BOOK OF ABSTRACTS

12TH INTERNATIONAL CONFERENCE ON
Luminescent Detectors and Transformers of Ionizing Radiation

JUNE 16-21, 2024, RIGA, LATVIA

ORGANIZERS:

INSTITUTE OF SOLID STATE PHYSICS
UNIVERSITY OF LATVIA

LU CFI FONDS

UNIVERSITY OF LATVIA
FACULTY OF PHYSICS, MATHEMATICS AND OPTOMETRY

SUPPORTERS:

UNIVERSITY OF LATVIA

EURADOS

12TH INTERNATIONAL CONFERENCE ON

Luminescent Detectors and Transformers of

Ionizing Radiation

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Organized by:

Institute of Solid State Physics, University of Latvia

Foundation of the Institute of Solid States Physics (LU CFI Fonds)

Faculty of Physics, Mathematics and Optometry, University of Latvia

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LUMDETR 2024 plenary, keynote and oral session program

SUNDAY, 16.06.2024

Time	Event
15:00 – 18:00	**Arrival and registration with refreshment**

UL House of Science – central hall

MONDAY, 17.06.2024

08:00 – 09:00	**Registration of the participants**		
09:00 – 09:40	**Opening ceremony**		Anatoli I. Popov
09:40 – 10:00	**In memoriam**		Anatoli I. Popov, Anatolijs Šarakovskis
10:00 – 10:30	**Coffee-break**		
Chairman	Anatoli I. POPOV Marina KONUHOVA		
10:30 –11:15	Mikhail Brik (Estonia)	MoPL-1 Plenary talk (45 min)	Defects in inorganic crystals and calculations of their properties **Mikhail G. Brik**
11:15 –12:00	Miroslav Dramicanin (Serbia)	MoPL-2 Plenary talk (45 min)	Multiparameter Approaches for Improved Temperature Readings from Luminescence **Miroslav D. DRAMICANIN**, Zoran RISTIC
12:00 –12:30	Yevheniia Smortsova (Germany)	MoK-3 Keynote presentation (30 min)	Vacuum ultraviolet time-resolved luminescence at P66 at DESY: instrument characteristics and applications **Yevheniia SMORTSOVA**, Aleksei KOTLOV, Oksana CHUKOVA
12:45 –14:00	**Lunch**		
Chairman	Miroslav D. DRAMICANIN Yevheniia SMORTSOVA		
14:00 – 14:30	Mamoru Kitaura (Japan)	MoK-4 Keynote presentation (30 min)	Visualizing Energy Levels of Lanthanides and Defects in Multicomponent Garnet Crystals by Mid Infrared Free Electron Laser **Mamoru Kitaura**, Heishun Zen, Shinta Watanabe, Hirokazu Masai, Kei Kamada, Kyong Jin Kim, Akira Yoshikawae
14:30 – 15:00	Tomoyuki Yamamoto (Japan)	MoK-5 Keynote presentation (30 min)	Investigation of local environment of 3d transition elements in phosphor materials **Tomoyuki YAMAMOTO**, Moe HIRANO, Dilshod NEMATOV, Amodulloi BURKHONZODA, Zafari UMAR, Mikhail G. BRIK

15:00 – 15:20	Kazuya Omuro (Japan)	MoO-6 Oral presentation (20 min)	Crystal Growth and Evaluation of 1-Inch Diameter GAGG:Ce,Tb Single-Crystal Scintillator for High-Resolution Synchrotron Radiation X-ray Imaging **Kazuya OMURO**, Masao YOSHINO, Liudmila Gushchina, Kei KAMADA, Kyoung Jin KIM, Takahiko HORIAI, Rikito MURAKAMI, Akihiro YAMAJI, Takashi HANADA, Yuui YOKOTA, Shunsuke KUROSAWA, Yuji OHASHI, Hiroki SATO, Akira YOSHIKAWA
15:20 – 15:40	Yuka Abe (Japan)	MoO-7 Oral presentation (20 min)	A study on single crystal growth and energy transfer in Ce^{3+} and Pr^{3+} co-doped $Lu_2Si_2O_7$ **Yuka ABE**, Takahiko HORIAI, Jan PEJCHAL, Martin NIKL, Yuui YOKOTA, Masao YOSHINO, Rikito MURAKAMI, Takashi HANADA, Akihiro YAMAJI, Hiroki SATO, Yuji OHASHI, Shunsuke KUROSAWA, Kei KAMADA, Akira YOSHIKAWA
15:40 – 16:00	Matteo Orfano (Italy)	MoO-8 Oral presentation (20 min)	Fast emitting nanocomposites for high-resolution ToF-PET imaging based on multicomponent scintillators **Matteo ORFANO**, Fiammetta PAGANO, Ilaria MATTEI, Francesca COVA, Valeria SECCHI, Silvia BRACCO, Edith ROGERS, Luca BARBIERI, Matteo SALA, Roberto LORENZI, Gregory BIZZARRI, Etiennette AUFFRAY, Angelo MONGUZZI
16:00 – 16:30	**Coffee-break**		
Chairman	Tomoyuki YAMAMOTO Mikhail G. Brik		
16:30 – 17:00	Michal Piasecki (Poland)	MoK-9 Keynote presentation (30 min)	Searching for better X-ray and γ-ray photodetectors: case of the $TlPb_2Br_5{-}xI_x$ quaternary system **M. Piasecki**, V. Pavlyuk, O. Y. Khyzhun,. L. Myronchuk, L. V. Piskach, A. O. Fedorchuk, I. Barchyi, M.G.Brik
17:00 – 17:20	Roberto Lorenzi (Italy)	MoO-10 Oral presentation (20 min)	Innovative approaches to advanced X-ray detection with layered garnet optical ceramics **Roberto Lorenzi**, Jan Hostaša, Andreana Piancastelli, Laura Esposito, Valentina Biasini, Francesco Picelli, Alberto Paleari, Anna Vedda, and Francesca Cova
17:20 – 17:40	Sandra Witkiewicz-Łukaszek (Poland)	MoO-11 Oral presentation (20 min)	Scintillation materials - LuAG, YAG and GAGG doped with Ce^{3+} in thermoluminescence dosimetry **Sandra WITKIEWICZ-ŁUKASZEK**, Paulina MICHALSKA, Janusz WINIECKI, Yuriy ZORENKO
17:40 – 18:00	Rikito Murakami (Japan)	MoO-12 Oral presentation (20 min)	Improvement of Scintillation Properties in Ce doped $(Gd,La)2Si_2O_7$ Single Crystals by Anisotropic Etching **Rikito Murakami,** Shunsuke Kurosawa, Masao Yoshino, Takahiko Horiai, Yuka Abe, Yasuhiro shoji, Kei Kamada, Akira Yoshikawa
18:00 – 18:20	Kei Kamada (Japan)	MoO-13 Oral presentation (20 min)	Evaluation of thermal neutron and gamma ray discrimination performance of $6LiCl/LaCl_3$ eutectic scintillators **Kei Kamada**, Rei Sasaki, Kyoung Jin Kim, Naoko Kutsuzawa, Masao Yoshino, Rikito Murakami, Takahiko Horiai, and Akira Yoshikawa

18:20 – 18:40	Yurii Syrotych (Poland)	MoO-14 Oral presentation (20 min)	Development of multilayered composite scintillators based on the single crystalline films and crystals of doped YAP and LuYAP perovskites **Y. Syrotych,** S. Witkiewicz-Lukaszek, V. Gorbenko, R. Kucerkova, J.A. Mares, M. Nikl, A. Petrosyan, C. Dujardin, Yu. Zorenko
18:40 – 20:30	**Welcome party**		

TUESDAY, 18.06.2024

Chairman	Sergii UBIZSKII Yaroslav ZHYDACHEVSKYY		
9:00-9:45	Francesca Cova (Italy)	TuPL-1 Plenary talk (45 min)	Defect-related phenomena in scintillating materials for high-energy radiation detection **Francesca Cova**
9:45-10:30	Alida Timar-Gabor (Romania)	TuPL-2 Plenary talk (45 min)	Multi-spectroscopic studies of luminescence emissions in natural quartz: towards understanding physical processed involved in dating and provenance applications using sedimentary grains **Alida TIMAR-GABOR**
10:30-11:00	**Coffee-break**		
Chairman	Francesca COVA Alida TIMAR-GABOR		
11:00-11:30	Arkadiusz Mandowski (Poland)	TuK-3 Keynote presentation (30 min)	Peculiarities of long-term luminescence decay in feldspars **Arkadiusz MANDOWSKI**, Robert SMYKA, Ewa MANDOWSKA
11:30-12:00	Magdalena Biernacka (Germany)	TuK-4 Keynote presentation (30 min)	Can lyoluminescence revolutionize the luminescence dating of evaporites? **Magdalena BIERNACKA**, Sebastian KREUTZER
12:00-12:20	Aleksandra Jung (Poland)	TuO-5 Oral presentation (20 min)	Thermoluminescence and optical properties of lithium fluorite after ultra-high dose rate irradiations **Aleksandra JUNG**, Agata CZUK, Zenon MATUSZAK, Jan SWAKON
12:20-12:40	Alicja Chruścińska (Poland)	TuO-6 Oral presentation (20 min)	Medium OSL component in quartz - resolving controversies about thermal stability **Alicja CHRUŚCIŃSKA**, Magdalena BIERNACKA, Piotr PALCZEWSKI, Marcin E. WITKOWSKI
12:40-13:00	Marija Majer (Croatia)	TuO-7 Oral presentation (20 min)	Dosimetric response of radiophotoluminescent glass detectors in heavy charged particle beams **Marija MAJER**, Luka PASARIČEK, Željka KNEŽEVIĆ, Tomislav BOKULIĆ, Georgios PROVATAS, Iva BOŽIČEVIĆ MIHALIĆ
13:00-14:00	**Lunch**		
Chairman	Arkadiusz MANDOWSKI Magdalena BIERNACKA		
14:00-14:30	Irene Villa (Italy)	TuK-8 Keynote presentation (30 min)	On the origin of the light yield enhancement in polymeric composites scintillators loaded with dense nanoparticles **Irene Villa**, Valeria Secchi, M. Campione, S. Rahimipour, Angelo Monguzzi

14:30-15:00	Shunsuke Kurosawa (Japan)	TuK-9 Keynote presentation (30 min)	Scintillation Properties of Red and Infrared Scintillator and their Applications – Dose-Rate Monitoring System for Decommissioning– **Shunsuke KUROSAWA**, Shhei KODAMA, Chihaya FUJIWARA, Akihiro YAMAJI
15:00-15:30	Michael Discher (Austria)	TuK-10 Keynote presentation (30 min)	Testing different luminescence measurement protocols for display glass as an accident dosimeter **Michael DISCHER**, Hyoungtaek KIM, Min Chae KIM, Jungil LEE, Young-Yong JI
15:30-16:00	Maksym Buryi (Chech republic)	TuK-11 Keynote presentation (30 min)	0D defects in isostructural Zn-based single crystals **Maksym BURYI**, Bohuslav REZEK, Andriy PROKHOROV, Zdeněk REMEŠ, Katarína RIDZOŇOVÁ, Karina LAMONOVA
16:00 – 16:30	**Coffee-break**		
Chairman	Irene VILLA Michael DISCHER		
16:30-17:00	Enrico Nichelatti (Italy)	TuK-12 Keynote presentation (30 min)	Energy diagnostics of the TOP-IMPLART linac proton beam via radiophotoluminescence of colour centres in lithium fluoride **Enrico NICHELATTI**, Alessandro AMPOLLINI, Maria Denise ASTORINO, Giulia BAZZANO, Rosa Maria MONTEREALI, Paolo NENZI, Valentina NIGRO, Concetta RONSIVALLE, Vincenzo SURRENTI, Emiliano TRINCA, Maria Aurora VINCENTI, Massimo PICCININI
17:00-17:20	Karol Bartosiewicz (Poland)	TuO-13 Oral presentation (20 min)	Shaping scintillation and micro-structure properties through synergistic lattice engineering and exciton-mediated energy transfer in Pr^{3+} doped $Lu_{1.5}Y_{1.5}Al_{5-x}S_xO_{12}$(x=0-2) garnet crystals **Karol BARTOSIEWICZ**, Justyna ZELER, Wioletta DEWO, Marcin E. WITKOWSKI, Konrad J. DROZDOWSKI, Masao YOSHINO, Takahiko HORIAI, Damian SZYMANSKI, Shunsuke KUROSAWA, Kei Kamada, Winicjusz DROZDOWSKI, Tomasz RUNKA, Eugeniusz ZYCH, Akira YOSHIKAWA
17:20-17:40	Takahiko Horiai (Japan)	TuO-14 Oral presentation (20 min)	Optical and radioluminescence of Fe^{3+}-doped $Lu_2Si_2O_7$ **Takahiko HORIAI**, Yuka ABE, Yuui YOKOTA, Masao YOSHINO, Kei KAMADA, Akira YOSHIKAWA
17:40-18:00	Ondrej Zapadlik (Chech Republic)	TuO-15 Oral presentation (20 min)	GSAG:Ce scintillator: Insights from Yttrium admixture **Ondrej ZAPADLIK**, Jan PEJCHAL, Vladimir BABIN, Viteslav JARY, Vojtech VANECEK, Romana KUCERKOVA, Alena BEITLEROVA, Martin Nikl
18:00-19:30	**POSTER SESSION-A**		
Chairman	Vladimir PANKRATOV		

WEDNESDAY, 19.06.2024

Chairman	Enrico NICHELATTI Maksym BURYI		
9:00-9:45	Christophe Dujardin (France)	WePL-1 Plenary talk (45 min)	Nanoporous scintillators for radioactive gas detection R.Marie-Luce, P.Mai, F.Lerouge, Y.Cheref, S.Pierre, B.Sabot, F.Chaput and **C. Dujardin**
9:45-10:30	Pawel Bilski (Poland)	WePL-2 Plenary talk (45 min)	Passive luminescent dosimetry in space exploration **Pawel Bilski**
10:30-11:00	**Coffee-break**		
Chairman	Christophe DUJARDIN Pawel BILSKI		
11:00-11:30	Miroslav Kucera (Czech Republic)	WeK-3 Keynote presentation (30 min)	Garnet Scintillators with Excellent Timing Characteristics - Material Engineering by Liquid Phase Epitaxy **Miroslav KUCERA**, Mamilla RATHAIAH, Martin NIKL
11:30-12:00	Sergii Ubizskii (Ukraine)	WeK-4 Keynote presentation (30 min)	Application of high Z phosphor to distinguish hazardous radioisotope radiation in absorbed dose measurement **Sergii UBIZSKII**, Oleksandr POSHYVAK, Zuzanna PAWŁOWSKA, Vadim CHUMAK, Elena BAKHANOVA, Yaroslav ZHYDACHEVSKYY
12:00-12:20	Mátyás Hunyadi (Hungary)	WeO-5 Oral presentation (20 min)	Thin-film scintillators of copper-halide perovskites developed for the spectroscopy of charged-particle radiations **Mátyás HUNYADI**, Lóránt CSIGE, Attila CSÍK, Cintia HAJDU, Csaba JANÁKY, Gergely F. SAMU
12:20-12:40	Daichi Sato (Japan)	WeO-6 Oral presentation (20 min)	Scintillation properties of Ce-doped $SrHfO_3$ transparent ceramics for photon-counting X-ray CT imaging **Daichi SATO**, Shunsuke KUROSAWA, Koichi HARATA, Kana FUJIOKA, Akihiro YAMAJI, Yusuke URANO, Makoto ARIMOTO, Fitri LUCYANA, Takahiro TOMODA
12:40-13:00	Jan Bárta (Czech Republic)	WeO-7 Oral presentation (20 min)	Photochemical synthesis of luminescent multicomponent oxide (nano)materials **Jan BÁRTA**, Xenie POPOVIČ, Lenka PROUZOVÁ PROCHÁZKOVÁ, František HÁJEK, Vojtěch SCHEINPFLUG, Václav ČUBA
13:00-14:00	**Lunch**		
Chairman	Miroslav KUCERA Alma DAULETBEKOVA		
14:00-14:30	Yaroslav Zhydachevskyy (Poland)	WeK-8 Keynote presentation (30 min)	Tuning of Mn^{4+} and Cr^{3+} luminesce in Ga_2O_3 by alloying with Al_2O_3 and In_2O_3 **Yaroslav ZHYDACHEVSKYY**, Vasyl STASIV, Vitalii STADNIK, Iryna LUTSYUK, Vasyl HREB, Vitaliy MYKHAYLYK, Leonid VASYLECHKO, Andriy LUCHECHKO, and Andrzej SUCHOCKI

