly enhanced with a protected calcination process, while still ensuring their structural properties are suitable as optical probes. By applying a silica shell to the nanoparticles, they may be calcinated without the agglomeration of the $GdVO_4:Nd^{3+}$ cores. This shell can afterward be removed by a NaOH solution. The resulting nanoparticles exhibit a higher crystallinity, vastly longer decay times, and an order of magnitude gain in luminescence intensity.

[1] A. Smith, M. Mancini, S. Nie, *Nature Nanotech* **4** (2009) 710-711.
[2] M. Delaey, S. Van Bogaert, E. Cosaert, D. Poelman, *Materials* **16** (2023) no. 19: 6471
[3] N. Hoshyar, S. Gray, H. Han, G. Bao, *Nanomedicine* **11(6)** (2016) 673-692
[4] T. Carbonati, C. Cionti, E. Cosaert, B. Nimmegeers, D. Meroni, D. Poelman, *J. Alloys Compd.* **862** (2021) 158413

This research is funded by FWO (Fund for Scientific Research-Flanders), projects I002418N and G025322N

Comparison of Upconversion to UVC and UVB in ABO_3: Pr^{3+} where A = Sc, Y, La, and Lu

P.J. Dereń *, **N. Rebrova, P. Zdeb-Stańczykowska**

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

* corresponding author: *p.deren@intibs.pl*

Keywords: UVC, Up-conversion, Borates, Praseodymium

In recent years, upconversion (UC) from the visible region to UVC and UVB has attracted increasing attention from researchers. Newly discovered phosphors such as Cs_2NaYCl_6: Pr^{3+} [1] and LuOBr:Pr^{3+} [2] have demonstrated significantly higher upconversion efficiency compared to the previously established benchmark β-Y_2SiO_5 [3].

Recently, it was discovered that borate $Sr_3(BO_3)_2$: Pr^{3+} [4] also exhibits excellent blue-to-UVC energy conversion, thereby opening new avenues for research in this matter. This publication revealed that, unlike for UC materials working in the visible range, where high-energy phonons are typically detrimental for emission, they can actually be advantageous for UC processes targeting the UVC region.

Building on this discovery, we present preliminary results for ABO_3 host matrices (where A=Sc, Y, La, and Lu) doped with Pr^{3+} ions, along with an explanation of the underlying upconversion mechanisms.

References:

[1] T. Förster, J. Reifenberger, T. Moumin, J. Helmbold, Ž. Antić, M.D. Dramićanin, M. Suta, Chem Sci (2025).

[2] Y. Du, Z. Jin, Z. Li, T. Sun, H. Meng, X. Jiang, Y. Wang, D. Peng, J. Li, A. Wang, H. Zou, F. Rao, F. Wang, X. Chen, Adv Opt Mater 12 (2024).

[3] E.L. Cates, F. Li, RSC Adv 6 (2016) 22791–22796.

[4] P. Zdeb, N. Rebrova, P.J. Dereń, J Phys Chem Lett 15 (2024) 9356–9360.

***Acknowledgments**. This work was supported by the NCN by grant no. 2021/41/B/ST5/03792, for which we are very grateful.*

O-19

Comparison of structural, luminescent and scintillation properties of $Gd_3Al_xGa_{5-x}O_{12}$:Ce, x=2.3-3 single crystals and single-crystalline films

Y. Syrotych[1], V. Gorbenko[1], S. Witkiewich-Lukaszek[1], T. Zorenko[1], R. Kucerkova[2], J.A. Mares[2], M. Nikl[2], O. Sidletskiy[3], K. Kamada[4], A. Yoshikawa[4], Yu. Zorenko[1]

[1]*Department of Physics Kazimierz Wielki University in Bydgoszcz, 85-090 Bydgoszcz, Poland*
[2]*Institute of Physics, Czech Academy of Sciences, 16200 Prague, Czech Republic*
[3]*Institute for Scintillation Materials, NAS of Ukraine, 61001 Kharkiv, Ukraine*
[4]*Institute for Materials Research, Tohoku University, 980-8577 Sendai, Japan*
* corresponding author: syr@ukw.edu.pl

Keywords: Liquid phase epitaxy, garnets, single crystals, single crystalline films, synchrotron radiation

Scintillating materials, when combined with photodetectors, are widely used to detect high-energy photons and particles in various applications, such as X-ray computed tomography, positron emission tomography, and other medical imaging techniques, as well as in high-energy and nuclear physics detectors. Among these materials, those with a garnet structure are considered promising candidates for scintillator applications. This is due to their well-established fabrication technology, originally developed for laser hosts and other optical use, combined with their excellent optical transparency and ability to be easily doped with rare-earth elements.

One such promising scintillator material is the Ce-doped $Gd_3Al_xGa_{5-x}O_{12}$; x=2.3-3 (GAGG:Ce) produced both in the single crystalline films (SCF) and single crystals (SC) forms (Fig.1a). GAGG:Ce offers several advantageous properties, including relatively high density of 6.6 g/cm³, a fast scintillation response of 80–90 ns primarily due to the 5d-4f radiative transition of Ce^{3+} that provides emission in the 500–550 nm range, and a light yield of 50–60 photons/keV [1].

This work is part of our ongoing research into the development of advanced composite scintillators based on epitaxial structures of garnet compounds [2]. Specifically, this report provides an overview of the creation of new types of composite scintillators and presents the results of structural studies, as well as investigations of their optical and scintillation properties.

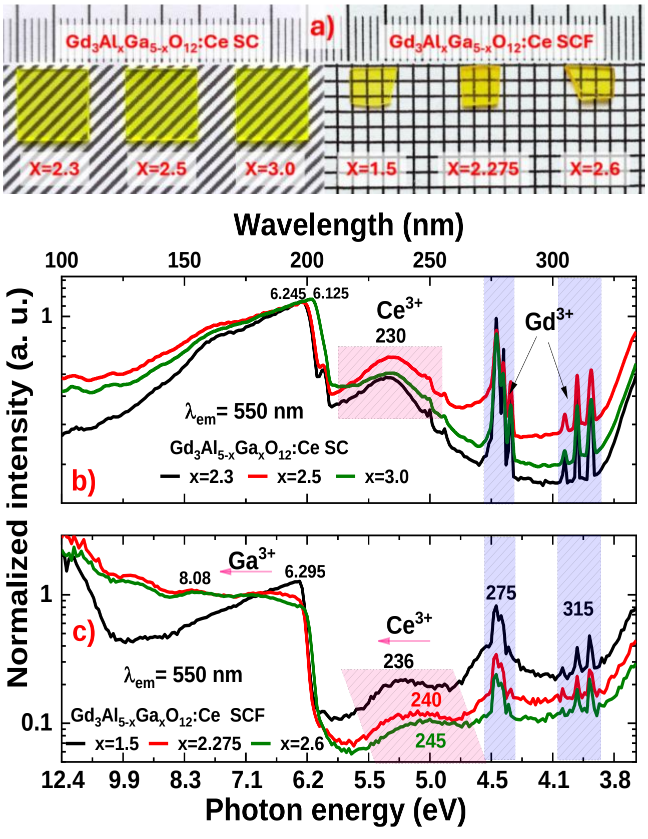


Fig. 1. The photo of GAGG:Ce SC and SCFs with different Ga/Al content (a) and LHe excitation spectra measured under excitation by synchrotron radiation (b – SC, c – SCFs)

A key aspect of this study was the examination of luminescence properties measured using synchrotron radiation at the Superlumi station at DESY, Hamburg (Fig. 1b, 1c). These unique and fundamental investigations aim to enhance our understanding of the electronic structure of SCF and SC samples, with substantial different concentration of antisite defects and oxygen vacancies due to their different growth conditions from the low temperature melt-solution and high-temperature melt.

[1] K. Kamada, at all, *J. Cryst. Growth* **352** (2012) 88–90.

[2] S. Witkiewicz-Lukaszek, at all. *Materials* **15(3)** (2022) 1249.

Acknowledgments: The work was performed in the frameworks of Polish NCN No 2022/47/I/ST8/02600 project.

WAR-DERIVED CARBON CONTAINING SMOKE NANOPARTICLES WITH HEAVY METALS: PHYSICOCHEMICAL PROPERY AND TOXICITY

G. Dovbeshko[1,2], T. Borisova[2,3] , O.Bezkrovnyi[2], O.Gnatyuk[1,2], A. Tolochko[1], V. Boiko[1,2], W.Strek[2]

[1]*Institute of Physics, National Academy of Sciences of Ukraine, 46 Nauky Ave, Kyiv, 03680, Ukraine*

[2]*Institute for Low Temperatures and Structure Research, Polish Academy of Sciences, P.O. Box 1410, 50-950 Wroclaw, Poland*

[3]*O.V.Palladin Institute of Biochemistry, National Academy of Sciences of Ukraine, Kyiv, 01054, Ukraine*

* corresponding author: matinelli@gmail.com

Keywords: smoke, carbon nanoparticles, Cu2+, Fe3+, Fe2+, toxicity

Currently, Ukraine is experiencing large-scale artillery, missile and drone strikes, which are generating large amounts of particulate matter (PM) pollution, including heavy metals and organic residues. This is why modeling and collecting these particles is important for understanding how they affect human health. These particles are carried by wind and water and pose a threat not only to the population of Ukraine but also to Europe as a whole.

A method for creating model carbon nanoparticles from various woods and plastics with the addition of metal ions was developed at the Palladin Institute of Biochemistry NAS of Ukraine and used to determine their effects on living organisms. Previously, we investigated model carbon nanoparticles with copper ions [1], here we present data on the study of the physicochemical and biochemical properties of PM with iron ions of different valence (3+ and 2+).

Optical and luminescent spectroscopy, dynamic light scattering, elemental analysis and TEM microscopy were applied. Experiments have shown that the particles formed by burning wood and/or plastics and then adding metal ions are a carbon core modified with various functional groups and metals. Molecular groups belonging to hazardous aromatic compounds have been identified. Correlation analysis of physicochemical properties and biochemical indicators showed the potential toxicity of the studied particles for the human body everywhere where these particles will be localized.

[1] N. Krisanova, N. Pozdnyakova, A. Pastukhov, M. Dudarenko, A. Tarasenko, A.Borysov, M. Driuk, A. Tolochko , O.Bezkrovnyi, K. Paliienko, R. Sivko, O. Gnatyuk, G. Dovbeshko, T.Borisova, *Food and Chemical toxicity* **193** (2024)115009.

Acknowledgments: This work was supported by the Polish Academy of Sciences in collaboration with U.S. National Academy of Sciences within the "Long-term program to support Ukrainian research teams", Project "War_derived air pollution nanohybrids composed of carbon-containing smoke nanoparticles and metal compounds: FTIR/Raman spectroscopic, fluorescent and membrane-active properties, their potential neurotoxicity and its prevention". Project PAN.BFB.S. BWZ.380.022.2023

O-21

Innovative Pr^{3+}-Activated $RbCaF_3$ Phosphor for Efficient UVC Emission via Visible and X-ray Excitation

N. Rebrova[1*], **A. Pushak**[2], **A. Grippa**[3], **V. Boiko**[1], **P. Zdeb-Stańczykowska**[1],
A. Voloshinovskii[2], **P.J. Dereń**[1]

[1] *Institute of Low Temperature and Structure Research, Polish Academy of Science, ul. Okólna 2, 50-422 Wrocław, Poland*

[2] *Ivan Franko National University of Lviv, 8 Kyryla i Mefodiya St, 79005, Lviv, Ukraine.*
[3] *Institute for Scintillation Materials, National Academy of Sciences of Ukraine, Nauky Avenue, 60, 61001, Kharkiv, Ukraine.*

* corresponding author: *n.rebrova@intibs.pl*

Keywords: Perovskite, Praseodymium, X-ray luminescence, Up-conversion

In recent years, increasing attention has been devoted to the development of novel luminophores capable of converting X-ray radiation and visible light (via anti-Stokes emission) into ultraviolet-C (UVC) radiation. This interest stems from the fact that UVC light exhibits a strong cytotoxic effect on deoxyribonucleic acid (DNA) and ribonucleic acid (RNA), ultimately leading to the apoptosis of microorganisms [1]. As a result, these new luminophores hold significant potential for applications in disinfection, sterilization, and even cancer phototherapy.

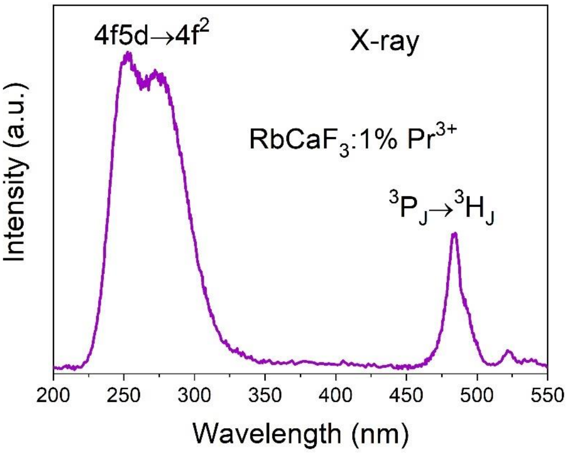


Fig. 1. X-ray excited luminescence of $RbCaF_3$:1%Pr^{3+}.

In this work, we developed a novel Pr^{3+}-doped $RbCaF_3$ phosphor exhibiting intense luminescence in the 220–340 nm range under X-ray and 444 nm excitation. The dependence of upconverted luminescence on the pump power and the concentration of Pr^{3+} ions will be discussed, and the mechanism responsible for upconversion will be established. In addition, the potential application of the obtained fluoroperovskite as an innovative ultraviolet phosphor will be discussed.

[1] T. Minamikawa, *Sci. Rep.* **11** (2021) 5070.

Acknowledgments This work was supported by grant no. 2021/41/B/ST5/03792, for which we are very grateful. One of the authors, A. Grippa (Oleksandr Gryppa), thanks the Polish Academy of Sciences for their support through the PAN-NANU (PAS-NASU) program for scientists cooperating with INTiBS PAN.

O-22

EXPLORING ULTRAFAST DYNAMICS IN HYBRID COLLOIDAL NANOSYSTEMS USING FS TRANSIENT ABSORPTION

Marta Gordel-Wójcik*[1,2,5], **Muhammed A. Thottappali**[2], **Marek Pietrzak**[3], **Elizaveta F. Petrusevich**[4], **Jiří Vohlídal**[5], **Jiří Pfleger**[2], **Beata Jędrzejewska**[3]

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

[2]*Department of Polymers for Electronics and Photonics, Institute of Macro-molecular Chemistry Czech Academy of Sciences Heyrovského nám. 2, 16206 Prague 6, Czech Republic*

[3]*Faculty of Chemical Technology and Engineering, Bydgoszcz University of Science and Technology, Seminaryjna 3, 85-326 Bydgoszcz, Poland*

[4]*Faculty of Chemistry, Wrocław University of Science and Technology, Wyb. Wyspiańskiego 27, PL-50370 Wrocław, Poland*

[5]*Department of Physical and Macromolecular Chemistry, Faculty of Science, Charles University, Prague, Czech Republic*

* corresponding author: *marta.gordel-wojcik@uwr.edu.pl*

Keywords: fs pump-probe, gold nanoshells, trimethoxysilylated azachalcones, hybrid nanomaterials

In this work, we present a novel synthetic route for the preparation of trimethoxysilylated azachalcones, donor-acceptor chromophores characterized by strong intramolecular charge-transfer behavior. Their distinctive optoelectronic properties, confirmed through extensive spectroscopic analysis and theoretical modeling, highlight their potential for advanced functional applications. To exploit and amplify their photophysical capabilities, the chromophores were covalently attached to plasmonic gold nanoshells (NSs), forming hybrid nanostructures designed to benefit from plasmon-molecule interactions. Femtosecond transient absorption spectroscopy revealed pronounced differences in the excited-state dynamics between the free chromophores and their hybrid counterparts. Upon integration with the NSs, all three excited-state lifetime components were significantly prolonged, from 700 fs, 1.93 ps, and 5.64 ps in the free state to 3.7 ps, 430.5 ps, and 15 ns, respectively.

This substantial lifetime extension is attributed to localized surface plasmon resonance (LSPR), which enhances the local electromagnetic field, facilitates hot-electron injection into the molecular LUMO, and suppresses non-radiative decay via restricted conformational motion and efficient electronic coupling at the metal-organic interface.

These findings emphasize the potential of plasmon-enhanced hybrid materials in applications requiring precise control over excited-state behavior. Prospective fields include photonic devices, optical sensing, and light-responsive biomedical technologies such as photodynamic therapy and high-resolution bioimaging, where extended excited-state lifetimes can directly improve performance and sensitivity.

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

MULTIMODAL TEMPERATURE SENSING IN HYBRID PEROVSKITES DOPED WITH Cr^{3+}

A. Kabański[1*], **K. Caputa**[1], **D. Stefańska**[1]

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

* corresponding author: *a.kabanski@intibs.pl*

Keywords: luminescent thermometry, chromium(III), optical sensors, hybrid perovskites

Optical thermometry has attracted growing interest due to its unique advantages, including high sensitivity, fast response time, and the capability for remote sensing. Optical thermometry is based on the temperature dependence of luminescent properties. To construct a thermometric model, it is possible to use the emission band position, luminescence lifetimes, or the intensity ratio of two spectral regions that differ in their temperature dependence.

Among various materials, metal-organic frameworks (MOFs) incorporating Cr^{3+} ions have emerged as promising candidates for the development of a new class of optical sensors designed for low-temperature environments. Hybrid compounds containing Cr^{3+} ions exhibit a significant influence of chemical composition and chromium(III) concentration on their luminescent properties. This is primarily due to the effect on the crystal field strength, which determines the dominant type of transitions in chromium(III) ions: narrow $^2E_g \rightarrow {}^4A_{2g}$ or broad $^4T_{2g} \rightarrow {}^4A_{2g}$. The analyzed hybrid compounds with the formula $[EA]Mn_{1-x}Cr_x(HCOO)_3$, where $x = 0$, 0.01, 0.03, and 0.05, show emission bands that can be effectively used to construct a thermometric model. The ratiometric method, based on the analysis of the intensity ratio of two temperature-dependent emission bands, is one of the most promising approaches. The selection of appropriate spectral regions is a crucial aspect in the design of optical sensors, and by adjusting the analyzed intervals, it is possible to develop an optimal model describing the temperature influence on emission intensity. Moreover, the investigated compounds show a temperature dependence of luminescence lifetimes, which can be successfully employed as a second thermometric parameter.

In this presentation, the comparison between various techniques for developing thermometric models, specifically focusing on the ratiometric method and lifetime analysis, will be presented. Additionally, the application of the lifetime-based thermometric approach in hybrid organic-inorganic perovskites doped with Cr^{3+} ions will be discussed.

[1] C. D. S. Brites, P. P. Lima, N. J. O. Silva, A. Millán, V. S. Amaral, F. Palacio and L. D. Carlos, Nanoscale, **4** (2012), 4799.

[2] A. Kabański, M. Ptak and D. Stefańska, ACS Appl Mater Interfaces **15** (2023) 7074–7082.

[3] D. Stefańska, A. Kabański, T. H. Q. Vu, M. Adaszyński, M. Ptak, Sensors **23** (2023) 6259

Acknowledgments: This research was supported by the National Science Centre (Narodowe Centrum Nauki) in Poland under the project SONATA 16 no. 2020/39/D/ST5/01289

O-24

OPTICAL COOLING IN CaF_2 MICROCRYSTALS DOPED WITH Yb^{3+} IONS

M. Dudek[1]*, P. Kuich[1], P. Karpiński[1]

[1]*Faculty of Chemistry, Wroclaw University of Science and Technology,*
Wybrzeze Wyspianskiego 27, 50-370 Wroclaw, Poland

* Corresponding author: *magdalena.dudek@pwr.edu.pl*

Keywords: optical cooling, lanthanide ions, optical spectroscopy

Temperature is a fundamental parameter influencing phenomena across physics, chemistry, and biology – from chemical reaction kinetics and phase transitions to metabolic processes. While heating can be readily achieved, even at the microscale, efficient cooling of microscopic systems remains a significant challenge. One promising approach to microscale cooling is laser refrigeration, which exploits anti-Stokes luminescence. In this process, a material absorbs lower-energy (longer-wavelength) photons and emits higher-energy (shorter-wavelength) photons, effectively extracting thermal energy in the form of phonons and resulting in a net cooling effect (Fig. 1a)) [1][2]. This mechanism is particularly efficient in materials doped with Yb^{3+} ions.

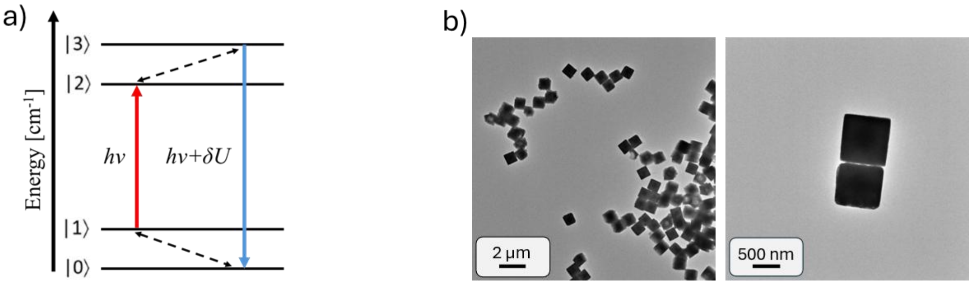


Fig. 1. a) Simplified four energy level model presenting optical cooling scheme. b) Transmission electron microscopy (TEM) images of CaF_2 crystals (12h, pH=4, pluronic F127).

In this study, we investigate CaF_2 as a potential host crystal for Yb^{3+} due to its high optical transparency. However, its relatively high phonon energy may limit cooling efficiency. CaF_2:Yb^{3+} microcrystals were synthesized via a hydrothermal method, employing both conventional oven and microwave rector. We systematically examined the influence of synthesis parameters – including reaction time, pH, and surfactant type – on the morphology and size of the resulting microcrystals. Crystallographic purity was verified using X-ray powder diffraction (XRD), while optical and transmission electron microscopy (TEM) were employed to characterize particles morphology (see Fig. 1b)). Optical cooling performance was evaluated using Raman spectroscopy. Specifically, temperature changes in the microcrystals were inferred from variations in the Stokes to anti-Stokes intensity ratio and from Raman mode softening. These measurements provide insight into the cooling dynamics and the potential of CaF_2:Yb^{3+} as a viable system for solid-state laser refrigeration.

[1] T. Kushida, J. E. Geusic, Phys Rev Lett **21** (1968)

[2] D.V. Seletskiy, R. Epstein, M. Sheik-Bahae, Rep. Prog. Phys. **79** (2016)

This work was financially supported by the National Science Center, Poland, 2020/39/I/ST3/01827.

O-25

BROAD BAND EMISSION MODELING WITH AUTOMATED CONSTRUCTION OF CONFIGURATIONAL DIAGRAM

A. Shyichuk[1,*], **E. Zych**[1]

[1]*University of Wroclaw, Faculty of Chemistry, 14 F. Joliot-Curie, 50-506 Wroclaw, Poland*

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

Keywords: photoluminescence, broad band, decomposition, configurational diagram

We propose a novel approach to broad emission band modeling. The ground state and the excited state of the emitter are represented as two continuous parabolic manifolds, where energy is proportional to the square of a certain geometrical coordinate ($E = kx^2$). The emitting level population is described by Boltzmann distribution, with absolute temperature as a parameter. Depending on the offset between the two parabolas and their curvatures (force constants) both symmetric and asymmetric Gaussian-like band shapes can be produced. Also proposed is a simple algebra that maps the input energy axis values of the experimental spectrum to the values of the geometrical (configurational) coordinate. The resulting band shape can be compared to the experimental one via least-squares fitting of the model parameters. Its usefulness in spectrum decomposition (deconvolution) is demonstrated using a few examples (doped inorganic phosphors; d-d, f-d and charge transfer transitions). Presence of absolute temperature in the definition of the model provides a potential for its use in primary luminescence thermometry.

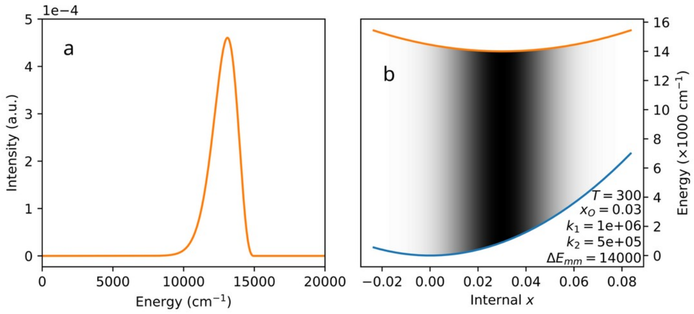


Figure 1: Fig. 1. An example asymmetric emission band (a) produced by two parabolas (b).

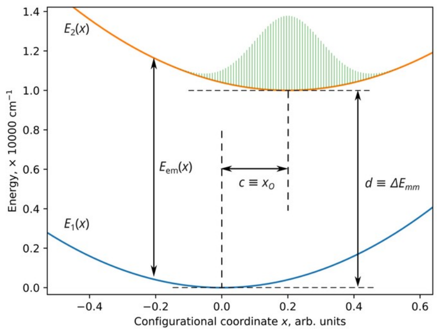


Figure 2: Parameters of the two parabolas

[1] A. Shyichuk, E. Zych, *RSC Advances* **15** (2025) 17405.

Acknowledgments: University of Wrocław, BPIDUB.21.2024.

O-26

Influence of manganese ions on Eu^{3+} emission in Eu^{3+}, Mn^{n+}:YVO_4 nanophosphor

<u>A. Watras</u>[1]*, P. Boutinaud[2] and R. J. Wiglusz[1,3]

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

[2] *Université Clermont Auvergne, Clermont Auvergne INP, Institut de Chimie de Clermont-Ferrand, Clermont-Ferrand, F-63000, France*

[3] *Meinig School of Biomedical Engineering, College of Engineering, Cornell University, Ithaca, New York 14853-1801, United States*

* corresponding author: *a.watras@intibs.pl*

Keywords: IVCT, MMCT, orthovanadate, luminescence, Eu^{3+} ions, manganese ions

Yttrium orthovanadates (YVO_4) are well-known and widely studied materials due to their ease of preparation and great optical properties when doped with rare earth and transition metal ions. However, no work has been done on YVO_4 doped with manganese ions.

In this study, we present a series of xEu^{3+}, yMn^{n+}:YVO_4 (x, y = 0, 1, 3, 5 $_{mol}$%) nanosized phosphors prepared by the co-precipitation synthesis. All materials were characterized to reveal their structural and spectroscopic properties. This study focuses on how manganese ions are built into the structure and their oxidation state.

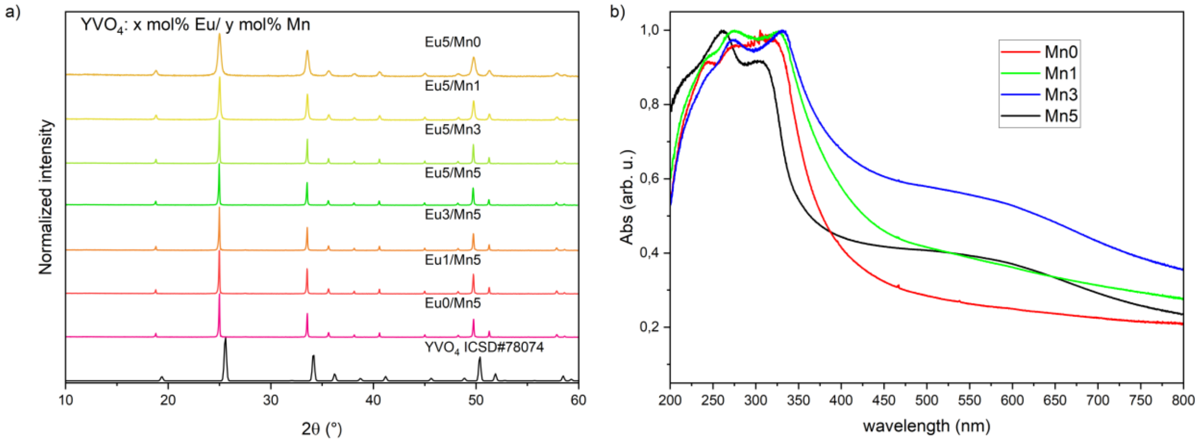


Figure 1. XRD diagrams (a) and absorption spectra (b) of Eu^{3+}, Mn^{n+}:YVO_4 nanophosphors.

In Figure 1, all prepared samples are phase-pure, which demonstrates that manganese ions are built into the YVO4 structure. Absorption spectra revealed a broad band around 550 nm for samples co-doped with manganese ions, suggesting that there are Mn^{2+} ions. More detailed studies will be presented during the conference.

O-27

SCINTILLATION PROPERTIES OF DMAC-TRZ DERIVATIVE CRYSTALS

W. Drozdowski[1,*], **K.J. Drozdowski**[1], **M.S. Eid**[1], **K. Wiśniewski**[1], **M.E. Witkowski**[1], **M. Mońka**[2], **I.E. Serdiuk**[2]

[1]*Institute of Physics, Faculty of Physics, Astronomy and Informatics,*
Nicolaus Copernicus University in Toruń, ul. Grudziądzka 5, 87-100 Toruń, Poland
[2]*Faculty of Mathematics, Physics and Informatics, University of Gdańsk,*
ul. Wita Stwosza 57, 80-308 Gdańsk, Poland

* corresponding author: *wind@fizyka.umk.pl*

Keywords: organic scintillator, light yield, time profile, radioluminescence, thermoluminescence

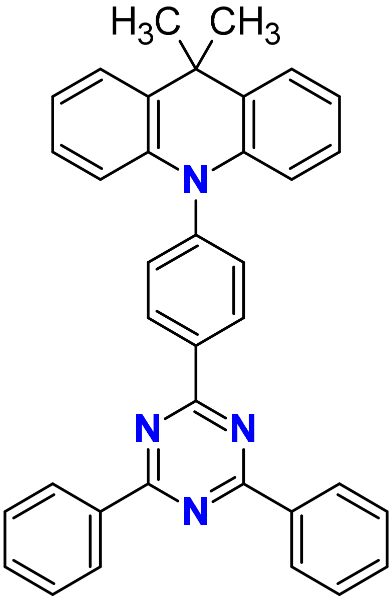


Fig. 1. Chemical structure of DMAC-TRZ.

In view of the growing interest in fully organic materials for scintillation applications [1-3], we have designed a derivative of the thermally activated delayed fluorescence (TADF) emitter [1], i.e. DMAC-TRZ with an enhanced rate of the T_1-S_1 transition. In a single-crystal state, this novel compound, featuring chlorine with a moderate heavy-atom effect [4], shows a significant reduction of the delayed fluorescence lifetime while maintaining the photoluminescence quantum yield up to 100%. In this Communication we present our preliminary assessment of the scintillation properties of these DMAC-TRZ derivative crystals. The pulse height measurement has allowed for a rough estimation of the scintillation light yield, while the recorded scintillation time profile has revealed a double-exponential decay with a mean decay time on the order of a single microsecond. Emission spectra under X-ray excitation have also been studied as a function of temperature in the range of 10-350 K, showing an almost monotonic increase in luminescence intensity with temperature. Additionally, the low-temperature thermoluminescence glow curve has indicated a negligible contribution from charge trapping processes. Undoubtedly the DMAC-TRZ derivative crystal still requires a further optimization, and there is clearly room for improvement. Nevertheless, the above observations make it a promising scintillator material for applications where timing performance is not of primary importance.

[1] W. Ma et al., *Nat. Mater.* **21** (2022) 210.

[2] F. Maddalena et al., *Cryst.* **9** (2019) 88.

[3] M. Zhao et al., *J. Mater. Chem.* **C13** (2025) 5424.

[4] Patent application no. P.448129 submitted to the Polish Patent Office on 28.03.2024.

Circularly Polarized Luminesce from pure and Eu-doped trigonal $TbPO_4 \cdot nH_2O$ nanocrystals coated with dicarboxylic acid

L. Ceccon[1], L. Di Bari[2], S. Ruggieri[1], M. Bettinelli[1], F. Piccinelli[1*]
[1]Luminescent Materials Laboratory, DB, Università di Verona, and INSTM, UdR Verona, Strada Le Grazie 15, 37134 Verona, Italy
[2] Dipartimento di Chimica e Chimica Industriale (University of Pisa), via Moruzzi 13, 56124, Pisa, Italy.
*e-mail: fabio.piccinelli@univr.it

In this work, a series of trigonal $TbPO_4$ nanocrystals (NCs) doped with Eu^{3+} ions ($TbPO_4 \cdot 0.67H_2O$:x%Eu^{3+}; x = 0, 0.5, 10, 100) have been synthesized by precipitation reaction in the presence of Tartaric Acid (L or D), which directs the formation of NCs with well-defined handedness ($P3_121$ or $P3_221$).[1] A structural (via powder X-ray diffraction) and spectroscopic characterizations has been performed, focusing on the $Tb^{3+} \rightarrow Eu^{3+}$ energy transfer process. The specific crystal handedness yields distinctive circularly polarized luminescence (CPL) signals in both green and red spectral regions.