14:30-15:00	Daniela Gogova (Sweden)	WeK-9 Keynote presentation (30 min)	GALLIUM OXIDE – A PROMISSING MATERIAL FOR THE NEXT GENERATION HIGH-POWER ELECTRONICS **Daniela Gogova**
15:00-15:20	Sophia Welti (Japan)	WeO-10 Oral presentation (20 min)	Radiochromic reactions and sensitivity changes of a radiophotoluminescence glass (FD-7) after repetitive irradiations with high-dose X-rays **Sophia WELTI**, Hiroshi ASUDA, Ryuto NOBE, Yuka YANAGIDA, Yasuhiro KOGUCHI
15:20-15:40	Luiz Jacobsohn (USA)	WeO-11 Oral presentation (20 min)	Controlled UV Emission from Gd-Doped $MgAl_2O_4$ Robin L. CONNER, David VAN DER HEGGEN, Dirk POELMAN, Philippe F. SMET, **Luiz G. JACOBSOHN**
15:40-16:00	Yusuke URANO (Japan)	WeO-12 Oral presentation (20 min)	Luminescence Properties of Novel Tl^{+} and Sr^{2+} Co-doped $Cs_3Cu_2I_5$ Scintillator for Boron Neutron Capture Therapy **Yusuke URANO**, Shunsuke KUROSAWA, Akihiro YAMAJI, Akira YOSHIKAWA, Yuntao WU
16:00 – 16:30	**Coffee-break**		
Chairman	Daniela GOGOVA Luiz G. JACOBSOHN		
16:30-17:00	Yuri Dekhtyar (Latvia)	WeK-13 Keynote presentation (30 min)	Near Threshold Electron Emission Spectroscopy Towards Dosimetry of Nanovolumes **Yuri Dekhtyar,** Mirko Rocca, Marina Romanova
17:00-17:30	Karina Lamonova (Ukraine)	WeK-14 Keynote presentation (30 min)	Modified Crystal Field Theory: New Possibilities for Optical Spectra Analysis **Karyna LAMONOVA**
17:30-19:00	**POSTER SESSION-B**		
Chairman	Vladimir Pankratov		
17:45-18:45	**Advisory Board meeting**		

THURSDAY, 20.06.2024

Chairman	Vladimir PANKRATOV Karina LAMONOVA		
9:00-9:45	Yuriy Zorenko (Poland)	ThPL-1 Plenary talk (45 min)	Recent advancements in research of the single crystals and single crystalline film phosphors using synchrotron radiation **Yuriy ZORENKO**
9:45-10:30	Aleksandr Lushchik (Estonia)	ThPL-2 Plenary talk (45 min)	Visualization of radiation Frenkel defects in wide-gap materials via optical and EPR methods **Aleksandr LUSHCHIK**
10:30-11:00	**Coffee-break**		
Chairman	Yuriy ZORENKO Aleksandr LUSHCHIK		
11:00-11:20	Masao Yoshino (Japan)	ThO-3 Oral presentation (20 min)	Development of a low-cost charged particle imaging detector using $GdAlO_3$: Tb-αAl_2O_3 PSSF and Raspberry Pi camera module **Masao YOSHINO,** Seiichi YAMAMOTO, Kei KAMADA, Nanase KOSHIKAWA, Jun KATAOKA, Akira YOSHIKAWA
11:20-11:40	Inesh Kenzhina (Kazakhstan)	ThO-4 Oral presentation (20 min)	Investigation of fusion breeder materials under neutron irradiation at WWR-K research reactor **I. Kenzhina,** T. Kulsartov, Ye. Kenzhin, Ye. Chikhray, A. Shaimerdenov, Zh. Zaurbekova, Yu. Gordienko, Yu. Ponkratov, A. Tolenova
11:40-12:30	**Lunch**		
12:30-23:00	**Excursion & Banquet**		

FRIDAY, 21.06.2024

Chairman	Anatolijs ŠARAKOVSKIS Vladimir PANKRATOV		
9:00-9:30	Andris Antuzevics (Latvia)	FrK-1 Keynote presentation (30 min)	Photochromism and persistent luminescence in complex oxides: Unveiling the role of paramagnetic centres **Andris ANTUZEVICS**, Guna KRIEKE, Guna DOKE, Dace NILOVA, Pavels RODIONOVS, Jekabs CIRULIS, Andris FEDOTOVS, Uldis ROGULIS
9:30-10:00	Juris Purans (Latvia)	FrK-2 Keynote presentation (30 min)	Near Field X-ray Optical Luminescence Scanning Probe Microscopy **Juris Purans**
10:00-10:30	Saulius Nargelas (Lithuania)	FrK-3 Keynote presentation (30 min)	Mechanisms of Aliovalent Codoping on the Timing Properties of the Multicomponent Garnet Scintillators **Saulius NARGELAS**, Yauheni TALOCHKA, Žydrūnas PODLIPSKAS, Arnoldas SOLOVJOVAS, Gintautas TAMULAITIS, Zuzana LUCENICOVA, Miroslav KUCERA
10:30-11:00	**Coffee-break**		
Chairman	Anatolijs ŠARAKOVSKIS Vladimir PANKRATOV		
11:00-11:30	Dariusz Hreniak (Poland)	FrK-4 Keynote presentation (30 min)	Low-temperature studies of transparent yttrium aluminum garnet ceramics doped with Sm^{3+} ions Yanqiu Jing, V. Boiko, P. Stachowiak, Tingsong Li, Chen Hu, B. Macalik, J. Komar, Jiang Li, **D. Hreniak**
11:30-12:00	Virginija Vitola (Latvia)	FrK-5 Keynote presentation (30 min)	Advances in persistent luminescence research - case of alkaline earth metal aluminates **Virginija Vitola**
12:00-12:20	Artur Majewski-Napierkowski (Poland)	FrO-6 Oral presentation (20 min)	Applications of YAG:Ce and LuAG:Ce crystal detectors for registration radiation activity of liquid wastes at Oncology Center in Bydgoszcz **Artur Majewski-Napierkowski**, Mateusz Wedrowski, Sergei Nizhankovskiy, Yurii Siryk, Oleg Sidleskiy, Yuriy Zorenko

12:20-12:40	Rodolfo Ruiz (Mexico)	FrO-7 Oral presentation (20 min)	Persistent luminescence properties of $E^{2+,}$ Dy^{3+} co-doped calcium aluminate synthesized by combustion method **R. Ruiz-Torres**, N.J. Zúñiga-Rivera, P. Salas-Castillo, R. Meléndrez and M. Barboza-Flores
12:40-13:00	Vladimir Pankratov (Latvia)	FrO-8 Oral presentation (20 min)	Cross-Luminescence in Doped BaF2 Single Crystals for Detection of Gamma and X-ray Radiation with Picosecond Resolution Viktorija PANKRATOVA, Roman SHENDRIK, Evgeny RADZHABOV, Aleksandra MYASNIKOVA, Kirill CHERNENKO, and **Vladimir PANKRATOV**
13:00-13:20	Nancy Zuñiga-Rivera (Mexico)	FrO-9 Oral presentation (20 min)	Luminescent Effect of Undoped and Chromium-doped $MgGa_2O_4$ Synthesized by Combustion **Nancy Jovaana ZUÑIGA-RIVERA**, Rodolfo RUIZ-TORRES, Rodrigo MELENDREZ, Pedro SALAS-CASTILLO, Marcelino BARBOZA-FLORES
13:20-13:40	Anatoli I.Popov	Closing Remarks	
13:40-14:30	**Final coffee with refreshment**		

Poster session A - Tuesday, 18 June, 2024

Code	Presenting author	Title, authors
PA01	Diana Junisbekova	Preparation of gallium oxide (Ga_2O_3) nanowires in SiO_2/Si track template **Diana JUNISBEKOVA**, Alma DAULETBEKOVA, Zein BAIMUKHANOV, Guldar BAUBEKOVA, Assyl-Dastan BAZARBEK
PA02	Alma DAULETBEKOVA	Synthesis of SnO_2 nanowires with activating impurities in track templates Zein BAIMUKHANOV, Diana JUNISBEKOVA, **Alma DAULETBEKOVA**, Aigerim SERIKBAYEVA, Muratbek BAIZHUMANOV
PA03	Anna Mrozik	Luminescent properties of composite detectors based on $MgAl_2O_4$ doped with rare-earth and transition metal ions **A. Mrozik**, P. Bilski, D. Kuźnik, V. Gorbenko, T. Zorenko, Y. Zorenko
PA04	Anatoliy Voloshinovskii	Luminescence of Sr^{2+}-activated $CsPbCl_3$ single crystals **Anatoliy Voloshinovskii**, Yaroslav Chornodolskyy, Oleksandr Pidhornyi, Andriy Pushak, Mariya Kovalenko, Oleg Bovgyra, Roman Gamernyk, Oleg Antonyak, Aleksei Kotlov, Yevgeniia Smortsova, Taras Malyi, Taras Demkiv
PA05	Aiman Akylbekova	Synthesis and luminescence of nanocrystalline ZnS formed in ion track templates a-SiO_2/Si-n **Aiman AKYLBEKOVA**, Ayaulym MUKHATAYEVA, Alma DAULETBEKOVA, Zein BAIMUKHANOV, Marina Konuhova,
PA06	Aiman AKYLBEKOVA	Synthesis of copper selenide nanowires into SiO_2/Si track template Gulnaz SARSEKHAN, **Aiman AKYLBEKOVA**, Zein BAIMUKHANOV, Abdirash AKILBEKOV, Abay USSEINOV, Muratbek BAIZHUMANOV
PA07	M. Usama Jamal	The impact of crystal structure on Tb^{3+} luminescence in double molybdates **M. Usama JAMAL**, Vitali NAGIRNYI, Dmitry SPASSKY
PA08	Michael Discher	Reinvestigation of TL properties of protective glasses of mobile phones for retrospective dosimetry using the red-emission range **Michael DISCHER**, Céline BASSINET, Yoann RISTIC
PA09	J.M. Salikhodzha A.K. Ospanova	Luminescence decay characteristics of CdSe nanoparticles A.Zh. Kainarbay, A.K**. Ospanova, D.K**. Daurenbekov, R. Suleimen, A.S. Akhmetova, T.N. Nurakhmetov, **J.M. Salikhodzha**, B.N. Ussupbekova, B.M. Sadykova, N. Temirkulova
PA10	J.M. Salikhodzha A.K. Ospanova	Enhancing photo- response in p-Si cells by luminescent down- shifting using different CdSe semiconductor nanoparticles A. Z. Kainarbay, A.K. **Ospanova, D.K.** Daurenbekov, A.S. Akhmetova, T.N. Nurakhmetov, **J.M. Salikhodzha**, B.N. Ussupbekova, B.M. Sadykova, N. Temirkulova
PA11	Irene Villa	Multicomponent nanoscintillators in radiotherapy and Alzheimer's disease treatment **Irene Villa,** Valeria Secchi, M. Campione, S. Rahimipour, Angelo Monguzzi
PA12	Guna Doke	$Mg_4Ga_8Ge_2O_{20}$: M (M = Cr^{3+}; Mn^{2+}) phosphors with multicolour persistent luminescence for advanced anti-counterfeiting applications **Guna DOKE**, Aleksej ZARKOV, Aldona BEGANSKIENE, Andris ANTUZEVICS, Pavels RODIONOVS, Aivaras KAREIVA
PA13	Katarina Milenkovic	Three-fold enhancement of Eu^{3+} emission intensity in $BaYF_5$ nanoparticles by Bi^{3+} co-doping **Katarina MILENKOVIC**, Vesna DJORDJEVIC, Sanja KUZMAN, Jovana PERISA, Bojana MILICEVIC, Miroslav D. DRAMICANIN
PA14	Aleksandr Lushchik	About thermal stability of the F^+ centers in MgO single crystals irradiated by fast neutrons or energetic Ar ions Guldar Baubekova, Ruslan Assylbayev, Alise Podelinska, Viktor Seeman, Evgeni Shablonin, Evgeni Vasil'chenko, **Aleksandr Lushchik**
PA15	Kuanyshbek Shunkeyev	Electron-hole recombination and exciton luminescence in the field of local lattice deformation by sodium impurity ions in KCl:Na single crystals **Kuanyshbek Shunkeyev**, Shynar Sagimbayeva, Daulet Sergeyev, Aleksandr Lushchik, Vitali Nagirnyi, Lyudmila Myasnikova, Zhiger Ubaev, Aleksei Krasnikov

PA16	Aleksandr Lushchik	Accumulation of oxygen interstitial-vacancy pairs under irradiation of corundum single crystals with energetic xenon ions Guldar Baubekova, Ruslan Assylbayev, Eduard Feldbach, Aleksei Krasnikov, Irina Kudryavtseva, Alise Podelinska, Viktor Seeman, Evgeni Shablonin, Evgeni Vasil'chenko, **Aleksandr Lushchik**
PA17	Vitalii Gorbenko	Development of composite scintillators based on epitaxial structures of garnet compounds for medical application **Vitalii GORBENKO**, Sandra WITKIEWICZ-LUKASZEK, Bogna SOBIECH, Janusz WINIECKI, Oleg SIDLETSKIY, Yuriy ZORENKO
PA18	Arnoldas Solovjovas	Investigation of emission properties in $YA_{1-x}Ga_xG$: Ce scintillators with different gallium content **Arnoldas SOLOVJOVAS**, Saulius NARGELAS, Oleg SIDLETSKIY, Gintautas TAMULAITIS
PA19	Céline Bassinet	Mobile phone screen protector glass for radiation accident dosimetry: a TL investigation of the intrinsic background signal in the red detection window **Céline BASSINET**, Michael DISCHER, Yoann RISTIC
PA20	Natalia K. Pawlak	Reconstructing the trap filling process in multiple trap systems using the dose-response curve measured for a single OSL trap **Natalia K. PAWLAK**, Alicja CHRUŚCIŃSKA
PA21	Michał Sądel	2D OSL dosimetry based on MgB_4O_7 prototype foils - facilitating the high-resolution proton radiotherapy **Michał SĄDEL**, Leszek GRZANKA, Janusz SWAKOŃ, Damian WRÓBEL, Sebastian KUSYK, Paweł BILSKI
PA22	Paweł Bilski	Performance of various TL/OSL detectors after irradiation with gamma-rays and protons at different dose rates **Paweł BILSKI**, Anna MROZIK, Michał SĄDEL, Jan SWAKOŃ, Damian WRÓBEL, Sebastian KUSYK, Dorota KUŹNIK
PA23	Anatoli I. Popov	Luminescence and TSL study of ScF_3 single crystals under UV-VUV and electron beam excitation **Anatoli I. Popov**, Irina Kudryavtseva, Aleksandr Lushchik, Eduard Feldbach, Marina Konuhova, Juris Purans, E. Aleksanyan
PA24	Anna Shakhno	Influence of Ce^{3+} doping and crystallization rates on the structural, optical and photoconversion properties of the Al_2O_3-YAG: Ce eutectic **Anna SHAKHNO**, Oleh VOVK, Sergei Nizhankovskyi, Mieczysław CIESZKO, Zbigniew SZCZEPAŃSKI, Tetiana ZORENKO, Yuriy ZORENKO
PA25	Taras Demkiv	Energy transfer in $CsPbCl_3$: Yb and $CsPbCl_3$: Yb,Er single crystals Roman GAMERNYK, Yaroslav CHORNODOLSKYY, Taras MUZYKA, Andriy PUSHAK, Borys TURKO, Sergiy MALYNYCH, Volodymyr SALAPAK, **Taras DEMKIV**, Anatolii VOLOSHINOVSKII
PA26	Zhanymgul Koishybayeva	RADIATION RESISTANCE OF GALLIUM OXIDE THIN FILMS TO THE ION IMPACT **Zhanymgul KOISHYBAYEVA**, Sergey PAVLOV, Fedor KONUSOV, Dmitry SIDELYOV, Denis CHESHEV, Alexey PIROZHKOV, Artur NASYRBAEV, Igor IVANOV, Vladislav TARBOKOV, Ruslan GADIROV, Abdrash AKILBEKOV, Elena POLISADOVA
PA27	Alexander Platonenko	Mechanical properties of Y_2SiO_5-Lu_2SiO_5 solid solutions from *ab initio* calculations **Alexander Platonenko**, Dmitry Bocharov, Anatoli I. Popov
PA28	Jekabs Cirulis	Neutron radiation defect EPR analysis in gadolinium gallium garnet **Jekabs CIRULIS**, Uldis ROGULIS, Nina MIRONOVA-ULMANE, Andris ANTUZEVICS
PA29	Katarzyna Maria Szufa	The attempt to reconstruct a dose after irradiation with gamma source of unknown dose rate using KCl dietary supplements **Katarzyna Maria SZUFA**, Renata MAJGIER, Arkadiusz MANDOWSKI
PA30	Artem L. Kozlovskiy	Radiation-stimulated optical and luminescent effects in ZrO_2 ceramics **Artem L. Kozlovskiy**
PA31	Dana S. Yerimbetova	Assessment of prospects for the use of optical and luminescent methods for determining the density of latent tracks in polymer film detectors **Dana S. Yerimbetova**, Artem L. Kozlovskiy, Umitali N. Tuichiyev
PA32	Dana S. Yerimbetova	Improving the method of detecting α-particles with film polymer detectors using optical analysis methods Umitali N. Tuichiyev, **Dana S. Yerimbetova**

PA33	Ainur M. Zikirina	The influence of radiation damage on the band gap, optical and luminescent properties of CoZn/CoZnO nanostructures **Ainur M. Zikirina**, Artem L. Kozlovskiy
PA34	Karyna Lamonova	Quantum Dots as a Precondition for the $ZnCr_2Se_4$ Spinel Formation in ZnSe:(Fe, Cr) Laser Crystal Matrixes **Karyna LAMONOVA**, Andrey PROKHOROV, Yuri KAZARINOV, Maksym BURYI
PA35	Sanu Bifal Maji	Influence of crystal structure on luminescence of Pr^{3+} doped barium lutetium fluoride nanocomposite **Sanu Bifal Maji**, Alexander Vanetsev, Hugo Mandar, Vitali Nagirnyi, Kirill Chernenko and Marco Kirm
PA36	Gulnur Tursumbayeva	Radiation processes in YAG single crystals irradiated with swift heavy Xe^{132} ions Guldar Baubekova, Ruslan Assylbayev, Zhakyp Karipbayev**, Gulnur Tursumbayeva**, Evgeni Shablonin, Zh. Dosmagambetov, A. Dauletbekova, Anatoli Popov, Aleksandr Lushchik
PA37	Renata Majgier	Characterization of IRSL decays of copper-doped potassium sulfate **Renata MAJGIER**, Arkadiusz MANDOWSKI
PA38	Inesh E. Kenzhina	Determination of the effect of ZrO_2 doping with magnesium oxide on the optical and luminescent properties of ceramics used as fuel cells **Inesh E. Kenzhina**, Artem L. Kozlovskiy
PA39	Halyna Klym	Analysis of Positron Trapping Defects through Free-Volume Study in Chalcogenide Glass **Halyna KLYM**, Ivan KARBOVNYK, Oleksiy KUSHNIR
PA40	Halyna Klym	Evolution of Free-Volume Defects in the $BaGa_2O_4$ Ceramics Doped with Eu^{3+} Ions **Halyna KLYM**, Yuriy KOSTIV, Vladimir PANKRATOV, Ivan KARBOVNYK

Poster session B - Wednesday, 19 June, 2024

Code	Presenting author	title, authors
PB01	Kuanyshbek Shunkeyev	The nature of high-temperature peaks of thermally stimulated luminescence in NaCl, NaC:Li, KCl and KCl:Na crystals **Kuanyshbek Shunkeyev**, Shynar Sagimbayeva, Lyudmila Myasnikova, Adelya Kenzhebayeva
PB02	Aliya Omarova	Studying the prospects for using photosensitive ACdSe (A – Co, Ni) thin films **Aliya Omarova**, Artem L. Kozlovskiy
PB03	Kymbat Tynyshbayeva	Application of optical analysis methods to assess destructive changes in the surface layer of SiC ceramics exposed to high-dose irradiation **Kymbat Tynyshbayeva**, Artem L. Kozlovskiy
PB04	Zhussupbek Salikhodzha	First principles calculations of the structure, electronic structure, elastic properties, and processes of formation of some defects in the Na_2SO_4-V crystal **Zhussupbek SALIKHODZHA**, Fatima ABUOVA, Turlybek NURAKHMETOV, Aset KAINARBAY, Abzal AKHMEDOV, Aislu KASSEKEYEVA
PB05	Zhussupbek Salikhodzha	DFT STUDY OF STRUCTURAL, ELECTRONIC AND ELASTIC PROPERTIES OF c-ZrO_2 **Zhussupbek SALIKHODZHA**, Guldari BAIRBAYEVA, Raigul SULEIMEN
PB06	Aisulu Abuova	Investigating novel double half-Heusler Alloys: a study of electronic, magnetic, elastic properties and their Implications Nurgul SOLTANBEK, Nurpeiis MERALI, Fatima Abuova, **Aisulu Abuova**
PB07	Leonid Rusevich	First principles calculations of the advanced phosphor materials **Leonid RUSEVICH**, Ilya CHERVYAKOV, Eugene KOTOMIN, Igor MIKHAILOV, Dmitry BOCHAROV, Mikhail BRIK
PB08	Jurij Grechenkov	DFT study of ternary zinc based pnictogenides ($ZnAX_2$) with chalcopyritic structure **Jurij Grechenkov**, Dmitry Bocharov, Sergei Piskunov
PB09	Viktorija Veretennikova	Predictions of $LiInSe_2$ scintillating properties from DFT calculations **Viktorija Veretennikova**, Jurij Grechenkov, Dmitry Bocharov, Sergei Piskunov
PB10	Zhakyp Karipbayev	Thermal stability of color centers in lithium fluoride crystals irradiated with electrons and N, O, Kr, U ions Zhadra MALIKOVA, **Zhakyp KARIPBAYEV**, Abdirash AKILBEKOV, Alma DAULETBEKOVA, Guldar BAUBEKOVA, Anatoli POPOV
PB11	Inesh E. Kenzhina	Use of optical and luminescent methods for detecting radiation damage in ZrO_2 – Al_2O_3 ceramics **Inesh E. Kenzhina**, Aktolkyn Tolenova, Artem L. Kozlovskiy
PB12	Edgars ELSTS	Thermoluminescence study of neutron-irradiated $MgAl_2O_4$ crystals doped with rare-earth ions **Edgars ELSTS**, Marina KONUHOVA, Nina MIRONOVA-ULMANE, and Anatoli I. POPOV
PB13	Dmitry Bocharov	XANES analysis sheds new light on the structural properties of up- converting TiO_2 nanoparticles doped with rare earth elements Alise PODELINSKA, Elina NEILANDE, Victoria PANKRATOVA, Jurij GRECHENKOV, Vladimir PANKRATOV, Aliaksandr BURKO, Diana LAPUTSKO, Valeria MURASHKO, Anatoli I POPOV, Hanna BANDARENKA, **Dmitry BOCHAROV**
PB14	Halyna Klym	Exploring Luminescence Spectra of Eu-Doped $BaGa_2O_4$ Ceramics through Synchrotron Studies **Halyna KLYM**, Yuriy KOSTIV, Vladimir PANKRATOV, Ivan KARBOVNYK

PB15	Rafał Porzeziński	Quasi-equilibrium conditions in the model of semi-localized transitions (SLT) **Rafał PORZEZIŃSKI**, Arkadiusz MANDOWSKI
PB16	Vasyl Stasiv	Studies of optically stimulated luminescence of the $YAlO_3:Mn^{2+}$ crystals grown by the floating zone and Czochralski methods **Vasyl STASIV**, Oleksandr POSHYVAK, Jan FINK-FINOWICKI, Yaroslav ZHYDACHEVSKYY, Sergii UBIZSKII, Marek BERKOWSKI, Andrzej SUCHOCKI
PB17	Pavels Rodionovs	Optical properties of multi-site $CaAl_{12}O_{19}$ phosphors doped with Cr^{3+}, Fe^{3+}, or Mn^{2+} **Pavels RODIONOVS**, Meldra KEMERE, Andris ANTUZEVICS, Andris FEDOTOVS, Uldis ROGULIS, Anatolijs SARAKOVSKIS
PB18	Dace Nilova	Characterization and enhancement of UV-C persistent luminescence in $Ca_2Al_2SiO_7:Pr^{3+}$ **Dace NILOVA**, Guna DOKE, Guna KRIEKE, Pavels RODIONOVS, Andris ANTUZEVICS
PB19	Aleksandra Jung	Thermoluminescence and optically stimulated luminescence properties of some gemstones Barbara WOJTAS, Julia ŁEPKOWSKA, Magdalena DUMAŃSKA-SŁOWIK, **Aleksandra JUNG**
PB20	Viktorija Pankratova	Temperature Behavior of Luminescence in LYSO:Ce Single Crystals under Synchrotron Radiation Excitation in VUV Range **Viktorija PANKRATOVA**, Kirill CHERNENKO, Vladimir PANKRATOV
PB21	Viktorija Pankratova	Study of Swift Heavy Ion Induced Radiation Defects in Relevant Garnet Crystals by VUV Excitation of Synchrotron Radiation **Viktorija PANKRATOVA**, Kirill CHERNENKO, Aleksei KOTLOV, Zhakyp T. KARIPBAEV, Gulnara M. ARALBAYEVA, Igor A. IVANOV, and Vladimir PANKRATOV
PB22	Zhakyp Karipbayev	Temperature dependence and dynamics of luminescence of gallium oxide single crystals Aizat BAKYTKYZY, **Zhakyp KARIPBAYEV**, Alma DAULETBEKOVA, Yana SUCHIKOVA, Abay USSEINOV, Meldra KEMERE, Anatoli I. POPOV
PB23	Zhakyp Karipbayev	Optimizing Ga_2O_3:Ce for Advanced Optoelectronic Applications: Synthesis and Properties Askhat KAKIMOV, **Zhakyp KARIPBAYEV**, Kuat KUMARBEKOV, Zhunusbekov AMANGELDY, Aizat BAKYTKYZY, Yana SUCHIKOVA, Anatoli POPOV
PB24	Yana Suchikova	Effects of High-Energy Ion Irradiation on Luminescent Properties of Gallium Oxide Crystals Aizat BAKYTKYZY, Zhakyp KARIPBAYEV, Alma DAULETBEKOVA, **Yana SUCHIKOVA**, Igor IVANOV, Vladimir PANKRATOV, Anatoli I. POPOV
PB25	Yana Suchikova	Enhanced Luminescence in YAG Ceramics Doped with Eu, Cr, and Er Zhassulan ZhILGILDINOV, **Yana SUCHIKOVA**, Zhakyp KARIPBAYEV, Kuat KUMARBEKOV, ZHUNUSBEKOV Amangeldy
PB26	Zhakyp Karipbayev	Luminescence of Unintentional Impurities in $Gd_3Ga_5O_{12}$ Crystals Kuat KUMARBEKOV, **Zhakyp KARIPBAYEV,** Gulnar ARALBAYEVA, Amangeldy ZHUNUSBEKOV, Anatoli I. POPOV, DMITRO SUGAK, Sergei B. UBIZSKII
PB27	Didzis Salnajs	Phosphate matrix-based phosphors for luminescence in UV spectral range **Didzis SALNAJS**, Dace NILOVA, Pavels RODIONOVS, Andris ANTUZEVICS
PB28	Viktorija Pankratova	Swift Heavy Ions Induced Defects Influence on Optical and Luminescent Properties of $Gd_3Ga_2Al_3O_{12}$ Single Crystals **Viktorija PANKRATOVA**, Kirill CHERNENKO, Aleksei KOTLOV, Zhakyp T. KARIPBAEV, Gulnara M. ARALBAYEVA, Igor A. IVANOV, and Vladimir PANKRATOV
PB29	Anatoly Trukhin	The study of $Ag^+(Cu^+)$ center creation in α-quartz crystals by thermal annealing at 1200°C in O_2 atmosphere from metallic Ag and Au **Anatoly Trukhin**, Madara Leimane
PB30	Fatima Abuova	Characteristics of rhombohedral $BaTiO_3$/Graphene (111) surface Balzan Satanova, **Fatima Abuova**, Gulbanu Kaptagay, Aisulu Abuova
PB31	Daniela Constantin	Luminescence and ESR characterisation of quartz extracted from granite source rocks and the derived sediments used for provenance studies **Daniela Constantin**, Zuzanna Kabacińska, Aditi Dave, Mihai Ducea and Alida Timar-Gabor

PB32	Bauyrzhan K. Abyshev	Study of the influence of varying compositions for producing lithium- containing ceramics on changes in structural and optical properties determined using optical spectroscopy and luminescence methods **Bauyrzhan K. Abyshev**, Artem L. Kozlovskiy
PB33	Ilze MANIKA	Hardening effect and structural changes in $ZnWO_4$ crystals irradiated with swift ^{6}C, ^{8}O, ^{36}Kr and ^{54}Xe ions **Ilze MANIKA**, Anatoli I. POPOV, Zhakyp T. KARIPBAYEV, Marina Konuhova
PB34	Vladimir PANKRATOV	Time-Resolved Luminescence of Embedded Mixed-Halide Perovskite Nanocrystals Anastasiia BABKINA, Artur BOGACHOV, Yevheniia SMORTSOVA, **Vladimir PANKRATOV**
PB35	Zhakyp Karipbayev	Optical absorption, photoluminescence and Raman scattering of $LiNbO_3$ single crystals irradiated by $^{84}Kr^{+}$ ions D. Sugak, Ya. Zhydachevskyy, P. Ciepielewski, U.Yakhnevych, O. Buryy, A. Dauletbekova, **Zh. Karipbayev**, A. Kozlovskii, M. Konuhova, A. Suchocki, A.I. Popov
PB36	Edgars ELSTS	Thermostimulated luminescence properties of neutron and thermochemically-reduced $Y_3Al_5O_{12}$ **E. Elsts** V. Grāveris M. Konuhova, E. Shablonin, E. Vasil'chenko
PB37	Anatoli I. POPOV	Are color centers possible in ceria? **A.I. Popov**, E.A. Kotomin, D. Gryaznov and J. Maier
PB38	Anatoli I. POPOV	Analysis of the self-trapped hole center mobility and recombination in alkali halides and complex metal halides **Anatoli I. Popov** and Marina Konuhova
PB39	Ewa Mandowska	Thermoluminescence Spectra Properties of feldspars **Ewa MANDOWSKA,** Robert SMYKA, Arkadiusz MANDOWSKI

Abstracts
(Plenary, Keynote and Oral presentations)

MoPL-1

Defects in inorganic crystals and calculations of their properties

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Defects in inorganic crystalline solids play an important role in formation of their electronic and optical properties. Applications of optical materials – scintillating, lighting, lasing etc – are all based on the interplay of properties of defects and crystalline hosts. Various kinds of defects can exist in crystal lattices, e.g. vacancies, interstitial atoms, antisite defects (when two cations swap their positions), substitutional defects (when intentionally introduced chemical species, usually transition metal or rare earth elements, replace host's cations) etc.

Different methods of calculations of defects' properties will be reviewed in this presentation, such as i) crystal field calculations of impurity ions' energy levels in crystals, and ii) first-principles calculations of the structural, electronic and optical properties for neat and defect-containing crystals. Advantages and limitations of the presented models will be highlighted and illustrated by examples from recent publications [1-5].

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MoPL-2

Multiparameter Approaches for Improved Temperature Readings from Luminescence

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Temperature has a significant impact on the luminous characteristics of materials. By monitoring different luminescence features of materials, it is possible to precisely measure temperature in various environments [1]. The method is frequently termed as luminescence thermometry or phosphor thermometry [2]. The three features that are exploited most are the emission intensity, lifetime, and the shape of the emission spectrum. However, luminescent thermometry is not as good as other major thermometry methods in several ways. The most significant factors are the extended response time and the reduced accuracy and precision. In recent times, a lot of efforts have been devoted to enhancing the accuracy and precision of luminescence thermometry. Mainly, the strategies are based on the selection of luminescent materials with both high brightness and high temperature sensitivity for luminescence features. In this lecture, we demonstrate that monitoring more than one temperature indicator can significantly improve the performance of thermometry. For this purpose, we discuss the use of linear multiparameter regression and the principal component analysis approaches for temperature readings from luminescence with improved precision and accuracy. We show the foundation of these approaches and present results obtained using the near-infrared emission of Mn^{5+} [3] and the visible emission of Pr^{3+}.

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MoK-3

Vacuum ultraviolet time-resolved luminescence at P66 at DESY: instrument characteristics and applications

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In March 2024, P66 vacuum ultraviolet (VUV) time-resolved luminescence beamline marks two years and a half of successful operation. Inheriting its main features from previous SUPERLUMI beamline at DORIS III storage ring [1], P66 is requested by leading scientists from more than 30 scientific groups around the world. Excitation and emission energy scans of the luminescence intensity within a unique excitation range of 3.7-40 eV, enabled by the ultrahigh vacuum conditions and added the time resolution down to circa 150 ps, employing the pulsed nature of the synchrotron radiation at DESY and fast detectors and electronics, make the setup a singular instrument to probe impurity/defect states, to determine the bandgap of dielectric materials and to unravel the energy relaxation and recombination mechanisms after VUV excitation. Absorbed by nearly all materials, VUV is a universal tool to study matter, in particular surfaces (the penetration depth of this radiation is circa 100 nm). An integrated cryostat provides a possibility to cool samples down to 8 K with the use of liquid helium, so even the weakest luminescence is enhanced, cutting away thermal relaxation processes. The applications of the method range from material science to fundamental physics: from fast scintillators for medical imaging and LEDs [2] to persistent phosphors for safety signs and luminophores for colour display panels are studied next to the first principles spectroscopy of nanophosphors [3].