To further enhance the luminescence intensities, the nanocrystals were functionalized via surface coating with aromatic dicarboxylic acids such as dipicolinic acid (DPA)(Fig 1) and phthalic acid.

These ligands act as organic antennae, efficiently sensitizing the lanthanide ions by absorbing UV light and transferring energy non-radiatively to the Tb^{3+} or Eu^{3+} centers, thus amplifying their characteristic emissions.

This array of diverse luminescent characteristics forming a unique fingerprint signal alongside the reduced synthetic costs and the superior photo- and chemical stability typical of inorganic materials compared to counterparts presented in literature, makes the investigated orthophosphate compounds promising candidates for the design of a new generation of chiroptical materials for anticounterfeiting applications.[2]

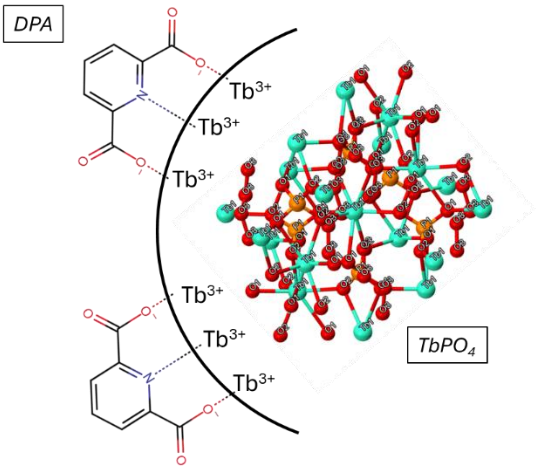


Fig. 1: $TbPO_4 \cdot 0.67H_2O$ coated with dipicolinic acid (DPA).

Acknowledgement: *Authors from the University of Verona gratefully thank the Facility "Centro Piattaforme Tecnologiche" (CPT) to access the equipments for diffraction and fluorometry*

References

[1] L. Ceccon, E. Cavalli, S. Ruggieri, M. Bettinelli, F. Piccinelli *Inorg. Chem. 2024, 63, 29, 13636–13643* DOI: https://doi.org/10.1021/acs.inorgchem.4c01869
[2] K. Valentín, P. Wild, S. Štolc, F. Daubner, M. Clabian, *ProcSPIE,* 9995 (2016) 999503. DOI: https://doi.org/10.1117/12.2241169

O-29

Dimensionality reduction algorithms as a pathway to enhance the performance of single-center Eu^{III} luminescent thermometer

L. F Saraiva*[1], A. L. Costa[1], A. G. Bispo Jr.[2], F. A. Sigoli[3], S. A. M. Lima[1], A. M. Pires*[1]

[1]São Paulo State University, Presidente Prudente, 19060-560, Brazil
[2] University of São Paulo, São Paulo, 05508-900, Brazil.
[2]University of Campinas, Campinas, 13083-970, Brazil.

* corresponding author: *leonardo.f.saraiva@unesp.br*, *ana.maria@unesp.br*

Keywords: Rare-Earths, Luminescence thermometry, Data analysis, Probes

Temperature – the foremost thermodynamic state variable – must be measured with uncompromising precision, particularly in state-of-the-art technologies that underpin the high-performance computing and communication capabilities of interconnected devices[1]. In such settings, contact-based temperature readings are inadequate: the accuracy of a physical probe is intrinsically constrained by its own dimensions[1]. This limitation has fueled studies to devise remote thermometric strategies, within which luminescent thermometers (LThs) have become the benchmark for sub-micron temperature sensing by deriving temperature-induced changes in the spectroscopic properties of probes. Although substantial effort has been invested in engineering new luminescent materials to enhance the performance of LThs, less attention has been devoted to refining the data-processing protocol that underpins thermal readouts from classical essays – an oversight capable of hampering the full potential of LThs[2]. This shortfall motivated the present investigation, which pairs data analysis algorithms with multiple thermometric parameters, thereby offering a forward-looking framework for post-processing data analysis methodologies for LThs. Precisely, both linear and nonlinear dimensionality reduction (DR) techniques – multiple linear regression (MLR), non-negative matrix factorization (NMF), and kernel principal component analysis (k-PCA) were employed on a proof-of-concept SrY_2O_4:Tb$^{III/IV}$(2 at.%),Eu^{III}(5 at.%) phosphor synthesized by an adapted Pechini route. The algorithms were fed a joined thermometric parameter that integrates (*i*) the intensity ratio between the thermally coupled Eu^{III} $^5D_{0,1}$ (Δ) levels and (*ii*) the $^5D_0$ lifetime (τ). Compared to conventional single-parameter fitting and integration methods, the DR approaches produced a marked enhancement in performance: the relative sensitivity (S_r) climbed from 0.897% K^{-1} and 0.402% K^{-1} (using single parametric Δ and τ, respectively) to 1.82% K^{-1} with MLR, 2.08% K^{-1} with NMF, and 3.68% K^{-1} using k-PCA. Simultaneously, the associated temperature uncertainty fell below 0.1 K across the 77 – 500 K operational range, affording sub-decikelvin thermal resolution. Overall, these findings demonstrate that advanced DR algorithms can extract synergistic information from multiple thermal readouts, substantially extending the reach of LThs. The data-centric methodology, introduced here, thus paves the way for expanding the frontiers of the field.

[1] M. Suta, A. Meijerink, *Adv. Theory Simul.* ***3***, 12 (2020) 2000176.

[2] L. F. Saraiva, A. G. Bispo-Jr., A. L. Costa, F. A. Sigoli, S. A. M. Lima, A. M. Pires, *Chem Mater*. **37 9** (2025) 3125 – 3136.

Acknowledgments: FAPESP (2023/05718-9), CNPq (309448/2021-2)

O-30

The feature of Cr^{4+} doped $Y_3Al_5O_{12}$ transparent ceramic spectroscopic properties

Mykhailo Chaika

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

*: *m.chaika@intibs.pl*

Keywords: YAG, Cr^{4+}, luminescence, lifetime

Over the last decades, Cr^{4+}:YAG has been widely used as a laser host material. The unique properties of this materials arise from the splitting of Cr^{4+} energy levels in the crystal field of distorted tetrahedron with D_{2d} symmetry. This crystal field splitting provides both advantages and disadvantages including the presence of multiple Cr^{4+} emission centers. These centers can reduce the laser performance of Cr^{4+} ions. The nature of these emission centers might be related to the orientation of Cr^{4+} along specific crystallographic axis, differences in charge compensation mechanisms, or possible misinterpretation of the crystal field splitting components of the Cr^{4+} ions. This work focuses on the spectroscopic properties of Cr^{4+}:YAG transparent ceramic. Absorption, excitation and emission spectra were measured over a temperature range from 5K to 300K. Low temperature absorption spectra reveal sharp and narrow lines corresponding to partially allowed transition from the ground state to the crystal field splitting components of $^4T_2$ energy level. The shape of the excitation spectra was found to be independent from the monitored emission wavelength, indicating that Cr^{4+} emission originates from the lowest excited state. Low temperature emission spectra exhibit sharp and narrow ZPL, accompanied by the vibronic sidebands extending up to ~2000 cm^{-1}. Both absorption and emission spectra of the lowest excited state at low temperature consists of a doublet, with a splitting of 28 cm^{-1}. The temperature dependence of the spectroscopic parameters of this doublet is reported. Based on the obtained results, possible explanations of its origin are proposed.

Temporal Control of Dynamic Upconversion Mediated by Energy Transfer

Long. Yan[1*]

[1] *School of Integrated Circuits, Chongqing University of Posts and Telecommunications,*
Chongqing, China

* corresponding author: Yanlong@*cqupt.edu.cn*

Keywords: upconversion, temporal, photochromic

Photon upconversion has garnered significant attention across multiple disciplines due to its characteristic anti-Stokes emissions, yet achieving both high-efficiency luminescence and dynamic color control remains challenging. This study demonstrates multidimensional regulation of upconversion through two innovative strategies. First, an activator-sensitizer alloyed nanoparticle design enables minimized Yb^{3+}-Er^{3+} separation for efficient energy transfer, yielding over two orders of magnitude enhancement in upconversion intensity and a 20-fold quantum yield improvement under weak excitation (0.26 W cm^{-2}). This system exhibits Yb^{3+}-content-dependent green-to-red emission gradation while enabling dynamic color switching through laser pulse-width modulation. Second, in core-shell nanostructures, the introduction of a Yb sublattice sensitization interlayer facilitates precise control of Er^{3+} upconversion dynamics via interfacial energy transfer (IET), achieving red/green switchable emissions through non-steady-state excitation and time-gating techniques.

These synergistic approaches reveal the critical role of temporal control in multiphoton upconversion processes: short pulses preferentially activate green emission, while long pulses/continuous-wave excitation enhance red output through either Er^{3+} three-photon processes or cross-relaxation pathways. The study establishes universal design principles for dynamic color modulation, with promising applications in near-infrared photodetection, optical anti-counterfeiting, and velocity sensing technologies..

[1] Long Yan; Jinshu Huang; Zhengce An; Qinyuan Zhang; Bo Zhou*; Spatiotemporal control of photochromic upconversion through interfacial energy transfer. Nature Communications, 2024, 15(1):1923.

[2] Long Yan; Lili Tao*; Qizheng Zhang; Haozhang Huang; Qinyuan Zhang; Bo Zhou*; Amplifying photon upconversion in alloyed nanoparticles toward near-infrared photodetector. Nano Letters, 2024, 24(15):4580-4587.

Acknowledgments: This work was supported by the National Natural Science Foundation of China (Grant Nos 52272151 and 51972119), the Fundamental Research Funds for the Central Universities (2022ZYGXZR015 and 2023ZYGXZR053).

NEAR INFRARED SCINTILLATORS BASED ON RARE-EARTH DOPED CsI SINGLE CRYSTALS

V. Pankratov[1*], R. Shendrik[2], V. Pankratova[1], D. Sofich[2]

[1]*Institute of Solid State Physics, University of Latvia, Riga, LV-1063, Latvia*
[2]*Vinjgradov Institute of Geochemistry, Irkutsk, Russia*

* corresponding author: *vladimirs.pankratovs@cfi.lu.lv*

Keywords: cesium iodide; scintillator; europium; ytterbium; samarium;

Red-emitting scintillators represent a crucial class of materials capable of converting ionizing radiation energy into red and near-infrared luminescence. These materials are of significant interest for radiation monitoring, medical imaging, and high-energy physics, as their spectral characteristics closely match the sensitivity range of semiconductor photodetectors. Ultra-compact yet highly sensitive scintillator-photodetector assemblies could be particularly valuable for real-time dosimetry monitoring during radiation therapy.

Traditional scintillator materials often rely on trivalent rare-earth ions as activators; however, divalent samarium (Sm^{2+}) has emerged as a promising alternative for NIR emission. Sm^{2+} exhibits characteristic 5d→4f transitions that result in strong emission in the red and NIR regions, making it suitable for applications requiring efficient light conversion at these wavelengths. Also, divalent samarium exhibits low self-absorption, which contributes to high light yield even at high activator concentrations. However, the practical application of Sm^{2+}-activated scintillators can be limited by the need for efficient energy transfer mechanisms. To address these limitation, a sensitization strategy involving co-doping with other rare-earth ions such as ytterbium (Yb^{2+}) or europium (Eu^{2+}) is proposed. Yb^{2+} and Eu^{2+} can act as efficient sensitizers, absorbing energy from the host lattice and transferring it to Sm^{2+} via energy transfer processes, thereby enhancing the overall scintillation efficiency.

In current research we focus on the development and characterization of novel scintillator materials based on CsI crystals activated with divalent samarium (Sm^{2+}) and sensitized with ytterbium (Yb^{2+}) or europium (Eu^{2+}). We explore the luminescence and scintillation properties of these materials under visible, near ultraviolet, synchrotron and X-ray excitation.

Our results demonstrate that divalent europium and ytterbium ions serve as efficient sensitizers for samarium ions (Sm^{2+}) in CsI crystals, where Sm^{2+} exhibits a broad 5d-4f emission band in the red and near-infrared spectral region. The light yield of the obtained crystals under X-ray excitation was evaluated to be approximately 37,000 photons/MeV for CsI:Yb,Sm and 40,000 photons/MeV for CsI:Eu,Sm. Further optimization of crystal growth techniques could significantly enhance the light output, potentially leading to the development of cost-effective infrared scintillators. These findings open new possibilities for creating efficient scintillation materials with emission in the near-infrared range.

Acknowledgments: V. Pankratov is grateful the LZP grant lzp-2023/1-0063. V. Pankratova acknowledges the LZP grant lzp-2022/1-0611. Authors are thankful to Kirill Chernenko for his assistance in beamtime experiments at MAX IV Laboratory (Lund, Sweden).

O-33

Photon Statistics as a Tool to (Dis)Prove Quantum Cutting in Near-Infrared Emitting Materials

V.R.M. Benning[1,2], **N. van de Mortel**[1], **M. Waakop Reijers**[1], **M. Mastwijk**[2], **S.J.W. Vonk**[1,3], **A. Meijerink, F.T. Rabouw**[1,2,*]

[1]*Soft Condensed Matter and Biophysics, Debye Institute for Nanomaterials Science, Utrecht University, Princetonplein 1, 3584 CC Utrecht, the Netherlands*

[2]*Condensed Matter and Interfaces, Debye Institute for Nanomaterials Science, Utrecht University, Princetonplein 1, 3584CC Utrecht, The Netherlands*

[3]*Optical Materials Engineering Laboratory, Department of Mechanical and Process Engineering, ETH Zurich, Leonhardstrasse 21, 8092 Zurich, Switzerland*

* corresponding author: *f.t.rabouw@uu.nl*

Keywords: cooperative energy transfer, photon statistics, rare earths, quantum cutting, photovoltaics

Solar spectrum conversion has the potential to enhance solar cell efficiencies, by shifting short-wavelength photons to longer wavelengths where the photovoltaic response is stronger. Realizing these benefits of spectral conversion requires the process of quantum cutting, where two longer-wavelength photons are emitted by a material following the absorption of one shorter-wavelength photon. This type of color conversion can approach 100% energy efficiency, thus using the high-energy part of the solar spectrum with maximum effectivity
Quantum cutting has been claimed for various materials over the past two decades, but follow-up research often disproved initial claims. Typical techniques used to prove quantum cutting are integrating-sphere quantum yield measurements, time-resolved emission or transient absorption spectroscopy. These techniques are complex and not always conclusive.
In this presentation, we show that the photon correlation analysis[1] is a universal strategy to unambiguously reveal quantum cutting. We have tested two materials, YPO_4 co-doped with Tb^{3+} and Yb^{3+} and YAG co-doped with Ce^{3+} and Yb^{3+}. Both are reported in the literature to perform quantum cutting via absorption of blue light followed by cooperative energy transfer to near-infrared-emitting Yb^{3+}.[2,3] We find that YPO_4:Tb^{3+}, Yb^{3+} shows bunched emission, characteristic of quantum cutting. In contrast, YAG:Ce^{3+}, Yb^{3+} shows regular Poissonian emission statistics. This reveals that YAG:Ce^{3+},Yb^{3+}, despite various claims,[3,4] is not a quantum-cutting material.

[1] M. de Jong, *Nat. Commun.* **8** (2017) 15537.
[2] P. Vergeer, *Phys. Rev. B* **71** (2005) 014119.
[3] T. Yuping, *RSC Adv.* **8** (2018) 23268-23273.
[4] H. Lin, *J. Appl. Phys.* **107** (2010) 043107.

O-34

Stepwise Photochromism Regulated by Multiple Color Centers in Inorganic Photochromic Materials

W. Hu[1], **D. Van der Heggen**[1], **F. He**[1], **D. Poelman**[1,*], **P. F. Smet**[1,*]

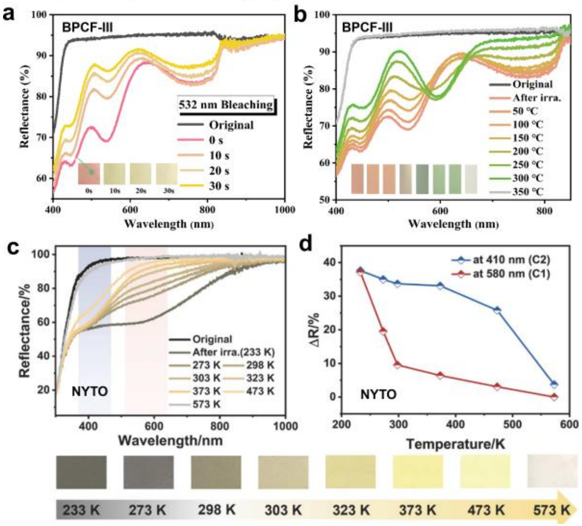
[1]*LumiLab, Department of Solid-State Science, Ghent University, 9000 Ghent, Belgium*

* Corresponding author: *Philippe.Smet@ugent.be*; *Dirk.Poelman@ugent.be*

Keywords: Photochromism, Multi color, Stepwise photochromism, Color center, Defect level

Photochromism typically refers to a reflectance or absorption change (body color change) under various radiations. With this merit, they have been used in direct indicator or dosimetry applications, such as radiation dosimeters. However, to date, the indicators developed from inorganic photochromic materials primarily rely on a single color change (colorimetry, either pale or deep) rather than showing a distinct color variation to various stimuli (color-change indication), which may cause some confusion to the naked eye, possibly requiring costly instruments for further check. The common strategy to facilitate multiple color responses is to mix several photochromic materials physically, but this also compromises the performance of each component. Therefore, there is a strong incentive to develop single-component multicolor photochromic materials that respond differently to multiple stimuli.

In our work, we developed a series of multicolor single-component photochromic materials featuring stimulus-specific responses to different wavelengths and thermal stimuli. By implementing a multi-step calcination and a dopant-defect matching strategy, we successfully introduced multiple defects into Ba$_5$(PO$_4$)$_3$Cl$_{0.8}$F$_{0.2}$:Eu, Ce (BPCF-III), and NaYTiO$_4$:Bi (NYTO)$^{1-2}$. Following UV charging, these multiple color centers exhibit varying bleaching behaviors in response to different stimuli, which subsequently trigger photochromic color switch (stepwise photochromism, See **Figure 1**). By delicately constructing multiple color centers and precisely redistributing electrons in traps, it is theoretically possible to achieve a full range of color switching for practical indicator applications.



This figure is reproduced from [1-2]

Figure 1. Reflectance of a) thermo- and b) optical bleaching of colored BPCF-III (Insets are the real images of sample). c) Reflectance of thermo-bleaching of colored NYTO. d) Evolution of the changes in two center absorptions with temperature.

[1] W. Hu, Z. Qiu, Y. Bao, *et al. ACS Energy Lett.*, 2024, 9, 2145-2152.

[2] Y. Bao, W. Hu, Y. Zhou, *et al. Sci. China Mater.*, 2025, 68, 1064-1073.

The author acknowledges the support of the CSC-BOF joint scholarship (01SC4224).

O-35

NANO-ENGINEERED PHOSPHORS FOR WHITE LEDS

V. Khanin[1,*], F. Montanarella[1], A. Sontakke[1], J. Mulder[1], J. Floreal[1], J. Kong[1], L. Rodriguez[1], Z. Gijsberg[1], D. Lenting[1], V. Favale[1], M. Tachikirt[1], M. Krames[1,2], M. van de Haar[1]

[1]Seaborough Materials Research BV, Amsterdam, 1098 XG, The Netherlands
[2]Arkesso LLC, Palo Alto, California 94306, United States

* corresponding author: *v.khanin@seaborough.com*

Keywords: nano-materials, nano YAG:Ce, interparticle energy transfer, white LEDs

Advancement in white-LED industry requires new phosphors that provide higher luminous efficacy and color quality. The main struggle remains with the development of materials converting the blue-LED emission into narrow-band red luminescence. We are working on engineering such a material with a novel approach of interparticle resonant energy transfer (IFRET) [1]. With this approach we decouple the requirements of having a strong absorber of blue light (YAG:Ce^{3+}) and a perfect red line-emitter in the red (Eu^{3+}-doped oxide) into separate nanoparticles. We then mix the nanomaterials on nano-scale to ensure the energy transfer between the Ce^{3+} and Eu^{3+} and to simultaneously avoid the harmful Ce^{3+}-Eu^{3+} metal-to-metal charge transfer (MMCT) quenching [2].

Here, we present an approach to achieving stable, well-defined sub-50 nm nano-YAG:Ce^{3+} with near-unity luminescence quantum efficiency. We give physical insight into the common issues of nanoscale YAG:Ce materials and provide strategies to overcome these. We attribute the improved performance of our YAG:Ce nanoparticles to lattice densification, improved dopant distribution and Ce^{3+}/Ce^{4+} fraction, which we control via post-treatments and annealing.

We also demonstrate sufficient sensitization of Eu^{3+} in various nanomaterials by nano-YAG:Ce^{3+} in different nano-engineered geometries, their bottlenecks and advantages. Furthermore, we explore the quality of the light (CRI, LER, CCT parameters) generated by the wLED prototypes based on these nano-phosphor mixes.

[1] M.A. van de Haar, et al. *The Journal of Physical Chemistry Letters* **11.3**, 689-695 (2020).

[2] G. Blasse. *Complex chemistry,* 153-187 (2005).

O-36

Fluoroperovskite solid solutions: A platform for the study of 5d → 4f luminescence

V. Vaněček[1,*], V. Babin[1], R. Kučerková[1], A. Kotlov[2], M. Yoshino[3], A. Yamaji[3], A. Yoshikawa[3,4,5]

[1]*FZU-Institute of Physics, Czech Academy of Sciences, Na Slovance 1999/2, 182 00 Prague 8, Czech Republic*

[2]*Deutsches Elektronen-Synchrotron DESY, Notkestr. 85, 22607 Hamburg, Germany*
[3] *NICHe, Tohoku University, 6-6-10 Aza-Aoba, Aoba-ku, Sendai, Miyagi, 980-8579 Japan*
[4] *IMR, Tohoku University, 2-1-1, Katahira, Aoba-ku, Sendai, Miyagi, 980-8577 Japan,*
[5] *C&A corporation, 6-6-40 Aza-Aoba, Aramaki, Aoba-ku, Sendai, Miyagi, 980-8579 Japan*

* corresponding author: *vanecekv@fzu.cz*

Keywords: fluoroperovskite, crystal field splitting, cerium, praseodymium

$RbCaF_3$ and $CsCaF_3$ belong to the fluoroperovskite family, exhibiting an undistorted perovskite structure (space group Pm-3m, No. 221). In our previous work [1], we demonstrated that these two compounds form a continuous solid solution series over the entire composition range. This enables precise tuning of the lattice parameter from 4.456 Å ($RbCaF_3$) to 4.525 Å ($CsCaF_3$), allowing controlled adjustments of bond lengths within the $(CaF_6)^{4-}$ octahedra without directly modifying the first coordination sphere of Ca^{2+}. In this structure, the monovalent alkali metal cations occupy 12-fold coordinated cuboctahedral sites, whereas Ca^{2+} resides in an 8-fold coordinated site. The Ca^{2+} site is sterically suitable for accommodating larger trivalent lanthanides such as Ce^{3+} and Pr^{3+}, given the similarity of ionic radii in 6-fold coordination (Ca^{2+}: 1.14 Å, Ce^{3+}: 1.15 Å, Pr^{3+}: 1.13 Å). Consequently, Ce^{3+} and Pr^{3+} ions are expected to preferentially occupy the Ca^{2+} sites over the large alkali metal site (2.02 Å for Cs^{+} in 12 coordination). Although substituting Ca^{2+} by Ln^{3+} is expected to cause deformation in the $(LnF_6)^{3-}$ octahedra, it is reasonable to assume that such deformation remains consistent throughout the $Cs_{1-x}Rb_xCaF_3$ series. We investigated how solid solution formation influences the 5d → 4f luminescence of Ce^{3+} and Pr^{3+} using both steady-state and time-resolved photoluminescence techniques. Variations in photoluminescence decay times with changing Rb content cannot be explained solely by shifts in emission energy arising from altered crystal field strength. Therefore, the influence of the local field on the transition probabilities, arising from changes in the refractive index due to Rb substitution, must be taken into account. Additionally, we examined the temperature dependence of both photoluminescence intensity and decay kinetics for Ce^{3+} and Pr^{3+} 5d → 4f emissions, revealing remarkable thermal stability.

[1] V. Vaněček, T. Horiai, M. Yoshino, A. Yamaji, A. Yoshikawa, M. Nikl, *Journal of Crystal Growth* **2025**, *649*, 127919.

Acknowledgments: The work is supported by Mobility Plus project no. JSPS-25-19 and OP JAC project LASCIMAT – CZ.02.01.01/00/23_020/0008525.

O-37

THE ROLE OF Eu^{2+} IN PHOSPHORS FOR WHITE AND NEAR-INFRARED LIGHT-EMITTING DIODE APPLICATIONS

D. Stefańska*, **M. Adaszyński, K. Adamczak, A. Kabański, D. Szymański**

Institute of Low Temperature and Structure Research PAS, Wroclaw, 50-422, Poland

* corresponding author: *d.stefanska@intibs.pl*

Keywords: aluminosilicates, Eu^{2+} ions , Cr^{3+} ions, energy transfer

Phosphor-converted light-emitting diodes (PC-LEDs) play a crucial role in modern solid-state lighting, display technologies, and near-infrared (NIR) LED systems. Key objectives in their development include achieving full-spectrum white light, a broad color gamut for displays, and efficient NIR emission. These functionalities are closely linked to the luminescent properties of the employed phosphors.

Europium(II), owing to its characteristic 5d-4f transition, is among the most extensively studied activators in PC-LED phosphors. Eu^{2+}-doped materials exhibit excellent optical properties, including multicolor emission, tunable emission bandwidths, high thermal stability, and notable quantum efficiency. These features drive ongoing research into novel Eu^{2+}-activated phosphors tailored for specific LED applications, such as white light generation, indoor agriculture, and luminescence thermometry.

Both lanthanide and transition metal ions, such as Eu^{2+} and Cr^{3+}, are fundamental for tuning phosphor performance. Their emission profiles are highly sensitive to the host crystal field, enabling spectral tuning through appropriate host selection. Notably, energy transfer between Eu^{2+} and Cr^{3+} is feasible due to the spectral overlap between Eu^{2+} emission and Cr^{3+} absorption, offering a pathway for visible-to-NIR conversion.

Here, the advantages of Eu^{2+} multisite emissions for white light generation and the mechanisms of Eu^{2+}–Cr^{3+} energy transfer facilitating NIR emission will be discussed. The development of UV-excited phosphors for plant-oriented solid-state lighting will also be addressed. The dual emission profile (broadband Eu^{2+} and narrow Cr^{3+}) closely overlaps with the absorption spectra of key plant photoreceptors, including chlorophylls, carotenoids and phytochromes, making this type of material ideal for enhancing photobiological responses in plants.

Acknowledgments: This work was funded by the National Centre for Research and Development in Poland under grant no. LIDER/19/0103/L-12/NCBR/2021.

O-38

THE LUMINESCENCE OF Gd^{3+} AND Ce^{3+} DOPED ZnO NANOPARTICLES

O. Chukova[1,*], K. Nii[2], H. Amano[2], Y. Ichiyanagi[2], L.G. Jacobsohn[3]

[1]Deutsches Elektronen-Synchrotron DESY, Notkestr. 85, 22607 Hamburg, Germany
[2]Yokohama National University, Yokohama, Kanagawa, Japan
[2]Dept.of Materials Science and Engineering, Clemson University, Clemson, SC 29634, USA

* corresponding author: oksana.chukova@desy.de

Keywords: ZnO, Gd^{3+}, Ce^{3+}, luminescence

Rare-earth (RE) doped ZnO luminescent nanoparticles are applied across a wide range of optoelectronic, sensing, and energy-related fields due to the unique combination of characteristic emission of the RE ions and the luminescence of the host. Given ZnO's relative biocompatibility - especially when coated or encapsulated - ZnO-based composites are also widely employed in biomedical applications. In order to expand the range of ZnO applications in the development of efficient optical and chemical sensors, it is essential to enable changes in the luminescence profile and intensity in response to environmental conditions, chemical surrounding and excitation energy. In this work, we investigate the feasibility of creating additional spectral responses from ZnO by doping it with RE ions whose typical emissions overlap the near-edge absorption of the ZnO matrix.

The synthesis of the Gd^{3+} and Ce^{3+} -doped ZnO nanoparticles was described in [1], with the dopant concentrations being varied from 1% to 10%. The luminescent properties were investigated using a wide range of the excitation wavelengths from visible light to UV, VUV and X-rays excitations. Emission spectra are composed of a wide band luminescence that appeared at distinct spectral regions depending on the dopant concentration and excitation used. Radioluminescence is composed by a wide band located at 630 and 680 nm for the Gd^{3+} and Ce^{3+} dopants, respectively. The same bands are observed in the photoluminescence spectra obtained with high energy excitation within the VUV and UV spectral ranges. However, as the excitation energy approached the ZnO absorption edge (~3.3 eV), additional bands were observed, out of which a main band located around 450 nm. Typical bands of the Ce^{3+} emission were also observed at selected excitations within the visible spectral range.

The assumption is made that the RE-doping can create in the ZnO crystal lattice certain defect-induced hole centers. The observed red emission band could be explained by recombination processes between the RE-induced hole centers and interstitial zinc defects. The obtained rich variations of emission spectra depending on excitation conditions could be used for the development of efficient optical sensors based on the RE-doped ZnO nanoparticles.

[1] H. Amano et al., *Phys. Chem. Chem. Phys.* **27** (2025) 10.1039/D5CP00124B

Acknowledgments: This project received funding through the MSCA4Ukraine project that is funded by the European Union (Project 101101923). The measurements carried out at DESY PETRA III P66 beamline were sponsored by the I-20231168 PETRA III Regular Proposal. Authors also acknowledge the Fulbright Visiting Scholar Program.

P-1

Luminescence lifetime thermometry based on thermally induced phase transition of Yb^{3+} doped $LiYO_2$

M. T. Abbas[1*], **M. Szymczak**[1], **V. Kinzhybalo**[1], **M. Drozd**[1], **L. Marciniak**[1]

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

* corresponding author: m.abbas@intibs.pl

Keywords: optical thermometry, phase transition, luminescence kinetics, luminescence intensity ratio

The luminescence thermometry has gained considerable research interest recently, owing to its unique characteristics such as remote measurements, fast response, high accuracy, and reliability. The many approaches have been developed to enhance the thermometric performance of the luminescence thermometer. Among them, the thermally induced phase transition-based luminescence thermometry has attracted notable attention due to its excellent thermometric performance. In this work, for the first time, a luminescence lifetime thermometer based on the thermally induced phase transition of $LiYO_2$: x%Yb^{3+} (x = 1, 2, 5, 10, 20) was investigated. The structural phase transition from low temperature to high temperature alters the point symmetry of the site occupied by the luminescent ion. The thermally induced increase in point symmetry from C_2 to D_{2d} decreases the probability of the radiative depopulation rate (W_R) of the emitting level, thereby increasing the luminescence decay profile. This shows a highly unusual thermal behavior, contrasting with the typical trend observed in most lifetime-based luminescence thermometers, where increasing temperature usually leads to a reduction of lifetime due to thermal depopulation of the excited state through multi-phonon relaxation or phonon-assisted energy transfer process. The thermal elongation in the luminescence decay profile was observed for all concentrations of Yb^{3+} ion. The maximum value of relative sensitivity for this approach was 0.5% K^{-1} observed for 5% Yb^{3+}. Furthermore, the luminescence intensity ratio based on the phase transition of $LiYO_2:Yb^{3+}$ was investigated. The maximum value S_R = 5.3% K^{-1} was obtained for $LiYO_2$:5%Yb^{3+} at 280 K for ratiometric approach.

[1] M. T. Abbas, M. Szymczak, V. Kinzhybalo, M. Drozd and L. Marciniak, *Laser Photonics Rev.*, **2025**, 19, 2401108.

[2] L. Marciniak, W. Piotrowski, M. Szalkowski, V. Kinzhybalo, M. Drozd, M. Dramicanin, A. Bednarkiewicz, *Chemical Engineering Journal* **2022**, 427, 131941.

[3] M. Back, J. Ueda, J. Xu, D. Murata, M. G. Brik, S. Tanabe, *ACS Appl Mater Interfaces* **2019**, 11, 38937.