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MoK-4

Visualizing Energy Levels of Lanthanides and Defects in Multicomponent Garnet Crystals by Mid Infrared Free Electron Laser

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Multicomponent garnet crystals doped with lanthanides have been extensively studied for the application of various optical materials. Visualizing energy-level locations of lanthanides between valence and conduction bands is significant to understand the migration of photocarriers in valence and conduction bands, the energy relaxation from host to lanthanides, and trapping and detrapping of conduction electrons or valence holes at lanthanides. It was difficult to clarify the electronic interaction between host and lanthanides experimentally and theoretically, because different approaches are required to investigate electronic structures of host and lanthanides. For example, the electronic structure of host is approximated by the one-electron band picture, while that of lanthanides is described by the many-electron atomic picture with configuration interaction. One solution to this was the construction of vacuum referred binding energy (VRBE) diagrams for lanthanides-doped phosphor materials [1]. The VRBE diagram was the nice guide to see energy-level locations of lanthanides relative to host energy bands, which provided a better understanding of the electronic interactions between lanthanides and host.

We have performed the pump-probe experiment using a mid-infrared free electron laser (MIR-FEL [2]) at the Kyoto University FEL (KU-FEL) facility, to determine energy-level locations of lanthanides and defects in multicomponent garnet crystals more accurately. MIR-FEL has the advantages of (i) the turnability of wavelengths, (ii) pulse-train structure, and (iii) high-power radiation. The application of MIR-FEL leads to the successful observation of electron trap levels due to antisite defects in $Gd_3Al_2Ga_3O_{12}$:Ce by detecting MIR-stimulated Ce^{3+} 5d-4f luminescence [3]. In the present study, we performed the determination of the charge transfer (CT) transition from the Ce^{3+} 4f level to the conduction band minimum in $Gd_3(Al,Ga)_5O_{12}$:Ce crystals by using a photo-induced free carrier plasma absorption in the MIR region. The weak CT absorption competed with the strong Ce^{3+} 4f-5d absorption, so that it was difficult from ordinary absorption spectra to determine the energy threshold for the CT transition. The application of MIR-FEL demonstrated that the CT transition energy was smaller compared to the VRBE diagram.

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MoK-5

Investigation of local environment of 3d transition elements in phosphor materials

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Most of the current phosphor materials are realized by doping of rare-earth or 3d transition elements in the host materials with wide band gap. Although a lot of efficient phosphors doped with rare-earth ions have been developed, there are some limitations to use rare-earth elements, that are 1) rare-earth elements can be obtained only from limited areas and 2) rare-earth elements are expensive. Then the rare-earth free phosphors are demanding recently, for which 3d transition metal elements the candidates to replace rare-earth. There are wide variety of the phosphor materials with various emission wavelengths. Among them, red phosphors are especially of interest for the wide area of applications, such as white LED and smart agriculture. In order to develop the efficient phosphor materials, it is essential of know the local environment of doped ions as emission center in an atomic scale. However, it is usually difficult to know it, since the concentration of the doped ions is often very dilute. There are two powerful methods to determine local environment of such dilute elements, which are X-ray absorption Near Edge Structure (XANES) and Electron Spin Resonance (ESR). For the former XANES analysis, combined use of the theoretical calculations plays a crucial role in determination of the local environment of dilute dopants by making theoretical fingerprints of the XANES spectra [1].

In the current study, we demonstrate local environment analysis of Mn ions in the efficient red phosphors such as Mn-doped $CaAl_{12}O_{19}$ [2, 3] and Y_2MgTiO_6 by using the theoretical calculations within a density functional theory and the experimental approaches using XANES and ESR.

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MoO-6

Crystal Growth and Evaluation of 1-Inch Diameter GAGG:Ce,Tb Single-Crystal Scintillator for High-Resolution Synchrotron Radiation X-ray Imaging

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Scintillators play a key role in X-ray imaging which has diverse applications such as nondestructive testing, medical diagnostics, and airport security controls. One of the pivotal parameters in high-resolution X-ray imaging is sensitivity, with both light output and density playing crucial roles in achieving heightened sensitivity. Compounds with a garnet structure are promising materials for scintillation applications because of their good optical transparency, high density and flexible cation substitution. Particularly noteworthy is gadolinium aluminum gallium garnet (GAGG), which has garnered attention for its impressive density of 6.63 g/cm³ and exceptional light yield surpassing 50,000 photons/MeV [1]. Recently, Ce and Tb co-doped scintillators such as GAGG: Ce,Tb have been explored due to efficient energy transfer between Ce^{3+} and Tb^{3+}, which enable to improve the luminescence and scintillation properties [2]. In this study, Czochralski (Cz) method was used for growing 1inch GAGG:Ce,Tb single crystal with high quality for high-resolution synchrotron radiation X-ray imaging.

A mixture of 4N CeO_2, Tb_4O_7, Gd_2O_3, Y_2O_3, Ga_2O_3 and Al_2O_3 powders was used as the starting materials. 1inchφ $(Gd, Ce, Tb)_3Ga_3Al_2O_{12}$ single crystal was grown by Cz method. Furthermore, 3 mol% of Ga_2O_3 was introduced to offset any loss due to evaporation. The crystal was grown utilizing an iridium crucible in an atmosphere composed of N_2+2%O_2, with a GAGG:Ce single crystal employed as the seed.

We were succeeded in growing a single crystal of GAGG:Ce,Tb (Fig. 1). In the radioluminescence (RL) emission spectra (Fig. 2), the typical emission associated with the Ce^{3+} $5d_1$-4f transition and Tb^{3+} 4f-4f transition were simultaneously observed. The results of X-ray imaging tests will be presented.

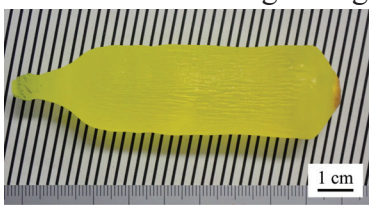

Fig. 1 Photograph of the grown 1inchφ GAGG:Ce,Tb crystal.

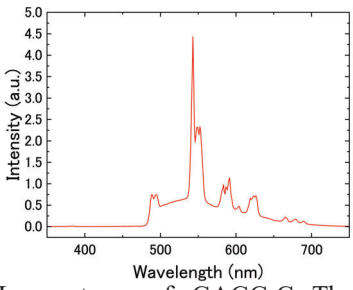

Fig. 2 RL spectrum of GAGG:Ce,Tb

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MoO-7

A study on single crystal growth and energy transfer in Ce^{3+} and Pr^{3+} co-doped $Lu_2Si_2O_7$

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1. Introduction Ce^{3+}-doped $Lu_2Si_2O_7$ (Ce:LPS) scintillator shows promising performance, such as a high light yield (26,300 photons/MeV) and a fast decay time (~38 ns) [1]. Ce:LPS is an attractive scintillator for applications, for example, positron emission tomography (PET) and oil well logging [1]. To improve the luminescence properties, Feng et al. have investigated Pr^{3+} co-doped Ce:LPS scintillator, and found that the Pr^{3+} co-doping tended to improve the optical performance [2]. In this study, we focused on the optimization of the Ce^{3+}/Pr^{3+} ratio and grew Pr^{3+} co-doped Ce:LPS single crystals with systematically changing the ratio of Ce^{3+} to Pr^{3+}.

2. Materials and Methods As starting materials, we used Lu_2O_3, Pr_2O_3, CeO_2 and SiO_2 powders with a purity of more than 99.9%. The crystal growth was performed by micro-pulling-down (μ-PD) method using the LPS as a seed crystal under Ar + O_2 gas atmosphere [3]. The pulling down rate was 0.03–0.05 mm/min. For the optical and scintillation properties, photoluminescence (PL) emission and excitation spectra, PL decay times, light yield and decay times were evaluated.

3. Results The crystals grown by the μ-PD method are shown in Figure 1. We succeeded to grow transparent (Ce_x Pr_y $Lu_{1-x-y})_2Si_2O_7$ ((x, y) = (0.005, 0.000), (0.002, 0.005), (0.005, 0.005), (0.010, 0.005), (0.000, 0.005)) crystals. From the PL emission spectra (λ_{ex} = 349 nm) of ($Ce_{0.005}$, $Pr_{0.005}$) sample, the typical broad emission due to Ce^{3+} $5d_1$–$4f$ transition (350-500 nm) and the sharp peaks due to Pr^{3+} 4f–4f transitions (600-650 nm) were observed (Figure 2). In addition, it is worth noting that the excitation peak around 250 nm (dashed line, λ_{em} = 383 nm) is attributed to the Pr^{3+} 4f–5d transition, indicating that an energy transition from Pr^{3+} to Ce^{3+} is occurring.

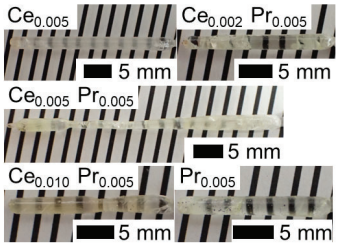

Fig. 1 Photograph of the (Ce_x Pr_y $Lu_{1-x-y})_2Si_2O_7$ growth crystals.

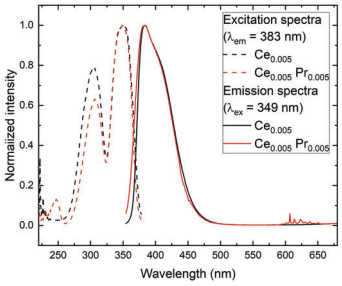

Fig. 2 PL spectra of (Ce_x Pr_y $Lu_{1-x-y})_2Si_2O_7$.

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MoO-8

Fast emitting nanocomposites for high-resolution ToF-PET imaging based on multicomponent scintillators

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Time-of-Flight Positron Emission Tomography is a medical imaging technique, based on the detection of two back-to-back γ-photons generated from radiotracers injected in the body. Its limit is the ability of employed scintillation detectors to discriminate in time the arrival of γ-pairs, i.e. the coincidence time resolution (CTR). A CTR < 50 ps would enable fast imaging with ultralow radiotracer dose. Monolithic materials do not have simultaneously the required high light output and fast emission characteristics, thus the concept of scintillating heterostructure is proposed, where the device is made of a dense scintillator coupled to a fast-emitting plastic scintillator. Here is presented a composite polymeric scintillator loaded with hafnium oxide nanoparticles. This enhanced by +300% its scintillation yield, surpassing commercial plastic scintillators. The nanocomposite is coupled to bismuth germanate oxide (BGO) realizing a multilayer meta-scintillator [1]. We observed the energy sharing between its components, which activate the nanocomposite fast emission enabling a net CTR improvement of 25% with respect to monolithic BGO. These results demonstrate that a controlled loading with dense nanomaterials is an excellent strategy to enhance the performance of polymeric scintillators for their use in advanced radiation detection and imaging technologies.

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MoK-9

Searching for better X-ray and γ-ray photodetectors: case of the $TlPb_2Br_{5-x}I_x$ quaternary system

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Room-temperature X-ray and γ-ray photodetectors are advantageous for a wide range of medical and industrial applications. There is, however, a limited number of materials, which can be utilized in such photodetectors, due to several stringent requirements (*i.e.*, high average atomic number, large physical density, large electrical resistance, wide optical band gap, and high value for a merit factor $\mu \cdot \tau$, where μ is carrier mobility and τ is lifetime). Furthermore, ease of synthesis and quality of the obtained crystals imply additional limits. Apparently, none of the existing detector materials meets all the requirements, which stimulates the search for new detector materials. Therefore, developing X-ray and γ-ray detectors with stable operation at ambient temperature and high energy resolution is an open challenge. Here, we present an approach to search for new detector materials, combining binary photodetector compounds. For such purpose we explored quaternary $TlPb_2Br_{5-x}I_x$ compositions, relying on materials synergy between TlBr, TlI, and PbI_2 photodetectors [1]. We discover a broad solid solution in the $TlPb_2Br_5$–$TlPb_2I_5$ section, which can be derived from a new quaternary compound, $TlPb_2BrI_4$, by partial substitution of Br by I atoms. The first-principles band-structure computations were made within DFT framework and employing different approaches for XC potential to understand and explain results of measurements [2,3]. The XPS measurements evidence high chemical firmness of $TlPb_2BrI_4$ crystal surface with respect to Ar^+-ion treatment and its low hygroscopicity [3]. This is a major advantage of $TlPb_2BrI_4$ single crystal compared to commonly used detectors.

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MoO-10

Innovative approaches to advanced X-ray detection with layered garnet optical ceramics

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The efficient detection of ionizing radiation is crucial in various tools developed for X-ray-based security, particle identification, and medical diagnostics. Intensive research is underway to enhance the performance of current detectors, focusing on improving sensitivity, and timing response. In the well-known garnet single crystal family, new complex compositions are emerging, with $Gd_3(Ga,Al)_5O_{12}$ (GGAG) recently gaining attention due to its high light yield of over 10^4 photons/MeV and short scintillation lifetime of a few tens of ns when doped with Cerium. Nevertheless, the challenges associated with producing bulk crystals have prompted a search for alternative and more manageable materials.

In this context, advancements in sintering techniques for transforming crystalline micro-grains into bulk ceramics with high optical quality have enabled optical ceramics to become highly competitive compared to single crystals. This is due to the relative ease of production, the ability to uniformly incorporate high concentrations of activators, and the versatility of shaping that allows for complex geometries in a single piece without requiring mechanical post-processing or bonding. Our recent research efforts have resulted in the development of fully densified Ce:GGAG optical ceramics through reaction sintering using commercial oxide powders [1]. We optimized the synthesis process to eliminate porosity and achieve good optical quality by employing a combined approach involving pressureless sintering in air followed by hot isostatic pressing, along with the use of sintering aids.

Furthermore, directional sensitivity is a crucial requirement for detectors used in locating orphan nuclear sources. To address this, we also explore unconventional geometries by combining two layers of different garnets (Ce:GGAG and Pr:YAG), revealing a scintillation response strongly influenced by the material architecture, extending the potential of layered optical ceramics for energy- and direction-sensitive X-ray detectors [2].

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MoO-11

Scintillation materials - LuAG, YAG and GAGG doped with Ce^{3+} in thermoluminescence dosimetry

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Thermoluminescent dosimetry (TL) is a versatile tool for assessing ionizing radiation dose [1]. Recent publication [2] have demonstrated the capability of monitoring dose distributions of clinical radiotherapeutic photon beams using unconventional TL detectors based on Ce^{3+} doped $Y_3Al_5O_{12}$:Ce (YAG:Ce) crystals with a density of ρ=4.5g/cm^3 and an effective atomic number Z_{eff}=35. The results indicated that this garnet is a suitable TL material for use in 6 MV photon beam radiotherapy due to its excellent radiation stability, high TL response intensity at a typical therapeutic dose of 2 Gy, and a favorable position of the main TSL peak at around 280 K [2]. Meanwhile, the TL curve intensity is significantly influenced not only by the dose but also by the X-ray radiation energy in the range of 6-15 MeV. Consequently, the radiation effect strongly depends on the density and effective atomic number of the TL-absorbing materials, especially when registering high-energy (15 MV) X-ray radiation.

Based on these considerations, TL detectors were investigated using garnet crystals with significantly higher density and effective atomic number, such as Ce^{3+} doped $Lu_3Al_5O_{12}$ (LuAG:Ce) Z_{eff}=61 and $Gd_3Al_{5-x}Ga_cO_{12}$:Ce (GAGG:Ce) Z_{eff}=53.4 garnets with various Ga content. Samples were irradiated with 6 MV and 15MV X-ray beams using the Clinac 2300 C/D linear accelerator manufactured by Varian Medical Systems, located at the Oncology Center in Bydgoszcz. The obtained results were analyzed in comparison to YAG:Ce TL detectors. Based on the data collected from YAG:Ce and LuAG:Ce TL detectors, the creation of composite TL detectors is being considered. These detectors are based YAG:Ce sincle crystalline films, grown using the Liquid Phase Epitaxy growth method onto LuAG:Ce crystal substrates [3].

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MoO-12

Improvement of Scintillation Properties in Ce doped $(Gd,La)_2Si_2O_7$ Single Crystals by Anisotropic Etching

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Ce-doped $(Gd,La)_2Si_2O_7$ (Ce:La-GPS) is a silicate scintillator with a light output of 42,000 photons/MeV, an energy resolution of 5% (662 keV, FWHM), and a fast decay time of 62 ns [1]. Ce:La-GPS is an ideal candidate material for applications such as natural resource exploration and radiation imaging. However, practical applications require higher luminescence properties and lower process costs.

Etching is a surface treatment method commonly used for scintillator crystals. It has been reported that surface treatment can improve scintillation properties [2].

Since Ce:La-GPS has a monoclinic crystal structure (space group $P2_1/c$), it was expected that not only the optical propagation properties would be anisotropic but also the surface morphology would change due to anisotropic etching.

In this study, we aimed to optimize the etching conditions and investigate the effect of anisotropy on scintillator properties in Ce:La-GPS crystals to obtain better luminescence properties.

2-inch diameter $(Gd_{0.750},La_{0.235},Ce_{0.015})_2Si_2O_7$ crystal was grown by the Czochralski method, and 5 x 5 x 5 mm cubic samples with each face consisting of {001}, {010}, {20-2} were cut. After dehydration by heating phosphoric acid, etching was performed at several temperatures from 105 to 126 °C. After etching, the thickness in each orientation was measured with a micrometer, and the surface condition was observed with a scanning electron microscope. For optical properties, transmission spectra and photoluminescence properties were examined. Scintillation properties were measured at room temperature using a photomultiplier tube (PMT) with a gamma-ray source (^{137}Ce, 662 keV). Annealing in air and Ar+3%H_2 atmospheres was performed to maximize the properties.

Etching showed characteristic anisotropic etching behavior, especially at {20-2} (Figure 1), and an increase in luminescence intensity of more than 10% due to etching.

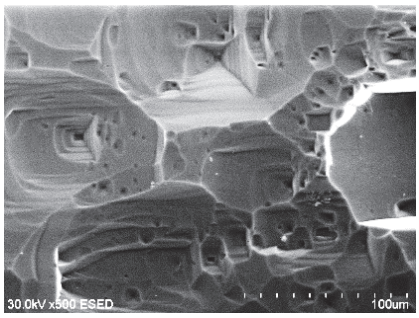

Fig. 1 Secondary electron image of {20-2} surface of Ce:La-GPS single crystal after etching

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MoO-13

Evaluation of thermal neutron and gamma ray discrimination performance of $^{6}LiCl/LaCl_3$ eutectic scintillators

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In recent years, scintillation detectors using inorganic solid scintillators containing ^{6}Li have been increasingly employed owing to their ease of handling and radiation resistivity. In the past decade, inorganic solid scintillators containing Li, such as Ce or Eu:$LiCaAlF_6$ (LiCAF) [1] and Ce:Cs_2LiYCl_6 (CLYC) [2], have been developed in addition to the traditional Li-glass scintillator for thermal neutron (n) detection. To achieve neutron detectors with excellent performance, it is necessary to develop scintillators with high Li content, low density, high light yield and fast decay time. In compound crystals, the Li content is limited by the chemical composition. On the other hand, the Li content can be increased in the eutectic according to the phase diagram. Up to now, fluorides such Ce:LiF/$LiGdF_4$, Eu:LiF/$BaCl_2$, Eu:LiF/CaF_2/$LiBaF_3$, chlorides such Eu:LiCl/Li_2SrCl_4, Eu:LiCl/$BaCl_2$, Ce:LiCl/$LaCl_3$ [3], etc. have been reported. Eutectics are composed of neutron-capturing phases containing ^{6}Li and scintillator phases. The ^{6}Li-containing phase converts n-rays into α-rays and ^{3}H, which are absorbed by the scintillator phase and converted into light.

In this study, $LaCl_3$ (pure, Ce doped) were selected as scintillator phase and $LiCl/LaCl_3$ (pure, Ce doped) eutectics were fabricated. The pulse shape discrimination (PSD) performance of the eutectics was compered (fig.1) considering with the α/γ-ray discrimination performance of the scintillator phases. In the presentation, details of eutectic growth, PSD performance and scintillator properties scintillator characterization will be reported.

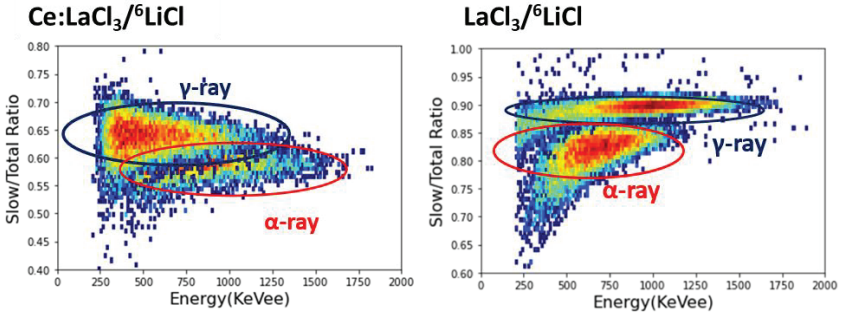

Fig.1 PSD mapping of the $LiCl/LaCl_3$ (pure, Ce doped) eutectics.

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Development of multilayered composite scintillators based on the single crystalline films and crystals of doped YAP and LuYAP perovskites

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This work presents the results of development of multilayered composite scintillators based on epitaxial structures of Ce^{3+}, Sc^{3+} and Bi^{3+} doped single crystalline films (SCF) of (Gd,Lu,Y)AP mixed perovskites, grown by the liquid phase epitaxy method onto the single crystals (SC) substrates of Ce^{3+} and Pr^{3+} doped $YAlO_3$ (YAP), YAP:Pr and $Lu_{0.5}Y_{0.5}AP$:Ce (LuYAP) perovskites. Such composite scintillators are intended for simultaneous registration of various components of mixed radiation fluxes. Recently we have shown [1] that the ideal composite scintillators represents a thick-enough substrate comprising a high-density/Z_{eff} material, and thin-enough low- or medium-density/Z_{eff} film scintillator transmitting a high-penetrating components. YAP, GdAP and LuAP perovskites with medium (5.37 g/cm^3), high (7.45 g/cm^3) and extremely high (8.22 g/cm^3) densities and effective atomic numbers (Z_{eff}=31.4, 56.2 and 64.9), respectively, can thus serve as excellent hosts to create such multilayer SCF scintillators.

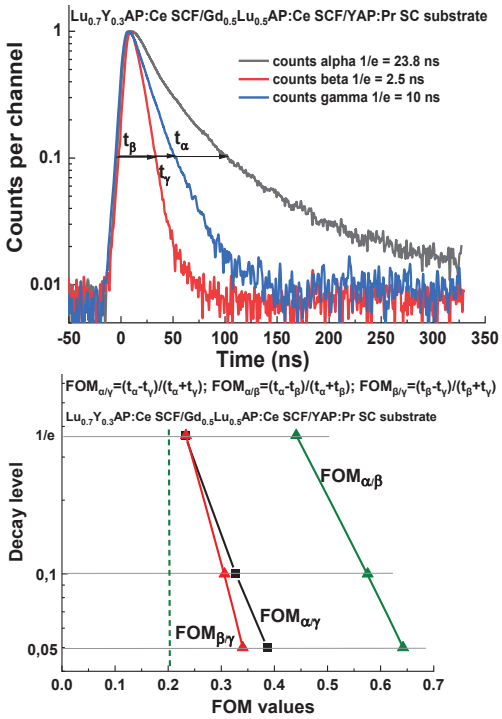

Fig.1 Decay kinetic in $Lu_{0.7}Y_{0.3}AP$:Ce SCF/$Gd_{0.5}Lu_{0.5}$ AP:Ce SCF/YAP:Pr SC under excitation by α-(^{241}Am) and β- (^{90}Sr) particles and γ-rays (^{137}Cs) excitations.

Firstly, we have selected several specific compositions of perovskite scintillators in the form of SCs and SCFs, which are suitable for the simultaneous detection of various types of low-penetrating particles and high-penetrating quanta in mixed ionization fluxes (Fig.1). For the characterization of the luminescent and scintillation properties of SCF and crystal-substrate parts of composite scintillators, the absorption spectra, cathodoluminescence spectra and scintillation decay kinetics under α–particles excitation by ^{241}Am and ^{239}Pu sources, β–particles by ^{90}Sr source and γ-quanta excitation by ^{137}Cs source were used. The possibility of using a different of radiation detection methods (e. g. emission spectra, pulse height spectra and scintillation decay kinetics) in such multilayer scintillators is considered, analyzing their advantages and limitations. Understanding peculiarities of these techniques is crucial for the further development of radiation detectors and their effectiveness for radiation monitoring in nuclear physics and medicine.

The tests of prototypes of multilayered composite scintillators based on the mentioned perovskite compounds for simultaneous registration of α- and β-particles and γ-quanta were performed, and obtained results were analyzed with aim of the optimization of their scintillation performance. The best scintillation properties demonstrated of the two-layered $Gd_{0.5}Lu_{0.5}AP$:Ce SCF/YAP:Pr SC and three-layered $Lu_{0.7}Y_{0.3}AP$:Ce SCF/$Gd_{0.5}Lu_{0.5}$ AP:Ce SCF/YAP:Pr SC epitaxial structures (Fig.1).

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TuPL-1

Defect-related phenomena in scintillating materials for high-energy radiation detection

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The detection of ionizing radiation is at the heart of many strategic applications in both science and technology, including high-energy/particle physics, space exploration, medical diagnostics, border security, and industrial and environmental monitoring. In all such areas, the most widely used detectors are scintillating materials that convert the energy deposited by incoming ionizing radiation into UV or visible photons, which are then turned into electrical signals by coupled photodetectors.

Scintillation light often originates from radiative transitions at intrinsic centres or dopants used as activators: therefore, a fast and efficient transport to the luminescent centres of carriers generated upon the interaction between ionizing radiation and the scintillating material is fundamental in the scintillation process. The efficiency and speed of carrier transfer through the host matrix are affected by the presence of defects, leading to trapping levels in the forbidden energy gap, which can temporarily capture migrating charge carriers, either delaying their radiative recombination at emission centres or decreasing the overall scintillation efficiency. Therefore, the study of the characteristics and role of defects in the scintillation mechanism becomes essential in the science of scintillators and has seen significant progress in the recent years, extending from inorganic single crystals to glasses, ceramics, and hybrid systems like colloidal semiconductor nanocrystals, metal-organic frameworks, and polymeric nanocomposites.

In this context, I discuss an effective approach for the investigation of the role of trapping sites in scintillating materials and for the determination of the effects of long-term and high dose ionizing radiation exposure. Specifically, the results obtained on two main targeted materials are presented, moving from rare-earth (Ce, Pr) doped silica fibers produced by sol-gel method [1,2], to $CsPbBr_3$ perovskite nanocrystals and acrylate perovskite-based nanocomposites [3,4].

Remarkably, the in-depth analysis of the role of point defects and of their close interplay with luminescent activators in the recombination processes governing the scintillation emission is not commonly encountered in amorphous materials, such as silica, because the inhomogeneous disorder of glass leads to the broadening of electronic levels related to defects. On the other hand, metal halide nanocrystals and nanocomposites are recently emerging as a promising new class of scintillating materials; however, despite their potential, as of today, few examples tackled in depth the mechanism leading to scintillation light, as well as not much is known on the details of trapping and detrapping processes involved in their scintillation emission.

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TuPL-2

Multi-spectroscopic studies of luminescence emissions in natural quartz: towards understanding physical processed involved in dating and provenance applications using sedimentary grains

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Even the purest quartz crystal contains a vast number of defects, which may be either intrinsic (e.g., O-vacancies and related defects or Si vacancies) or due to impurities, most often as combination of monovalent (H^+, Li^+, and Na^+) and trivalent (Al^{3+}, Fe^{3+}, and B^{3+}) cations. Some of these defects remain unchanged under ionizing radiation bombardment by the omnipresent natural radioactivity, while others are being transformed. Some of these defects are paramagnetic and thus can be identified by electron spin resonance measurements (e.g. E', an unpaired electron at an oxygen vacancy site (≡Si·), peroxy intrinsic defect centers (≡Si-O-O·), nonbridging oxygen NBOHC, (≡Si–O·), Al related paramagnetic defects such as Al-hole, $[AlO_4]^0$, titanium impurity defects such as $[TiO_4/M^+]^0$, germanium defects $[GeO_4]^0$, $[GeO_4/\ M^+]$ where M^+ is a cation, etc.) while others have the ability to emit light upon stimulation and were identified and characterised by techniques such as photoluminescence or cathodoluminescence (nonbridging oxygen, NBOHC, ≡Si–O·, oxygen deficiency center, ODC, ≡Si-Si≡ etc.).

Based on the dynamics of these radiation sensitive defects under irradiation, quartz can record the amount of ionizing radiation it has been exposed to since a resetting event. These signals can be excited and quantified by controlled heating or light exposure as well as by subjecting the sample to a magnetic and microwave field. As such, for almost half a century quartz is successfully used for dating geological and archaeological materials by thermoluminescence or optically stimulated luminescence (OSL) as well as by electron spin resonance (ESR), generically known as trapped charge dating methods. The moment dated by these methods is the moment of sediment deposition when the signal is set to zero by light exposure, or the moment of heating in the case of burnt materials. The assumption on which these methods are based is that the signal growth in nature due to exposure to natural radioactivity can be reproduced by performing laboratory irradiations. At the same time, during the last decade some of the properties and signals used in dating studies have been recently exploited for provenance, in other words geological fingerprinting. However, unravelling the source of the signals used in these applications and understanding the physical mechanisms involved in defects formation and their later modification due to the interaction of natural nuclear radiations used in various geological and archaeological applications needs further investigations. For this purpose, here we present investigations using ESR as well as hyperspectral resolved cathodoluminescence scanning electron microscope-based investigations on quartz of different geological origins and ages through the world that was previously investigated for classical optically stimulated luminescence applications.

TuK-3

Peculiarities of long-term luminescence decay in feldspars

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Feldspars exhibit good luminescent properties after exposure to ionizing radiation. These minerals are commonly used to date Quaternary sediments. However, the structure of this material is very complex. As a result the optically (OSL) and thermally stimulated luminescence (TL) is quite unusual.

The paper presents various OSL properties of feldspar samples measured at different conditions. The continuous-wave optically stimulated luminescence (CW-OSL) signal was also measured under strong stimulation light during a very long time period of the order of several hours. The measurements were performed using Helios III OSL reader. Surprisingly, even after very long period of time the trapped charge carriers were not completely bleached. Moreover, the luminescence decay exhibit some unexpected features.

The data were analysed in the framework of several models taking into account various trapping and recombination mechanisms. In particular, discrete localized, delocalized, semi-localized as well as continuous energy schemes were considered. The continuous energy distribution model is commonly applied to feldspar, however it does not offer a general explanation of all the luminescence features observed in these materials.

A simplified mechanism is suggested taking into account both continuous energy distribution of trap states as well as a spatial and energy redistribution of trapped charge carriers during the stimulation process. It seems that the model is able to explain at least the basic unusual features observed in long-term luminescence decay of feldspars.

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TuK-4

Can lyoluminescence revolutionize the luminescence dating of evaporites?

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Luminescence methods on natural minerals like quartz and feldspar are routinely used in Earth Sciences and archaeology geochronology studies covering the last ~750 thousand years. Despite their popularity, conventional luminescence dating has limitations, such as signal saturation, incomplete signal resetting, and sensitivity changes during measurements. These factors can impact dating accuracy and temporal range. Our research revisits lyoluminescence (LL) as a novel dating tool in Earth Sciences. LL is light emission during the solvation of previously irradiated crystalline insulators in the liquid-solid interface [1]. It offers a promising new approach that has not yet been extensively explored as a dating method. With a presumed saturation dose of ~10 kGy [2] under realistic dose rates of ~4 Gy/ka [3], LL signals from evaporites like sodium chloride-based minerals could extend the luminescence dating range to 2.5 Ma!

We hypothesize that LL, naturally observable in salt minerals, will allow dating the last recrystallization event significantly beyond the age limits of conventional luminescence-dating methods. While previous studies have indicated the potential of halite for optically stimulated luminescence dating [e.g., 4, 5], LL offers a unique advantage. Unlike other luminescence methods targeting heat or light exposure events, LL focuses on the crystallization event. This approach may facilitate the exploration of archives and subsurface processes, where solely the last hydration event is of interest.

We will present and discuss the concept of using LL as a potential new dating technique, a prototype reader design for field LL measurements, and preliminary results of natural LL signals.

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TuO-5

Thermoluminescence and optical properties of lithium fluorite after ultra-high dose rate irradiations

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Ultra-high dose rate (UHDR) irradiations, known as FLASH radiotherapy (RT), delivers therapeutic doses at dose rate several orders of magnitude higher than those routinely used in conventional radiotherapy. The extremely short radiation delivery leads to reduced normal tissue toxicity compared to conventional dose rate RT [1, 2]. However, UHDR dosimetry is challenging and it is crucial to understand the effects that will influence the detector response. The effect of the UHDR procedure on the dosimetric properties of thermoluminescent detectors has been the subject of only a few reports. The goal of the study was to verify the applicability of lithium fluoride detectors in ultra-high dose estimation and to describe the possible detector aging process.