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

$Ca_{19}Zn_2(PO_4)_{14}$:Mn^{2+},Ce^{3+}AS A SENSITIVE VISUAL LUMINESCENT THERMOMETER

Y. Abe[1], **M. Szymczak**[1], **L. Marcinik**[1*]

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

* corresponding author: *l.marciniak@intibs.pl*

Keywords: luminescence thermometry, lanthanide ions, transition metal ions, high sensitivity

Luminescence thermometry enables precise and remote temperature measurements by monitoring temperature-induced variations in the spectroscopic properties of phosphors. Among the various measurable parameters, the ratiometric approach, based on the relative emission intensities of two luminescence bands, is widely recognized for its reliability and robustness[1]. To achieve high relative sensitivity of sch thermometer, the selected emission bands must exhibit distinctly different thermal quenching behaviors.

Transition metal ions, such as Mn^{2+}, are particularly promising in this context due to their strong sensitivity to temperature changes, which directly affects their luminescence intensity. In contrast, lanthanide ions such as Ce^{3+} display much more thermally stable emission, making them ideal as internal luminescent references [2]. By combining these two classes of dopants, it is possible to construct a highly sensitive ratiometric luminescent thermometer.

In this study, a $Ca_{19}Zn_2(PO_4)_{14}$ co-doped system utilizing Mn^{2+} and Ce^{3+} ions was employed to develop an efficient ratiometric temperature sensor. Both dopants emit in the visible spectral range, allowing thermal variations to manifest as perceptible color changes in the emitted light. As such, the material serves not only as a precise thermometer but also as a visually responsive indicator, suitable for applications requiring straightforward temperature readout without sophisticated instrumentation.

The thermal evolution of the emission spectra, as well as the thermometric performance of the Mn^{2+},Ce^{3+}-doped $Ca_{19}Zn_2(PO_4)_{14}$, were systematically investigated as a function of dopant concentration and temperature and are discussed in detail in this work.

[1] C. D. S. Brites, R. Marin, M. Suta, A. N. Carneiro Neto, E. Ximendes, D. Jaque and L. D. Carlos, *Adv. Mater.* **35**, (2013) 2302749.

[2] L. Marciniak, K. Kniec, K. Elżbieciak-Piecka, K. Trejgis, J. Stefanska, M. Dramićanin, *Coord. Chem Rev*. **469** (2022) 214671.

Acknowledgments: This work was supported by the Foundation for Polish Science under First Team FENG.02.02-IP.05-0018/23 project with funds from the 2nd Priority of the Program European Funds for Modern Economy 2021-2027 (FENG).

UNVEILING CRYSTAL FIELD EFFECT AND TEMPERATURE- DEPENDENT LUMINESCENCE OF Mn^{4+} ACTIVATED DOUBLE PEROVSKITES

A. Basheer[1*], M. Szymczak[1], M. Piasecki[2], M. Brik[2], L. Marciniak[1]

[1]*Institute of Low Temperature and Structure Research, Polish Academy of Sciences, 50-422 Wroclaw, Poland*
[2]*Faculty of Science and Technology, Jan Długosz University, Armii Krajowej 13/15, 42-200 Częstochowa, Poland*

* corresponding author: *a.basheer@intibs.pl*

Keywords: Luminescence Thermometry, Mn^{4+} activated phosphor, Lifetime, Sensitivity

Luminescence thermometry has gained significant attention for its applications in diverse fields ranging from industrial process to biomedical diagnostics. It has emerged as a versatile, remote technique for temperature sensing, exploiting the luminescence properties of materials in response to temperature fluctuations, to overcome the limitations of conventional contact thermometers. Among many different spectroscopic parameters used in luminescence thermometry, luminescence intensity ratio and luminescence kinetics are considered as the most reliable. Recently, there have been numerous research studies on transition metal-activated ions especially Mn^{4+} for applications in luminescence-based thermometry. The luminescence in transition metal ions doped phosphors arises from *d-d* transitions, where the *d* orbitals are not shielded by outer electrons, making them sensitive to the surrounding crystal field of host [1]. What is especially interesting from the thermometric perspective, the change in the host material composition enables optimization of the spectral position of the emission band and luminescence thermal quenching rate. Hence, thermometric performance of transition metal ions based thermometer can be modulated to meet requirements of given type of application.

However to create such a thermometer the thorough understanding on the correlation between host material composition and the thermometric performance of the luminescence thermometer is needed. In this work we are primarily focusing on the thermal dependence of the lifetime of the ^2E state of Mn^{4+} ions. As its lifetime is susceptible to temperature and host material composition, it is a promising dopant to design an optical thermometer based on the lifetimes measurements for high-precision, wide-range temperature sensing [2].

As a first step of our research we are carrying out a comparative study of the variations in the crystal field splitting, Racah parameter of the Mn^{4+} ions in various double perovskite structured host crystals. For this we started with $KLaMgTeO_6$, $NLaMgTeO_6$: Mn^{4+} doped double perovskites, relating the variations in the parameters to change in the covalency of Mn^{4+}- ligand bonding in the crystal.

[1] L. Marciniak, K. Kniec, K. Elżbieciak-Piecka, K. Trejgis, J. Stefanska, M. Dramićanin, *Coord. Chem. Rev.* 469 (2022) 214671.

[2] H. Li, L. Li, L. Mei, W. Zhao, X. Zhou, Y. Wang, P. Du, *J. Mater. Chem. C* 11 (2023) 12637

Acknowledgments: This work was supported by National Science Center Poland (NCN) under project No UMO- 2023/49/B/ST5/03384.

IMPROVING Cr^{3+}-Yb^{3+} ENERGY TRANSFER IN A SPINEL MATRIX

V. Boiko[1*] M. Fandzloch[1], E. Milan[2], E. Radicchi[3], A. Speghini[2], D. Hreniak[1]

[1]*Institute of Low Temperature and Structure Research, Polish Academy of Sciences, Wroclaw, PL-50-422, Poland*
[2]*NRG - Department of Biotechnology, University of Verona, Strada Le Grazie 15, Verona, I-37134, Italy*
[3] *Department of Engineering DIMI, University of Verona, Strada Le Grazie 15, Verona, I-37134, Italy*

* corresponding author: v.boiko@intibs.pl

Keywords: energy transfer, transition elements, rare-earth elements, spinel, $ZnGa_2O_4$

Optical imaging of biological objects using the fluorescence technique directly relates to developing luminescent probes. However, the imaging performance of conventional fluorescence probes often suffers from the poor signal-to-noise ratio caused by autofluorescence and scattered light in the biological environment under external excitation in the ultraviolet and visible range [1]. Also, the luminescence should be monitored not only during and/or at the site of direct excitation, but its migration in real time should also be observed to detect post-treatment effects (i.e., apoptosis) [2–4]. Persistent luminescent nanoparticles, which exhibit long-lasting emission after the shut off of the excitation, are then an ideal choice, also with the possibility of overcoming autofluorescence issues if the emission is in the near-infrared (NIR) biological window ranges (NIR-I: 700-950 nm, NIR-II: 1000-1350 nm and NIR-III: 1550-1870 nm). The Cr^{3+} and Yb^{3+} dopant ions are interesting as optical probes in biomedicine, as they show luminescence in NIR-I (Cr) and NIR-II (Yb).

In the current work, a series of $Zn_{1-x}Ca_xGa_2O_4$ spinel, with x = 0.15, 0.25, and 0.35, doped with Cr^{3+} and Yb^{3+} ions, were successfully synthesized with a hydrothermal method [5]. The microstructure of the obtained powders was confirmed through X-ray powder diffraction (XRPD) analysis. The crystallite size was calculated for each sample to investigate the effect of the introduction of the Ca^{2+} ion on the spinel structure. Based on experimental diffuse reflectance spectra, it was found that increasing the Ca^{2+} concentration induces changes in the conduction band structure. Incorporation of Yb^{3+} ions into the crystal structure was confirmed by diffuse reflectance and emission spectra. Characteristic Yb^{3+} emission was observed upon direct excitation and through energy transfer processes due to Cr^{3+} ions and matrix excitation. According to thermoluminescence data, it was shown that a series of traps with activation energy near 0.6±0.05 eV are present in each sample. The introduction of Ca^{2+} ions changes the number of traps but has a negligible effect on their position. The influence of Ca^{2+} on the Cr-Yb energy transfer, traps creation, and their redistribution is discussed in detail based on optical and structural data analysis.

[1] E. Hemmer, et al., *Nanoscale Horiz.* **1** (2016) 168.
[2] W. Sun, et al., *ACS Omega* **5** (2020) 31700.
[3] T. Staufer, et al., *Sci. Rep.* **13** (2023) 11505.
[4] D.L. Fritzen, et al., *Nanomater.* **10** (2020) 1.
[5] A. Gerus, et al., *Mater. Res. Bull.* **168** (2023) 112473.

This work was supported by the National Science Centre, grant No. 2024/52/L/ST5/00102.

P-5

NEAR-INFRARED PERSISTENT LUMINESCENCE IN Fe-DOPED $ZnGa_2O_4$

V. Boiko[1,2,*], **M. Fandzloch**[1], **O. Bezkrovnyi**[1], **A. Smalyuk**[3,4], **Yu. Hizhni**[3,4],
Ya. Zhydachevskyy[4], **D. Hreniak**[1]

[1] *Institute of Low Temperature and Structure Research, Polish Academy of Sciences, Wroclaw, PL-50-422, Poland*
[2] *Institute of Physics, National Academy of Sciences of Ukraine, Kyiv, UA-03028, Ukraine*
[3] *Taras Shevchenko National University of Kyiv, Kyiv UA 01033, Ukraine*
[4] *Donetsk Institute for Physics and Engineering named after O.O. Galkin, National Academy of Sciences of Ukraine, Kyiv, UA-03028, Ukraine*
[5] *Institute of Physics, Polish Academy of Sciences, Warsaw PL-02-668, Poland*

* corresponding author: *v.boiko@intibs.pl*

Keywords: persistent luminescence, spinel, transition elements

Luminescent materials that emit light in the near-infrared (NIR) range have attracted significant attention due to their promising applications in various fields, including phosphor-converted light-emitting diodes, as well as food and chemical detection. One particularly noteworthy application is in bio-visualization, where emission in the biological windows of NIR-I (700-950 nm), NIR-II (1000-1350 nm), and NIR-III (1550-1870 nm) is essential. Cr^{3}-doped PersL NPs offer a promising solution due to their long-lasting red emission in the first biological window, NIR-I [1]. Additionally, incorporating transition metals that emit in the NIR-II range could expand the applications of these materials. However, there have been only a few publications where other transition metal ions, specifically nickel (Ni) [2] and iron (Fe) [3] were used.

In the present work, spinel crystals, $ZnGa_2O_4$, singly doped with iron (ZGO:Fe) were synthesized by the hydrothermal method, and which synthesis conditions were optimized earlier [1]. Synthesized samples were studied by both structural and spectroscopic methods. Additionally, based on Raman and thermoluminescence data, the presence of antisite defects in the obtained samples was analyzed.

The electronic structure calculations of the set of iron-related point defects (Fe substitutions on cation positions and their combinations with cationic antisites and native vacancies) in ZGO crystals were carried out by the DFT band-periodic method CASTEP within the supercell approach. Results of the calculations are compared with experimental data on optical spectroscopy of the synthesized samples.

[1] Gerus, A. et al. *Mater. Res. Bull.* **168** (2023) 112473

[2] Castaing, V. et al. *J. Phys. Chem. C* **125** (2021) 10110–10120

[3] Xiang, L. et al. *J. Lumin.* **252** (2022) 119293

This work was supported by NSC grant Nr: DEC-2024/08/X/ST5/00392 (VB), Grant for study visit from the Polish Academy of Sciences (YH).

PMMA/Eu^{3+}-Tetrakis Hybrid Films for Smart Window Use: A Combined LSC and Luminescent Thermometer

F. S. M. Canisares[1], M. V. Correa[5], Juliana Izidoro[5], P. R. S. Santos[1], A. G. Bispo-Jr[1], J. H. A. Neto[1], J. A. Ellena[2], O. L. Malta[3], M. C. F. C. Felinto[4], H. F. Brito[1,*]

[1]University of São Paulo, São Paulo, 05508-900, Brazil
[2]University of São Paulo, São Carlos, 13566-590, Brazil
[3]Federal University of Pernambuco, Recife, 50670-901, Brazil
[4]Nuclear and Energy Research Institute, São Paulo, 05508-900, Brazil
[5]Scientific Learning Program, Dante Alighieri School, São Paulo, 01420-002, Brazil
* corresponding author: hefbrito@iq.usp.br

Keywords: PMMA films, Europium complex, temperature sensing, solar concentrator

The integration of photovoltaic (PV) technologies into architectural elements is a strategic way to improve building energy performance [1]. Among these, luminescent solar concentrators (LSCs) stand out for their versatility, allowing use on surfaces unsuitable for traditional PV systems [2]. Furthermore, LSCs can be engineered into multifunctional composites, contributing to the advancement of smart materials. Among such multifunctionalities, luminescence thermometry is an interesting feature aiming to develop self-temperature probed LSCs to be used as smart windows [3]. Seeking to design multifunctional LSCs, we prepared a series of PMMA (polymethyl methacrylate) films doped with a Eu^{3+}-tetrakis β-diketonate complex ($EtN_4[Eu(ntfa)_4]$, where EtN_4^+ denotes tetraethylammonium and ntfa$^-$ represents 4,4,4-trifluoro-1-(naphthalen-2-yl)butane-1,3-dionate). The films were prepared by the drop-casting method, and the doping concentration was changed from 1 to 5 wt%. All films exhibited red luminescence under sunlight exposure, arising from the Eu^{3+} $^5D_0 \rightarrow {}^7F_J$ (J = 0 to 4) transitions. The excitation bands cover a broad spectral range from 250 to 450 nm, highlighting its potential to absorb energy that is not fully absorbed by typical Si PV cells. Steady-state photoluminescence measurements revealed an intrinsic photoluminescence quantum yield of 52% for the film doped at 2 wt%, which is the highest among the tested concentrations. Considering such condition, the temperature dependency of $^5D_0$ level lifetime was monitored over the temperature range of 80 to 420 K to study the luminescence thermometry capability. The lifetime becomes shorter at temperatures above 300 K, rendering a relative thermal sensitivity that goes from 0.10% K^{-1} (300 K) to 4.74% K^{-1} (397 K). Although the relative thermal sensitivity is low within 0 – 40 °C, some environments can achieve temperatures as high as 60 °C, such as rooftops or windows closely linked to metallic parts (such as vehicles). In conclusion, the 2wt.% film yields intense red luminescence displaying large quantum efficiency, while the temperature-dependent luminescence lifetime underscores the material's capacity for temperature sensing within the 300 – 400 K. Collectively, these findings highlight the promise of such films as innovative LSCs components for energy-efficient and adaptive building technologies.

[1] Yin, H. M., et al. *Solar Energy* **87** (2013) 184-195. [2] Figueiredo, Gonçalo, et al. *Advanced Science* **11.35** (2024) 2400540. [3] Stoychev, Georgi, et al., *Advanced Optical Materials* **7.16** (2019) 1900067.

Acknowledgments: HFB thanks FAPESP (2021/08111-2). FSMC thanks FAPESP (2023/16684-8) for a post-doctoral scholarship.

A STRUCTURAL AND SPECTROSCOPIC INSIGHT INTO PRASEODYMIUM(III) ION-DOPED NANOSIZED $YP_{1-x}V_xO_4$ SOLID-STATE SOLUTION

A. Bartkowiak[1], N. Charczuk[1,*], A. Watras[1], M. Kardach[1], P. Boutinaud[2]
and R.J. Wiglusz[1,3,*]

[1]Institute of Low Temperature and Structure Research, Polish Academy of Sciences,
Wroclaw, 50-422, Poland
[2] Université Clermont Auvergne, Clermont Auvergne INP, Institut de Chimie de
Clermont-Ferrand, Clermont-Ferrand, F-63000, France
[3] Meinig School of Biomedical Engineering, College of Engineering, Cornell University,
Ithaca, New York 14853-1801, United States

* corresponding authors: n.charczuk@intibs.pl; r.wiglusz@intibs.pl

Keywords: yttrium orthophosphate-vanadates, nanostructures, photoluminescence.

Yttrium-based orthophosphates (YPO_4) and orthovanadates (YVO_4) doped with rare earth ions represent an important class of oxide phosphors with promising applications in advanced optical technologies, particularly in optoelectronics [1].

This study investigates the properties of nanosized $Y_{1-z}Pr_zP_{1-x}V_xO_4$ ($x = 0$-1 with a step of 0.1, and $z = 0.1$, 0.5, 1) materials synthesized *via* co-precipitation. The nanocrystals were characterized using XRPD, FTIR, XPS, ICP-OES, HR-TEM, SEM, and N_2 adsorption-desorption techniques. The photoluminescence spectral and dynamical properties were also investigated. The focus was on how substituting phosphates $(PO_4)^{3-}$ with vanadates $(VO_4)^{3-}$ and incorporating Pr^{3+} ions influences the structural and photoluminescence properties of the resulting phosphors. Results show that the structural transition from yttrium phosphate to yttrium vanadate leads to significant changes in lattice parameters, crystal morphology, and luminescence behavior, particularly in the red spectral region. The photoluminescence analysis revealed that the emission properties of Pr^{3+} ions are highly dependent on the host matrix composition, with a notable decrease in emission intensity as the vanadate content increases. Additionally, the study highlights the effect of matrix composition on the decay times of Pr^{3+} emissions, indicating the presence of quenching effects in specific compositions. These findings provide insights into the photophysical properties of Pr^{3+}ion-doped materials, which could be relevant for applications that require tailored luminescence properties.

[1] E. Cavalli, F. Angiuli, A. Belletti, P. Boutinaud, *Opt. Mater.* **36** (2014) 1642.

Acknowledgements: The authors would like to acknowledge for financial support within the Projects 'Preparation and modulation of spectroscopic properties of $YXZO_4$, where X and Z – P^{5+}, V^{5+}, As^{5+}, doped with "s^2-like" ions and co-doped with rare-earth ions' (UMO-2019/33/B/ST5/02247) under the National Science Centre Poland (NCN) and 'Nanosized composites with biomimetics' properties for precise medical application' (BPN/BEK/2023/1/00309, Bekker programme) under the Polish National Agency for Academic Exchange.

Spinel nanocrystals exhibiting persistent luminescence and quantum-cutting effect for bio-imaging

V. Čirgelis[1, 2*], **S. Streckaitė**[1], **L. Golubewa**[1], **V. Gulbinas**[1]

[1]*Center for Physical Sciences and Technology, Vilnius, 02300, Lithuania*

[2]*Physics faculty, Vilnius university, Vilnius, 10222, Lithuania*

**corresponding author: vilius.cirgelis@ftmc.lt*

Keywords: quantum-cutting, spinels, bio-imaging

Spinels are minerals with general formula of $A^{2+}B_2^{3+}O_4$ with cubic crystal structure. Many different spinel crystals have been synthesised and investigated, due to their possible application in optoelectronics, plasmonics, biomedicine [1], [2]. Spinels are chemically inert, biocompatible, making them especially interesting for bio-imaging applications. In recent years, gallate spinel nanocrystals (NCs) doped with chromium ions were investigated. Studies show that spinel NCs can be easily synthesized via hydrothermal synthesis approach [3]. During the synthesis procedure NCs of different sizes can be synthesised, and dopants can be introduced to the crystal structure. Cr^{3+} emission matches the biological window, approximately at 700 nm, where the least tissue scattering and absorption occurs. Cr^{3+} doped spinel NCs exhibit persistent luminescence (PersL) when charge carriers are slowly released from energy traps. PersL allows long-lasting luminescence after the excitation, which lasts from seconds to days, allowing imaging without autofluorescence. It is possible to cover any part of VIS-NIR spectra with lanthanide ion emission , and to achieve photoluminescence quantum yields (PLQY) higher than 100%, theoretically reaching 200% via quantum-cutting (QC) phenomenon [4]. During QC, one UV-VIS photon is converted to two NIR photons, in case of 200% PLQY. Finally, QC combined with PersL could improve performance of bio-imaging.

In our study, $ZnGa_2O_4$ NCs doped with lanthanide ions will be synthesized hydrothermally. Surface of NCs will be modified with NH_2 and COOH functional groups, stabilizing NCs in aqueous media. Later, NCs will be incorporated into, to improve the biocompatibility and NC specific accumulation inside the living cells and used for bio-imaging. Structural properties of synthesized spinel NCs will be investigated with XRD and TEM measurements. Optical properties of $ZnGa_2O_4$ doped with lanthanide ions will be investigated with diffuse reflectance and fluorescence spectroscopy. Raman and FTIR measurements will provide insights on successful surface modification of NCs.

[1] M. N. Da Silva, et al., ACS App. Nano. Mat. 2019, **2**, 6918–6927
[2] O. Kendall, *et al.*, Nano. Lett. 2023, **23**, 2974–2980
[3] A. Gerus, et al., Mat. Res. Bull. 2023, **168**, 112473
[4] D. M. Kroupa, et al., ACS En. Lett. 2018, **3**, 2390–2395

Acknowledgments: this research was funded by Polish-Lithuanian research project DAINA-3, agreement No [S-LL-24-11].

Dye-doped polymeric films based on BODIPY and lanthanide, aiming for applications as luminescent sensors and solar concentrators

Beatriz S. Cugnasca[1,2*], **Felipe S. M. Canisares**[1], **Airton G. Bispo-Jr**[1], **Frederico Duarte**[2], **Hugo M. Santos**[2,3], **José Luis Capelo-Martínez**[2,3], **Emilia Bértolo**[4], **Carlos Lodeiro**[2,3,4], **Alcindo A. Dos Santos**[1], **Hermi F. Brito**[1]

[1]*Institute of Chemistry, University of São Paulo, São Paulo, 05508-900, Brazil*
[2]*LAQV-REQUIMTE, NOVA School of Science and Technology (FCT-UNL), NOVA University Lisbon, Caparica, 2829-516, Portugal*
[3]*PROTEOMASS Scientific Society, Caparica, 2825-466, Portugal*
[4]*Canterbury Christ Church University, Canterbury, United Kingdom*

*Corresponding author: beatriz.cugnasca@usp.br

Keywords: BODIPY, lanthanide, europium, luminescence

In recent years, the development of new polymeric films doped with dyes has been growing, with a notable range of applications in various areas, including power generation, solid-state sensing, industry, biomedicine, cellular imaging, drug delivery, solar concentrators, and smart windows, among others.[1] Thus, in this work, new polymeric films doped with BODIPY derivatives were obtained through the drop-casting methodology to be applied as luminescent sensors for temperature and ammonia in water. Initially, polymeric films doped with functionalized BODIPY derivatives (containing Br or Se) were developed using poly(methyl methacrylate) (PMMA) or thermoplastic polyurethane (TPU) as the polymer matrix. The solid-state photophysical properties of these materials were evaluated, and thermometric studies were conducted through emission spectra. Heating/cooling cycles were performed (25 – 190 ºC), demonstrating the reversibility of the process and the potential of the new materials as luminescent temperature sensors.[2] Reactivity of the materials was evaluated against ammonia, observing an abrupt change in color from red to yellow with intense luminescence for films doped with BODIPY derivatives containing Br or Se atoms. Polymeric particles doped with BODIPYs were also obtained, and it was possible to demonstrate the detection of ammonia in water through fluorescence. Polymeric films simultaneously doped with a BODIPY derivative and a lanthanide complex ($Et_4N[Eu(ntfa)_4]$) were obtained by varying the concentration of Eu^{3+} complex (0.5 – 20.0 wt.%) and maintaining the BODIPY concentration at 0.01 wt.%, targeting applications such as luminescent solar concentrators (LSCs) for smart windows. The values of emitting state lifetimes of BODIPY (8.87 – 12.29 ns) and Eu^{3+} complex (0.4593 – 0.4786 ms) suggest that an intramolecular energy transfer process occurs between BODIPY and Eu^{3+} complex. A thermometric study was performed using a film doped with 2.0 wt.% Eu^{3+} complex and BODIPY (0.01 wt.%), resulting in a ratiometric response with maximum relative thermal sensitivity of 3.60% K^{-1} at 393 K. When exposed to sunlight, modulation in the color of the film emission from green to red was obtained, presenting potential for future applications in smart windows.

[1] Fleischmann, C.; Lievenbruck, M.; Ritter, H. Polymers (Basel) 2015, 7, 717–746. [2] Cugnasca, B. S.; Duarte, F.; Santos, H. M.; Capelo-Martínez, J. L.; Bértolo, E.; Dos Santos, A. A.; Lodeiro, C. Microchimica Acta, **2024**, 191:746.

The authors thank FAPESP (2025/03447-3, 2023/01092-8, 2019/07634-1, 2023/16684-8, 2021/08111-2), CNPq (141855/2019-3, 308872/2022-3), and CAPES for financial support. BSC thanks Sociedade Brasileira de Química (SBQ) and Royal Society of Chemistry (RSC) for the "Prêmio Jovem Pesquisador - Royal Society of Chemistry - RASBQ 2025".

P-10

Photoluminescence Quantum Yield of Difficult Samples

G. Cumming[1*]

[1]*Edinburgh Instruments Ltd., 2 Bain Square, Livingston, EH54 7DQ, United Kingdom*

* corresponding author: grant.cumming@edinst.com

Keywords: Quantum Yield, Photoluminescence, PLQY

Photoluminescence quantum yield (PLQY) is a critical parameter in the complete characterisation of luminescent materials. Accurate PLQY determination regularly presents significant challenges for some samples such as those with low PLQY; small Stokes shift; or large Stokes shift where the absorption and emission regions span beyond the range of a single detector.

Low PLQY materials: For weakly emissive samples, achieving adequate signal-to-noise for the sample emission requires the use of high-intensity excitation. This high excitation power frequently exceeds the dynamic range of the detector leading to signal saturation when measuring the excitation peaks of the PLQY experiment. Signal saturation causes inaccurate determination of the number of photons absorbed, which results in the calculated PLQY being incorrect. This poster discusses a method to mitigate detector saturation by employing a neutral density filter to attenuate the excitation flux to be within the linear response range of the detector, while still maintaining sufficient signal for reliable determination of the number of photons emitted by the sample.

Small Stokes shift samples: Materials which have substantial overlap between absorption and emission spectra show increased secondary inner-filter effects when measured in an integrating sphere. This is because any PL emission is reflected within the sphere multiple times, leading to increased self-absorption by the sample. This in turn leads to the observed PLQY being an underestimation of the true PLQY. This poster will discuss how to identify this effect and mathematical approaches to account for this phenomenon.

PLQY over broad spectral ranges: Precisely measuring PLQY presents a challenge for materials that absorb or emit light across a wide spectral range. This is especially true for those exhibiting large Stokes shifts – such as some rare earth materials – where the excitation and emission regions often span beyond the range of a single detector. PLQY measurements of such samples require the use of systems equipped with multiple detectors. The challenge here lies in robustly accounting for the different optical path efficiencies and spectral sensitivities of the individual detectors and their associated optics. This poster will discuss methods for using excitation and emission data from distinct lightpaths to achieve accurate PLQY determination of such samples.

This poster outlines some common challenges faced when characterising the PLQY of demanding samples and demonstrates some strategies to overcome these issues.

P-11

INFLUENCE OF FLUORIDE AND OXIDE MODIFIERS ON STRUCTURAL AND OPTICAL PROPERTIES OF PHOSPHATE GLASSES

K. Dej[1*], M. Kuwik[1], M. Sitarz[2], W. A. Pisarski[1]

[1]University of Silesia, Katowice, 40-007, Poland
[2]AGH University of Krakow, Kraków, 30-059, Poland

* corresponding author: karolina.dej@us.edu.pl

Keywords: phosphate glass, lanthanides, modifiers, local structure

Phopshate glasses are well known from the literature as interesting materials for applications due to the possibility of doping them with higher concentrations of lanthanide ions, in comparison to other glass systems, while retaining their amorphous structure. On the other hand, high hygroscopic nature of phosphate pentoxide and high phonon energy of phosphate matrix may lead to luminescence quenching of Ln^{3+} ions. In order to improve optical properties of phosphate glasses, fluoride and oxide modifiers can be introduced into the matrix [1,2]. It was observed that for systems containing BaF_2 as modifier, intensity of emission band and value of luminescence lifetime for $^4I_{13/2}$ level of Er^{3+} ions increased [3]. Furthermore, the presence of oxide modifiers changes the local structure of phosphate glasses by depolymerization of glass network and converting Q^3 units into Q^1 units. Shortening of phosphate chains increases the possibility for uncontrolled crystallization [2]. The purpose of this research was to synthesize and analyze structural and optical properties of phosphate glasses doped with Eu^{3+} ions containing fluoride and oxide modifiers. Analysis of diffraction patterns confirmed the amorphous structure of transparent samples and identified crystalline phases in semi-crystalline samples. Analysis of IR and Raman spectra allowed characterization of the structural changes in the matrix occurring with changing type and concentration of modifiers. Based on recorded emission spectra, the maximum phonon energy and red-to-orange ratio (R/O) parameter were determined. The determination of the luminescence lifetime for $^5D_0$ level of Eu^{3+} ions confirmed the influence of changes in the chemical composition of phosphate glasses on the optical properties of the studied systems.

[1] M. Kuwik, J. Pisarska, W. A. Pisarski, Materials **13** (2020) 4746.

[2] J. Rocherullé, M. Cai, P. Bénard-Rocherullé, R. Lebullenger, L. Calvez, J. Trolès, D. Le Coq, X-H Zhang, J. Massera, L. Petit, JNCS **551** (2021) 120431.

[3] K. Linganna, R. Narro-García, P. Manasa, H. Desirena, E. De la Rosa, C.K. Jayasankar, RE **36** (2018) 58-63.

P-12

Direct insights into ligand exchange dynamics on $NaYF_4$ nanocrystals using ^{1}H-NMR

<u>A.J.H. Dekker</u>[1,2]*, M. Kikkert[1,2], P.C.A. Bruijnincx[1], F.T. Rabouw[2]

[1]*Organic Chemistry and Catalysis, Institute for Sustainable and Circular Chemistry, Faculty of Science, Utrecht University, Universiteitsweg 99, 3584 CG, Utrecht, The Netherlands*

[2]*Soft Condensed Matter & Biophysics, Debye Institute for Nanomaterials Science, Faculty of Science, Utrecht University, Princetonplein 1, 3584 CC, Utrecht, The Netherlands*

* corresponding author: *a.j.h.dekker@uu.nl*

Keywords: nanocrystals, ligand exchange, lanthanide host-materials, NMR

Lanthanide-doped $NaYF_4$ can be used in many applications such as bioimaging, luminescence thermometry, lighting, and increasing solar cell efficiency. For most of these, nanometer-scale crystals are needed for high spatial resolution, to benefit from solution processability, or to prevent light scattering. Generally, these nanocrystals (NCs) are synthesized using coprecipitation or thermal decomposition in the presence of molecules that function as stabilizing surface ligands. Oleic acid or oleyl amine are popular as these are practical in use and lead to high-quality NCs. However, other ligands are often necessary for applications. For instance in bioimaging, polar ligands are needed to disperse the NCs in aqueous environments. Ligand exchange is either a one-step process where post-synthesis ligands are displaced with a large excess of the desired ligand, or a two-step process where the post-synthesis ligand is stripped with an acid or nitrosonium tetrafluoroborate before introducing the desired ligand. The success of these strategies depends on the thermodynamics and kinetics of ligand binding and unbinding. These exchange dynamics are poorly understood and have not been studied directly on this material.

Here, we directly study the self-exchange of oleic acid on $NaYF_4$ NCs using simple ^{1}H-NMR. To this end, we investigate how exactly oleic acid is bound to the NC surface and gain insight into the exchange mechanism. We probe exchange dynamics and use this to explore how washing affects ligand density, which directly influences NC stability. Here, we exploit the dependence of NMR shift on the chemical environment by comparing peak positions of NMR signals from dispersed NCs to pure freely dissolved oleic acid to determine the amount of free and bound oleic acid in a specific system. This ratio informs us on the free-to-bound exchange rate of oleic acid on these NCs. With these results we aid the rational design of post-synthesis treatment of NCs to achieve desired ligand coverage.

TEMPERATURE SENSING WITH Pr^{3+}-DOPED MATERIALS ANALYZED BY PRINCIPAL COMPONENT ANALYSIS

V. Đorđević[1, *], Z. Ristić[1], A. Rajčić[1], Lj. Đačanin Far[1], T. Gavrilović[1], Ž. Antić[1], M. D. Dramićanin[1]

[1] *Center of Excellence for Photoconversion, Vinča Institute of Nuclear Sciences – National Institute of the Republic of Serbia, University of Belgrade, P.O. Box 522, Belgrade, 11001, Serbia*

* corresponding author: *vesipka@vin.bg.ac.rs*

Keywords: Luminescence thermometry, Principal component analysis, Phosphor, Praseodymium

Temperature-dependent emission spectra of Pr^3-doped $LiLaP_4O_{12}$, Y_2O_3, and $YNbO_4$ were acquired under 450 nm excitation between 93 K and 523 K. The photoluminescence spectra of these samples display multiple temperature-induced changes, with some features showing strong variations and others more subtle shifts. This complex pattern of spectral modifications arises from the manifold of f-f electronic transitions within the Pr^{3+} ion. Such diverse temperature-dependent spectral changes imply that conventional luminescence thermometry approaches based on single parameters, such as luminescence intensity ratios, bandwidth changes, or emission band shifts, may not fully capture the rich information contained within the emission spectrum. This limitation motivates the application of multivariate data analysis techniques, such as principal component analysis (PCA), which can effectively utilize the full spectral data set to extract temperature-sensitive features and improve thermometric performance.