In this study, LiF: Mg, Cu, P and LiF: Mg, Ti detectors, commercially known as MCP-N and MTS-N, respectively (produced at the INP, Krakow, Poland), were applied. A proton beam with a high dose rate at the level of 50 Gy/s was used for detector irradiations. Doses were in the range of 12-100 Gy. The thermoluminescence signal was measured in standard mode, including pre-exposure annealing at 240°C/10 minutes for MCP-N, 400°C/2 hours, and 100°C/1 hour for MTS-N; exposure; post-exposure annealing at 100°C/10 minutes; and readout at 2°C/s to 245°C and 280°C for MCP-N and MTS-N, respectively (*lexygresearch* TL/OSL), except filtration, which was optimised for such high signals registration. The area under the peak and the amplitude were utilised for dose estimation, linearity, sensitivity, and fading analysis. The optical properties, of both the non-irradiated and irradiated detectors were compared using reflectance spectrometry (*Ocean Insight*).

Results show linear dose dependence for both kinds of detectors. The sensitivity of the readout with optimized filtration was almost twice as high for MTS-N. Fading analysis is currently under evaluation. MCP-N detectors have a repeatable TL spectrum shape, while MTS-N detectors have peaks that change their positions depending on the total dose. In the detectors studied, a change in optical properties (a decrease in reflectance values) was observed, a process was associated to the aging of the detectors. The preliminary results indicate that lithium fluoride detectors may be used for UH dose measurements; however, further studies related to the stability and repeatability of the signal are necessary.

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TuO-6

Medium OSL component in quartz - resolving controversies about thermal stability

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Optically stimulated luminescence (OSL) dating using quartz is a widely used method for determining the age of geological sediments. It uses the so-called fast OSL component in quartz. Its suitability for dating was confirmed by showing its high sensitivity to light and adequate thermal stability [1]. A significant problem in dating quartz from a significant part of the sediments is the low intensity of the fast OSL component or its absence [2]. The signal measured in such cases is dominated by quartz's next fastest decaying OSL component, the so-called medium component. Unfortunately, so far, the suitability of this signal for dating has not been definitively confirmed. The lack of resolution of these controversies does not allow quartz, whose OSL is not dominated by a fast component, to be used for dating.

Recent OSL studies of quartz using thermally modulated stimulation (TM-OSL) have shown that the component previously observed as a medium differs significantly in optical cross-section from the fast component [3]. One has also shown that one can effectively separate the medium component from the fast component using optical stimulation with a wavelength of 620 nm that effectively extinguishes the fast component and then the light with a shorter wavelength (e.g. 530 nm). The same experiments also showed that isolating the medium component from the slower OSL components is more complicated. This fact makes measuring the trap parameters responsible for the medium component quite a challenge.

In this presentation, we will demonstrate what problems arise when measuring trap parameters that are the source of a complex OSL signal and how they can be solved. It will be shown that when the tested OSL signal does not come from a single type of trap, the thermal OSL depletion curve measurements and the pulse annealing (PA) method lead to underestimation of the trap parameters and, consequently, the electron lifetime in the trap. In such a situation, the PA method combined with the VHR method [4] is helpful. It has been successfully used to determine the trap parameters responsible for the medium component in quartz from sediments of various origins. The presented case is a good illustration of how to determine the parameters of OSL traps when it is difficult to indicate the associated TL signal.

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TuO-7

Dosimetric response of radiophotoluminescent glass detectors in heavy charged particle beams

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Radiophotoluminescent (RPL) glass detectors have proven to be reliable for dosimetry of sparsely ionising radiation (photons and electrons) and are widely used in personal, environmental and medical dosimetry in photon fields, but also in mixed photon/neutron fields due to their low sensitivity to neutrons. In the last decades, hadron radiotherapy and space dosimetry became important topics and raised the question whether RPL detectors can be used for dosimetry of densely ionising radiation (protons and heavier charged particles). The luminescence efficiency in heavy charged particle fields strongly depends on the linear energy transfer (LET), so characterizing the efficiency of the detectors' as a function of the particle LET is very important. However, the data available in the literature for RPL detectors are sparse.

In this study, RPL detectors made of silver activated phosphate glass were exposed to narow, monoenergetic ion beams that were completely stopped in the detectors [1]. Four ^{1}H ion beams and one ^{7}Li and ^{12}C ion beam with energies of (1 – 15) MeV and corresponding LET_w values of (8 – 674) keV μm^{-1} were provided by the accelerator facility at the Ruđer Bošković Institute. For every ion beam, the linear dose (fluence) response of the RPL glass detectors was first confirmed for the investigated dose (fluence) range and then the RPL efficiency relative to the ^{60}Co gamma rays was evaluated. A decrease in relative efficiency with increasing LET was observed, but an ion dependence in addition to the LET dependence is suggested. The results obtained are compared with those found in the literature.

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TuK-8

On the origin of the light yield enhancement in polymeric composites scintillators loaded with dense nanoparticles

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Fast emitting plastic scintillators are currently highly requested for advanced applications where high signal-to-noise detections is required in a short time window as like for rare event in high energy physics experiments, or to acquire high quality image for diagnostics at low doses of radiotracers.[1] Polymeric composite nanoscintillators are proposed in tandem with traditional dense inorganic crystals to realize heterostructures exploiting the benefits from both the building block materials, i.e. fast time response and high light yield (LY).[2] However, the density of plastic scintillators is low, thus they show a limited stopping power of high energy radiation and low light output intensity. Additional dyes as wavelength shifter can be used to harvest more efficiently the energy deposited in the matrix and then populate the final emitters through energy transfer mechanisms. However, this strategy results in a delayed system's time response. The loading of the polymeric host with high-Z nanoparticles is another strategy proposed to enhance the stopping power of plastics and sensitize their scintillation but preserving the fast time response. To point out the mechanism behind the LY enhancement in composites, we investigate the scintillation properties of polymeric composites based on polystyrene doped with POPOP as scintillating dye. This is then modified i) by adding the p-terphenly (TP) as wavelength shifter and ii) by loading with hafnium dioxide (HfO_2) nanoparticles (ρ = 9.68 g cm^{-3}). The scintillation mechanism is modelled considering the energy transfer processes involved as a function of the material composition and studied by photoluminescence and scintillation spectroscopy. Notably, the light yield scintillation enhancement of 200% achieved with the loading of HfO_2 nanoparticles is comparable to the one obtained using the wavelength shifting dye while preserving the scintillator fast time response. We ascribe this effect to a locally enhanced release of energy in proximity of the nanoparticles. The locally increased density of diffusing charges boosts their recombination probability to form the emissive POPOP molecular excitons, thus increasing the material light yield. Our findings indicate that the loading with optically inert dense nanoparticles could be an excellent strategy to surpass the limits of the currently employed fast emitting conjugated materials by finely controlling the punctual release of energy to manipulate the charges recombination kinetics at the nanoscale.

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TuK-9

Scintillation Properties of Red and Infrared Scintillator and their Applications – Dose-Rate Monitering System for Decommissioning–

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Real dose monitors under the high dose-rate condition are required to remove the debris in the decommissioning step. Our group have proposed a dose-rate monitor consisting of a scintillator, optical fibre and photodetector, and scintillation materials are required to have a long-emission-wavelength of 550 - 1000 nm and high light output.

Several novel materials have been developed such as Cs_2HfI_6 and Rb_2HfI_6 grown by the vertical Bridgman-Stockburger method for gamma-ray detection [1]. These scintillators had light outputs of 20,000 – 70,000 photons/MeV, and emission wavelengths of 600 to 750 nm. Using these scintillation materials, a demonstration test was operated with an optical fibre and CCD monochrome camera in Co-60 Gamma-ray Irradiation Facility of Kyoto University. Here, the diameter of the fibre core was 0.6 mm, and the measurement time of the one spot was less than 3 sec. The activity of the ^{60}Co source was around 50 TBq.

The dose-rate dynamic range was found to be 10 mGy to over 1 kGy for Cs_2HfI_6, and our system showed a wide dose-rate range in real time. In addition, radiation hardness for Cs_2HfI_6 was also investigated, and the light output remained after gamma-ray irradiation with a dose of around 50 kGy.

Moreover, dual-sensitive scintillation materials for gamma-ray and neutrons have been developed, and Li_2HfBr_6 was found to have an emission band of 600 to 750 nm and high light output [2]. This material was irradiated with neutrons in Research reactors at Kyoto University.

In this paper, we show the scintillation properties of these red and infrared scintillation materials and the demonstration test using the dose-rate monitor consisting of such scintillators.

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TuK-10

Testing different luminescence measurement protocols for display glass as an accident dosimeter

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Luminescence dosimetry is a crucial tool in retrospective dosimetry for assessing the absorbed dose after a radiological overexposure. Components of a mobile phone serve as useful proxies for measuring the dose received by an individual. Various research groups have extensive experience in characterizing different elements of mobile phones (i.e. electronic components, display or touch screen glass) for physical retrospective dosimetry. In recent years, several measurement protocols have been developed for display glass using thermoluminescence (TL) or optically stimulated luminescence (OSL) methods. However, realistic testing through an irradiation experiment was lacking.

This paper aims to collect the protocols, such as pre-bleached TL [1,2], photo-transferred TL (PTTL) [3], and thermally assisted OSL (TA-OSL) protocols [4,5], which use different stimulation wavelengths and readout temperatures, and perform a dose recovery test. For this purpose, an intact mobile phone (Samsung Galaxy S3) was exposed to a Cs-137 gamma radiation source at the Korea Atomic Energy Research Institute (KAERI) and then disassembled for a chemical pre-treatment of the glass samples. The glass samples were then shipped to the Salzburg laboratory and stored in a drawer for 15-20 days to simulate a delayed dose reconstruction in a real-world exposure scenario. The available protocols were applied in Salzburg using a Lexsyg Research reader, and the so-called accident dose was reconstructed.

The various measurement protocols were subjected to a realistic performance test, and the results are critically discussed and summarized.

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TuK-11

0D defects in isostructural Zn-based single crystals

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One of the potentially possible applications of zinc oxide as well as caesium lead bromide is time-of-flight (TOF) positron emission tomography (PET) [1]. Therefore, the timing and light yield of a scintillating detector are very important. Strong excitonic luminescence with the decay time around 400-500 ps has been measured in ZnO nanoparticles [2]. $CsPbBr_3$ nanoparticles also have very fast (about 300 ps) and strong excitonic luminescence [3]. A ZnO/$CsPbBr_3$ core/shell heterostructure exhibited remarkable enhancement of photoluminescence intensity (17 times) [4]. This can be potentially applicable in the TOFPET scintillating detector.

The factors influencing photophysics of luminescent materials are in most cases 0D defects (point defects) of different origin. To understand their influence on the ZnO/$CsPbBr_3$ heterostructures, the ZnO substrate should be investigated first [5]. Note, that the influence of the Zn- or O-face along the <0001> axis or the Zn and O mixture along the <1010> (or similar) axis on the X-ray induced 0D defects is not known in ZnO. Therefore, this is the aim of the present research. Moreover, to understand the role of oxygen, it was replaced by Se and Cr doping was applied.

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TuK-12

Energy diagnostics of the TOP-IMPLART linac proton beam via radiophotoluminescence of colour centres in lithium fluoride

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Lithium fluoride (LiF) crystals and thermally-evaporated thin films have been routinely employed to assess the energy characteristics of the TOP-IMPLART proton beam during commissioning [1-3]. TOP-IMPLART is a modular proton RF pulsed linear accelerator located in the ENEA laboratories in Frascati, near Rome, Italy [4]. Developed for proton therapy applications, it currently delivers a maximum output beam energy of 71 MeV. A lower-energy bending-magnet vertical beamline, adjustable from 3 to 7 MeV, has recently been established for cell radiobiology.

The evaluation of the energy characteristics of the TOP-IMPLART beam has been accomplished using the aforementioned LiF radiation detectors, leveraging their capability to record full Bragg curves, with linear dose response [1] and wide dynamic range, through the spatial distributions of visible radiophotoluminescence (RPL) that arises from the stable formation of colour centres in the LiF crystal lattice due to interactions with incoming protons.

This presentation provides an overview of the current state of these RPL-based energy diagnostics approaches and methods, covering their latest developments and findings, including improvements made to the theoretical model used for analysis.

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TuO-13

Shaping scintillation and micro-structure properties through synergistic lattice engineering and exciton-mediated energy transfer in Pr^{3+} doped $Lu_{1.5}Y_{1.5}Al_{5-x}Sc_xO_{12}$ (x=0-2) garnet crystals

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This investigation presents a novel approach to optimizing the luminescence and scintillation properties of Pr^{3+} doped $Lu_{1.5}Y_{1.5}Al_{5-x}Sc_xO_{12}$ crystals by creation of exciton centers and lattice engineering techniques, focusing on the expansion of dodecahedral and octahedral coordinations [1]. This approach employs the deliberate incorporation of Sc atom concentrations (x=0-2) to systematically investigate the impact of ScO_6 polyhedral framework expansion - from subtle to significant - on material properties. Key findings demonstrate that Sc concentration exceeding x> 1.5 leads to the saturation of ScO_6 polyhedra. This results in the formation of (Lu,Y)ScO_3 secondary phase inclusions, ultimately leading to the development of a eutectic microstructure. Furthermore, increasing Sc concentration not only promotes a homogeneous distribution of Pr^{3+} ions, but introduces localized potential perturbations as well. These perturbations induce lattice distortions and the formation of localized states, which act as efficient exciton traps, facilitating the creation of bound electron-hole (e^--h^+) pairs surrounding Sc^{3+} ions [1]. The energy states of these excitons resonate with the $4f \rightarrow 5d_1$ (~4.6 eV) absorption transition energy of Pr^{3+} ions, establishing an additional pathway for energy transfer. Therefore, an observed monotonic increase in scintillation light yield values coincides with a lengthened mean scintillation decay time [2]. Increasing Sc concentration influences the thermal stability of Pr^{3+} ions [3]. These findings offer valuable insights into the intricate interplay between lattice engineering, local structural rearrangements, and energy transfer mechanisms. This knowledge paves the way for the design and development of high-performance, efficient radiation detectors and temperature sensors based on disordered high-entropy garnets.

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Acknowledgments:

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TuO-14

Optical and radioluminescence of Fe^{3+}-doped $Lu_2Si_2O_7$

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[Introduction] Scintillators can convert ionizing radiation such as gamma-rays and X-ray into ultraviolet and visible light. In recent years, scintillators having near-infrared emission have been actively developed for use in radiotherapy and real-time dose monitoring in nuclear power plants. Currently, Cr^{3+}-doped α-Al_2O_3 is used, however its emission wavelength (~ 694 nm) is shorter than 700~1100 nm, which is easily transmitted through the human body, and 770~910 nm, which causes less optical fiber attenuation [1]. For the development of novel scintillators with emission in the near-infrared (NIR) region, we focused on doping Fe^{3+} as the luminescent center. Here, it has been reported that Fe^{3+} luminescence from tetrahedrally coordinated Fe^{3+} ions emit in the 650-750 nm range, while distorted octahedrally coordinated Fe^{3+} ions emit at wavelengths longer than 800 nm [2]. Thus, in this study, we decided to grow Fe^{3+}-doped $Lu_2Si_2O_7$ single crystals and to evaluate their optical and scintillation properties.

[Materials and Methods] The single crystal growth was performed using the micro-pulling-down (μ-PD) method [3]. After weighing Fe_2O_3, SiO_2 and Lu_2O_3 with a stoichiometric composition of $(Fe_x\ Lu_{1-x})_2Si_2O_7$ (x = 0.001, 0.005, 0.010), wet mixing was performed with an agate mortar and ethanol. The undoped $Lu_2Si_2O_7$ single crystal was used as a seed crystal and pulling down was performed at 0.03 mm/min in an Ar + 2% O_2 atmosphere.

[Results] We succeeded in growing Fe^{3+}-doped $Lu_2Si_2O_7$ single crystals with various Fe^{3+} concentrations. The results of photoluminescence emission spectra excited with a wavelength of 320 nm show that Fe^{3+}-doped $Lu_2Si_2O_7$ have a broad emission peak around 835 nm. This emission peak is considered to originate from the Fe^{3+} $^4T_1$ (^4G) → $^6A_1$ (^6S) transition. On the other hand, the X-ray radioluminescence (XRL) spectra (Figure 1) show two emission peaks, one at 835 nm for Fe^{3+} d-d transition and the other at around 400 nm. This is considered to be emission originating from the host material (e.g., self-trapped exciton).