The choice of host materials for Pr^{3+} doping reflects diverse structural and optical environments affecting luminescence. $LiLaP_4O_{12}$, a phosphate compound with a stable and rigid crystal framework, supports efficient Pr^{3+} emission with minimal non-radiative losses and maintains stability over a wide temperature range, making it ideal for studying thermal effects. Y_2O_3, a well-known oxide host, offers high chemical and thermal stability along with excellent optical transparency in the visible and near-infrared regions, reducing reabsorption and scattering to preserve intrinsic emission. $YNbO_4$, a niobate host, features a unique crystal field due to Nb ions and lattice symmetry, influencing Pr^{3+} transition splitting and intensity. Doping Pr^{3+} into $YNbO_4$ allows investigation of how such a distinctive environment impacts luminescence thermometry, potentially enhancing sensitivity or altering temperature responses.

This comprehensive approach, combining multiple host matrices and the advanced spectral analysis method of PCA, aims to deepen the understanding of Pr^3-based luminescent thermometry and explore its capabilities beyond traditional measurement techniques. The results promise to provide insights into optimizing Pr^3-doped materials for reliable and accurate temperature sensing across a broad thermal range.

Acknowledgments: This research was supported by the Science Fund of the Republic of Serbia, Grant No 7017, Technology for Remote Temperature Measurements in Microfluidic Devices – REMTES and Ministry of Science, Technological Development, and Innovation of the Republic of Serbia under contract 451-03-136/2025–03/200017.

SCINTILLATION AND OPTICAL PROPERTIES OF CZOCHRALSKI-GROWN PURE AND Si-DOPED β-$(Al_xGa_{1-x})_2O_3$ SINGLE CRYSTALS

K.J. Drozdowski[1,*], **M.E. Witkowski**[1], **K. Wisniewski**[1], **W. Drozdowski**[1],
L. Swiderski[2], **Z. Galazka**[3]

[1]*Institute of Physics, Faculty of Physics, Astronomy and Informatics,*
Nicolaus Copernicus University, Grudziadzka 5, 87-100 Torun, Poland
[2]*National Centre for Nuclear Research, Andrzeja Soltana 7, 05-400 Swierk-Otwock, Poland*
[3]*Leibniz-Institut für Kristallzüchtung, Max-Born-Str. 2, 12489 Berlin, Germany*

* corresponding author: 503545@doktorant.umk.pl

Keywords: gallium oxide, semiconductor scintillator, light yield, time profile, radioluminescence, thermoluminescence, transmission

Although the present day scintillator market is dominated by inorganic insulators, some attention has been shifted to semiconductors in the recent years [1,2]. In particular, gallium oxide (β-Ga_2O_3) crystals have been recognized as promising scintillators, opening perspectives for applications of novel operability, unavailable for insulators. Efforts have been made to improve the scintillation properties of β-Ga_2O_3 and to understand its scintillation mechanism [2-4].

In this Communication we present the results of our recent studies performed on β-$(Al_xGa_{1-x})_2O_3$ and β-$(Al_xGa_{1-x})_2O_3$:Si solid-solution crystals grown by the Czochralski method at Leibniz-Institut für Kristallzüchtung in Berlin [5,6]. The research, including pulse height spectra (with determination of light yield and energy resolution), scintillation decay time, thermoluminescence in a wide range of temperature, and X-ray excited emission spectra recorded as a function of temperature, has been aimed to assess the influence of partial replacing gallium with aluminum on the scintillation properties. Furthermore, transmission measurements have been conducted to analyze the effect of the bandgap gain of the studied compounds.

[1] S.E. Derenzo et al., *Nucl. Instr. Meth.* **A805** (2016) 36.

[2] W. Drozdowski et al., *Opt. Mater.* **105** (2020) 109856.

[3] W. Drozdowski et al., *Opt. Mater. X* **15** (2022) 100157.

[4] A.J. Wojtowicz et al., *Heliyon* **9** (2023) e21240.

[5] Z. Galazka et al., *J. Appl. Phys.* **133** (2023) 035702.

[6] Z. Galazka et al., *Adv. Mater. Interfaces* **12** (2024), 2400122.

Acknowledgements: Crystal growth and sample preparation was funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) project under grant number AOBJ 681632. The authors thank Andreas Fiedler and Mike Pietsch from Leibniz-Institut für Kristallzüchtung for Hall effect measurements.

P-15

FROM LEAD TO CADMIUM IN 2D $BA_2Pb_xCd_{1-x}Br_4$ PEROVSKITES: A PATH TOWARD MORE EFFICIENT SCINTILLATORS

M. S. Eid[1,*], **M. E. Witkowski**[1], **M. Makowski**[2], **S. Mahato**[2], **D. Kowal**[2], **F. Maddalena**[3], **W. Drozdowski**[1], **M. D. Birowosuto**[2]

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

[2] *Łukasiewicz Research Network—PORT Polish Center for Technology Development, Stabłowicka 147, 54-066 Wrocław, Poland.*

[3] *CINTRA UMI CNRS/NTU/THALES 3288, Research Techno Plaza, 50 Nanyang Drive, Border X Block, Level 6, Singapore 637553, Singapore*

* Corresponding author: mohanadeid@doktorant.umk.pl

Keywords: 2D Perovskites, Cadmium, Scintillators, Light Yield, Luminescence

Two-dimensional (2D) hybrid lead halide perovskites have emerged as promising materials for optoelectronic and scintillation applications due to their tunable electronic properties, structural versatility, high scintillation light yield, and emission tunability via organic cation and halide anion combinations. [1] This study investigates the impact of compositional engineering through partial and full substitution of lead (Pb^{2+}) with cadmium (Cd^{2+}) cations on the scintillation properties of 2D perovskites ($BA_2Pb_xCd_{1-x}Br_4$). A comparative analysis of scintillation properties was conducted through a series of tests. [2] The scintillation time profile revealed a faster decay time for perovskites contain Cd (~20 ns) compared to their Pb-based counterparts. Pulse height measurements indicated an improved light yield output with Cd substitution. Radioluminescence (RL) mapping of the samples showed consistent emission regions. Surprisingly, the addition of Cd shifted the emission to higher temperatures, approaching room temperature. Furthermore, Shibata fitting [3] of the integrated RL intensity demonstrated that Cd doping increased the energy (~150 meV) required to activate thermal quenching indicating higher thermal stability. Thermoluminescence measurements showed a rapid afterglow with a negligible glow-curve signal. This suggests that these 2D perovskites possess minimal charge carrier traps, and their luminescence properties are primarily governed by radioluminescence rather than long-term thermoluminescence processes. These findings highlight the potential of cadmium substitution to tailor and enhance the scintillation performance of 2D hybrid perovskites.

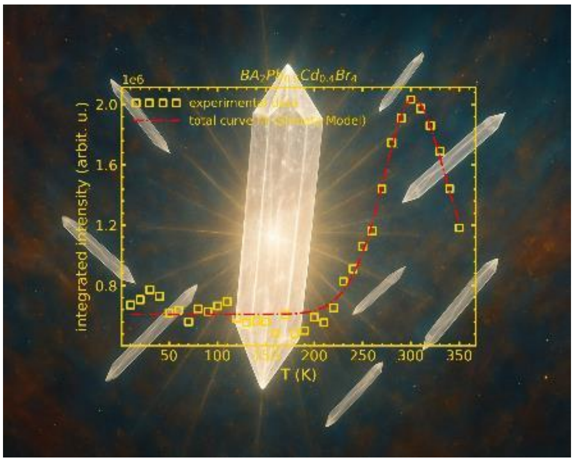


Fig. 1. RL behavior of $Ba_2Pb_{0.6}Cd_{0.4}Br_4$ crystals, Inset: Temperature-dependent integrated RL intensity fitted using the Shibata model.

[1] A. Xie, et al., *Chem. Mater.* **32** (2020) 8530.

[2] L.J. Diguna, et al., *Mater. Adv.* **3** (2022) 5087.

[3] H. Shibata, *Jpn. J. Appl. Phys.* **37** (1998) 550.

DEVELOPMENT OF RATIOMETRIC LUMINESCENT PH SENSORS BASED ON LIGNIN DERIVED CARBON QUANTUM DOTS

K. Elzbieciak-Piecka[1,*], **M. Szymczak**[1], **L. Marciniak**[1], **J. Iskra**[2], **J. Papan Djaniš**[2,3]

[1]Institute of Low Temperature and Structure Research Polish Academy of Sciences, Wroclaw, 50-422, Poland
[2]Faculty of Chemistry and Chemical Technology, University of Ljubljana, Ljubljana, 1000, Slovenia

[3]Centre of Excellence for Photoconversion, Vinča Institute of Nuclear Sciences, National Institute of the Republic of Serbia, University of Belgrade, Belgrade, 11351, Serbia

* corresponding author: *k.elzbieciak@intibs.pl*

Keywords: lignin, carbon quantum dots, luminescence properties, pH sensing

The importance of the pH parameter is widely emphasized in many areas such as biomedicine, environmental protection, industrial processes, and agriculture. Accurate monitoring of pH is essential not only in scientific research but also in practical applications including medical diagnostics, environmental monitoring, and the analysis of food and beverages [1-2]. To extend the applicability of pH sensors to so-called microenvironment, which is beyond the measurement capabilities of conventional pH electrodes and particularly important from biological purposes, optical pH sensors have been proposed. Carbon quantum dots, due to their unique optical properties have been found to be ideal candidates as luminescent pH sensors, offering significant advantages over commonly used quantum dots based on heavy metals or organic dyes [3]. The fundamental mechanism of the luminescence response to pH changes in carbon quantum dot solutions involves the protonation and deprotonation of acidic and basic functional groups present on the dots surface. This process affects their luminescence properties, influencing both the intensity and shape of the emission band [1,4]. Since pH detection based on changes in the intensity of a single band is prone to interferences and its reliable readout is limited, a ratiometric method of pH measurement has been introduced [5-6]. This approach involves measurement of two emission bands under a single excitation wavelength, which effectively eliminates background signal interference, improves the accuracy of the readout and facilitates the practical implementation of the method. Therefore, the main aim of this work is to confirm the potential of lignin-based carbon quantum dots derived from spruce biomass and doped with m-aminophenylboronic acid as effective ratiometric luminescent pH sensors.

[1] C. Liu, F. Zhang, J. Hu, W. Gao, M. Zhang, *Front. Chem.* **8** (2021) 605028.
[2] C. Liu, et al. *Phys. Chem. Lett.* **12** (2021) 2727–2735.
[3] Z. L. Wu, et al. *Nanoscale* **6** (2014) 3868-3874.
[4] H. Ehtesabi, et al. *Microchim Acta* **187** (2020) 150.
[5] J. Shangguan, et al. *Anal Chem* **88** (2016) 7837–7843.
[6] H. Nie, et al. *Chem. Mater.* **26** (2014) 3104–3112.

This work was supported by National Science Center Poland under project WEAVE-UNISONO No. 2023/05/Y/ST5/00013.

P-17

The Scintillation Properties of Cr Doped $Cs_2AgInCl_6$ Double Halide Perovskite and Application for Gamma-ray Detection in High Dose Rate Conditions

Chihaya Fujiwara[1,2] *, Shunsuke Kurosawa[1,3,4,5], Akihiro Yamaji[1,3], Akira Yoshikawa[1,3]

[1]Institute for Materials Research, Tohoku University, Sendai, 980-8577, Japan
[2] Department of Materials Science, Graduate School of Engineering, Tohoku University, Sendai, 980-8579, Japan

[3] New Industry Creation Hatchery Center, Tohoku University, Sendai, 980-8579, Japan
[4] Institute of Laser Engineering, Osaka University, Osaka, 565-0871, Japan
[5] Institute for Integrated Radiation and Nuclear Science, Kyoto University, Osaka, 590-0494, Japan

* Corresponding author: *fujiwara.chihaya.p8@dc.tohoku.ac.jp*

Keywords: Double Halide Perovskite, Halide Phosphor, Scintillator, First principal calculation

Remote radiation monitoring systems under ultra-high dose rate conditions (1 kSv/h or higher) like the decommissioning process for the Fukushima nuclear power plant are required. We have proposed a detector using optical fiber and scintillators with red-infrared emission wavelength, because the transmission efficiency of photons in an optical fiber is more efficient at red-infrared wavelengths. Therefore, we have developed the scintillators such as Cs_2HfI_6 [1] (λ_{em}=700 nm) and Cr: $Gd_3Ga_5O_{12}$ [2] (λ_{em}=800 nm). However, we found some noises originating from the optical fiber itself such as luminescence and Cherenkov photons at 400 -900 nm [3]. Therefore, scintillator materials with over 900 nm emission wavelength are required. Here, $Cs_2AgInCl_6$ phosphors have recently been reported to have high atmospheric stability and high luminescence efficiency by elemental doping[4]. Since $Cs_2AgInCl_6$ is composed of trivalent In^{3+}, Cr^{3+} dopant is available which is a typically emission center for red-infrared phosphors. Therefore, the objective of this study is to develop an infrared emitting scintillator based on $Cs_2AgInCl_6$ for radiation monitoring in high-dose rate fields using optical fibers.

Figure 1 shows the X-ray radioluminescence spectra of Cr:$Cs_2AgInCl_6$. The peak of the emission spectrum was approximately 950 nm, and this result indicated the sample is more suitable for remote radiation detection with optical fiber than that of Cs_2HfI_6 and Cr:$Gd_3Ga_5O_{12}$. The details of the optical and radiation properties is discussed at this conference.

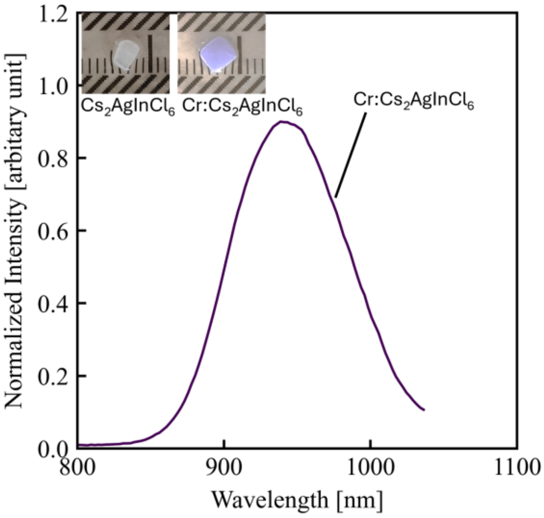


Figure 1. X-ray radioluminescensce sprctra of Cr:$Cs_2AgInCl_6$.

[1] S. Kodama *et al.,Appl. Phys. Express*, vol. 13, no. 4, Apr. 2020.
[2] D. Matsukura *et al., J. Cryst. Growth*, vol. 630, no. 127581, p. 127581, Mar. 2024.
[3] D. Matsukura *et al.*, process,” *J. Instrum.*, vol. 19, no. 02, p. C02053, Feb. 2024.
[4] Y. Liu *et al.*, *Angew. Chem. Int. Ed Engl.*, vol. 133, no. 21, pp. 11696–11707, 2020.

P-18

CaF_2 NANOCRYSTALS DOPED WITH Yb^{3+} IONS AS THE OUTPUT MATERIAL FOR ACHIEVING A PERSISTENT LUMINESCENCE EFFECT INDUCED BY UPCONVERSION PHOTONS

G.E.Gagliardo Briuccia[1,*], **V.Boiko**[1], **D.Hreniak**[1,*]

[1] *Division of Optical Spectroscopy, Institute of Low Temperature and Structure Research,*
Polish Academy of Sciences, Okólna 2, 50-422 Wrocław, Poland

* corresponding author: *g.gagliardo@intibs.pl, d.hreniak@intibs.pl*

Keywords: CaF_2, Rare-earth, PersL, Up-conversion

Persistent luminescence nanoparticles with emission in the red and near infrared region have many attractive applications, from specific markers in biotechnology to optical security, for the authentication of valuable objects. Another attractive task is to obtain persistent luminescence (PersL) of materials that integrate PersL properties and up-conversion (UC), i.e. the process of luminescence as a result of multiphoton excitation, in one host lattice. For this purpose, we focused on obtaining fluoride materials doped with ytterbium ions (Yb^{3+}) as the main ion used to achieve the first step of up-conversion process. In current work a series of calcium fluoride (CaF_2) nanoparticles doped with different concentrations (1, 5, 10 and 20%) Yb^{3+} were synthetized by co-precipitation method. To determine the changes in structure and optical properties depending on Yb concentration, appropriate methods were used. The x-ray diffraction patterns confirmed the cubic structure of the fluorite within all Yb^{3+} concentration range, although slight lattice distortions were observed at higher doping levels. The transmission electron microscopy images revealed well dispersed nanoparticles with an average size of 9 nm for the 5% dopant concentration. The emission spectra exhibited the typical near-infrared emission of Yb^{3+} ions.. Preliminary measurements of thermoluminescence curves have been carried out to investigate the existence of defects that could be used as trapping centers in the PersL process. These results highlight the potential of CaF_2:Yb nanoparticles which will be used in the next steps of research as base materials to provide after proper co-doping the UC-induced PersL effect.

P-19

Europium-doped yttrium molybdate: from synthesis to advancements in luminescence thermometry

<u>T. Gavrilović</u>[1*], V. Đorđević[1*], A. Ćirić[1], M. Medić[1]. Z. Ristić[1], Ž. Antić[1], M. Dramićanin[1]

[1]*Center of Excellence for Photoconversion, Vinča Institute of Nuclear Sciences-National Institute of the Republic of Serbia, University of Belgrade, 11001 Belgrade Serbia*

* corresponding authors: tamarag@vin.bg.ac.rs, vesipka@vin.bg.ac.rs

Keywords: phosphor; luminescence thermometry; molybdates; europium; principal component analysis

Herein, $Y_{2-x}Eu_xMo_3O_{12}$ (x = 0.04; 0.16; 0.2; 0.4; 0.8; 1; 1.6; 2) was synthesized via solid-state reaction. Structural, morphological, and optical properties were examined with varying Eu^{3+} concentrations. Luminescence thermometry was also investigated, incorporating machine learning to improve temperature sensitivity and accuracy.

X-ray diffraction showed that the replacement of Y^{3+} with larger Eu^{3+} resulted in a transformation from orthorhombic (low doping concentrations) through tetragonal (high doping concentrations), reaching a monoclinic structure for complete replacement in $Eu_2Mo_3O_{12}$. The intensity of Eu^{3+} red emission slightly increases in the orthorhombic structure, then rises significantly with dopant concentration, and has the highest value for the tetragonal $Y_2Mo_3O_{12}$:80mol% Eu^{3+}. The complete substitution of Y^{3+} with Eu^{3+} in monoclinic $Eu_2Mo_3O_{12}$ leads to decreased emission intensity and lifetime.

Temperature-sensing properties of the sample with the highest red Eu^{3+} emission, $Y_2Mo_3O_{12}$:80mol% Eu^{3+}, were analyzed by the luminescence intensity ratio method. The peak-sharpening algorithm was introduced for the first time in luminescence thermometry to separate overlapping peaks, offering an alternative to the traditional peak deconvolution method. The maximal relative sensitivity (Sr) of 2.8 % K^{-1} was obtained at room temperature. Further, we studied the performance of principal component analysis (PCA) on the 80mol% Eu^{3+}-doped $Y_2Mo_3O_{12}$ luminescent probe, contrasting it with the traditional luminescence intensity ratio (LIR) method. By employing PCA to analyze the full emission spectra collected at varying temperatures, we achieve an average accuracy (ΔT) of 0.9 K and a resolution (δT) of 1.0 K, significantly outperforming the LIR method, which yielded an average accuracy of 2.3 K and a resolution of 2.9 K. Our findings demonstrate that while the LIR method offers a maximum Sr of 0.5 % K^{-1} at 472 K, PCA's enhances the reliability of temperature measurements, marking a crucial advancement in luminescence thermometry.

Acknowledgement: The authors would like to acknowledge funding from the Ministry of Science, Technological Development, and Innovation of the Republic of Serbia under contract 451-03-136/2025-03/200017 and by the Science Fund of the Republic of Serbia, #GRANT No 7017, Technology For Remote Temperature Measurements In Microfluidic Devices-REMTES.

NEW INSIGHTS INTO THE Ln-Ln ENERGY TRANSFER PROCESS IN COORDINATION COMPOUNDS WITH A SHORT CARBONYL BRIDGE

A. N. Carneiro Neto[1]*, A. Lipa[2], Y. H. Pham[2], L. Jerzykiewicz[2], A. Bieńko[2], V. A. Trush[3], V. M. Amirkhanov[3], O. L. Malta[4], P. Gawryszewska[2]*

[1]*Department and CICECO-Aveiro Institute of Materials University of Aveiro, 3810-193 Aveiro, Portugal,*

[2]*Faculty of Chemistry University of Wroclaw, 50-383 Wroclaw, Poland,*
[3]*Department of Chemistry Kyiv National Taras Shevchenko University, 01601 Kyiv, Ukraine*
[4]*Departamento de Química Fundamental, Universidade Federal de Pernambuco, 50740-560 Recife, Brazil*

* corresponding author: *paula.gawryszewska-wilczynska@uwr.edu.pl*, *albanoneto@ua.pt*

Keywords: lanthanide, energy transfer, crystal structure, antenna effect, single-molecule magnet

Modern technologies take advantage of the luminescence of lanthanide (Ln^{3+}) compounds, which, however, requires sensitization due to its low brightness. One way of sensitization is the so-called antenna effect, in which organic ligands play the role of excitation energy donors. This is a complex process due to the different nature of the donor and acceptor and the multitude of competing processes.

We propose a new concept of Tb→Eu and Nd→Yb energy transfer in compounds of the type **$[Ln_2L_6]$** and **$[Ln_2L_5(H_2O)]NO_3$** (L - N-(diphenylphosphoryl)-pyrazine-2-carboxamide) with an antenna effect and single-molecular magnet (SMM) behaviour, in which the Ln^{3+} ions are connected by a short bridge (distance 3.8 Å). This helps to explain the unexpected extension of the donor lifetime in the presence of an acceptor. Understanding and controlling this process are important because of the possibility of creating systems sensitive to stimulating multicolor emission through external stimuli such as pressure or temperature. Moreover, lanthanide coordination compounds with effective antenna effects and multifunctional optical-magnetic activity are highly suitable for potential applications.

The research includes: determination of crystal structure, radiative lifetime, intrinsic and overall emission quantum yield, electron properties of Ln^{3+} compounds by using time-dependent density functional theory (TD-DFT), intramolecular energy transfer (IET) rates. Based on the IET and the rate equation model, the overall emission quantum yield was simulated and new intramolecular transfer pathways and mechanisms were proposed.

STABLE AND HIGHLY EFFICIENT NANO-YAG:Ce^{3+} PHOSPHORS

<u>Z. Gijsberg</u>[1], V. Khanin[1], F. Montanarella[1], A. Sontakke[1], J. Mulder[1], J. Floreal[1], J. Kong[1], L. Rodriguez[1], D. Lenting[1], V. Favale[1], M. Tachikirt[1], M. Krames[1,2], M. van de Haar[1,*]

[1]*Seaborough Materials Research B.V., Science Park 106, Amsterdam, 1098 XG, The Netherlands*

[2]*Arkesso LLC, 2625 Middlefield Road, No. 687, Palo Alto, California 94306, United States*

* *Corresponding author: m.vandehaar@seaborough.com*

Keywords: YAG:Ce, nanoparticles, luminescence, LEDs,

$Y_3Al_5O_{12}:Ce^{3+}$ (YAG:Ce^{3+}) is widely used in white LEDs due to its intense green-yellow emission, high robustness, strong blue light absorption, and exceptional stability. As LED chips continue to shrink into mini- and micro-LED formats, there is a growing demand for wavelength converters at the nano- to submicron scale. While nano-sized YAG:Ce^{3+} shows promise, conventional synthesis methods often produce agglomerated or irregular particles with low absorption, poor energy conversion efficiency, and limited long-term stability.

At Seaborough, we have addressed these challenges by optimizing synthesis and protected annealing processes. Our nano-YAG:Ce^{3+} materials exhibit near-unity luminescence quantum efficiency, with precise size control from several hundred nm down to 10–20 nm. We detail how different synthesis routes and post-treatment methods affect quantum yield and stability. The enhanced performance is attributed to lattice densification, surface passivation, and improved Ce^{3+}/Ce^{4+} ratios.

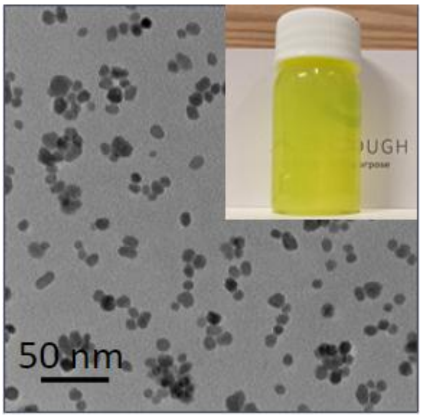


Fig. 1 Transmission electron microscopy image of nano-YAG:Ce^{3+} and (inset) digital photograph of a colloidal dispersion of YAG:Ce^{3+} nanoparticles

[1] A. C. Berends, M. A. van de Haar, M. R. Krames. *Chem. Rev.* **120** (2020) 13461.

2,2′-Bipyridine *N,N*′-dioxide as a perspective rigid O-donor platform for transition- and f-metal complexes

<u>P. Godlewska*,</u>[1] W. Sąsiadek[1], E. Kucharska[1], P. Ropuszyńska-Robak[1], L. Dymińska[1], J. Hanuza[2], M. Ptak[2]

[1] *Department of Bioorganic Chemistry, Faculty of Production Engineering, Wrocław University of Economics and Business, 118-120 Komandorska str., 53-345 Wrocław, Poland*

[2] *Institute of Low Temperature and Structure Research, Polish Academy of Sciences, 2 Okólna str., 50-422 Wrocław, Poland*

* corresponding author: *patrycja.godlewska@ue.wroc.pl*

Keywords: *N*--oxide, O-donor ligands, metal complexes, DFT and spectroscopic analysis

2,2′-Bipyridine *N,N*′-dioxide (BPDO) consists of two pyridine *N*-oxide rings [1] linked by a C–C bond, yielding a planar, centrosymmetric scaffold with a fixed O···O separation. Each N→O group acts as a strong and hard Lewis base, allowing (BPDO) to bind metals either by coordinating through both oxygen atoms (as a chelate), or more commonly, by bridging between two metal centers to form one-, two-, or three-dimensional coordination networks.

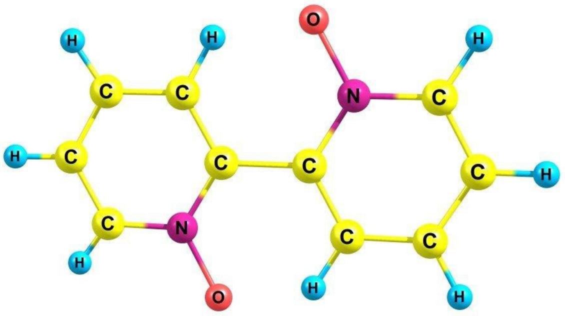


Fig. 1. Structure of the 2,2′-Bipyridine *N,N*′-dioxide (BPDO)

BPDO readily assembles mono-, di- and polynuclear complexes with a broad spectrum of 3d metals—including Fe(II/III), Co(II), Ni(II), Cu(II), Zn(II) and Mn(II), highlighting its versatility as an O-donor ligand. For lanthanide ions, BPDO supports eight- or nine-coordinate geometries and builds topologically rich networks [2]. The combination of rigid geometry, dual O-donor capacity and π-conjugation therefore makes BPDO a versatile building block for magnetic exchangers, luminescent sensors and robust porous materials, enriching the functional landscape of heteroaromatic *N*-oxide chemistry. The studied compounds have been determined by quantum chemical DFT analysis. The 6-311 G(2d,2p) basis set with the B3LYP functional has been used to discuss their optimized structure and vibrational dynamics. Their IR and Raman spectra have been measured and compared to the calculated wavenumbers and to those of similar compounds previously reported by us [3]. Normal modes of NO and pyridine rings have been identified together with the PED values. As well as electron UV-Vis and ^{1}H and ^{13}C NMR spectra were measurements.

[1] Long *et al*., *Chem. Commun.*, 2000

[2] González Mantero, Neels, Stoeckli-Evans, *Inorg. Chem.* 45 (2006) 3287–3294

[3] I. Bryndal, E. Kucharska, W. Sąsiadek, M. Wandas, T. Lis, J. Lorenc, J. Hanuza, *Spectrochim. Acta A.* 96 (2012) 952.

P-23

Loganic acid as a versatile O-donor ligand for transition- and f-metal complexes

P. Godlewska[1], **W. Sąsiadek**[1], **J. Michalski**[1], **P. Ropuszyńska-Robak**[1], **L. Dymińska**[1], **A. Zając**[1], **J. Hanuza**[2], **M. Ptak**[2], **J. Janczak**[2],

[1] *Department of Bioorganic Chemistry, Faculty of Production Engineering, Wrocław University of Economics and Business, 118-120 Komandorska str., 53-345 Wrocław, Poland*

[2] *Institute of Low Temperature and Structure Research, Polish Academy of Sciences, 2 Okólna str., 50-422 Wrocław, Poland*

* corresponding author: *patrycja.godlewska@ue.wroc.pl*

Keywords: loganic acid, O-donor ligand, transition metal complexes, green oxidation catalysis

Loganic acid (LA), a naturally occurring iridoid monoterpenoid ($C_{10}H_{16}O_4$), combines a hydroxy-substituted lactone ring with a free carboxylate group. These two oxygen-rich sites make LA an attractive, yet underexplored, O-donor ligand for coordination chemistry. Preliminary work on the LA/Me(III) confirms that mild, aqueous conditions suffice to generate stable, neutral chelates, suggesting broader applicability to other metal ions.

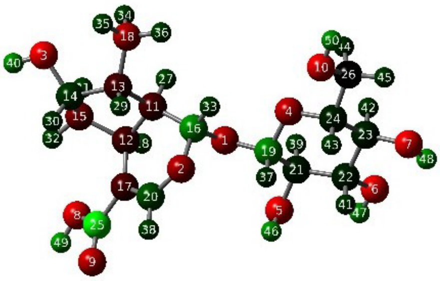


Fig. 1. Structure of the loganic acid

Because the lactone carbonyl and carboxylate can act either in a κ²-(O,O′) chelating fashion or as separate monodentate donors, LA is expected to support octahedral 3 d metals (e.g. Cr^{3+}, Fe^{3+}, Co^{2+}, Ni^{2+}). Mixed N/O coordination spheres attainable via ancillary ligands could modulate redox potentials, opening avenues for green oxidation catalysis or electrochemical sensing.Synthetic access is straightforward: neutral-pH complexation of LA with metal carbonates or acetates in water/ethanol, followed by gentle heating and slow cooling to induce crystallisation. Standard spectroscopic tools (UV–Vis, FT-IR, Raman, NMR) and single-crystal X-ray diffraction will clarify binding modes and lattice structure. The studied compounds have been determined by quantum chemical DFT analysis. In summary, loganic acid offers a sustainable ligand platform merging natural-product functionality with the structural versatility required for modern coordination, catalytic and biomedical applications.

[1]. Zając, A., Michalski, J., Ptak, M., Dymińska, L., Kucharska, A. Z., Zierkiewicz, W., & Hanuza, J. (2021). Molecules, 26(22), 7027. https://doi.org/10.3390/molecules26227027

[2]. Dzydzan, O., Brodyak, I., Sokół-Łętowska, A., Kucharska, A. Z., & Sybirna, N. (2020). Life, 10(12), 349. https://doi.org/10.3390/life10120349

[3]. Danielewski, M., Matuszewska, A., Nowak, B., Kucharska, A. Z., Sozański, T., 2020, 2735790, 12 pages, 2020. https://doi.org/10.1155/2020/2735790

[4]. Kwaśniewska, M., Waśkiewicz, A., & Drygas, W. (2023). 12(8), 1598. https://doi.org/10.3390/antiox12081598

P-24

LUMINESCENT PROPERTIES OF Cu IONS IN YAG, YAP, AND Al_2O_3 SINGLE CRYSTALLINE FILMS STUDIED BY CONVENTIONAL AND SYNCHROTROM BASED SPECTROSCOPY

<u>V. Gorbenko</u>[1,*], S. Witkiewicz-Łukaszek[1], T. Zorenko[1], Yu. Zorenko[1]

[1]*Department of Physics, Kazimierz Wielki University, Bydgoszcz, 85-090, Poland*
* corresponding author: gorbenko@ukw.edu.pl

Keywords: Liquid phase epitaxy, single crystalline film, YAG, YAP, Al_2O_3, Cu^+, Cu^{2+} dopant luminescence, synchrotron radiation.