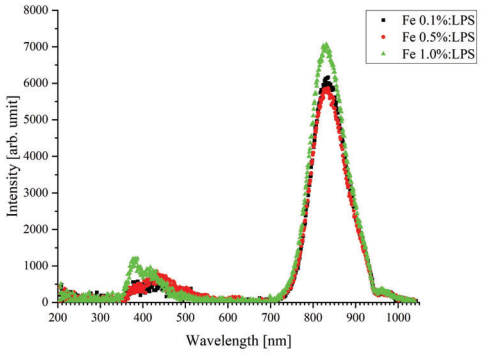

Fig.1 XRL emission spectra of Fe^{3+}-doped $Lu_2Si_2O_7$

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TuO-15

GSAG:Ce scintillator: Insights from Yttrium admixture

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The GSAG:Ce ($Gd_3(Sc,Al)_5O_{12}$) scintillator represents a cost-effective alternative to the expensive GGAG:Ce ($Gd_3(Ga,Al)_5O_{12}$) [1]. The substitution of Ga with Sc in GGAG host allows the use of much cheaper Mo crucible-based technology. However, its present composition suffers from low light yield (10 000 ph/MeV [2]), which was attributed to the thermal quenching effect. In this study, we employ the strategy of yttrium (Y) admixture to the GSAG matrix to increase the thermal activation energy. The scintillation, optical, and luminescence properties of $Gd_{(3-x)}Sc_2Y_xAl_3O_{12}$:Ce (x = 0, 0.02, 0.05, 0.2, 0.5, 0.8) grown by μ-PD method are thoroughly studied and reported. We further investigate the correlation between Y content and other characteristics (scintillation rise time, light yield, decay, etc.). The magnitude of thermal quenching is evidenced by the temperature-dependent measurement of photoluminescence decay and thermoluminescence measurements. We further report excitation and emission spectra in the deep ultraviolet range. The presented results suggest that thermal ionization is not the primary reason for the low performance of GSAG:Ce composition and other defects related to the presence of scandium (Sc) must play a role. This research provides valuable insights into scintillation mechanism of GSAG:Ce single crystals.

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WePL-1

Nanoporous scintillators for radioactive gas detection

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The measurement of pure beta emitting radioactive elements such as ^{3}H and ^{85}Kr, is a major and a mandatory measurement for nuclear safety authorities issue for the monitoring of the territory, in particular for the monitoring of the expending nuclear activities for the carbon-free production of electricity. The short penetration length of these electrons in the air makes their detection very difficult. It requires mixing the radioactive gas with the sensitive element which is done with ionization chamber (gas-gas mixture) or liquid scintillation (gas-liquid mixture for ^{3}H only). However, these two methods do not meet all the needs since neither of them combines sensitivity to both gases, real-time analysis, and ease of wide deployment on the territory. Here we demonstrate that the new approach, based on the gas-solid mixture, allows to combine all the criteria allowing the efficient and real time detection of tritium and ^{85}Kr, and more generally of pure beta radioactive elements. We show that by synthesizing a transparent and scintillating nanoporous material, here a highly porous aerogel based on doped inorganic scintillators, we detect in real time with an efficiency of 95% and 20% the ^{85}Kr and the ^{3}H (illustrative results are presented Figure 1). We achieve sub-Bq.cm^{-3} in 100 s of accumulation, which is the best performance obtained so-far in real time. In this contribution, the latest results in terms of new materials characteristics including time-resolved luminescence, and detection performances will be presented.

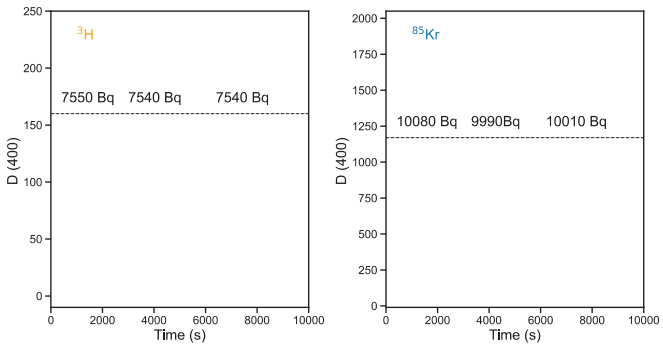

Figure 1: Typical measurements and their reproducibility for ^{3}H and ^{85}Kr detection. D(400) corresponds to the number of double coincidences measured in 400ns.

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WePL-2

Passive luminescent dosimetry in space exploration

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Luminescent detectors have been used for dosimetric measurements in space almost since the beginning of the space age - more than 60 years ago [1]. They have been, and still are, used in all areas of operational dosimetry, as well as for various experimental work in orbit, being the detector of choice among passive systems. Mostly they are thermoluminescent detectors (TLD), but in recent years also optically stimulated detectors (OSLD) and fluorescent nuclear track detectors (FNTD) have been used.

The talk will give an overview of the history of luminescent dosimetry during spaceflights. The recent measurements in the frame of the DOSIS 3D project on board the International Space Station on Earth's orbit [2] and MARE experiment in the frame of the Artemis 1 mission to the Moon orbit [3] will be also presented.

The cosmic radiation spectrum is extremely complex, consisting of a variety of particles with energies extending in a very wide range. This affects the relative efficiency of TLD/OSLD, which depends on the particle type and LET. In the talk, the problem of the efficiency of TLD/OSL for the complex cosmic radiation spectrum will be also discussed.

Acknowledgments:
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WeK-3

Garnet Scintillators with Excellent Timing Characteristics - Material Engineering by Liquid Phase Epitaxy

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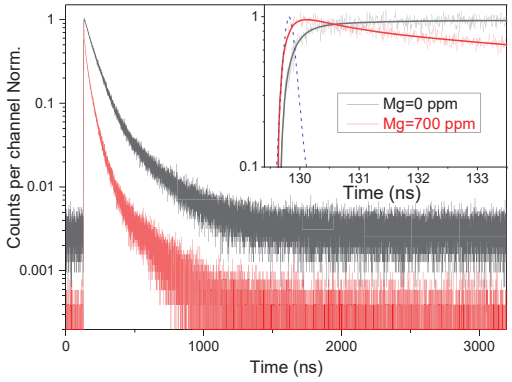
Scintillation materials with short decay times and low afterglow are crucial in applications where fast response is required. Excellent scintillation properties were reported for multicomponent GAGG:Ce garnets due to their high light yield of 58 000 photons/MeV, and good energy resolution of 4.2 % at 662 keV [1]. Here we focus on oxide scintillator films, primarily on garnets and perovskites activated by Ce^{3+} and Pr^{3+} ions prepared by the liquid phase epitaxy [2]. Particular attention is paid to luminescence and scintillation properties of multicomponent garnets of nominal composition $(GdLu)_3(AlGaSc)O_{12}$:Ce and the effect of aliovalent codoping by divalent ions.

A significant improvement in the timing properties of garnets was observed upon doping of Mg^{2+} ions. The increased Mg content from 0 to 700 ppm resulted in a considerable decrease of the afterglow signal to 0.02% at 4 ms after the X-ray excitation cut-off and a shortening of the decay and rise times, see figure. The results show a large suppression of slow components in the scintillation decay and inactivation of shallow traps due to Mg co-doping and acceleration of Gd-to-Ce nonradiative energy transfer. Markedly shorter decay times of 18 and 8 ns, respectively, were observed in Ce and Pr doped perovskites. These features, namely excellent timing properties along with low afterglow, make Mg and Pr co-doped garnets competitive candidates for ultra-fast applications, e.g. for high-rate imaging techniques, medical applications, or e-beam inspection systems, where nanosecond timing resolution is required. Luminescence and scintillation properties of multicomponent garnets and perovskites grown using liquid phase epitaxy will be reviewed and discussed in more detail.



X-ray excited decays of Mg-codoped LuGAGG:Ce,Mg garnets. Inset: initial parts of the decay curves.

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WeK-4

Application of high *Z* phosphor to distinguish hazardous radioisotope radiation in absorbed dose measurement

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Usually, when measuring the absorbed dose of ionizing radiation by luminescent passive dosimetry, one tries to use tissue-equivalent storage phosphors, i.e. those with an effective atomic number Z_{eff} close to biological tissues. This makes the measurement of the dose absorbed by the human body based on the luminescent response of dosimetric phosphorus independent of the radiation energy. However, in the case of terrorist attacks involving radiation sources that are unknown to rescuers, it is critical to immediately identify the type of source to allow for an adequate response. This work is devoted to solving this problem with the use of optically stimulated luminescence (OSL) dosimetry using a pair of phosphors – one tissue-equivalent and the other with a high Z_{eff}.

To solve this problem, a set of studies was carried out, including the study of the high Z_{eff} dosimetric phosphors and their OSL response, the development of a design of a tandem dosimeter consisting of two dosimetric detectors and a special reader of OSL response from both detectors, the study of the energy dependence of photon energy absorption in different dosimetric materials, and the analysis of the possibility of recognizing isotopes by measurements of absorbed dose by two detectors with different Z_{eff} for those radioisotopes, that could potentially be used for terrorist attacks, and, finally, performing an experimental test of the concept of the proposed solution.

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WeO-5

Thin-film scintillators of copper-halide perovskites developed for the spectroscopy of charged-particle radiations

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Scintillators have long been powerful tools in radiation detection, however, cannot offer a practical alternative to solid-state detectors in charged-particle spectroscopy in the MeV-range. The main reasons are related to the common experience of their poor energy resolution, and technological obstacles of producing thin films adopted to the short stopping range of low-energy particles, which should obey criteria of long-term stability and high luminescence yield. Conventional scintillator materials appear to have various properties that raise functional and stability concerns that can be overcome by developing polycrystalline thin-film layers, however, only a limited number of materials is capable of the desired spectroscopic performance. In order to find an adequate solution our work was inspired by the sudden rise of synthetic perovskites based on the recognition of their outstanding optoelectronic behaviour [1]. Perovskite research mainly focuses on photovoltaic and light-source applications, while marginally on the development of X-ray screens for radiographic imaging [2]. In contrast, the particle-induced scintillation, especially by heavy ions has scarcely been explored so far [3]. Exploiting the availability of the rich compositional landscape of perovskites, we have selected the group of copper-halides, which have been found superior in many physico-chemical properties to the majority of scintillator materials [4,5]. Thin layers were successfully built with a polycrystalline morphology in the thickness range of 1-100 μm by a new spray-coating technique. The brightest composition of the copper-halide group was $Cs_3Cu_2I_5$ exhibiting a scintillation yield of ~20000 photons/MeV for protons, and an energy resolution of ~5%. A systematic measurement with heavy-ion beams up to Sn-120 has also been performed to determine the sensitivity and linearity of particle detection in the energy range of 0.01-1 MeV/nucleon. Our heavy-ion measurements revealed a reduced luminescence quenching and better energy resolution for $Cs_3Cu_2I_5$ thin-films with respect to CsI(Tl) and GAGG(Ce) scintillators. Furthermore, we have tested the tolerance factors for radiation damage and thermal shock effects, as well as measured the temperature dependence of scintillation characteristics in a range of 4.2 to 473 K. The evaluation of the spectroscopic performance, material stability and potential applications will be presented.

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WeO-6

Scintillation properties of Ce-doped $SrHfO_3$ transparent ceramics for photon-counting X-ray CT imaging

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X-ray computed tomography (CT) is widely used in medical diagnostics to visualize structures inside the body noninvasively. In addition, novel X-ray CT systems equipped with a photon-counting detector (PC-CT) have been developed in recent years to obtain X-ray energy information [1], and the PC-CT estimate each concentration of multiple contrast agents from the obtained information [2]. Thus, this modality is expected to provide advanced diagnostics, such as visualising different types of tumours separately as concentration mapping images.

On the other hand, the maximum X-ray count rate is limited to be approximately 4 Mcps using conventional scintillation materials (Ce-doped garnet-type) with a decay time of around 160 ns [3], while the lower limit of the count rate is expected to be 10 Mcps, corresponding to the level of clinical use. Here, the maximum count rate is limited by the decay time of scintillator, and Ce-doped $SrHfO_3$ has that time of around 20 ns [4, 5]. Therefore, we introduced Ce:$SrHfO_3$ ceramics as scintillators into our established PC-CT system to improve the maximum count rate for the future clinical application.

Mg/Al/Ce:$SrHfO_3$ ceramics were prepared by Spark Plasma Sintering (SPS) method, and their optical and scintillation properties were investigated. The SPS method was performed under the following conditions: (i) the Mg/Al/Ce:$SrHfO_3$ powder was pre-sintered at 1,400°C for 12 h in a chamber filled with air. (ii) pressure of 100 MPa was applied to the pre-sintered powder and the sintering temperatures up to 1,700°C. (iii) the sintered samples were polished. Figure 1 shows the sintered sample of Mg/Al/Ce:$SrHfO_3$ ceramics, and the optical and scintillation properties of sample were investigated after cutting. Emission peak of Mg/Al/Ce:$SrHfO_3$ excited by X-rays was found to be approximately 400 nm, and the light output was approximately 5,000 photons/MeV.

In this presentation, we report the scintillation properties of Mg/Al/Ce:$SrHfO_3$ ceramics and the initial results of CT imaging using our PC-CT equipped with the ceramics scintillator. The ceramics sample was cut into 1 mm × 1 mm × 1 mm cubes to be combined with a Silicon Photomultiplier, and we discuss the CT image quality compared with that of conventional scintillator-based PC-CT system.

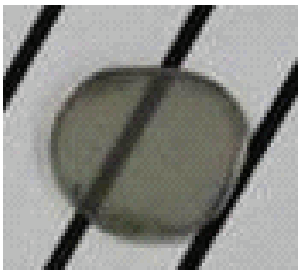

Fig 1. Sintered sample of Ce/Al/Mg:$SrHfO_3$ ceramics pre-sintered at 1,400°C. Diameter is 10 mm.

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WeO-7

Photochemical synthesis of luminescent multicomponent oxide (nano)materials

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Recently, scintillating nanomaterials have been attracting a considerable attention from research communities and the industry. Nanomaterials with high chemical / radiation stability and low manufacturing costs are often sought after for incorporation into nanocomposites, optical ceramics or aerogels [1], for luminescent probes, innovative drug systems *etc*.

Photochemical reactions offer several important advantages for the synthesis of nanomaterials. The primary photochemical processes are independent of solution temperature; thus, the synthesis can be precisely controlled by the intensity and duration of the irradiation. Following homogeneous reactions often result in nanoparticle formation with narrow particle distribution. The relatively inexpensive light sources used (usually gas discharges) allow easy scalability of the synthesis [2]. Photochemical precipitation can be utilized for homogeneous incorporation of many different metal ions into the formed nanoparticles or gel. Heat treatment of the dried solid precursor then leads to crystallization of multicomponent materials according to their thermodynamic stability. Relatively low calcination temperatures are often required to achieve pure phases; however, particle necking, intergrowth and sintering increase the grain size during any heat treatment. Limiting the growth of nanoparticles presents a significant technological challenge.

This work focuses on the synthesis of solid precursors to Ce-doped yttrium aluminium garnet (YAG) and multiple (Gd,Y)AlO_3 perovskites (GYAP) and their subsequent treatment. Gelatinous precursor to YAG:Ce synthesized in a 90-litre photochemical pilot plant was separated from the solution through a) microfiltration (0.45 μm membrane filter) or large-scale lyophilisation after b) slow freezing or c) fast freezing at 77 K. All three solid precursors were calcined at different temperatures, then thoroughly characterized and compared regarding composition and crystallite size. GYAP:Ce solid precursors prepared in a 2-litre photoreactor were microfiltered; they had to be heat-treated at high calcination temperatures (1600 °C) to obtain pure or almost pure perovskites, as confirmed by XRPD. Both radio- and photoluminescence spectra showed typical Ce^{3+} $5d - 4f$ emission doublet from aluminate perovskites, whose energy red-shifted with increasing Y content.

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WeK-8

Tuning of Mn^{4+} and Cr^{3+} luminesce in Ga_2O_3 by alloying with Al_2O_3 and In_2O_3

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It is known that alloying of gallium oxide (Ga_2O_3) with aluminum or indium oxide (creation of solid solutions) allows changing their physical properties in a wide range primarily due to modification of the crystal structure and the energy band gap of the material. When the material is activated with Cr^{3+}, photoluminescence (PL) properties of Cr^{3+} ions can also be changed significantly by modification of the crystal field strength experienced by Cr^{3+} ions. Up to now, there were no reports on Mn^{4+} PL in any of the Ga_2O_3-based alloys. So, it is unknown how the Mn^{4+} PL will behave when the α-Al_2O_3 crystal lattice is modified by the addition of Ga.