Copper-doped oxide materials continue to attract considerable interest for their potential applications in photonics, scintillators, and solid-state lighting. This study systematically investigates the luminescent behaviour of copper ions incorporated into single-crystalline films (SCF) of $Y_3Al_5O_{12}$ garnet (YAG), $YAlO_3$ perovskite (YAP), and Al_2O_3 sapphire, grown using the liquid phase epitaxy (LPE) method from PbO-B_2O_3 flux. The films were doped with copper during LPE growth in 0.1-1% range, enabling controlled incorporation of Cu ions into specific crystallographic sites of mentioned oxide hosts.

The optical properties of SCF samples were studied using both conventional spectroscopic techniques and synchrotron-radiation (SR) based luminescence spectroscopy with aim to evaluate their potential for optical and scintillation applications. Initial characterization included absorption, cathodoluminescence, and photoluminescence (PL) measurements, as well as evaluation of scintillation light yield (LY) and decay kinetics at room temperature.

Distinct emission bands attributed to Cu^+ and Cu^{2+} ions were identified, with their spectral positions and intensities strongly dependent on the host matrix and coordination environment. In YAG and YAP, broad emissions in the visible range were observed and assigned to the $3d^{10} \rightarrow 3d^9 4s^1$ transitions of Cu^+ [1], while in Al_2O_3, while in sapphire, narrower emissions suggested the presence of Cu^{2+} d-d transitions [2] (Fig.1). The lifetime measurements revealed significant differences in decay kinetics across the three hosts, reflecting the varying local crystal field strengths and site symmetries. The SCFs exhibited also different scintillation decay kinetics and LY efficiencies, reflecting the influence of host structure and defect environment [1, 2].

To gain deeper insight into the excitation mechanisms and electronic structure, luminescence properties SCFs under study were further investigated under SR excitation in the 3.7–25 eV range at the Superlumi station at DESY (Germany) [3]. PL excitation spectra under SR excitation provided detailed information on energy transfer processes, fundamental absorption edges, and trap-related states, highlighting differences in excitation efficiency and recombination pathways among the studied hosts. Thermal quenching behaviour and energy transfer mechanisms were also analyzed.

The combined use of conventional and SR-based spectral methods enabled a comprehensive understanding of the luminescence processes in Cu-doped oxide films. These researches provide insights into host-dependent tuning of copper-related luminescence and demonstrated and the suitability and potential of these materials for advanced optical and scintillation applications.

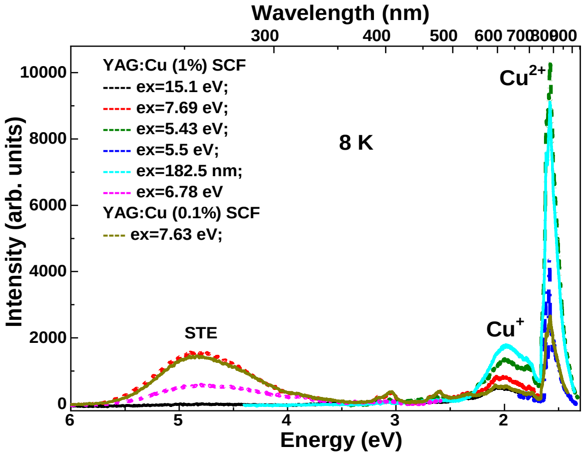


Fig.1. Emission spectra of YAG:Cu (0.1%) and YAG:Cu (1%) (2) SCF under excitation by SR with different energies.

1. Blasse, G., & Grabmaier, B. C. *Luminescent Materials*. Springer, 1994.
2. Dorenbos, P. *J. Lumines.* **91** (2000) 155–176
3. Zimmerer, G. *NIM A*, **308** (1991) 178–183.

Acknowledgments: The investigations was performed in the frameworks of Polish NCN 2022/45/B/ST8/ 01757 project and also supported by the MNiSW of Poland in frame of nr RID/SP/ 0048/2024/01 project.

P-25

Thermoluminescent Properties of $LaAlO_3$ Doped with Cr^{3+}, Sm^{3+}, and Er^{3+}

D. Grzesiak*, **E. Zych**, **J. Zeler**

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

* corresponding author: *340666@uwr.edu.pl*

Keywords: $LaAlO_3$, thermoluminescence, luminescence thermometry, nanoparticles

Lanthanum aluminate doped with Cr^{3+}, Sm^{3+} and Er^{3+} ions is a perovskite-type phosphor that exhibits luminescence across the spectral range from green to near-infrared (NIR). When properly activated, they show efficient emission of thermoluminescent light following exposure to external irradiation, such as X-rays or UV radiation [1].

We synthesized nanoparticles of $LaAlO_3:Cr^{3+},Sm^{3+},Er^{3+}$ and investigated their physicochemical properties. The structural and luminescence characteristics were analyzed using X-ray diffraction (XRD), scanning and transmission electron microscopy (SEM and TEM, respectively), photoluminescence (PL), and thermoluminescence (TL). The experimental results indicate that these triply doped nanoparticles exhibit promising afterglow properties following X-ray irradiation (see Figure 1).

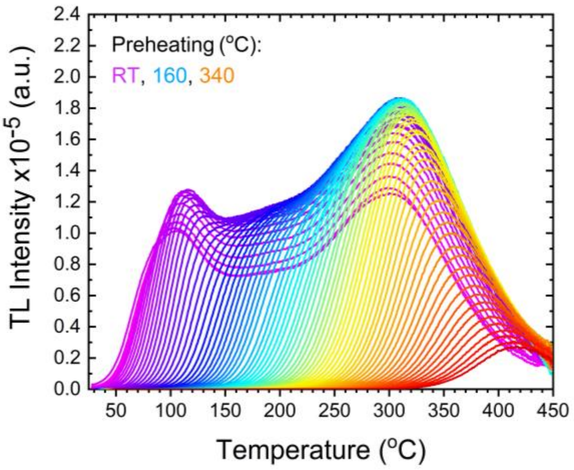


Figure 1. TL glow curves as a function of the preheating temperature in the range of RT-390 ℃ (the T_{max}-T_{stop} experiment) of $LaAlO_3:Cr^{3+},Sm^{3+},Er^{3+}$ after X-ray irradiation.

Furthermore, the thermoluminescence of this material after X-ray irradiation shown the presence of two very broad and overlapping TL peaks covering the temperature range of RT-450 ℃ with maxima around 115 ℃ and 310 ℃. The efficient TL suggest their potential application as persistent luminescence thermometry.

This poster presentation will highlight our findings on luminescence of (Cr^{3+},Sm^{3+},Er^{3+})-doped $LaAlO_3$, emphasizing their thermoluminescence properties.

[1] M.Pellerin, E. Glais, T. Lecuyer, J. Xu, J. Seguin, S. Tanabe, C. Chanéac, B. Viana, C. Richard, *J. Lumin*. **202** (2018) 83.

Acknowledgments: This research was funded by National Science Centre, Poland under OPUS grant no. 2023/49/B/ST5/04265.

P-26

Site-selective occupancy of Cr^{3+} enabling ultra-broadband near-infrared luminescence in $Mg_2TiO_4:Cr^{3+}$

F. He[1,2], W. Hu[1], D. Poelman[1,*]

[1]LumiLab, Department of Solid State Sciences, Ghent University, Ghent, 9000, Belgium
[2]State Key Laboratory of Luminescent Materials and Devices, Guangdong Provincial Key Laboratory of Fiber Laser Materials and Applied Techniques, South China University of Technology, Guangzhou 510641, China

* corresponding author: Dirk.Poelman@ugent.be

Keywords: near-infrared, chromium, phosphor-converted light-emitting diode, tissue imaging

Broadband near-infrared (NIR) phosphors have attracted significant attention for their potential application in next-generation NIR light sources. However, exploring highly efficient luminescent materials with targeted broadband NIR emission remains a great challenge. In this study, $Mg_2TiO_4:Cr^{3+}$ is designed and optimized as a NIR phosphor with a very large full width at half maximum (FWHM) emission spectrum, by site selective occupancy of Cr^{3+}. Although low Cr^{3+} concentration samples exhibit a relatively narrow far-red band at around 700 nm, a broad NIR band becomes dominant with increasing Cr^{3+} concentrations. At low doping levels, Cr^{3+} ions tend to substitute into the $[TiO_6]$ octahedral sites with a strong crystal field environment. With increasing Cr^{3+} concentration, the substitution gradually shifts toward the $[MgO_6]$ octahedra, which possess weaker crystal field, resulting in the redshift and spectral broadening. Therefore, the emission spectra vary from narrowband to a remarkably broad NIR emission centered at ~900 nm, with a FWHM expanding to 305 nm. In this work, partial substitution of Ti^{4+} by Sn^{4+} was used to break the inversion symmetry of the Cr^{3+} centers for greatly improving the probability of the parity-forbidden 3d–3d transitions of Cr^{3+}, resulting in a ~1.7-fold enhancement in emission intensity. Finally, a NIR phosphor-converted light-emitting diode was fabricated through combining the optimal $Mg_2Ti_{0.6}Sn_{0.4}O_4:0.01Cr^{3+}$ phosphor with a blue LED, showing great potential in deep tissue imaging applications.

This research is funded by FWO (Fund for Scientific Research-Flanders), project G025322N.

LUMINESCENCE OF Eu^{3+},Gd^{3+}, AND Tb^{3+} DOPED $CaMoO_4$: OVERCOMING THE CHARGE COMPENSATION ISSUES

D. Hreniak[1], A. Musiałek[1], M. Chaika[1], J. Hölsä[1,2*]

[1]Institute of Low Temperature and Structure Research, PAS, PL-50-422 Wrocław, Poland
[2]Department of Physics, University of the Free State, ZA-9301 Bloemfontein, South Africa

* corresponding author: *jholsa@utu.fi*

Keywords: Persistent, Luminescence, Charge Compensation, Structure

The usual composition of a Luminescence material – including the Persistent Luminescence (PersLum) ones – consists of a **stable** and **affordable host** and **small amount**(s) of **dopant**(s) (even a rare earth one) as impurities. The dopants present no real **financial** problems because of their low amounts. In contrast, the price of the host materials has led to a quest for **cheaper**, more accessible and versatile materials. First hosts to disappear will be the pure rare earth (R^{3+}) compounds (eg R_2O_3). Due to chemical similarity (& size), the lavish and (spectroscopically) inert *alkaline earth (eg Ca^{2+}, Sr^{2+} and Ba^{2+}*) compounds are now under revaluation. The main issue is the **mismatch** (***Vegard's 1st rule***) between the charge of the efficient R^{3+} dopant and the M^{II} host cation can be solved by using divalent Eu^{2+} (/Sm^{2+}/Yb^{2+}) dopants. In late 1960s (*sic!*), it was suggested that this issue can be circumvented by applying the simple **2+2 = 1+3 rule**. Instead of the chemical symbols - for those not familiar with those, their charges can also be used giving for $M^{II}MO_4$:R^{3+} Ca^{2+}+Ca^{2+}=$\mathbf{Na}^{+}$+ R^{3+} where Na^{+} implies the **charge compensation**. However, it is now *more important* to take care that ***Vegard's 2nd rule*** on the ionic sizes is obeyed (with a tolerance ±5%). ***Vegard's 3rd rule on the similar structure (of the end members) in the (Na^{+}-Ca^{2+}-R^{3+}) series*** may become more actual as well though not paid any attention for a number of reasons/excuses**.** ***May that be as it is, the relaxation of the charge rule widens the choice for new host materials, dopants etc.***

The purpose of this contribution dealing with the **Na^{+} co-doped $CaMoO_4$:Eu^{3+}/Gd^{3+}/Tb^{3+}** is to demonstrate that the 2+2 = 1+3 rule can really widen the use of M^{2+} based hosts to house the R^{3+} dopants in short (and expensive) supply - virtually only Eu^{3+}/Tb^{3+} at the moment. As a result, *ease of preparation* at as low temperatures as *80 °C in aqueous solutions*, *better structural* quality of the materials are achieved also avoiding uncertain and hazardous *charge compensation* between Ca^{2+} and R^{3+}. Eventually, ever *increased doping* concentrations due to the better cation *solid solubility* can be achieved. **All these *strengthen PersLum***. Besides, significant quenching of emission from the higher excited energy levels of Eu^{3+} and Tb^{3+} (red and green) lead to more *monochromatic emission* occurring practically only from the lowest excited 5D levels. Of course, not every improvement is needed for every application though new applications can now be developed.

As usual, nothing is free and more exact planning of the preparation of the Na^{+} co-doped $CaMoO_4$:R^{3+} phosphors is needed to *realize the maximum gain* from the use of the possibly more complex but more versatile and efficient $(Na_{1-x}Ca_{1-2x}R_{1+x})MoO_4$ phosphors.

The final impact of the new preparation method on the PersLum properties of the $CaMoO_4$:R^{3+} phosphors must be evaluated carefully. The creation of the *charged $[Na_{Ca}]^{\bullet}$ and $(R_{Ca})'$ form traps required by the PersLum* is the main development without any doubt. The simplicity of the ***doping achieved by chemical means*** can have no other than a positive effect.

P-28

PERSISTENT LUMINESCENCE OF $Lu_2O_3:Tb^{3+}$

G.E.G. Briuccia[1], V. Boiko[1], D. Hreniak[1], J. Hölsä[1,2*]

[1]Institute of Low Temperature and Structure Research, PAS, PL-50-422 Wrocław, Poland
[2]Department of Physics, University of the Free State, ZA-9301 Bloemfontein, South Africa

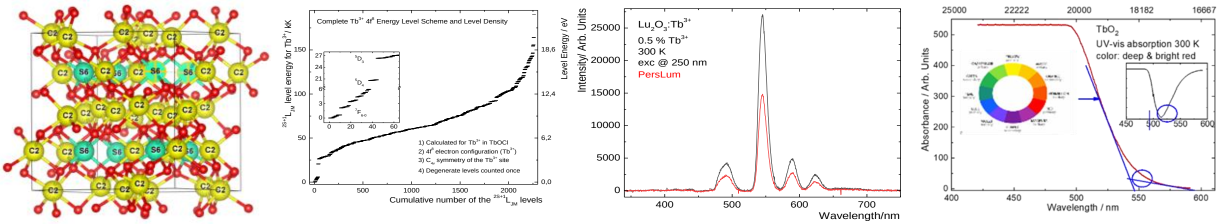
* corresponding author: *jholsa@utu.fi*

Keywords: Persistent, Luminescence, Terbium, Traps, Dopant Oxidaton

Persistent Luminescence (PersLum) (or afterglow or phosphorescence or whatever) has been known since the *pre BC age* **though** without characterization which followed for the **Bologna Stone** (impure $BaSO_4$ barite mineral in fact, *reduced BaS*) in the 17th century. More recent studies were invigorated by the pure rare earths (R) made available due to ^{235}U separation in 1950s for military applications. Some display phosphors (as *Eu^{2+} doped $M^{II}Al_2O_4$*) were *discarded* (by Philips) due to *strong afterglow* but they were rehabilitated in 1996 with *R^{3+} co-doping*. The basic excitation and emission characteristics had by then been studied by (too) many spectroscopists but the novelty, *persistence and energy storage were not understood at all*. A new field due to *defects in structure and composition* were (and still are) out of the comfort zone of people working on the 3rd aspect of luminescence (time). Mechanisms based on the *in situ REDOX changes* involving Eu^{2+}/Eu^{3+} (more generally: $R^{2+}/R^{3+}/R^{IV}$) were assumed to take place *during* the energy storage. In 1997, these *delusions* lead to a *naïve Eu^+* revealing the very thin knowledge of authors on the R^{n+} materials. *No smoke without fire though*, the REDOX of R^{3+} may take place *during the phosphor making due to impurities* (air, humidity) but **NOT** *during the energy storage* since then the REDOX processes have insufficient energies in the typical working conditions (room temperature/vis-UV irradiation).

In this report, the fascinating **PersLum properties** are described for the $Lu_2O_3:Tb^{3+}$ *powder* phosphors. First, Tb^{3+} is **oxidized** *in part* due to post-annealing either by airborne humidity (or O_2) to *Tb^{IV}* followed by **charge compensation**: the excess positive charge by the oxidic agents creating **Tb^{IV}_{Lu}–O^{2-}-Tb^{IV}_{Lu}** chains (*space permitting*). These defects act as *positive* and *negative* traps (Kröger-Vink notations: $O^{\bullet\bullet}$ and Tb′, respectively) attracting charge carriers (e^- and h^+). Energy to **fill the traps** is provided by vis-UV **irradiation** (excitation) and traps are **emptied by thermal energy** eventually yielding PersLum.

Ionic radii of the species involved are 1.04, 0.977, & 0.88 Å (CN 6) for Tb^{3+}, Tb^{IV}, & Lu^{3+} in cubic C-type Lu_2O_3. Since CN 6 is low for a large Tb^{3+}, the **driving force** to the $Tb^{3+} \rightarrow Tb^{IV}$ oxidation comes mainly from the urge to relax structural stresses.



Figs. 1→4. Structure of Lu_2O_3, 3003 Tb^{3+} cf levels, $^5D_4$ emission of Tb^{3+}, Tb^{IV} absorption.

PersLum from the $^5D_3$ (& partly $^5D_4$) levels is **quenched by Tb^{IV}** absorption in UV, blue (and green). Tb^{3+} PersLum is **short, weak and polychromatic**. **Fierce Competition** between **emitting Tb^{3+}** and **trapping Tb^{IV}** species requires difficult **control of dopant distribution**.

A ratiometric and lifetime-based near-infrared luminescent thermometer based on structural phase transition in $Na_3Sc_2(PO_4)_3$:Yb^{3+}

Anam Javaid[1*], Maja Szymczak[1], Malgorzata Kubicka[1], Justyna Zeler[2], Vasyl Kinzhybalo[1], Marek Drozd[1], Damian Szymanski[1], Lukasz Marciniak[1]

[1] Institute of Low Temperature and Structure Research, Polish Academy of Sciences,

Wrocław, 50-422, Poland

[2]Faculty of Chemistry, University of Wroclaw, Wroclaw, 50-383 Poland

* corresponding author: *a.javaid@intibs.pl*

Keywords: luminescent manometer, luminescence thermometry, optical sensors, ratiometric approach

The ratiometric approach is the most commonly utilized approach for remote temperature sensing in luminescent thermometery[1]. Being self-referenced and cost effective, it is easier to implement by using affordable spectrometers or even digital cameras. However, this approach has one significant limitations: the risk of measurement disturbance in thermometers where emission bands are highly spectrally separated due to dispersion in the surrounding medium [2]. To overcome these limitations, we propose a luminescent thermometer based on the structural phase transition in $Na_3Sc_2(PO_4)_3$:Yb^{3+}. The incorporation of Yb^{3+} ions as dopants in $Na_3Sc_2(PO_4)_3$ host lattice along-with changes in energies of Stark levels resulting from thermally induced phase transition from low temperature monoclinic (α) to high temperature trigonal (β) phases lead to the development of a ratiometric thermometer achieving high value of relative sensitivity reaching upto S_{Rmax}=1.5% K^{-1} at 340 K for $Na_3Sc_2(PO_4)_3$:0.1%Yb^{3+}. In addition, the structure phase transition has been shown to change the probability of the radiative depopulation process of $^2F_{5/2}$ excited state of Yb^{3+} ions, thereby enabling the development of lifetime-based luminescent thermometer achieving high value of the relative sensitivity reaching upto S_{Rmax}=1.2% K^{-1} at 355 K for $Na_3Sc_2(PO_4)_3$:1%Yb^{3+}. Furthermore, phase transition temperature and thus the thermometric performance of $Na_3Sc_2(PO_4)_3$:Yb^{3+} can be systematically tuned by altering the concentration of Yb^{3+} ions, thereby providing the enhanced flexibility for tailoring the host material to specific application requirements.

[1] L. Marciniak, K. Kniec, K. Elzbieciak-Piecka, K. Trejgis, J. Stefanska and M. Dramicanin, *Coord. Chem.* **469** (2022) 214671.

[2] A. Javaid, M. Szymczak, M. Kubicka, J. Zeler, V. Kinzhybalo, M. Drozd, D. Szymanski, L. Marciniak, *Journal of Materials Chemistry C.* **13** (2025) 9174-9184.

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

Exploring the Synergy Between Thermoluminescence and Luminescence Thermometry – Can We Combine Them for a Common Goal?

D. Jurkowska*, **E. Zych, J. Zeler**

Faculty of Chemistry, University of Wroclaw, Wroclaw, 50-137, Poland

* corresponding author: *345333@uwr.edu.pl*

Keywords: Thermoluminescence, Luminescence Thermometry

Temperature is one of the most important physical parameters influencing the behavior of biological and engineering systems. It is an inseparable parameter for the processes of thermoluminescence and luminescence thermometry [1].

The persistent luminescence phenomenon is a delayed emission of light that occurs mainly in semiconductors and insulators with a large bandgap. The energies of their electronic levels (occupied or empty) should be precisely engineered compared to the valence and conduction bands of the entire system. Such levels can act as traps for charge carriers. When the traps are filled as a result of irradiation, persistent luminescence at ambient temperature may be produced for a long time. The probability of releasing charge carriers from the trap is strongly dependent on temperature [2]. Luminescence thermometry, on the other hand, allows for non-invasive, high-resolution temperature monitoring e.g. inside living cells under physiological conditions [3].

The combination of thermoluminescence and luminescence thermometry has a great potential in the diagnostics and treatment of cancers, in our study the melanoma and breast cancer. Using materials based on perovskites triple-doped with Cr^{3+} ions and thoughtfully selected Ln^{3+} ions we can create a nanomaterial that potentially generates thermoluminescent light for diagnostic purposes, and, simultaneously, allows for reading the temperature of specific cells/organelles for treatment/targeted treatment of cancer cells.

[1] C. D. S. Brites, P. P. Lima, N. J. O. Silva, A. Millán, V. S. Amaral, F. Palacio, L. D. Carlos, *Nanoscale* **4** (2012) 4799.
[2] S. W. S. McKeever, *Thermoluminescence of Solids*, (1985).
[3] R. Piñol, J. Zeler, C. D. S. Brites, Y. Gu, P. Téllez, A. N. Carneiro Neto, T. E. da Silva, R. Moreno-Loshuertos, P. Fernandez-Silva, A. I. Gallego, L. Martinez-Lostao, A. Martínez, L. D. Carlos, A. Millán, *Nano Lett* **20** (2020) 6466.

This research was funded by National Science Centre, Poland under OPUS grant no. 2023/49/B/ST5/04265.

Ytterbium-based coordination compounds: Solid-state emission quantum yield measurement approach

Ewa Kasprzycka[1*], **Albano N. Carneiro Neto**[2], **Jarosław Komar**[3], **Nataliia Kariaka**[4], **Vasyl Kinzhybalo**[3], **Viktor A. Trush**[4], **Volodymyr M. Amirkhanov**[4], **Oscar L. Malta**[5], **Paula Gawryszewska**[1]

[1]*Faculty of Chemistry University of Wroclaw, Wrocław 50-383, Poland*
[2] *Physics Department and CICECO-Aveiro Institute of Materials University of Aveiro, Aveiro 3810-193 Portugal*
[3] *Institute of Low Temperature and Structural Research Polish Academy of Sciences Wroclaw, Wrocław 50-422, Poland*
[4]*Department of Chemistry Kyiv National Taras Shevchenko University, Kyiv 01033, Ukraine*
[5] *Departamento de Química Fundamental, Universidade Federal de Pernambuco, Recife 50590-470, Brazil*
* corresponding author: *ewa.kasprzycka2@uwr.edu.pl*

Keywords: ytterbium, emission quantum yield, energy transfer mechanism

This work presents experimental and theoretical results that enabled the proposal of a detailed energy transfer mechanism for Yb^{3+} complexes characterized by an unusually large energy gap between ligand excited states and the Yb^{3+} $^2F_{5/2}$ level. The investigated systems comprise Yb^{3+} compounds with N-phosphorylated carboxy- and sulfonamide ligands, specifically $Na[YbL_4]$ and $NEt_4[YbL_4]$ complexes, which exhibit remarkable photophysical properties despite the energetically unfavorable configuration.

A major experimental challenge in this study was the accurate determination of quantum yields for Yb^{3+} complexes with organic ligands. The characteristic NIR emission of Yb^{3+} around 1000 nm falls within a spectral region where detector sensitivity is significantly reduced, particularly for InGaAs photodiodes and photomultiplier tubes commonly used in luminescence spectroscopy. This low detector sensitivity in the Yb^{3+} emission range introduces substantial uncertainties in photoluminescence quantum yield measurements, making precise efficiency determinations extremely challenging.

Furthermore, the lack of suitable solid-state standards for NIR quantum yield measurements compounds these difficulties. While established liquid standards exist for visible light measurements, reliable solid-state reference materials for the 950-1100 nm range are scarce, limiting the accuracy of comparative quantum yield determinations for powder samples. This absence of appropriate standards represents a significant gap in current photophysical characterization methodologies for lanthanide-based solid materials.

Despite these experimental challenges, through careful spectroscopic analysis and theoretical DFT calculations, we demonstrate that the investigated complexes achieve remarkable emission sensitization efficiency and exhibit relatively long Yb^{3+} emission lifetimes on the order of several microseconds.

That provides new insights into energy transfer mechanisms in challenging energetic configurations and contribute to the rational design of efficient Yb^{3+}-based NIR-emitting materials, while highlighting the urgent need for improved experimental methodologies and standards for solid-state lanthanide photophysics.

P-32

Lutetium Orthophosphates as Radioluminescent Thermometers

A. Klecha[1], M. Witkowski[2], W. Drozdowski[2], E. Zych[1],
J. Zeler[1]

[1] University of Wroclaw, Faculty of Chemistry, 14 F. Joliot-Curie Street, 50-383 Wroclaw, Poland

[2] Faculty of Physics, Astronomy and Informatics, Nicolaus Copernicus University in Toruń, 5 Grudziądzka Street, 87-100 Toruń, Poland

Rare-earth-doped phosphors is a class of luminescent materials with diverse applications, including ionizing radiation detection and medical imaging. Their remarkable optical properties arise from the unique electronic configurations of lanthanide ions, which enable efficient emission. Among them, lutetium orthophosphate ($LuPO_4$) stands out due to its high density, excellent chemical stability, and favorable luminescence characteristics when doped with suitable lanthanide ions. These attributes make $LuPO_4$ a promising candidate for advanced ionizing radiation detection technologies [1].

$LuPO_4$:Eu exhibits interesting luminescent properties, especially upon exposure to ionizing radiation, partial reduction of Eu^{3+} to Eu^{2+} occurs, leading to modifications in the emission characteristics as presented in Figure 1 [2]. The combination of high emission efficiency and tunable oxidation states of the dopant, makes these materials highly suitable for potential applications as scintillation thermometers.

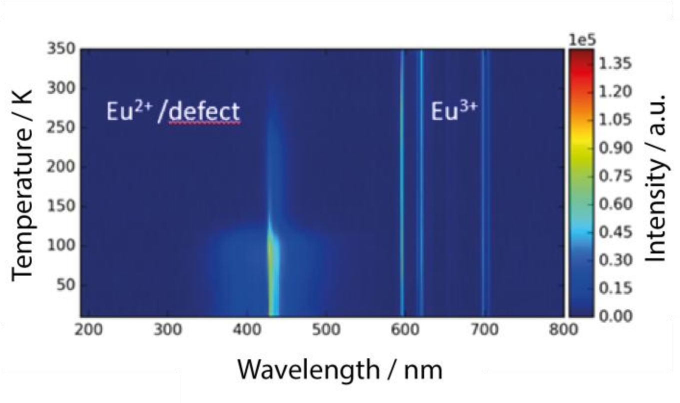


Figure 1. The radioluminescence spectra of $LuPO_4$:Eu phosphor in the temperature range of 15-350 K.

Scintillation thermometry is a temperature measurement technique based on the use of scintillation phenomena, primarily the emission upon exposure to ionizing radiation. This method can be considered useful in extreme conditions, such as the interiors of nuclear reactors, space or to improve control over radiotherapy by precisely monitoring the radiation dose and temperature of tissues [3]. We will show that Eu-doped $LuPO_4$ presents high resistance to radiation damage and the ability to detect temperature based on changes in radioluminescence characteristics.

1. Blasse, G., and Grabmaier, B. C. ”Luminescent Materials’’, Springer-Verlag, 1994, Berlin/Heidelberg.
2. Zeler, J., Meijerink, A., Kulesza, D., & Zych, E. Journal of Luminescence 207, 435-442, (2019)
3. Allison, S. W., and G. T. Gillies. Review of scientific instruments 68.7, 2615-2650, (1997).

This research was funded by National Science Centre, Poland under OPUS grant no. 2023/49/B/ST5/04265.

P-33

C-TYPE ULTRAVIOLET RADIATION FROM $LuF_3:RE^{3+}$: UV-C SCINTILLATORS FOR MEDICAL PHOTONICS

M. Kubaszewski[*], **J. Zeler, E. Zych**

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

[*] corresponding author: *352848@uwr.edu.pl*

Keywords: LuF_3:Pr; UV-C luminescence; cancer treatment

C-type ultraviolet (UV-C) radiation plays a key role in modern medical applications such as sterilization, disinfection, and phototherapy. Its use is increasingly being considered for the targeted destruction of cancer cells, which is the subject of the research project within which this study is being conducted. However, the search for stable, efficient, and biocompatible UV-C phosphors remains a challenge due to the complex requirements of biological and medical applications.

This presentation discusses the luminescent and scintillation properties of Pr/Yb-doped lutetium fluorides, $LuF_3:Pr^{3+}$, $LuF_3:Pr^{3+}$. Owing to the low phonon energy and high density, LuF_3 enables high absorption of X-rays and efficient UV-C emission from Pr^{3+} or Yb^{3+} ions.

The phosphors were synthesized via a hydrothermal method, with synthesis parameters optimized to obtain favorable powder morphology and uniform activator distribution. The presented photoluminescence and X-ray-induced radioluminescence spectra enable the identification of UV-C emission mechanisms and the assessment of energy conversion efficiency. The results indicate that $LuF_3:Pr^{3+}$ and $LuF_3:Yb^{3+}$ are promising UV-C emitters for applications in advanced medical photonics, particularly in the development of methods for precise radiation-based tissue targeting. Broader studies will be performed.

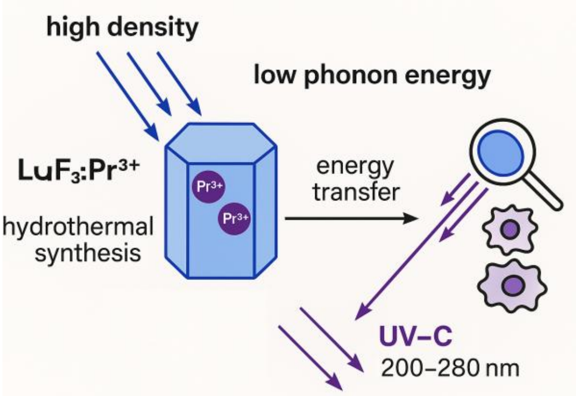


Figure 1. *From synthesis to medical photonics to make cancer treatment more efficient and safer.*

[1] C. Li, X. Liu, P. Yang, C. Zhang, H. Lian, J. Lin, *J. Phys. Chem. C,* **112(8)** 2008 2904-2910.

Acknowledgements: This research was funded by the National Science Centre, Poland (NCN), under the grant OPUS UMO-2024/53/B/ST5/02551.

P-34

LUMINESCENCE THERMOMETRY PERFORMANCE OF Pr^{3+} IN $Ca_3Sc_2Si_3O_{12}$ and $Ca_3Sc_2Ge_3O_{12}$ GARNETS

D. Kulesza[1*], **J. Zeler**[1], **M. Suta**[2], **E. Zych**[1,3]

[1]*University of Wroclaw, Faculty of Chemistry, 14. F. Joliot-Curie Street, 50-383 Wroclaw, Poland*

[2]*Inorganic Photoactive Materials, Institute of Inorganic Chemistry, Heinrich Heine University Düsseldorf, Universitätsstr. 1, D-40225 Düsseldorf, Germany*

[3]*Helmholtz-Zentrum Dresden-Rossendorf, Bautzner Landstrasse, 40001328 Dresden, Germany*

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

Keywords: luminescence thermometry, Pr^{3+} luminescence, wide range thermometry, garnets

As a rapidly growing technique, luminescence thermometry offers the possibility for remote and non-invasive temperature sensing for applications ranging from materials engineering to medical diagnostics [1]. Yet, a real challenge lies in combining wide-range operation, up to and beyond 1000 K, with high and stable thermal sensitivity and signal-to-noise [2]. However, it was very recently shown that $Sr_3Y_2Ge_3O_{12}:Pr^{3+}$ and $Sr_3Sc_2Ge_3O_{12}:Pr^{3+}$ garnets can indeed meet these requirements [3].

In this presentation we introduce the newest results for the next Pr^{3+}-activated garnet-type phosphors, $Ca_3Sc_2Si_3O_{12}$ and $Ca_3Sc_2Ge_3O_{12}$ [4]. We will show a comprehensive analysis of the temperature-dependent steady-state and time-resolved luminescence, accompanied by energy transfer modeling between the excited states of Pr^{3+}. The role of the host composition in shaping the temperature response of Pr^{3+} luminescence and thus its impact on key thermometric parameters will be thoroughly discussed. A relative thermal sensitivity exceeding $0.5\%\cdot K^{-1}$, sustained across nearly the entire temperature range from 10 K up to over 1200 K obtained for $Ca_3Sc_2Si_3O_{12}:Pr$ represents a remarkable achievement in luminescence thermometry.

These findings may serve as a foundation for the further development of Pr^{3+}-based luminescent thermometers, enabling precise temperature measurements in diverse scientific and technological domains.

[1] C. D. S. Brites, R. Marin, M. Suta, A. N. Carneiro Neto, E. Ximendes, D. Jaque, L. D. Carlos *Adv. Mater.* **35** (2023) 2302749.

[2] J. M. Herzog, D. Witkowski, D. A. Rothamer *Meas. Sci. Technol.* **32** (2021) 054008.

[3] P. Bolek, T. van Swieten, J. Zeler, A. Meijerink, E. Zych *Chem. Mater.* **36** (2024) 8894.

[4] D. Kulesza, J. Zeler, M. Suta, E. Zych *Chem. Mater.*, in revision.

Acknowledgments: This research was supported by the Polish National Science Centre (NCN) under grant no. UMO-2023/51/B/ST5/02341. M.S. gratefully acknowledges a scholarship by the "Young College" of the North-Rhine Westphalian Academy of Sciences, Humanities, and the Arts, as well as funding by an Exploration Grant of the Boehringer Ingelheim Foundation.

EFFECT OF OXIDE GLASS FORMERS ON THE OPTICAL PROPERTIES OF PHOSPHATE GLASSES FOR RED LIGHT GENERATION

M. Kuwik[1,*], **K. Dej**[1], **J. Pisarska**[1], **W.A. Pisarski**[1]

[1]*University of Silesia, Institute of Chemistry, Szkolna 9 Street, 40-007 Katowice, Poland*

* corresponding author: *marta.kuwik@us.edu.pl*

Keywords: phonon energy, visible luminescence, Eu^{3+} ions,

Recent advances in the research field of materials chemistry contributed to the increase in interest in phosphate systems doped with rare earth ions that have been studied for the following applications: light-emitting diodes LEDs, optical amplifiers, and solar cells [1-3]. These glasses have been extensively investigated due to unique characteristics such as a low melting point, low refractive index, and high transparency in the broad spectral range [4]. However, the application of phosphate glasses is often limited by low chemical durability and their hygroscopic properties that contribute to, among others, the lower luminescence for rare earth ions [5]. Therefore, searching for new compositions of phosphate systems with optimal structural, thermal, and spectroscopic properties while having acceptable chemical durability is still an important issue. One way to approach this goal is to introduce other oxide glass formers into the phosphate glass host.

This work comprehensively analyzed the influence of glass compositions on the optical properties of phosphate systems doped with Eu^{3+} ions. The effect of substituting the one glass former, P_2O_5, with the other one (such as GeO_2, B_2O_3, or TeO_2) was examined using luminescence spectroscopy. The excitation and visible emission spectra and luminescence decay curves for studied glass systems were registered. Based on the spectroscopic parameters such as phonon energy, fluorescence intensity ratio R/O, and measured lifetimes for the $^5D_0$ state of Eu^{3+} ions, the relationship between structural and optical properties of studied glasses was analyzed and discussed in detail. Additionally, Commission Internationale de I'Éclairage (CIE) chromaticity coordinates (x, y) were calculated in relation to the influence of glass formers on visible luminescence. Our results confirm that composition affects the properties of phosphate-based glasses doped with Eu^{3+} ions that can be suitable for red light generation.

[1] L. Han, J. Song, W. Liu, Z. Xiao, L. Zhang, A. Lu, Z. Xiao, W. You, Q. Zhang, *J. Lumin.* **227** (2020) 117559.
[2] G.S. Li, C.M. Zhang, P.F. Zhu, C. Jiang, P. Song, K. Zhu, *Ceram. Int.* **42** (2016) 5558.
[3] G. Li, C. Zhang, P. Song, P. Zhu, K. Zhu, J. He, *J. Alloys Compd.* **662** (2016) 89.
[4] V. Venkatramu, R. Vijaya, S.F. León-Luis, P. Babu, C.K. Jayasankar, V. Lavín, L.J. Dhareshwar, *J. Alloys Compd.* **509** (2011) 5084.
[5] I.A.A. Terra, A.S.S. de Camargo; L.A. de O. Nunes, R.A. Carvalho, M.S. Li, *J. Appl. Phys.* **100** (2006) 123103.

CATHODOLUMINESCENCE-BASED EVALUATION OF RADIATION-RESISTANT NANOPARTICLES

O. Lalinsky[1,*], **V. Vojta**[1], **X. Lytvynenko**[2], **V. Krzyzanek**[1]

[1] *Institute of Scientific Instruments of the CAS, Kralovopolska 147, Brno 612 64, Czech Republic*

[2] *Department of Nuclear Chemistry, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University in Prague, Brehova 7, Prague 115 19, Czech Republic*

* corresponding author: *xodr@isibrno.cz*

Keywords: cathodoluminescence, nanoparticles, decay, imaging

Luminescent nanoparticles (LNPs) show great promise for biomedical applications like bioimaging and photodynamic therapy (PDT) due to their optical properties, including photoluminescence and upconversion [1]. Garnet-based nanoparticles such as $Lu_3Al_5O_{12}$:Pr^{3+} are especially suited for X-ray induced PDTX in cancer treatment [2]. In SEM, fast luminescence decay improves cathodoluminescence (CL) image clarity and reduces blurring, while faster scanning lowers sample damage by minimizing local heating and charging [3].

We synthesized garnet and silicate nanoparticles using a photochemical method in an 80-liter reactor with 28 UV lamps, producing over 250 g per batch. Ce^{3+} and Pr^{3+} were chosen as dopants for bioimaging and PDTX. The ~30 nm particles were analyzed using a DualBeam FIB-SEM Helios G4 HP with Delmic SPARC CL detection and a specialized setup for measuring CL decay [4].

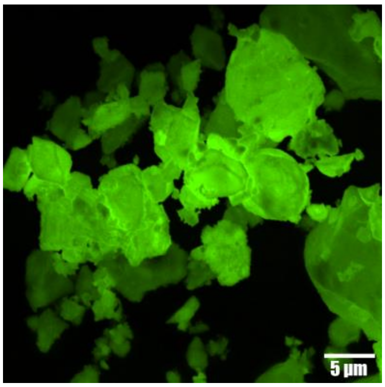


Fig. 1. $Y_3Al_5O_{12}$:Ce^{3+} (YAG:Ce) nanoparticles in CL imaging.

CL intensity varied between nanoparticles, likely due to charging and geometry-related effects. The particles remained stable under 10 keV beam exposure (0.26 A/m²) for several minutes with no degradation. Although clustering was observed, CL spectra were consistent across single particles and aggregates, confirming uniform luminescence.

These nanoparticles show strong potential for biomedical use. Improved sample preparation is needed to reduce clustering, charging, and working distance variability during SEM analysis.

[1]W. Chen and D. Cao. *Nanomaterials*. **13** (2023) 1047.
[2] K. Popovich, et al. *J. Photochem. Photobiol. B: Biol.* **179** (2018) 149.
[3] R.M. Reed and K.L. Milliken. *J. Sediment. Res.* **73** (2003) 328.
[4] J. Bok and P. Schauer, *Rev. Sci. Instrum.* **82**, (2011) 113109.

Acknowledgments: The research was supported by the Technology Agency of the Czech Republic (TN02000020); the infrastructure by the Czech Academy of Sciences (project RVO:68081731).

LUMINESCENCE THERMOMETRY PERFORMANCE OF $KMgLaTeO_6$ AND $NaMgLaTeO_6$ DOPED WITH $Tb^{3+}$and Mn^{4+}

P. M. Lewis[1,*], **M. Szymczak**[1], **L. Marciniak**[1]

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

* corresponding author: *p.lewis@intibs.pl*

Keywords: Luminescence thermometry, Tb^{3+}, Mn^{4+}, Temperature sensor, Luminescent thermometer

Luminescence thermometry has emerged as of one the most versatile optical techniques for remote or temperature measurements. It relies on analyzing the spectroscopic properties of specially designed luminescent materials, which exhibit temperature-dependent changes in their emission behaviours. Such materials enable more effective, precise, and non-invasive monitoring of physicochemical and spectroscopic changes under extreme conditions. In pursuit of such materials, the current work investigates the temperature sensitivity of Tb^{3+}, Mn^{4+} doped $KMgLaTeO_6$, and $NaMgLaTeO_6$ phosphors synthesized by a high-temperature solid-state reaction method. Through the effective monitoring of the changes in luminescence under varying temperature conditions, the temperature sensitivity of these materials has been explored. Thus, revealing their capability to function as a luminescent thermometer.

The luminescent properties of these phosphors have not been explored widely. Though there are a few reports on Mn^{4+} doping [1, 2], temperature-dependent emission properties, such as thermometric performance, have not been precisely studied. Likewise, there is no reported evidence of Tb^{3+} doping or co-doping reported in these host materials. Mn^{4+} being the red emitter (*ca.* 700 nm - $^2E_g \rightarrow {}^2A_{2g}$), is known to be temperature sensitive. On the other hand, Tb^{3+}, a sharp green emitter (*ca.* 545 nm - $^5D_4 \rightarrow {}^7F_5$), is expected to be barely dependent on temperature. In this context, the present work analyses the functionality of Tb^{3+} and Mn^{4+} co-doped $KMgLaTeO_6$ and $NaMgLaTeO_6$ phosphors as ratiometric temperature sensors. The sensing capability of the phosphors will be determined through the analysis of change in thermal quenching rates in the luminescence spectrum, which respond to thermal influences. This approach of thermometry using these phosphors can be proven to be advantageous in environments where traditional thermometers find it challenging. Consequently, these phosphors can also be potentially used in tough environments such as high-temperature industrial processes, aerospace applications, and deep-sea explorations for temperature sensing, imaging, and anticounterfeit applications.

[1] K. Li, *Dalton Trans.* **47** (2018) 2501-2505.

[2] K. Li, *Dyes Pigments* **162** (2019) 214-221.

This work was supported by the Foundation for Polish Science under First Team FENG.02.02-IP.05-0018/23 project with funds from the 2nd Priority of the Program European Funds for Modern Economy 2021-2027 (FENG)

P-38

SPECTROSCOPIC, STRUCTURAL AND MAGNETIC PROPERTIES OF HOMO- AND HETERODINUCLEAR Ln^{3+} CHELATES WITH CARBOXYAMIDE LIGANDS

A. Lipa[1], Y.H. Pham[1], V.A. Trush[2], L. Jerzykiewicz[1], A. Bieńko[1], V.M. Amirkhanov[2], A.N. Carneiro Neto[3]*, O.L. Malta[4], P. Gawryszewska[1]*

[1]*Faculty of Chemistry, University of Wroclaw, 14 F. Joliot-Curie Str., Wroclaw 50-383, Poland*

[2]*Kyiv National Taras Shevchenko University, Volodymyrska str. 64, Kyiv 01601, Ukraine*
[3]*Department of Physics, University of Aveiro, 3810-193 Aveiro, Portugal*
[4]*Departamento de Química Fundamental, Universidade Federal de Pernambuco, Cidade Universitária, 50740-560 Recife, Brazil*

* corresponding author: *paula.gawryszewska-wilczynska@uwr.edu.pl*; *albanoneto@ua.pt*

Keywords: lanthanide, luminescence, energy transfer, single-molecule magnet

The various possibilities of using luminescent lanthanide ion coordination compounds in multifunctional materials stimulates the search for new compounds for their commercial use. Moreover, a deeper understanding of the connection between luminescence and magnetic properties with structure, as well as the improvement and testing of theoretical models, allows better design of materials with desired photophysical properties.

In the search for new, efficient electromagnetic radiation converters in the visible range, a series of hetero- and homo-dinuclear lanthanide (Ln^{3+}) luminescent materials have been obtained through the application of various crystal engineering strategies. The series of coordination compounds with N-(diphenylphosphoryl)pyrazine-2-carboxamides (HL) is designated by the formula Ln_2L_6 (Ln=Eu^{3+}, Gd^{3+}, Tb^{3+}) and $Tb_{2-x}Eu_xL_6$-type compounds with variable Eu^{3+} ion content (x= 0.2; 0.5; 0.8;1).

The structure, spectroscopic, and single-molecule magnet (SMM) properties were determined for the obtained compounds: emission and excitation spectra, emission lifetimes of the Ln^{3+} and ligand states were recorded at 300 and 77 K. Measurements of magnetization were performed in the 1.8 - 300 K range for DC and AC applied field and SMM behavior was analyzed. The overall emission quantum yield of Ln_2L_6 (Q^L_{Ln}), the sensitization efficiency of Eu^{3+} emission (η) were also determined. On the basis of experimental and theoretical data, an analysis of the ligand-to-metal and ion-ion (Tb→Eu) energy transfer processes was carried out and the unusual properties of ion-ion energy transfer were elucidated. This gives new insights into the energy transfer phenomenon for homo- and heterodinuclear Ln^{3+} coordination compounds.

P-39

Decoding Luminescent Signatures: Photo- and Thermoluminescence of Cr^{3+}, Eu^{2+}, and Eu^{3+}-Doped $SrAl_{12}O_{19}$ for Optical Thermometry

P. Łukaszczuk[1,*], J. Zeler[1], E. Zych[1]

[1] *University of Wrocław, Faculty of Chemistry, 50-383 Wrocław, 14 F. Joliot-Curie Street, Poland*

* corresponding author: 338803@uwr.edu.pl

Keywords: photoluminescence, thermoluminescence.

This study explores the photo- and thermoluminescence (PL and TL) properties of a fully inorganic $SrAl_{12}O_{19}$ phosphor, doped with Cr^{3+}, Eu^{2+}, and Eu^{3+}, with dopant concentrations ranging from 0.1 to 1 mol%. PL and TL measurements were carried out across an extensive temperature range (10–1000 K) to uncover the fundamental optical behavior of this multifunctional material and assess its potential as a high-performance luminescent thermometer.

PL results reveal strong temperature sensitivity in the emission profiles, highlighting the material's promise for thermal sensing applications. Notably, Cr^{3+} luminescence at deep cryogenic temperatures exhibits intriguing features (Figure 1a), while thermally driven changes in all three activator centers will be discussed in detail. Given that Cr^{3+} preferentially substitutes Al^{3+} in one of five crystallographically distinct sites, site-selective spectroscopy will be employed to resolve substitution dynamics and local environments.

The PL insights are further complemented by TL measurements, which provide valuable information on the distribution and behavior of charge carrier traps with varying depths and lifetimes. These traps, while sometimes beneficial for practical use, may also hinder precise temperature readout—an aspect crucial for optimizing thermometric performance. The TL glow curves display pronounced dependence on dopant concentrations (Figures 1b and 1c), offering further insights into defect-related processes and material design strategies.

Altogether, this work provides a comprehensive optical characterization of $SrAl_{12}O_{19}$:Cr^{3+},Eu^{2+},Eu^{3+} phosphors and advances their candidacy as versatile materials for next-generation optical thermometry.

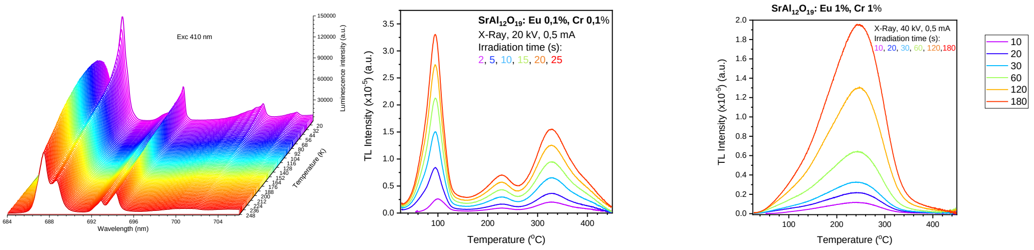


Figure 1.

This research was funded by the Polish National Science Centre, NCN, under the grant OPUS UMO-2023/51/B/ST5/02341.

Shining a Light on Temperature: Exploring Lanthanide-Doped $Ca_3Sc_2Si_3O_{12}$ Garnets for Next-Gen Optical Thermometry

K.A. Majdański[*], **D. Kulesza, E. Zych**

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

[*] corresponding author: *331279@uwr.edu.pl*

Keywords: Optical Thermometry, Garnets, $Ca_3Sc_2Si_3O_{12}$

Optical thermometry, although introduced nearly 90 years ago, has only in XXI century gained broader recognition among scientists and engineers. Luminescence thermometry utilizing lanthanide-ion activated matrices is currently attracting particular interest.

Compared to electronic temperature sensors, optical thermometers are resistant to electromagnetic interference. They also allow temperature measurements of fast-moving objects and mapping temperature distributions over large surfaces. Moreover, prone to miniaturization, they do not influence the studied object, enabling their application even at the nanoscale [1]. Lanthanide-doped thermometric materials may operate as primary (Boltzmann) thermometers. They measure temperature by exploiting luminescence emission changes based on fundamental physical laws, significantly reducing the need for calibration [2]. Nevertheless, recent studies suggest that Boltzmann thermometers may also suffer for nonlinear changes in luminescence parameters as a function of temperature. Their range of applicability depends on the lattice vibration energy [3].

This presentation shall focus on preliminary luminescence study of $Ca_3Sc_2Si_3O_{12}$ garnet host activated with selected lanthanides. The goal is to recognize their potentials in luminescence thermometry and identify the most suitable compositions. The effect of dopant concentrations will also be pursued.

[1] J. C. Martins, A. R. N. Bastos, R. A. S. Ferreira, X. Wang, G. Chen, L. D. Carlos, *Adv Photonics Res.* **2** (2021) 2000169.

[2] C. D. S. Brites, A. Millán, L. D. Carlos, in *Handbook on the Physics and Chemistry of Rare Earths*, Elsevier B. V. (2016) 339-427.

[3] T. P. van Swieten, J. M. Steenhoff, A. Vlasblom, R. de Berg, S. P. Mattern, F. T. Rabouw, M. Suta, A. Meijerink, *Light Sci Appl.* **11** (2022) 343.

Acknowledgements: This research was funded by the Polish National Science Centre, NCN, under the grant OPUS UMO-2023/51/B/ST5/02341.

EFFECT OF Gd SUBSTITUTION ON THE LUMINESCENCE BEHAVIOUR OF Ce-DOPED $Lu_{1-x}Gd_xAlO_3$ SINGLE CRYSTALLINE FILMS SCINTILLATORS

A. Majewski-Napierkowski[1*], V. Gorbenko[1], S. Witkiewicz-Łukaszek[1], T. Zorenko[1], Y. Zorenko[1]

[1]*Department of Physics, Kazimierz Wielki University in Bydgoszcz, Powstańców Wielkopolskich str., 2, 85-090 Bydgoszcz Poland*

* corresponding author: arthur@ukw.edu.pl

Keyword: $Lu_{1-x}Gd_xAP$:Ce perovskites, liquid phase epitaxy, luminescence, single crystalline films

The luminescent properties of Ce^{3+}-doped $Y_{1-x}Gd_xAlO_3$ perovskite solid solutions can be significantly modified by tuning the Gd content within the x = 0–1 range [1]. In this work, we investigate the influence of partial and complete substitution of Lu^{3+} by Gd^{3+} on the temperature-dependent luminescent properties of Ce-doped $LuAlO_3$ (LuAP:Ce) single crystalline films (SCFs). Films with the compositions $Lu_{1-x}Gd_xAlO_3$ (x = 0, 0.5, and 1) were grown by liquid phase epitaxy (LPE) from a $PbO–B_2O_3$-based flux.

The SCFs were initially characterized at room temperature using conventional spectroscopic methods, including optical absorption, cathodoluminescence (CL), photoluminescence, scintillation light yield, and decay kinetics under α-particle excitation. Further investigations were performed at 70 K using synchrotron radiation (SR) excitation in the 3.7–25 eV range at the SUPERLUMI station, located at the P66 beamline of the PETRA III storage ring at DESY (Hamburg, Germany).

Spectral measurements revealed that Gd substitution significantly influences both the shape and intensity of the Ce^{3+} excitation and emission bands (Fig. 1). In Ce-doped samples, the presence of Gd^{3+} induces a slight redshift of the Ce^{3+} emission, indicating modifications of the crystal field environment and possible energy transfer from Gd^{3+} ions to Ce^{3+} centers. The position of the main excitation peak E_{ex}(Ce), associated with the creation of an exciton bound to Ce^{3+} ions, shows a noticeable redshift from 7.54 eV in LuAP:Ce (x = 0) to 7.07 eV in GdAP:Ce (x = 1) with increasing Gd content. Temperature effects were observed as band broadening and variation in emission intensity, particularly at low temperatures.

These findings demonstrate that Gd substitution offers an effective means to tailor the optical and scintillation properties of LuAP-based perovskite materials, making them promising for use in advanced scintillation detectors and optoelectronic devices.

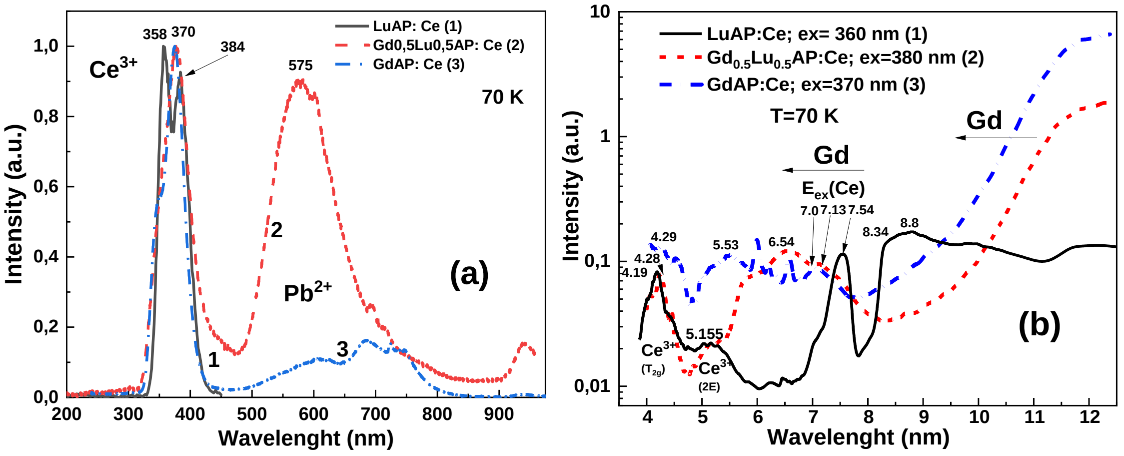


Figure 1. Emission and excitation spectra of LuAP:Ce (1), $Lu_{0.5}Gd_{0.5}$AP:Ce (2) and GdAP:Ce SCF (3) at 70 K.

[1] M. Kucera, M. Rathaiah, A. Beitlerova, R. Kucerkova, M. Nikl, IEEE TNS 67 (2000) 1049-1054

Acknowledgments: The work was performed in the frameworks of Polish NCN No 2022/47/I/ST8/02600 project.

P-42

Luminescent Perovskite Materials and their Biomedical Potential

A. Małoń[*], **J. Zeler, E. Zych**

Luminescent Materials Group, Faculty of Chemistry, University of Wroclaw , 14 F. Joliot-Curie, Wroclaw, 50-383, Poland

[*] Corresponding author: 322261@uwr.edu.pl

Keywords: thermoluminescence, optical thermometry, lanthanum aluminate perovskites

Luminescent materials capable of presenting simultaneous thermoluminescent emission and thermometric properties are gaining increasing interest in biomedical applications, particularly in optical tissue imaging and temperature monitoring of cancer cells. This presentation will show research on purposeful Cr^{3+}, Eu^{3+}, and Ho^{3+} triple-doped $LaAlO_3$ perovskites.

The material was synthesized and tested for phase purity using X-ray diffraction (XRD), and its morphology was analyzed using scanning and transmission electron microscopy (SEM/TEM). Comprehensive optical studies were also conducted, including photoluminescence (PL) measurements, excitation spectra (PLE), and time-resolved emission dynamics. A key aspect of the study was the analysis of thermoluminescent effects and the material's thermometric capabilities across a wide temperature range. The potential ability of this material to simultaneously emit in the near-infrared (NIR) region and accurately read temperature via thermoluminescent mechanisms may suggest its potential application in cancer diagnostics and temperature monitoring in pathological cells. This, in turn, may be a foundation for the development of advanced photothermal therapy.

The obtained results indicate a biomedical potential of the material for diagnostic and therapeutic applications in nanomedicine. However, further research is needed to determine its practical effectiveness in real-world biomedical conditions. The results will be discussed in detail during the poster presentation.

Acknowledgments: This research was funded by National Science Centre, Poland under OPUS grant no. 2023/49/B/ST5/04265.

P-43

Silicate phosphate hydroxyapatites functionalized with Li+, Eu3+ and Gd3+ ions as an innovative biomaterial enhancing chondrogenic differentiation of human bone marrow stromal cells

K. Marcinkowska[1*], **N. Charczuk**[2], **R.J. Wiglusz** [2], **A. Śmieszek**[1]

[1]Department of Pharmacology and Toxicology, Faculty of Veterinary Medicine, University of Environmental and Life Sciences, Norwida 25, 50-375 Wroclaw, Poland
[2]Institute of Low Temperature and Structure Research, Polish Academy of Sciences, Okolna 2, 50-422 Wroclaw, Poland

* corresponding author: klaudia.marcinkowska@upwr.edu.pl, ORCID number: 0000-0002-0610-0462

Keywords: BMSCs, lanthanide ions (Eu^3,Gd^3), miRNA, cartilage regeneration, tissue engineering

Human bone marrow stem cells (BMSCs) are multipotent progenitor cells capable of differentiating into osteoblasts, chondrocytes, and adipocytes. Due to the limited self-repair capacity of cartilage, injuries to this tissue remain a significant clinical challenge. Enhancing chondrogenic differentiation of mesenchymal stem cells (MSCs) through miRNA modulation represents a promising therapeutic approach. Given their regenerative potential, BMSCs are widely used in regenerative medicine and bone repair, and serve as a key in vitro model for evaluating the bioactivity of therapeutic biomaterials.

Our prior findings indicated that lithium-doped nanohydroxyapatite shows regenerative potential for bone tissue. Additional incorporation of europium (Eu^3) and gadolinium (Gd^3) further improves its structural and functional properties, paving the way for its use in theranostic approaches.

Non-coding RNAs (ncRNAs), including microRNAs (miRNAs) and long non-coding RNAs (lncRNAs), are now recognized as critical regulators of signaling pathways and lineage specification. In this study, we examined how lanthanide-functionalized nHAp/Li^+ affects the expression of selected miRNAs and lncRNAs during chondrogenic differentiation of human bone marrow stromal cells.

Using *in vitro* culture models and RT-qPCR analysis, we found that doping with rare earth ions significantly modulates the expression of key chondrogenesis-associated miRNAs, including miR-30a, miR-320, and miR-433-3p.

Our results demonstrate that modified nanohydroxyapatites can influence key molecular mechanisms and intracellular signaling pathways involved in cell differentiation, highlighting its potential as a next-generation biomaterial for cartilage repair. Moreover, this study underscores the role of microRNAs as precise molecular indicators of cellular response to biomaterials, supporting their application in evaluating biocompatibility and therapeutic effectiveness in tissue engineering.

Acknowledgments: The authors would like to acknowledge the National Science Centre Poland (NCN) for financial support within the Project 'Biocompatible materials with theranostics' properties for precision medical application' (No. UMO-2021/43/B/ST5/02960).

P-44

Structural and spectral characterization of nanostructure-liposome complexes using SEM and luminescence spectroscopy

G. Monastyrskyi[1]*,, O. Gnatyuk[1], M. Olenchuk[1], G. Dovbeshko[1]

[1]Institute of Physics, Natl. Acad. of Sci. of Ukraine, Prospect Nauky, 46, UA-03028, Kyiv, Ukraine

* corresponding author: *g.monastyrskyi@gmail.com*

Keywords: Liposomes, Scanning Electron Microscopy, Luminescence Spectroscopy, Nanoparticles, Liposome-Nanoparticle Interactions

Model liposomes serve as biomimetic systems that replicate the structure and functionality of biological membranes. In this study, we investigate structural changes and optical responses of DOPC-based liposomes upon interaction with two-dimensional (2D) nanoparticles, including MoS_2, WS_2, single-walled carbon nanotubes (SWCNTs), and nanodiamonds. The aim was to determine how the localization of nanoparticles—either inside or on the surface of the liposomes—affects their morphology and luminescence behavior.

Nanoparticles were introduced at two stages to generate internalized or surface-bound complexes. High-resolution scanning electron microscopy (SEM) was performed using a TESCAN MIRA LMU microscope in both secondary and backscattered electron modes. Sample preparation involved air/vacuum drying and gold sputtering (~20 nm) on silicon wafers to ensure conductivity and structural integrity.

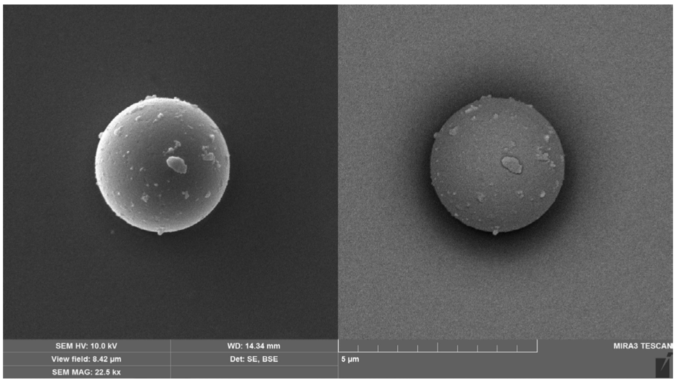


Fig. 1. SEM image, liposome with nanotubes on the surface

Representative SEM analysis revealed the insertion and adsorption of nanoparticles on liposomes, often accompanied by a 7–15% increase in vesicle diameter and local membrane deformation. Notably, surface-attached MoS_2 and WS_2 particles induced heterogeneities visible in both SE and BSE modes.

Luminescence spectroscopy was conducted using an FS5 spectrometer (Edinburgh Instruments). Results showed quenching of liposome fluorescence (~555 nm) upon complex formation with MoS_2 and emergence of a new band near 360 nm, indicative of strong nanoparticle–lipid interactions. In contrast, WS_2 nanoparticles preserved the liposome's intrinsic fluorescence when internalized, suggesting a milder interaction mode.

These findings offer a multiscale insight into membrane-nanoparticle interactions and provide a basis for the design of functional nanocarriers and biosensing platforms

Acknowledgments: Authors acknowledge NRFU project No 2021.01/0229 "Biophysical characteristics of circulating metastatic cells as potential targets of antimetastatic therapy". O. Gnatyuk acknowledges Academy of Finland mobility project Decision number 358103 for financial support, and G. Dovbeshko acknowledges Academy of Finland mobility project Decision number 359463.

P-45

High-fidelity simulation of AM 1.5G solar spectrum

M. Oleszko[1,2], **P. Zdeb-Stańczykowska**[1,2] , **K. Rogowski**[1,3] , **P. Paduch**[1]

[1]*OPTEL OPOLE Sp. z o.o., Opole, 45-564, Poland*
[2]*Institute of Low Temperature and Structural Research PAS, Wroclaw, 50-422, Poland*
[3]*Opole University of Technology , Opole, 45-758, Poland*

* corresponding author: *m.oleszko@intibs.pl*

Keywords: solar simulator, solar excitation, photovoltaics

The primary objective of solar simulation is to generate illumination that accurately replicates natural sunlight. Depending on atmospheric conditions and the angle of solar incidence, various spectral standards are applied, such as AM 1.5 G (Air Mass 1.5 Global), which corresponds to solar radiation reaching the Earth's surface at an average solar zenith angle of approximately 48°. The classification of solar simulators and the requirements for their parameters are defined by organizations such as the International Electrotechnical Commission (IEC) [1].

The first solar simulators designed for testing PV modules were developed in the 1980s, using xenon arc lamps as light sources. Xenon lamps emit radiation similar to sunlight, providing excellent spectral matching in the ultraviolet and visible light ranges. Their high intensity makes them ideal for applications that require a highly concentrated radiation beam. As a result, xenon lamp-based solar simulators are the most commonly used devices. However, xenon lamps require infrared filters to reduce their strong emission in that range. Additionally, they have a relatively short lifespan, require complex power supply systems, and are expensive.

The growing interest in light-emitting diodes (LEDs) has led to their use as alternative light sources in low-cost solar simulators. LEDs offer a number of advantages, such as compact size, low heat emission, affordability, long lifespan with minimal performance degradation, and a stable emission spectrum. Although one of the key advantages of using LEDs in solar simulators is the ability to precisely tailor the spectral distribution, the need to use multiple different LEDs increases the system's complexity.

The objective of the present invention [2] is to develop a simple and cost-effective hybrid solar simulator that uses a minimal number of light sources while still meeting Class A requirements under the AM 1.5 G spectral standard. In contrast to previous solutions, which required the use of multiple types of LEDs with different wavelengths or xenon arc lamps, the present invention demonstrates a continuous spectrum with a minimal number of spectral peaks.

[1] International Electrotechnical Commission (IEC), Solar simulator performance requirements, IEC 60904-9, 2020.

[2] M.Oleszko, P. Zdeb-Stańczykowska, Patent application P.451584, 2025.

Acknowledgments: This research was founded by the OCRG project FEOP.01.01-IP.01-0016/23.

INVESTIGATION OF POSSIBLE DOSE-RATE EFFECTS AT A DOSE OF 15 Gy IN THE THERMOLUMINESCENCE OF LiF:Mg,Ti.

L. Oster[1*], Y. Bokobza[1], Y.S. Horowitz[2]

[1]*Pysics Unit, Sami Shamoon College of Engineering, Beer Sheva, 84100, Israel*
[2]*Physics Department, Ben Gurion University, Beer Sheva, 84105, Israel*

*corresponding author: leonido@sce.ac.il

Keywords: Thermoluminescence, dose-rate, supralinearity, dose response

A carefully controlled experimental investigation carried out by our group did not discover dose-rate effects to within the precision of the measurements of ~ 5-10% (1 SD). To avoid problems of interpretation due to the supralinearity of the dose response of peak 5 in LiF:Mg,Ti, these experiments were carried out at levels of dose lower than 1 Gy, the threshold of non-linearity in the response of glow peak 5 in this material. We considered it necessary to carry out an additional dose-rate study at a higher level of dose between 1-30 Gy, specifically at 15 Gy. This range of doses is important in clinical radiation dosimetry where accuracy is of great importance. Each measurement of dose/dose-rate was carried out on calibrated samples: ten samples were irradiated at the Soreq nuclear research institution. The LiF:Mg,Ti (TLD-100) samples, of dimensions 3 mm × 3 mm× 0. 9 mm, are prepared using natural cooling following the 400◦C/1 h pre-irradiation anneal. The TL glow curves were obtained with a Harshaw/Bicron Model 3500 manual reader using a heating rate of $1◦Cs^{-1}$ with a temperature resolution of 1.75◦C/channel. It was previously demonstrated that the careful positioning of the samples in the center of the planchet and the mentioned temperature resolution leads to optimum precision of the measurements of main dosimetric peaks in TLD-100. The TL samples are placed on the planchet surrounding by a constant flow of N_2 to maintain an oxygen atmosphere for reduction of surface induced non-radioactive signals. The glow curves of five samples for each of the dose rates were determined and averaged at two dose-rates following $^{90}Sr/^{90}Y$ beta irradiations at a dose of 15 Gy. The high dose rate was 83.3E-05 (Gy s^{-1}) and the low dose rate was 1.58E-03 (Gy s^{-1}). No significant difference within 5% (1 SD) was observed in the glow curve shape or in the intensity of glow peak 5 at these dose rates differing by four orders of magnitude

Acknowledgements: This research was supported by the Israeli Ministry of Science and Technology and by the PAZY Foundation.

P-47

Afterglow Luminescence Thermometry of Triply Doped $LaAlO_3$

A. Owczarek[*], **E. Zych, J. Zeler**

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

* corresponding author: *322286@uwr.edu.pl*

Keywords: phosphors, luminescence thermometry, bioimaging, afterglow

This study focuses on the temperature-dependent afterglow of (Cr^{3+},Eu^{3+},Nd^{3+})-co-doped $LaAlO_3$, emphasizing their potential for bioimaging and thermal sensing applications in biomedicine. By analyzing persistent luminescence spectra at various temperatures, we investigate the influence of charge carrier trapping and de-trapping mechanisms, with a particular focus on their applicability in biological temperature sensing and imaging [1]. The materials were synthesized via co-precipitation method, followed by controlled annealing to optimize their structural and optical characteristics.

Figure 1 illustrates the thermoluminescence spectra recorded in the temperature range of 26-280 °C, showing a systematic changes in emission intensity of Cr^{3+} (the range of 660-800 nm) and Nd^{3+} ions (820-920 nm). Two maxima of TL process were observed at about 100 and 260 °C.

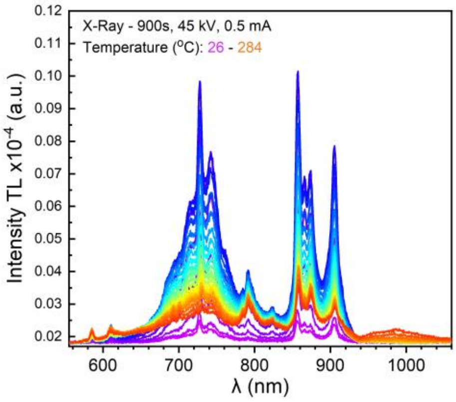


Figure 1. *TL spectra of X-ray irradiated $LaAlO_3$:Cr,Eu,Nd heat-treated at 1100 °C in the air atmosphere.*

The next step of the research will be the analysis of thermoluminescence spectra to determine their thermometric usefulness. These findings contribute to the fundamental understanding of thermally modulated thermoluminescence in the physiological temperature range in triply doped aluminates and lay the groundwork for their potential implementation as persistent luminescence thermometry phosphors in the nanomedicine.

[1] M. Pellerin, E. Glais, T. Lecuyer, J. Xu, J. Seguin, S. Tanabe, C. Chanéac, B. Viana, C. Richard, *J Lumin* **2018**, 202, 83.

This research was funded by National Science Centre, Poland under OPUS grant no. 2023/49/B/ST5/04265.

P-48

Luminescence properties and biocompatibility of $Ca_{10}(PO_4)_6C_{l2}$ co-doped with Ce^{3+} and Mn^{2+} ions

A. Pielok[1]*, **K. Szyszka**[1], **A. Śmieszek**[2], **K. Marcinkowska**[2], **A. Dolnicka**[2], **R.J.Wiglusz**[1]

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

[2] *Department of Pharmacology and Toxicology, Faculty of Veterinary Medicine, University of Environmental and Life Sciences, Norwida 25, 50-375 Wroclaw, Poland*

* corresponding author: a.pielok@intibs.pl

Keywords: luminescence, spectroscopy, chlorapatite, theranosctics, biocompatibility

The aim of this study was to find a potential biomaterial that could be utilized in theranostics. Therefore, our goal was to obtain a biomaterial that would simultaneously display luminescence in one of the biological windows (NIR-I, NIR-II, NIR-III) and osteoinductive properties in bone tissue environment [1]. Such combination would be beneficial in terms of bone defects therapy that require real time monitoring of the healing process. To meet these requirements we propose chlorapatite (CaClAp), ($Ca_{10}(PO_4)_6C_{l2}$) co-doped with Cerium (Ce^{3+}) and Manganese (Mn^{2+}) ions. Hydroxyapatite is the main inorganic component of bone tissue[2], however in order to obtain more effective emission we decided to substitute $(OH)^-$ groups with Cl^- ions. Cerium and Manganese ions were selected due to their potential for energy transfer which results in red luminescence in NIR-I. Furthermore, both Cerium and Manganese ions exhibit antibacterial properties, which are very beneficial in terms of bone tissue injuries as they minimize the risk of possible infection.

Physico-chemical properties of CaClAp:Ce^{3+}(0.3 mol%), Mn^{2+}(0-5 mol%) were evaluated with methods such as: XRD, SEM-EDS, ICP-OES and optical spectroscopy. The biocompatibility of obtained compounds was assessed in vitro using an established human osteosarcoma cell line (MG-63). The TOX8 assay was performed to analyze the viability of the MG-63 cells after 24h, 48h and 72h of incubation with the biomaterials. Additionally, the cells were visualized after 72h of incubation with the epifluorescent microscope, the MG-63 nuclei, F-actin fibers and mitochondria were stained using fluorescent dyes.

The obtained biomaterials were nanosized and exhibited phase purity. An energy transfer from Ce^{3+} to Mn^{2+} was observed and the intensity of Mn^{2+} luminescence (λ_{max}=588 nm) increased codependently with its concentration. The compounds demonstrated temperature-depended emission color transition from violet (0.3 mol% Ce^{3+}) to orange-red (0.3 mol% Ce^{3+},5 mol% Mn^{2+}). The concentration of Mn^{2+} had no significant influence on its average lifetime and upon excitation at 304 nm was around 26 ms. Furthermore the biomaterials did not display strong cytotoxic effects.

[1] E. Hemmer, *Nanoscale Horiz.*, **1** (2016) 168-184.

[2] Z. Bal, *emergent mater.*, **3** (2020) 521–544.

Acknowledgments: The presented study was founded by the National Science Centre Poland (NCN);(No. UMO-2021/43/B/ST5/02960).

P-49

From X-rays to UV-C: Harnessing Pr^{3+} Emission in Dense $LiLuF_4$:Pr for Medical Innovation

K. Popławska[*], **J. Zeler**, **E. Zych**

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

[*] corresponding author: *347587@uwr.edu.pl*

Keywords: $LiYF_4$:Pr; UV-C luminescence; cancer treatment

$LiLuF_4:Pr^{3+}$ emerges as a promising UV-C-emitting phosphor with potential relevance for future medical technologies. The high-density host (6.19 g/cm3) ensures efficient absorption of ionizing radiation - X-rays and γ-rays. This facilitates the generation of intense 5d→4f Pr^{3+} emission within the UV-C spectral range (200–280 nm). The UV-C radiation, known for its strong cytotoxicity, particularly toward cancerous tissues, positions this material as a compelling candidate for use in ionizing radiation-assisted cancer therapies or targeted disinfection protocols. The study highlights the luminescence mechanism under ionizing. The combination of a high-density fluoride host and efficient Pr^{3+} emission contributes to a robust radioluminescent response, paving the way for novel biomedical applications that leverage deep-penetrating radiation sources for localized UV-C radiation generation.

$LiLuF_4:Pr^{3+}$ was synthesized via a hydrothermal method. Analysis of the photoluminescence and X-ray-induced radioluminescence spectra enables the identification of UV-C emission mechanisms and the assessment of energy conversion efficiency. The results indicate that $LiLuF_4:Pr^{3+}$ is a promising candidate for the development of novel methods for precise radiation-based tissue targeting. The research will be continued.

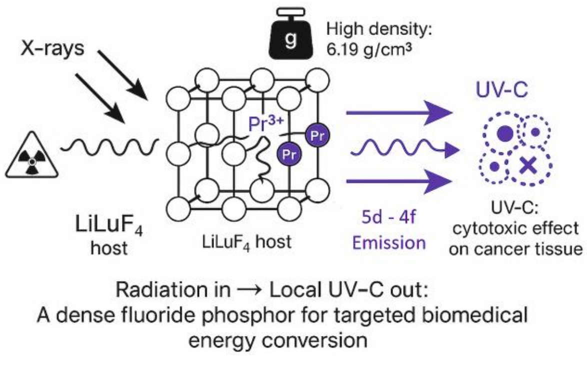


Figure 1. *From synthesis to medical photonics to make cancer treatment more efficient and safer.*

[1] C. Li, X. Liu, P. Yang, C. Zhang, H. Lian, J. Lin, *J. Phys. Chem. C* **112(8)** 2008 2904-2910.

Acknowledgements: This research was funded by the National Science Centre, Poland (NCN), under the grant OPUS UMO-2024/53/B/ST5/02551.

THE INFLUENCE OF Eu^{3+} IONS ON UP-CONVERSION PROCESSES IN YVO_4:Yb^{3+}, Ho^{3+}

M. Puchalska*, **M. Sobczyk, E. Zych**

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

* corresponding author: *malgorzata.puchalska@uwr.edu.pl*

Keywords: orthovanadates, up-conversion , decay time, Yb^{3+}, Ho^{3+}, Eu^{3+}

A series of yttrium orthovanadates $Y_{0.93-x}Ho_{0.02}Yb_{0.05}Eu_xVO_4$ (x=0, 0.002, 0.0025, 0.005, 0.0075, 0.01, 0.015, 0.02) was synthesized using the direct reaction of vanadium(V) oxide V_2O_5 with Yb_2O_3, Ho_2O_3 and Eu_2O_3 oxides at 900°C. X-ray diffraction (XRD) analysis confirmed the presence of a single phase of tetragonal YVO_4 with tetragonal zirconium structure [1]. Spectroscopic studies of all samples were performed, which included measurements of absorption and emission spectra (Stokes and anti-Stokes) and luminescence decay curves. Based on up-conversion luminescence measurements it was found that co-doping with Eu^{3+} ions leads to a weakening of the red anti-Stokes emission intensity from the $^5F_5$ level of the Ho^{3+} ion in relation to its green emission from the $^5S_2$ level. This effect increases with the increase of Eu^{3+} concentration and as a result, the emission color changes from yellowish orange (0%mol Eu^{3+}) to greenish yellow (1%mol Eu^{3+}). In the presence of Eu^{3+} ions, an additional process of energy transfer from the $^5I_7$ level of the Ho^{3+} ion to the $^7F_6$ level of the Eu^{3+} ion occurs, and hence non-radiative relaxation to the ground state (Fig.1).

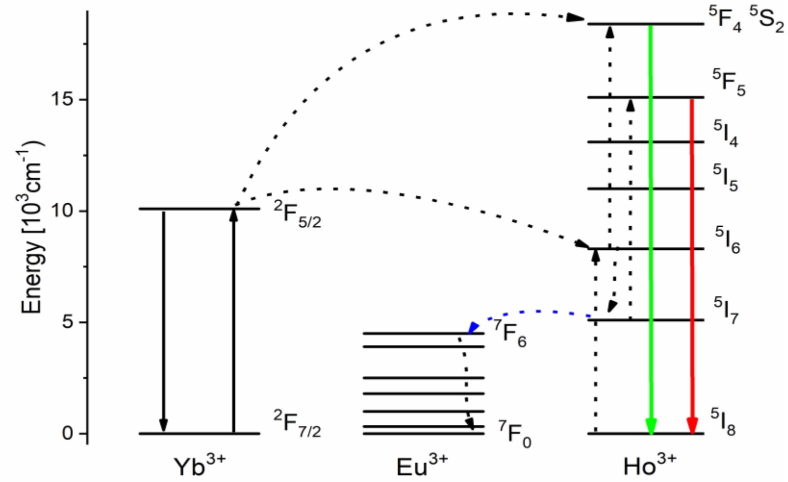


Fig.1 Diagram of the energy levels of Yb^{3+}, Ho^{3+} and Eu^{3+} ions along with the path of excitation energy conversion of the YVO_4:Yb^{3+}, Ho^{3+}, Eu^{3+}materials by the 980 nm line.

The proposed quenching mechanism was confirmed based on luminescence kinetics studies. As expected, the luminescence decay time (τ) from the $^5I_7$ level was observed to shorten with the increase of Eu^{3+} concentration from 0-1 mol%. The τ values changed significantly from about 1500 μs (0% mol) to about 70 μs for the concentration of 1% mol.

[1] J.A. Baglio, G. Gashurov, *Acta Crystllogr. B* **24** (1968) 29.

INORGANIC BROMIDE PEROVSKITE DOPED WITH YTTERBIUM AS A DOWN-CONVERTER FOR PHOTOVOLTAIC

K. Rauch[1,2*], B. Bondzior[1], E. Zielony[2], M. Ptak[1], M. Stefanski[1]**

[1] Institute of Low Temperature and Structure Research, Polish Academy of Sciences,
50-422 Wroclaw, Poland
[2] Faculty of Fundamental Problems of Technology, Wrocław University of Science and Technology,
50-370 Wrocław, Poland

* corresponding author: **karolrauch88@gmail.com*; ***m.stefanski@intibs.pl*

Keywords: perovskite, photovoltaic, ytterbium, spectral measurements

In 2024, 46.9% of electricity in the European Union was generated from renewable energy sources, with wind power contributing the most, followed by hydropower and solar power [1]. Photovoltaic (PV) technologies are environmentally friendly and can be deployed globally. However, they face fundamental limitations, including low quantum efficiency in the short-wavelength range. High-energy photons often fail to reach the absorber layer, and excess energy above the material's bandgap is lost through thermalization. To address this, researchers are developing down-conversion (DC) technologies [2], which transform high-energy photons into lower-energy ones that are more readily absorbed. Ideal DC materials exhibit strong UV absorption, visible-range emission, and short carrier lifetimes. Perovskites (ABX_3), containing metals like lead or tin, are promising candidates due to their efficient high-energy photon absorption. Their emission wavelength can be tuned by modifying the halide component (X). Doping them with rare earth elements can enhance stability and introduce additional emission lines. Ytterbium, with a simple two-level energy structure, not only offers an efficient emission channel but also significantly increases the Goldschmidt tolerance factor (t). This parameter tells how stable structure is. Perovskites with t between 0,8 and 1 are the most stable materials. For $CsPbBr_3$ $t \approx 0{,}817$, and after adding Yb $t \approx 0{,}829$ [3]. The study was conducted to investigate the structural and morphological properties of ytterbium-doped perovskites. The primary objective was to determine the optimal dopant concentration for potential application in photovoltaic devices. To evaluate the material's optoelectronic properties, spectroscopic analyses, including absorption and photoluminescence measurements, were performed.

[1] Eurostat. Accessed: May 22, 2025. [Online]. Available: https://ec.europa.eu/eurostat/web/products-eurostat-news/w/ddn-20250319-1
[2] D. Verma, et al, *38th IEEE Photovoltaic Specialists Conference*, (**2012**)
[3] J. Yang *et al.*, *J Mater Sci*, vol. 59, no. 11, pp. 4586–4595, (**2024**)

Acknowledgments: The authors acknowledge the support from grant no. NCN-2021/43/D/ST5/01865 funded by National Science Center, Poland

P-52

Effective Blue-to-UVC Upconversion of Pr^{3+}-doped $Sr_3Lu(PO_4)_3$ and $Ba_3Lu(PO_4)_3$ Phosphors: A Comparative Study

N. Rebrova*[1], A. Grippa[2], P. Zdeb-Stańczykowska[1], P.J. Dereń [1]

[1] *Institute of Low Temperature and Structure Research, Polish Academy of Science, ul. Okólna 2, 50-422 Wrocław, Poland*

[2] *Institute for Scintillation Materials, National Academy of Sciences of Ukraine, Nauky Avenue, 60, 61001, Kharkiv, Ukraine*

* corresponding author: *n.rebrova@intibs.pl*

Keywords: phosphates, upconversion, praseodymium, luminescent properties

With the enforcement of the Minamata Convention on Mercury, there is an urgent need to develop alternative sources of ultraviolet-C (UVC) light to replace traditional mercury-based lamps. In response, UV LEDs have gained popularity for sterilization applications due to their advantages such as long lifespan, low energy consumption, and compact design. However, their efficiency remains significantly lower than that of mercury lamps. Improving the performance of UVC LEDs is therefore a key priority in current scientific and technological research. The growing interest in UVC radiation stems from its ability to disrupt DNA molecules, leading to cell death, bacterial inhibition, and effective inactivation of viruses, including COVID-19. One promising strategy for developing new UVC light sources involves the use of upconversion, or anti-Stokes emission. This process enables the absorption of two or more lower-energy photons (e.g., blue light) and the subsequent emission of a single higher-energy photon in the UVC range, offering a novel route to efficient UVC generation.

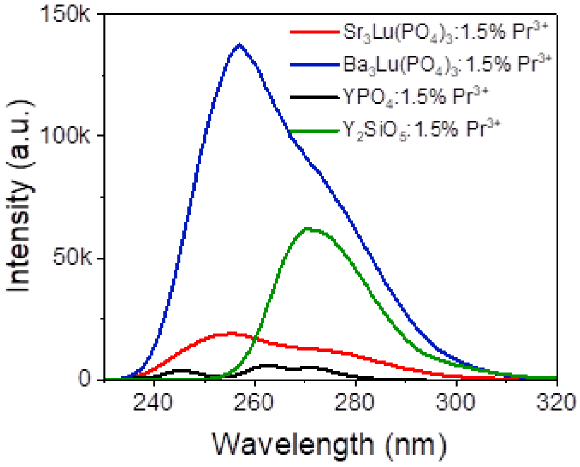


Fig. 1. Upconversion emission spectra of $A_3Lu(PO_4)_3$:1.5% Pr^{3+} (A=Sr, Ba) Y_2SiO_5:1.5Pr^{3+} and YPO_4:1.5% Pr^{3+} phosphors excited by a 444 nm laser.

In this work, we present the luminescent and upconversion properties of Pr^{3+}-doped $A_3Lu(PO_4)_3$ (A=Sr, Ba) crystallites synthesized by the sol-gel method. The influence of the activator concentration and pump power on the intensity of upconversion radiation will be discussed.

Acknowledgments: This work was supported by the National Science Centre under Grant No. UMO-2021/41/B/ST5/03792, which is gratefully acknowledged. The investigation using synchrotron radiation at the P66 SUPERLUMI station at DESY, Germany was performed within the framework of the I-20240194 EC project. One of the authors, A. Grippa (Oleksandr Gryppa), is thankful to the Polish Academy of Sciences for its support through the PAN-NANU (PAS-NASU) program for scientists cooperating with INTiBS PAN.

P-53

MULTILAYER GARNET COMPOSITES FOR ENHANCED PHOTOCONVERSION IN HIGH-POWER WHITE LEDs

A. Shakhno[1,*], **V. Gorbenko, S. Witkiewicz-Łukaszek**[1], **T. Zorenko**[1], **Yu. Zorenko**[1]

[1]*Department of Physics, Kazimierz Wielki University, Bydgoszcz, 85-090, Poland*
[2]*Department of Mechatronics , Kazimierz Wielki University, Bydgoszcz, 85-074, Poland*

* corresponding author: *shakhno@ukw.edu.pl*

Keywords: single-crystalline films, liquid-phase epitaxy, garnets, Ce^{3+} ions, composite film-crystal photoconverter, Planar-Chip-Level Conversion, white LEDs

In recent years, the Planar-Chip-Level Conversion (PCLC) design, where the phosphor layer is detached from the LED chip, has become a widely adopted approach for fabricating high-power white LEDs (WLEDs) excited by near-UV or blue light sources [1]. Since the discovery of YAG:Ce as an effective photoconverter in 1996, it has remained the most commonly used phosphor in WLEDs, despite its average photoconversion efficiency.

Building on our previous work with garnet-based composites, this study extends the investigation of multilayer garnet composites grown using the Liquid Phase Epitaxy (LPE) method. Our research focuses on the photoconversion properties of two-layered and three-layered structures composed of single-crystalline films of $Y_3Al_5O_{12}$:Ce (YAG:Ce) and $Tb_3Al_5O_{12}$:Ce (TbAG:Ce) garnets, deposited on $Gd_3GaxAl_{5-x}O_{12}$:Ce (GAGG:Ce) single-crystal substrates with Ga content values of $x = 2.5$ and 3.0. We analyzed how Ce^{3+} concentration in the GAGG:Ce substrate and the thickness of the YAG:Ce and TbAG:Ce films influence luminescence and photoconversion performance of mentioned composites.

Compared to conventional YAG:Ce converters, the proposed multilayer design demonstrates a broadened emission spectrum, resulting from the combined luminescence of yellow-orange emission from the TbAG:Ce and YAG:Ce films, and the GAGG:Ce substrate. This configuration effectively fills the blue-green gap and enhances red emission. By adjusting film thickness and dopant levels, the emission characteristics can be tuned across a wide chromaticity range, from green to orange. Our research underlines the potential of multilayered garnet-based composites for creating customizable, high-quality white light in phosphor-converted LEDs (pc-WLEDs).

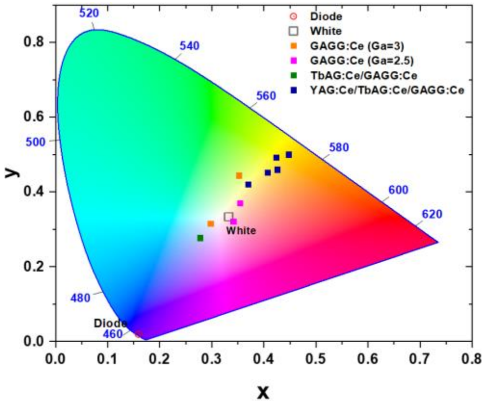


Fig. 1. CIE-1931 color space chromaticity diagram for the LED prototypes.

[1] N. Wei et al Appl. Phys. Lett. 101 (2012) 061902.
[2] S. Witkiewicz-Lukaszek et al CrystEngComm 20 (2018) 3994–4002.
[3] Y. Syrotych et al Optical Materials: X 24 (2024) 100372.

Acknowledgments: The research was performed in the frameworks of Polish NCN 2022/45/B/ST8/01757 project and also supported by the Ministry of Science and High Education of Poland in frame of nr RID/SP/ 0048/2024/01 project.

P-54

CADMIUM-FREE QUANTUM DOT-BASED TWO-PHOTON SENSORS FOR METAL IONS DETECTION

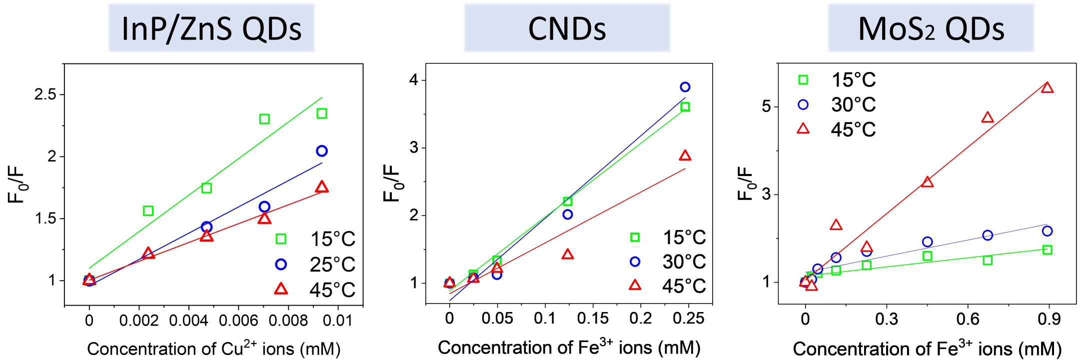
A. Siomra[1], **M. Nyk**[1,*]

[1]*Institute of Advanced Materials, Faculty of Chemistry, Wroclaw University of Science and Technology, Wyb. Wyspianskiego 27, 50-370 Wroclaw, Poland*

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

Keywords: quantum dots, two-photon absorption, fluorescence quenching, metal ions detection

Although cadmium-based quantum dots (QDs) exhibit superior optical properties, their potential applications are significantly limited due to the high risk of toxic cadmium ion release. Therefore, there is a strong demand for the development of non-toxic alternatives, such as silver sulphide quantum dots (Ag_2S QDs), sulphur quantum dots (SQDs), molybdenum sulphide quantum dots (MoS_2 QDs), carbon nanodots (CNDs) and indium phosphide/zinc sulphide quantum dots (InP/ZnS QDs). These materials not only offer desirable optical properties but also exhibit low toxicity, good biocompatibility and excellent water dispersibility, making them attractive candidates for a wide range of applications including heavy metal ion sensing [1,2]. We explore the capability of CNDs, MoS_2 QDs and InP/ZnS QDs to function as fluorescence quenching-based sensors for metal ions. Utilizing femtosecond laser pulses for the two-photon excited luminescence technique, we optimize the excitation wavelength in the near-infrared region and perform temperature-dependent measurements to elucidate the potential mechanisms underlying the observed photoluminescence quenching effects in two-photon regime. The results confirm the potential of studied materials as sensitive and selective two-photon active optical sensors suitable for applications in biological systems.


InP/ZnS QDs

CNDs

MoS2 QDs

Fig. 1. Examples of the Stern-Volmer plots at different temperatures in the presence of quencher under two-photon excitation ($\lambda_{exc.}$ for InP/ZnS QDs, CNDs and MoS_2 QDs, respectively: 840 nm, 720 nm, 720 nm)

[1] M. Gordel-Wójcik, M. Malik, A. Siomra, M. Samoć, M. Nyk, *J. Phys. Chem. Lett.* **14** (2023) 11117.

[2] A. Siomra, D. Wawrzyńczyk, M. Samoć, M. Nyk, *RSC Adv.* **14** (2024) 2439.

Acknowledgments: This work was supported by the project OPUS-25 No. UMO-2023/49/B/ST11/01536, funded by National Science Centre Poland (NCN).

P-55

TAILORING EMISSION COLOR IN Sm^{3+}/Li^{+}-DOPED CALCIUM HYDROXYAPATITE NANOCRYSTALS: A PATH TOWARD CRYOGENIC LUMINESCENT THERMOSENSORS

P. Sobierajska[1*] **and R. J. Wiglusz**[1,2]

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

[2]*Meinig School of Biomedical Engineering, College of Engineering, Cornell University, Ithaca, New York 14853-1801, United States*

* corresponding author: *p.sobierajska@intibs.pl*

Keywords: calcium hydroxyapatite, lithium(I)/samarium(III) ions, thermosensors, cryogenic applications

This study presents the synthesis and detailed physicochemical characterization of nanocrystalline calcium hydroxyapatite (nHAp) co-doped with Sm^{3+} and Li^{+} ions, developed as a cryo-compatible luminescent nanosized thermometer [1-2]. The material demonstrates a distinct, temperature-dependent emission color transition (Fig. 1) —from blue-green at 77 K to orange-red at 300 K —enabled by broadband, self-activated luminescence originating from the host lattice below room temperature. A high relative sensitivity is achieved, reaching a maximum in the 200–225 K range. These features allow for accurate, real-time temperature sensing in cryogenic environments. These nanosized thermometers hold significant potential in cryopreservation applications, where precise thermal control is critical for enhancing the viability and recovery of stored biological samples.

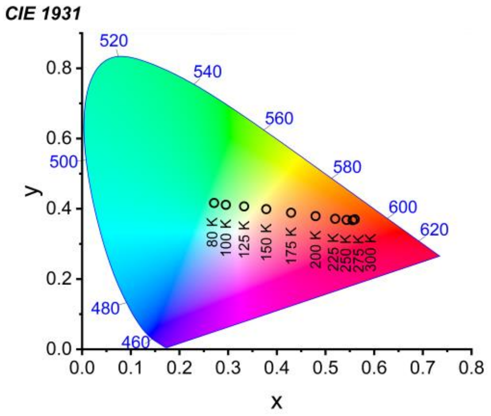


Fig. 1. CIE chromaticity diagram of 1 mol% Sm^{3+}, 5 mol% Li: nHAp.

[1] M. Quintanilla, M. Henriksen-Lacey, C. Renero-Lecuna, L.M. Liz-Marzán, *Chem. Soc. Rev.*, **51** (2022) 4223–4242. doi:10.1039/d2cs00069e.

[2] T.R. Machado, I.S. Leite, N.M. Inada, M.S. Li, J.S. da Silva, J. Andrés, et al., *Mat. Today Chem.* **14** (2019)

Acknowledgements: The authors would like to acknowledge for financial support within the Projects 'Biocompatible materials with theranostics' properties for precision medical application' (No. UMO-2021/43/B/ST5/02960) under the National Science Centre Poland (NCN).

P-56

INFLUENCE OF Rb$^+$ CO-DOPING ON THE OPTICAL PROPERTIES OF POWDERED CsPbCl$_3$:Yb^{3+} PEROVSKITE

W. Jagiełowicz[1], B. Bondzior[1], K. Rajfur[2], M. Ptak[1], M. Stefanski[1*]

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

[2]Faculty of Fundamental Problems of Technology, Wrocław University of Technology,
50-370 Wrocław, Poland

* corresponding author: *m.stefanski@intibs.pl*

Keywords: inorganic halide perovskites, solid-state reaction method, microcrystals, luminescence

Inorganic halide perovskites have been the subject of intensive research for their unique properties. Most current research focuses on halide ion exchange to modify the luminescence band gap and optical features. They are obtained mainly in colloids or thin layers, resulting in small grains with a narrow distribution. This work investigates an alternative way of tuning the band gap of powdered micrometric halide perovskites by substituting monovalent cations. The structural and spectroscopic properties of a concentration series of CsPbCl$_3$:10%Yb^{3+},x%Rb$^+$ (x = 5, 10, 20, 30, 40) prepared by the solid-state reaction method were analyzed. It is shown that doping the host with rubidium ions can strongly influence the quality of the crystal structure of the studied materials and their spectroscopic properties. Particularly, an increase in the concentration of Rb$^+$ ions in the host reduces the number of structural defects, allowing the intensity of the emission bands of both the matrix and the optically active dopant to be modified (Figure 1).

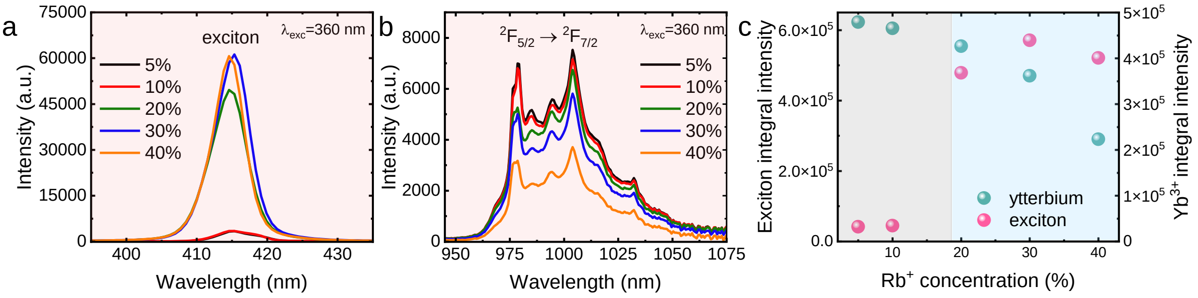


Figure 1. Emission spectra of the powdered CsPbCl$_3$:10%Yb^{3+} perovskites co-doped with Rb$^+$ ions recorded in the visible (a) and infrared (b) spectral range under 360 nm excitation and integral ytterbium and exciton emission intensities (c).

Acknowledgments

The authors acknowledge the support from grant no. NCN-2021/43/D/ST5/01865 funded by National Science Center, Poland.

P-57

TEMPERATURE-INDUCED OPENING OF ELECTRONIC TRANSITIONS OF YTTERBIUM IONS IN PEROVSKITE MATRIX

S. Streckaite[1*], **D. Rodz**[1], **M. Franckevičius**[1], **V. Boiko**[2], **M. Stefanski**[2],
D. Hreniak[2], **V. Gulbinas**[1]

[1]*Center for Physical Sciences and Technology, Sauletekio Ave. 3, 10257 Vilnius, Lithuania*
[2]*Institute of Low Temperature and Structure Research, Polish Academy of Sciences, Okólna 2,*
50-422 Wroclaw, Poland

* corresponding author: *simona.streckaite@ftmc.lt*

Keywords: lead halide perovskite, lanthanoid ytterbium, quantum-cutting, down-conversion

Ytterbium ions, as luminescent species, are important in the development of lanthanoid-based optical and optoelectronic materials. Suitable arrangement of Yb energy levels makes it a very promising photon-cutting material for the enhancement of the efficiency of silicon solar cells [1]. However, $^2F_{5/2}\rightarrow{}^2F_{7/2}$ optical transition responsible for the near infrared radiation is forbidden. Asymmetric matrix field makes this transition partly allowed and strongly dependent on temperature. Previous studies have identified monomeric and dimeric Yb^{3+} species in cesium lead halide perovskite lattice [2], each contributing differently to the quantum-cutting (QC) process. Here we investigate the temperature influence on the oscillator strength of $^2F_{5/2}\rightarrow{}^2F_{7/2}$ radiative transition of different Yb^{3+} species in $CsPbCl_{3-x}Br_x$ perovskite matrixes. By using time-resolved photoluminescence (PL) technique and exciting perovskite or Yb^{3+} ions (Fig. 1), we demonstrate that higher temperature causes faster PL decay and enhanced oscillator strength of Yb^{3+} species, however, with different temperature dependencies for dimeric Yb^{3+} species, active in QC, and monomeric species, which do not participate in QC. We show that transfer of perovskite exciton energy to single Yb^{3+} ion is very inefficient, but its efficiency increases with temperature.

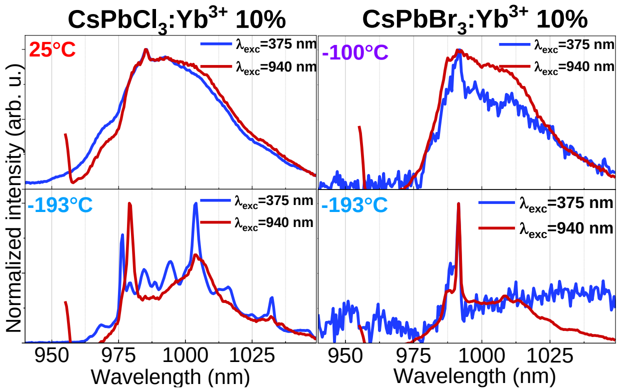


Fig. 1. PL spectra in NIR region at different temperatures of Yb-doped $CsPbCl_3$ (left) and $CsPbBr_3$ (right) samples upon 375 nm (blue lines) and 940 nm (red lines) excitation.

[1] D. Zhou et al., *Nano Lett* **19** (2019) 6904.

[2] S. Streckaitė, et al., *J. Mat. Chem.* **12** (2024) 11995.

Acknowledgments: This research has received funding from the European Union NextGenerationEU (agreement No 10-036-T-0009).

P-58

SUSTAINABLE LUMINESCENT pH SENSOR BASED ON SPRUCE-DERIVED CARBON DOTS

M. Szymczak[1*], **K. Elzbieciak-Piecka**[1], **J. Papan Djaniš**[2], **L. Marciniak**[1]

[1]*Institute of Low Temperature and Structure Research PAN, Wroclaw, 50-422, Poland*
[2]*Faculty of Chemistry and Chemical Technology, University of Ljubljana, Ljubljana, 1000, Slovenia*

[c] *Centre of Excellence for Photoconversion, Vinča Institute of Nuclear Sciences, National Institute of the Republic of Serbia, University of Belgrade, Belgrade, 11351, Serbia*

* corresponding author: *m.szymczak@intibs.pl*

Keywords: carbon quantum dots, spruce-derived lignin, luminescent pH sensor, sustainable sensor

In the context of the escalating global demand for non-renewable raw materials, the development of sustainable production processes is no longer a matter of choice but a pressing necessity. This includes minimizing the consumption of disposable materials and prioritizing renewable resources over exhaustible ones. In this landscape, green nanotechnology - particularly the synthesis of functional nanomaterials from biomass - has emerged as a promising approach to reconcile technological advancement with environmental responsibility. One of the most actively explored directions is the conversion of biomass into carbon quantum dots (CQDs). CQDs can be synthesized from a wide variety of renewable precursors, including lignocellulosic biomass and food industry byproducts. [1] Their well-established advantages - such as tunable luminescence, biocompatibility, low toxicity, and water dispersibility - make them highly attractive for diverse sensing, imaging, and optoelectronic applications. [2]

In light of this, the present study explores the use of CQDs derived from renewable sources for luminescence-based pH sensing. For this purpose, CQDs synthesized from lignin isolated from spruce biomass were employed. A distinctive feature of these CQDs is their exceptionally high sensitivity to pH changes between 7 and ~9, resulting in a clear luminescence shift from blue to green. To validate their practical potential, a 2D pH imaging experiment was conducted using a simple setup composed of a UV excitation source and a consumer-grade camera equipped with an optical filter. This approach shows great promise, as the real-time detection of luminescence changes confirms its potential for low-cost, remote pH monitoring using simple and widely available equipment. Consequently, the results presented here offer a compelling demonstration of how biomass-derived luminescent nanomaterials can serve as a foundation for sustainable, and scalable sensing technologies.

[1] V. Bressi, A.M. Balu, D. Iannazzo, C. Espro, *Curr. Opin. Green Sustain. Chem* **40** (2023) 100742

[2] B. Wang, S. Lu, *Matter*, **5** (2022) 110-149

Acknowledgments: This work was supported by ***National Science Center Poland (NCN)*** *under project No UMO- 2023/05/Y/ST5/00013.*

CHIRAL FLUORESCENT Ag_2S NIR-II QUANTUM DOTS: SYNTHESIS OPTIMIZATION AND OPTICAL CHARACTERIZATION

J. Tracz, J. Sokolnicki, M. Gordel-Wójcik*

Faculty of Chemistry, University of Wrocław, 50-383 Wrocław, Poland

* corresponding author: marta.gordel-wojcik@uwr.edu.pl

Keywords: quantum dots, NIR-II emission, chirality in nanomaterials, theranostics

The main goal of this project was to optimize the aqueous-phase synthesis of Ag_2S quantum dots (QDs) capped with the chiral ligand penicillamine, emitting in the second near-infrared window (NIR-II, 1000–1700 nm). Introducing chirality at the nanoscale has been attracting growing scientific interest, as it significantly influences the interaction of nanomaterials with biological systems, including protein adsorption, cellular uptake, blood circulation time, renal clearance, tumor targeting, and cytotoxicity. [1]

Despite the potential of Ag_2S QDs for theranostic applications, water-phase synthesized QDs typically suffer from low quantum yields (QY) and short fluorescence lifetimes, especially in the NIR-II range, limiting their practical use. In this work, we exploited the potential of the previously underestimated chiral penicillamine shell for Ag_2S QDs [2] and systematically optimized critical reaction parameters (time, temperature, and Ag:S ratio), in line with our earlier findings [3]. Structural and optical characterization was performed using circular dichroism (CD), UV–Vis absorption spectroscopy, fluorescence measurements, Z-Scan technique, and cytotoxicity assays.

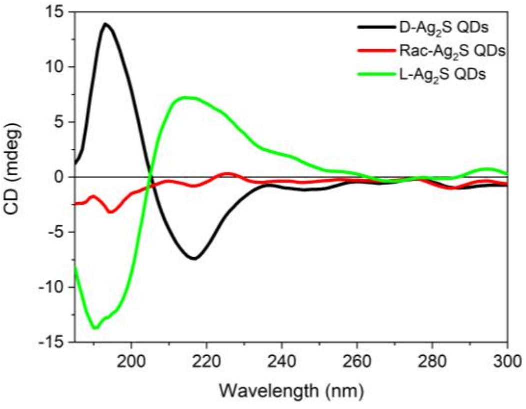


Fig. 1 CD spectra of Ag_2S QDs measured in aqueous solution.

As a result, we achieved a significant enhancement of the QDs optical performance. The synthesized chiral Ag_2S QDs exhibited strong NIR-II emission, fluorescence lifetimes of up to 84 ns – among the longest reported for aqueous Ag_2S QDs – and relatively high QY from 0.46% to 1.15%. These findings underscore the critical role of surface ligand conformation in defining the structural and optical properties of QDs, and open new perspectives for their use as advanced fluorescent probes and nanosensors in chirality-sensitive theranostic applications.

[1] Qu S. et al., *Sci Bull* 67, 1274–1283 (2022).

[2] Ren Q. et al., ACS Omega 6, 6361–6367 (2021).

[3] Gordel-Wójcik M. et al., Opt Mater 155, 115831 (2024).

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

P-60

FACILE SULFUR-FREE SYNTHESIS OF Y_2O_2S:Pr FROM $Y_2(SO_4)_3x8H_2O$ AND ITS BASIC LUMINESCENCE PROPERTIES

N. Trojanowska[*], **P. Łukaszczuk, J. Zeler, D. Kulesza, and E. Zych**

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

[*] corresponding author: *345875@uwr.edu.pl*

Keywords: Y_2O_2S:Pr, phosphor synthesis, Pr^{3+} luminescence

Yttrium oxysulfide (Y_2O_2S), along with Gd_2O_2S and La_2O_2S, is a technologically important host material widely used in luminescent and optical applications. However, its conventional synthesis typically relies on high-temperature solid-state reactions involving sulfurization agents such as elemental sulfur, hydrogen sulfide (H_2S), or carbon disulfide (CS_2), which pose notable safety and environmental risks. In this work, we present a novel and streamlined method for synthesizing Pr^{3+}-doped Y_2O_2S starting from hydrated yttrium sulfate, $Y_2(SO_4)_3)x8H_2O$, entirely avoiding the use of hazardous sulfurizing reagents. Our approach employs a controlled thermal decomposition pathway under mild, ambient-pressure conditions to directly yield the Y_2O_2S:Pr phosphor.

This simple and scalable route offers a safer and more sustainable alternative for preparing oxysulfide-based materials. The method has been validated using a Pr^{3+}-doped Y_2O_2S phosphor as a model system. Preliminary spectroscopic and luminescence data confirm the successful phase formation and functional optical properties of the synthesized material. Selected results are shown in Figure 1, and additional data will be presented during the poster session. The authors welcome discussion with ESTE2025 participants on the concept and implications of this work.

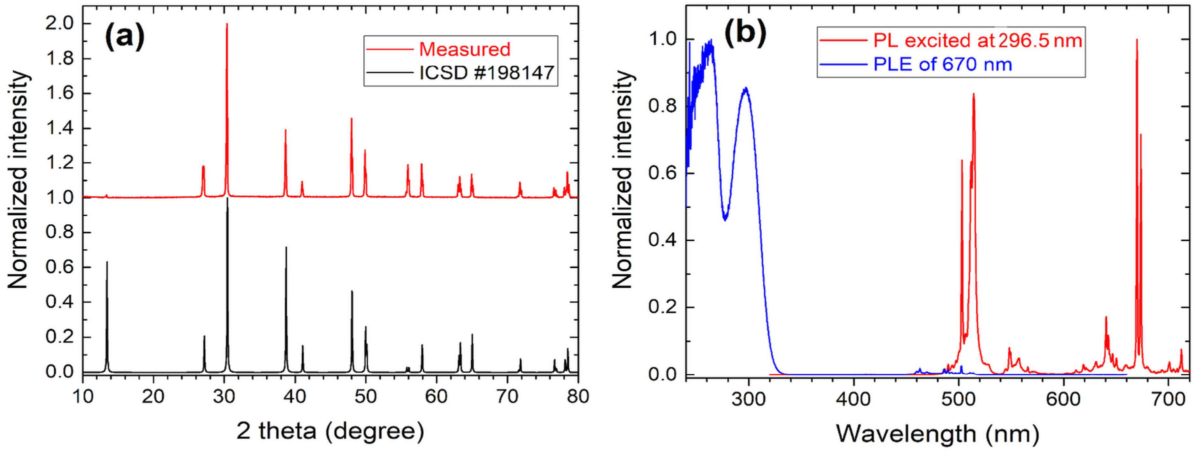


Fig. 1. (a) Measured (red) and theoretical (black) XRD patterns of Y_2O_2S:0.1%Pr and Y_2O_2S, respectively. (b) Excitatin (blue) and emission (red) spectra of Y_2O_2S:0.1%Pr.

This research was financed by the National Science Centre, Poland, under grant # UMO-2023/51/B/ST5/02341, which is gratefully acknowledged.

P-61

LIGHT IN TANDEM: Eu AND Tb CO-DOPING IN Y_2O_3 TRANSPARENT CERAMICS FOR DUAL-MODE LUMINESCENCE

J. Trojan-Piegza[1,*], Y. Wu[2], E. Zych[1]

[1]Faculty of Chemistry, University of Wrocław, 14 F. Joliot-Curie Street,
50-383 Wrocław, Poland
[2]Kazuo Inamori School of Engineering, New York State College of Ceramics,
Alfred University, 2 Pine Street, Alfred, NY, 14802, USA

* corresponding author: *joanna.trojan-piegza@uwr.edu.pl*

Keywords: yttrium oxide, transparent ceramics, thermoluminescence

Y_2O_3:Eu and Y_2O_3:Tb are among the most investigated phosphors for their attractive, high-quality red and green luminescence, respectively. A 2024 market report confirms steady demand for Y_2O_3:Eu phosphor worldwide, driven mostly by lighting and display technologies [1]. We found it interesting to investigate the doubly doped Y_2O_3:Eu,Tb, fabricated in the form of highly transparent sintered ceramics, to track the interplay and synergy between the two dopants.

In the studied $Y_2O_3:Eu^{3+},Tb^{3+}$ transparent ceramics, photoluminescence (PL) shows characteristic red emission of Eu^{3+} from the $^5D_0$ level (top lines in Figure 1). However, the thermoluminescent emission after X-ray irradiation identifies Tb^{3+} ion as the luminescence center (bottom line in Figure 1).

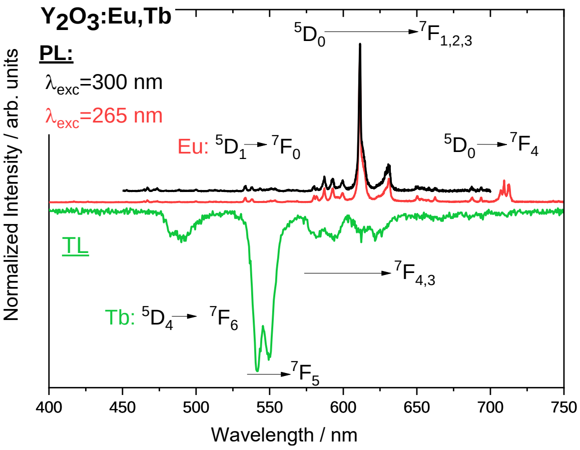


Fig. 1. PL (top) and TL after X-ray irradiation (bottom) spectra of Y_2O_3:Eu,Tb transparent ceramics.

The vacuum-referred binding energy (VRBE) diagram [2] reveals that the hole trap associated with Tb^{3+} is nearly twice as deep as the electron trap related to Eu^{3+}. A plausible carrier trapping during the exposure to X-rays involves the dopants' simultaneous valence state change from Eu^{3+}–Tb^{3+} → Eu^{2+}–Tb^{4+}. Detailed luminescent studies, especially related to TL, will be presented, and a complex interplay between the two co-dopants in the Y_2O_3:Eu,Tb transparent ceramics in photo-, radio-, and thermoluminescence will be discussed. Mostly, when excitation is applied to the ceramics, Eu^{3+} dominates the immediate luminescence response, generating its characteristic red luminescence. However, thermally stimulated luminescence reveals a striking shift: Tb^{3+} becomes the primary emitter, pointing to distinct trapping and energy transfer dynamics. Thus, Eu^{3+} tells the tale of excitation; Tb^{3+} speaks when traps release their charge.

[1] C. Jaiswal, *Market Research Future* **June** (2025) 1-111.

[2] P. Dorenbos, *J. Lumin.* **91** (2000) 155.

This research was supported by the Polish National Science Center (NCN) grant UMO-2023/51/B/ST5/02341.

P-62

BEYOND THE GLOW CURVE: ADVANCED THERMOLUMINESCENCE MAPPING IN MATERIALS DOPED WITH RARE EARTHS

K. Wisniewski[1,*], **M.E. Witkowski**[1], **A. Chruścińska**[1], **W. Drozdowski**[1]

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

* corresponding author: *wisniek@umk.pl*

Keywords: wavelength-resolved thermoluminescence, thermoluminescence, rare earth, traps

Lanthanide-doped materials are extensively employed in scintillation technology and photonics owing to their favourable luminescent properties. Despite intensive study, the mechanisms of charge-carrier trapping and their impact on luminescence efficiency remain incompletely understood. In the present work, we report thermoluminescence (TL) investigations of selected rare-earth-activated materials aimed at identifying and characterising trap states associated with these dopants. By implementing wavelength-resolved TL measurement technique, we demonstrate the ability to discriminate trap types and determine trap depths as a function of both dopant species and host lattice. Wavelength-resolved thermoluminescence measurements provide spectral discrimination of recombination centres, enabling the deconvolution of overlapping TL peaks and the assignment of specific emission bands to distinct trap depths. By correlating emission a wavelengths with thermal activation energies, it becomes possible to infer the charge state and spatial distribution of traps, thus enhancing the resolution of kinetic models describing trapping and detrapping mechanisms. Finally, we highlight competing radiative and nonradiative recombination pathways that govern the quantum yield and thermal stability of luminescence in these systems.

MODELING OF RADIOPHOTOLUMINESCENCE

M.E. Witkowski[1,*], **W. Drozdowski**[1]

[1]*Institute of Physics, Faculty of Physics, Astronomy and Informatics,*
Nicolaus Copernicus University, Grudziądzka 5, 87-100 Toruń, Poland

* corresponding author: *mwit@fizyka.umk.pl*

Keywords: radiophotoluminescence, traps, thermoluminsecence,

Early investigators involved in the development of what is now known as radiophotoluminescence (RPL) identified a fundamental relationship between RPL, thermoluminescence (TL), and optically stimulated luminescence (OSL) phenomena following the exposure of materials to ionizing radiation, such as gamma or X-rays. The term "radiophotoluminescence" was first introduced by Przibram [1,2] to denote a form of photoluminescence that arises only after the absorption of ionizing radiation. Prior to irradiation, the host material exhibits no inherent photoluminescent properties; the incident radiation induces the formation of luminescent defect centers that are otherwise absent in the pristine lattice.

In contrast to TL and OSL, the detection of the RPL signal does not involve ionization of these radiation-induced centers. Rather, the process entails promoting an electron, localized at a defect site, to an excited electronic state, followed by radiative relaxation to the ground state, resulting in photon emission. A distinguishing feature of RPL is its non-destructive readout capability: the luminescent signal can be repeatedly stimulated and recorded without depletion or degradation of the signal intensity. This contrasts with TL and OSL, where the readout process inherently leads to partial or complete signal erasure. Schulman et al. [3] later emphasized that RPL, alongside TL and OSL, possesses significant utility in the field of radiation dosimetry.

In this Communication the results of simulations of a simple RPL model, constructed with a shallow trap, an RPL trap, and a single recombination center, under various scenarios are presented.

[1] K. Przibram, E. Kara-Michailowa, *Wiener. Ber.* **131** (1922) 511.

[2] K. Przibram, *Zeit. Physik* **20** (1923) 196.

[3] J.H. Schulman et al., *J. Appl. Phys.* **22** (1951) 1479.

P-64

PRIMARY LUMINESCENCE THERMOMETRY
THE CASE OF THE $Lu_3(Al,Ga)_5O_{12}$:Pr PHOSPHOR

J. Zeler, **J. Trojan-Piegza, and E. Zych**[*]

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

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

Keywords: luminescence thermometry, primary thermometry, Pr^{3+} luminescence

Temperature sensors dominate the global sensor market (~80%). As emerging technologies demand greater precision, sensitivity, and speed, optical temperature sensing stands out for its immunity to electromagnetic interference and suitability for dynamic systems. Combined with ongoing miniaturization, these advantages make optical methods a future-proof solution. These benefits drive research in this area.

We investigate the luminescent properties of $Lu_3(Al_4Ga_1)O_{12}$:0.1%Pr phosphor across the 12 - 600 K temperature range, highlighting its suitability for optical thermometry. Key attention is given to thermally-assisted population redistribution between the $^3P_0$ and $^3P_1$ energy levels, enabling temperature readout governed by Boltzmann statistics. Notably, this mechanism delivers a reliable and sensitive response across a broad range of 100–600 K - far exceeding the predicted optimal range (217.6–371.4 K), see Eq. 1 [1,2]. Supporting data are shown in Figure 1. The redistribution between Stark levels of $^1D_2$ will also be treated.

$$\frac{\Delta E}{(2+\sqrt{2})k_B} \leq T \geq \frac{\Delta E}{2k_B} \qquad (1)$$

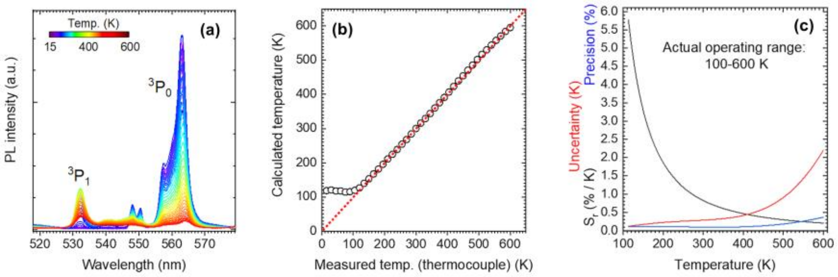


Fig. 1. 451 nm excited luminescence of $Lu_3Al_4Ga_1O_{12}$:0.1%Pr (a), comparison of temperatures measured with a thermocouple and calculated assuming a Boltzmann distribution (b), and computed thermometric parameters: relative thermal sensitivity, temperature uncertainty, and precision of measurements using luminescence spectra of the phosphor.

[1] M. Suta, and A. Meijerink, *Adv. Theory Simul.*, **3** (2020) 2000176.

[2] F.E. Maturi et al., *Chem. Mater.*, 35 (2023) 7229 – 7238.

This research was financed by the National Science Centre, Poland, under grant # UMO-2023/51/B/ST5/02341.

PHOTOCONVERSION PROPERTIES OF TWO- AND THREE-LAYERED EPITAXIAL STRUCTURES BASED ON Ce^{3+}-DOPED GARNETS FOR ENCHANCED PHOSPHOR-CONVERTED WHITE LEDs

V. Gorbenko[1,*], A. Shakhno[1,2], T. Zorenko[1], S. Witkiewicz-Łukaszek[1], Yu. Zorenko[1]

[1]*Department of Physics, Kazimierz Wielki University, Bydgoszcz, 85-090, Poland*
[2]*Department of Mechatronics , Kazimierz Wielki University, Bydgoszcz, 85-074, Poland*
* corresponding author: tzorenko@ukw.edu.pl

Keywords: liquid-phase epitaxy, single crystalline films, garnets, Planar-Chip-Level Conversion, WLEDs

This work presents the development and optical characterization of multilayered garnet-based structures aimed at tuning photoconversion performance for white LED (WLED) applications. Building on earlier research [1, 2], we designed and fabricated two- and three-layered epitaxial composites based on garnet compounds using the Liquid Phase Epitaxy (LPE) technique. The core layer in all structures is a single-crystal $Gd_3Ga_3Al_2O_{12}$:Ce (GAGG:Ce) substrate with a Ga content of 3.0, known for its high light yield and blue-green emission [1]. A second converter layer consists of LPE-grown films of GAGG:Ce with a lower Ga content (1.5-2.25), intended to broaden the emission spectrum by shifting part of the emission toward shorter wavelengths [1]. For the three-layered composite, a third top layer of $Tb_3Al_5O_{12}$:Ce (TbAG:Ce) was added to further enhance the composite converter in the yellow-orange region of the spectrum [2]. This multilayered approach aims to expand the overall emission spectrum by combining different garnet phases, each tailored for specific spectral ranges.

The optical properties of TbAG:Ce and GAGG:Ce (Ga=1.5–2.25) SCFs, GAGG:Ce (Ga=3.0) substrates, and composites based on them were investigated using conventional spectral methods, such as absorption and cathodo- and photoluminescence. The photo-conversion properties of these layered structures were evaluated under blue LED excitation (λ=450 nm), focusing on their emission spectra, chromaticity coordinates, and colour rendering index. We found that integrating garnet layers with different Ga and Tb contents enabled efficient spectral engineering, compensating for common dips in the green spectral region and allowing for smoother, broader emission (Fig. 1).

The results demonstrate that combining films and substrate properties enables flexible tuning of WLED color output and the tone of white light by simply adjusting film thicknesses and dopant levels. This multilayered design strategy not only enhances color rendering and luminous efficacy but also offers a pathway toward customizable solid-state lighting solutions.

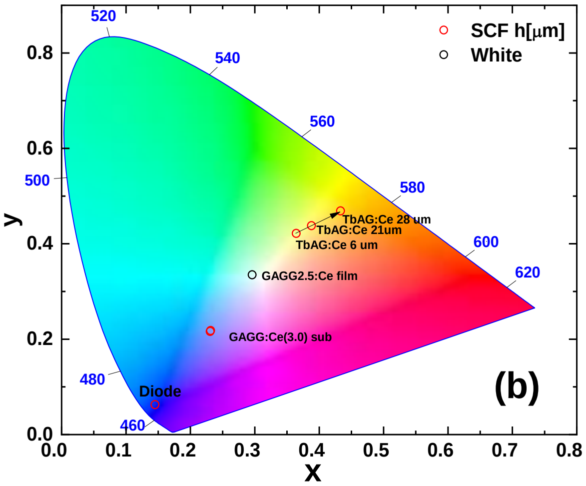


Fig. 1. Chromaticity diagram of a WLED prototype fabricated on the base of 450 nm LED chip and GAGG2.25:Ce SCF/GAGG3:Ce SC substrate and TbAG:Ce SCF/GAGG2.25:Ce SCF/GAGG3:Ce SC substrates with different upper SCF thickness.

[1] S. Witkiewicz-Lukaszek, et al. *Crystal Growth & Design*, 18 *(2018) 1834–1842.*

[2] S. Witkiewicz-Lukaszek, et al. *CrystEngComm* 20 (2018) 3994–4002.

Acknowledgments: The investigations was performed in the frameworks of Polish NCN 2022/45/B/ST8/01757 project and also supported by the Ministry of Science and High Education of Poland in frame of nr RID/SP/ 0048/2024/01 project.

P-66

Molecular Engineering of Lanthanide(III) Complexes Towards Dual-Function Single-Molecule Magnets Displaying Luminescence Thermometry

<u>Airton G. Bispo-Jr,</u>[1*] Diogo A. Gálico,[2] Fernando A. Sigoli,[3] Muralee Murugesu[2]

[1]*Department of Fundamental Chemistry, University of São Paulo (USP), Institute of Chemistry, São Paulo, São Paulo, 05508-900, Brazil.*
[2] *Department of Chemistry and Biomolecular Sciences, University of Ottawa, Ottawa, Ontario, K1N6N5, Canada.*
[3] *Department of Inorganic Chemistry, Institute of Chemistry, University of Campinas, Josué de Castro Street, Campinas, São Paulo, 13083-970, Brazil.*

* corresponding author: *<u>airton.bispo.junior@iq.usp.br</u>*

Keywords: Rare earths, single-molecule magnets, luminescence thermometry, quantum computing.

Lanthanide(III) (Ln^{III}) coordination compounds lead the field of single-molecule magnets (SMMs), offering promise for application in high-density data storage molecular devices. In these SMMs, luminescence provides additional insight into magnetic dynamics and enables molecular-level temperature sensing. However, enhancing both luminescence and magnetic properties remains a key challenge. Herein, mononuclear and dinuclear Ln^{III} species are presented to investigate how the precise structural control affects magnetic and luminescent properties through magneto- and opto-structural correlations. These complexes include $[Nd_2(valdien)_2(acac)_2]$ (1) (N^1,N^3-bis(3-methoxysalicylidene)diethylenetriamine, $acac^-$ = acetylacetonate), $[Nd_2(valdien)_2(NO_3)_2]$ (2), [Dy(acac)$_3$(bpm)] (3) (bpm = 2,20-bipyrimidine), $[Dy_2(bpm)(hexd)_6]$ (4) (hexd = 2,4-hexanedione), and $[Dy_2(bpm)(hpd)_6]$ (5) (hpd = 3,5-heptanedione). The Nd^{III} complexes show field-induced slow magnetic relaxation, with temperature-dependent dynamics linked to QTM and Raman processes due to a distorted D_{2d} coordination environment. The Dy^{III} species exhibit zero-field SMM behavior with effective barrier to the reversal of magnetization reaching up to 290 K (3), attributed to a slightly distorted D_{4d} coordination environment. Complexes 1 and 2 display Nd^{III} near-infrared luminescence, and the crystal field band components in the emission spectra enabled temperature sensing with a maximum relative thermal sensitivity (S_r) reaching 0.5% K^{-1} at 50 K. 3 – 5, in their turn, presented the typical Dy^{III} luminescence within the visible spectral range. This was also used to probe the temperature, achieving a maximum S_r of 1.5% K^{-1} at 70 K (3). The maximum S_r in these complexes is governed by ligand triplet state energy and local symmetry, tuned via electronic/steric effects. This investigation offers guidance for mapping structural parameters to design dual-functional magnetic–luminescent materials.

[1] A. G. Bispo-Jr, D. A. Gálico, R. M. Diaz-Rodriguez, J. S. Ovens, F. A. Sigoli, M. Murugesu, *Inorg. Chem. Front.* **10** (2023) 3929.

[2] A. G. Bispo-Jr, L. Yeh, D. Errulat, D. A. Galico, F. A. Sigoli, M. Murugesu, *Chem. Commun.* **59** (2023) 8723.

[3] A. G. Bispo-Jr, D. A. Galico, F. A. Sigoli, M. Murugesu, Dalton Trans. **54** (2025) 4876.

Acknowledgments: FAPESP (Process number: 2021/09755-0 and 2019/23763-6)

Participating author index

ISBN 978-83-60043-43-1

SPONSORS