Therefore we studied in detail the $(Al_{1-x}Ga_x)_2O_3:Mn^{4+}$ (x = 0; 0.05; 0.10; 0.15; 0.2; 0.25; 0.5; 0.75; 1.0), $(Ga_{1-x}Al_x)_2O_3:Cr^{3+}$ (y = 0; 0.1; 0.2) and $(Ga_{1-x}In_x)_2O_3:Cr^{3+}$ (x = 0.05; 0.1; 0.15; 0.2; 0.3; 0.4; 0.5) phosphors [1, 2]. In particular, photoluminescence (PL), PL excitation (PLE), diffuse reflection (DR) spectra and PL decay kinetics of the materials in the temperature range from 4 to 350 K were studied. Additionally, the persistent luminescence (PersL) and the thermally stimulated luminescence (TSL) after UV excitation were measured for the Cr^{3+}-doped materials in the temperature range from 77 to 600 K. The phase composition and crystal structure of the studied materials were examined by X-ray powder diffraction technique.

Obtained results demonstrate the potential for fine-tuning the performance of the studied materials as NIR persistent phosphors and non-contact luminescence thermometers through alterations in the chemical composition of the Ga_2O_3-based host material. Performed low-temperature and time-resolved PL studies shed light on the nature of the Cr^{3+} and Mn^{4+} centers available in the studied alloys. The luminescence results are discussed in correlation with the crystal structure data for the studied materials.

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WeK-9

GALLIUM OXIDE – A PROMISSING MATERIAL FOR THE NEXT GENERATION HIGH-POWER ELECTRONICS

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Efficiency in production, distribution and consumption of electricity is a key factor towards a sustainable energy future. Equally important to renewable electricity production via photovoltaics seems to be the efficient electricity distribution. Thus, power electronics is the enabling technology for efficient use, distribution, and conversion of electrical energy. Silicon, which is the base material in electronics nowadays, cannot provide a variety of functions needed in the future electronic devices. The transition from Si to wide band gap semiconductors will save tremendous amounts of electricity otherwise lost in operation. Recently, the ultra-wide bandgap gallium oxide (β-Ga_2O_3) has emerged as a novel material with tremendous potential, exhibiting a figure of merits overperformed only by diamond. β-Ga_2O_3 is the thermodynamically stable phase among the various polymorphs of gallium oxide and has impressive properties, e.g., a bandgap of ~4.85 eV, a breakdown field of 8 MV/cm [1] and a rather good radiation stability [2,3]. The Baliga figure of merit of β-Ga_2O_3 (3444) [1] is an order of magnitude higher than that of SiC and approximately 4 times larger than the corresponding value of GaN. The unique properties of this material, combined with the availability of simple and low-cost, in comparison to GaN substrates [4,5], melt growth methods for mass production of bulk single crystals: edge-defined film-fed growth, Czochralski and float zone [6] have made β-Ga_2O_3 a strong candidate for next generation high-power devices.

MOVPE epitaxial growth, material properties, and potential applications of the β-polytype of gallium oxide in future high-power electronic devices related to electric vehicles, electric trains, distribution systems, as well as high and low voltage switching networks will be discussed.

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WeO-10

Radiochromic reactions and sensitivity changes of a radiophotoluminescence glass (FD-7) after repetitive irradiations with high-dose X-rays

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Radiophotoluminescence (RPL) dosimeter of Ag-doped alkali-phosphate glass is successfully applied to personnel and environmental dosimetry, with potential use in phantoms for radiotherapy treatment planning and machine calibration. The commercially available RPL glass (FD-7) is colored by high-dose irradiation [1]. This feature of radiochromic reaction limits the use of the RPL dosimeter for monitoring in a wider dose range, although the same material was found to present simply increasing EPR signals with dose up to 300 kGy [2]. There is an undetermined relationship between coloration and changing sensitivity in the RPL signal of the dosimeter. Investigating changes in color and sensitivity with repeated exposures at higher doses will provide reliable understanding of the limitations of FD-7. We aim to expand the range in which the dosimeter can be practically reused by quantifying the changes in RPL signals of the glass at higher doses.

In the present study, we examined the radiochromic reactions and the change in the RPL intensities of FD-7 after repetitive irradiations with high-dose X-rays (160 keV, 6.3 mA). In previous investigations, the color of FD-7 changed to brown following tens of Gy irradiation and the level of coloration increased with dose [1,2]; high dose irradiation is considered to cause changes in sensitivity in FD-7, which is unfavourable for reuse. To quantify these issues, the present study conducts parallel investigations into coloration and decoloration at different doses and temperatures, and simultaneously into the impact of repeat irradiations to various doses on the sensitivity of the RPL glass. To study temperature and decoloration, plates of FD-7 glass were irradiated up to 300 Gy and then stored at different temperatures up to 160°C. Optical absorption measurements were conducted regularly during decoloration process. To assess changes in sensitivity, rod-shaped samples of FD-7 were irradiated up to 300 Gy and RPL intensity was measured throughout the dosimetry process (pre-irradiation, post-irradiation, preheating, and after annealing). Obtained results are presented in comprehensive ways.

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WeO-11

Controlled UV Emission from Gd-Doped $MgAl_2O_4$

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$MgAl_2O_4$ stands out as a wide band gap optical material that can accommodate numerous activators, including rare earths. It has been investigated as a scintillator and luminescence dosimeter, but limited attention has been paid to engineering its UV emission. $(Mg_{1-x}Gd_x)Al_2O_4$ with x = 0, 0.01, 0.05, 0.075, 0.1 and 0.2 were prepared by the co-precipitation method followed by 2h-long calcination at 900 ºC in air. The powders were characterized by XRD, SEM/EDX, XPS, and evaluated in their photophysical properties by diffuse reflectance, radioluminescence (RL) under X-ray excitation from room temperature (RT) to 450 ºC, and by photoluminescence emission (PL), excitation (PLE) and lifetime measurements. XRD indicated a single phase and progressive structural disorder as per the broadening of the diffraction peaks for higher x values. RL showed UV emission at 314 nm due to the Gd^{3+} $^6P_{7/2} \rightarrow {}^8S_{7/2}$ transition, with the x = 0.075 material having the most intense emission. Lifetime measurements revealed two lifetimes, *ca.* 1.7 and 4.9 ms, whose relative contributions vary as a function of the Gd content. This behavior was tentatively attributed to the existence of Gd with different chemical bonds as shown by XPS. The UV emission intensity showed a linear decrease as a function of the temperature, being 70% of the RT intensity at 200 ºC.
This material is based upon work supported by the National Science Foundation under Grant No. DMR-1653016.

WeO-12

Luminescence Properties of Novel Tl^+ and Sr^{2+} Co-doped $Cs_3Cu_2I_5$ Scintillator for Boron Neutron Capture Therapy

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In boron neutron capture therapy (BNCT), a form of radiation-based cancer therapy, developing a detector for measuring the treatment effect remains a challenge issue. To estimate the treatment effect in real time, the use of prompt gamma rays (478 keV) emitted by the $^{10}B(n,\alpha)^{7}Li$ reaction during BNCT therapy has been proposed [1]. In this case, to discriminate the 478-keV gamma-ray signal from the background (BG) events including 511-keV gamma rays from positron and electron annihilation, scintillators are required to have an energy resolution better than 6.5 % (FWHM) at 511 keV. $Cs_3Cu_2I_5$ (CCI) scintillator [2] has a high light output of 41,500 photons/MeV and high energy resolution of 4.4% at 662 keV (FWHM) [2].

In iodide scintillators, it has been reported that co-doping Tl^+ and Sr^{2+} improves energy resolution, faster scintillation decay time, and significantly improves non-proportionality [4]. Therefore, we grew Tl^+ and Sr^{2+} co-doped CCI (Tl,Sr:CCI) crystals and evaluated their luminescence and scintillation properties.

Tl,Sr:CCI crystals were grown by the vertical Bridgman-Stockburger method. The phase of the obtained crystals were investigated by the powder X-ray diffraction (D8 DISCOVER,Bruker). The scintillation decay times were measured with an oscilloscope (TDS3052B, Tektronix). We measured the temperature dependence of photoluminescence excitation and emission spectra from 10 K to 350 K at UVSOR BL3B beam line.

We succeeded in growing Tl^+ and Sr^{2+} co-doped $Cs_3Cu_2I_5$ crystals. Each crystal phase was confirmed by the powder XRD measurements. The temperature dependence of emission intensity for Tl,Sr:CCI excited with 292 to 375-nm photons as shown in Fig. 1. As the temperature was increased from 40 to 100 K, the emission intensity decreased. In addition, the emission wavelength was red-shifted. In this presentation, we report detailed luminescence properties of Tl,Sr:CCI.

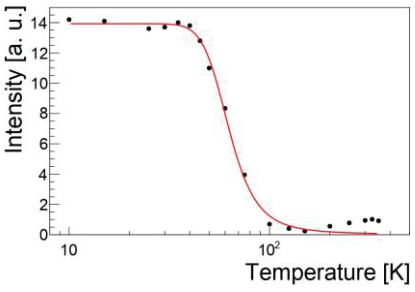

Fig.1 Temperature dependence of emission intensity of Tl,Sr:CCI

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WeK-13

Near Threshold Electron Emission Spectroscopy Towards Dosimetry of Nanovolumes

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Nano-dosimetry (ND) is inspired by modern radiation therapy (RT) technologies and molecular and micro radiobiology needs. ND aims to detect radiation dose absorbed by nano volumes.

Modern RT provides extremely high absorbed dose gradients within a patient's body. Therefore, to detect a distribution of the dose, a linear size of the detector should fit the scale from 100 nm to a couple of micrometres.

Because RT aims to destroy DNS in which a single unit is sized to a nanometric scale, ND is of radiobiology importance.

When the high dose gradient is provided a thin film detector or thin surface layer of the solid material could be used for dosimetry.

If 3D nano-volume is of the interest, the nano-dotted/particle originated detector is possible to employ.

Weak electron near threshold photoemission (PE) is considered for readout of the dose absorbed by the nano-sized detector. The application of PE for ND is connected with the nanometric mean free path of the emitting electron.

PVDF nanofilms, the surface of a crystalline Si, PbS nanodots and diamond nanoparticles are considered for ND.

WeK-14

Modified Crystal Field Theory: New Possibilities for Optical Spectra Analysis

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A new semi-empirical technique called the Modified Crystal Field Theory (MCFT) has been proposed for the analysis of optical spectra, which allows the calculation of the electron structure of transition and rare-earth impurity metal ions placed in arbitrarily distorted complexes of different chemical nature [1].

MCFT is based on the traditional Crystal Field Theory (CFT) but it has a number of significant differences. Within MCFT, the crystalline potential is generated by the point charges of the electrons and nuclei surrounding a paramagnetic ion, and a single configuration approximation is assumed. The complete set of the basic functions corresponding to a given electron configuration includes a finite number of orthonormal antisymmetric many-electron functions, which depend parametrically on the coordinates and charges of the ligands. Multi-electron functions are in turn formed from single-electron hydrogen-like functions with an effective nuclear charge, Z_{eff}, as an unknown variable parameter. Z_{eff} is defined as the difference between the effective nuclear charge of a free ion and the screening magnitude related to the crystal field influence. Z_{eff} can be determined by the independent calculations or by additional experimental data. In a physical sense, such a variation can be interpreted as an implicit consideration of the covalence degree of a chemical bond. Ultimately, it allows us to parameterize the problem with a minimal set of parameters, and it does not require time-consuming computational resources. In addition, the parameterization significantly extends the scope of the method to classes of compounds such as dilute magnetic semiconductors, coordination polymers, molecular magnets, organic insulators doped with magnetic ions, photochromic materials, etc.

Within the MCFT, all the types of relativistic interactions (spin-own-orbit, spin-spin, spin-other-orbit, orbit-orbit) are taken into account and it allows to study the conditions for realizing the different spin states of paramagnetic ions and the transitions between them. A spin-state diagram technique is proposed to visualize spin-state transformations in 3d-containing complexes induced by temperature or pressure. MCFT allows the interaction of paramagnetic ions with an external magnetic field to be taken into account. MCFT allows the interaction of paramagnetic ions with an external magnetic field to be taken into account. The application of MCFT allows the successful theoretical fitting of EPR, optical absorption, and luminescence spectra.

As some examples of MCFT application, the formation mechanism of absorption and emission spectra obtained from co-doped ZnSe:(Cr, Fe) samples has been considered.

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ThPL-1

Recent advancements in research of the single crystals and single crystalline film phosphors using synchrotron radiation

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Substantial differences in the methods and conditions of phosphor preparation from the melt (crystals) and solution in the melt (single crystalline films) of complex oxide compounds (garnets, perovskites, orthosilicates, etc.) result in the significant variations in their luminescent properties. Such variations are caused by different types of intrinsic defects, their concentration, different distributions of the dopant ions between cationic sites and the interaction of dopants with defect and dopant centers in the crystal and film phosphors.

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

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

The aim of this presentation is to show the characteristic examples of comparison of the structure of luminescent centers in crystals and film phosphors based on the Ce^{3+} doped mixed $Gd_3(Al,Ga)_5O_{12}$ garnets, $(Lu,Y)AlO_3$ perovskites and $(Lu,Y)_2SiO_5$ orthosilicates using the conventional spectral methods as well as the time-resolved luminescent spectroscopy under synchrotron radiation excitation at VUV stations at P66 line at PETRA3 storage ring at DESY, Germany.

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ThPL-2

Visualization of radiation Frenkel defects in wide-gap materials via optical and EPR methods

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Wide-gap metal oxides demonstrates various fascinating properties and are exploited in different technological applications. In particular, corundum (α-Al_2O_3) and mineral spinel ($MgAl_2O_4$) single crystals/ceramics are considered by the EUROfusion consortium as promising window materials for projected *D-T* fusion devises. As is known, the degradation of optical materials under intense irradiation is predominantly caused by the elastic collisions of incident energetic particles (neutrons, ions, electrons) with metal oxide nuclei resulting in the formation of interstitial-vacancy pairs of Frenkel defects in both oxygen and cation sublattices.

The radiation damage caused by fast fission neutrons or ~GeV swift heavy ions has been studied in α-Al_2O_3 and $MgAl_2O_4$ crystals via optical absorption, EPR and cathodoluminescence methods [1-6]. The correlation between the EPR and optical characteristics (emission and absorption bands) allowed the tracking of the creation, accumulation and further thermal stepwise annealing of classical *F*-type defects (an oxygen vacancy with one (F^+) or two trapped electrons and relevant F_2 dimers) as well as more complex cation-containing defects (spinel [3, 4]). A number of novel paramagnetic radiation defects was revealed in neutron-irradiated mineral spinel (a set of trapped-hole *V* centers [1]) and corundum (a single oxygen interstitial – a complementary defect to the F^+ [2]; a double charged F_2 dimer).

The experimentally measured annealing kinetics of the *F* and F^+ centers (via integral of an optical absorption Gaussian or a relevant EPR signal) in metal oxides were also modelled in terms of diffusion-controlled recombination reactions [2, 5]. In addition, the accumulation of single/dimer *F*-type defects have been analyzed in neutron- or Xe-ion-irradiated corundum single crystals via the time-resolved cathodoluminescence spectra [5]. The limitations of the use of specific luminescence bands for the detection of radiation damage are considered.

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ThO-3

Development of a low-cost charged particle imaging detector using $GdAlO_3$:Tb-αAl_2O_3 PSSF and Raspberry Pi camera module

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For the advancement of novel radiopharmaceuticals and the dosimetry of internal alpha radiation therapy, acquiring dose distributions of charged particles within microenvironments, such as organs and tumor tissues, is imperative [1]. Our research cohort has pioneered an alpha-particle micro-imaging system utilizing GAGG:Ce in conjunction with magnification optics and EM-CCD/qCMOS to capture tracks of alpha particles with a line width of 0.34 μm FWHM [2, 3]. However, this system encounters a challenge due to the costly nature of the objective lens and EM-CCD/qCMOS camera utilized in the magnification optics, which amount to several ten thousand dollars or more as a complete system. In this study, we devised a charged-particle imaging detector comprising $GdAlO_3$:Tb-αAl_2O_3 phase-separated scintillator fibers (GAP:Tb-αAl_2O_3 PSSFs) directly optically coupled to a Raspberry Pi camera module V2 sensor, with the aim of reducing the expenses associated with charged-particle imaging detectors.

The GAP:Tb-αAl_2O_3 PSSFs employed in this study were grown through the micro-pulling-down technique, trimmed to dimensions of 3 mm × 3 mm × 0.5 mm, and meticulously polished to a mirror finish. These prepared GAP:Tb-αAl_2O_3 PSSFs were integrated with a camera module to assemble a charged-particle imaging detector, as illustrated in Fig. 1 (a). The response of the detector to irradiation from a ^{241}Am sealed RI source is depicted in Fig. 1 (b). Alpha particles were effectively captured with the developed detector. The spatial resolution of the alpha particle image was determined to be approximately 3 μm FWHM. Moreover, the emitted beta rays from ^{90}Sr were also assessed, resulting in a distinct track image for the beta rays.

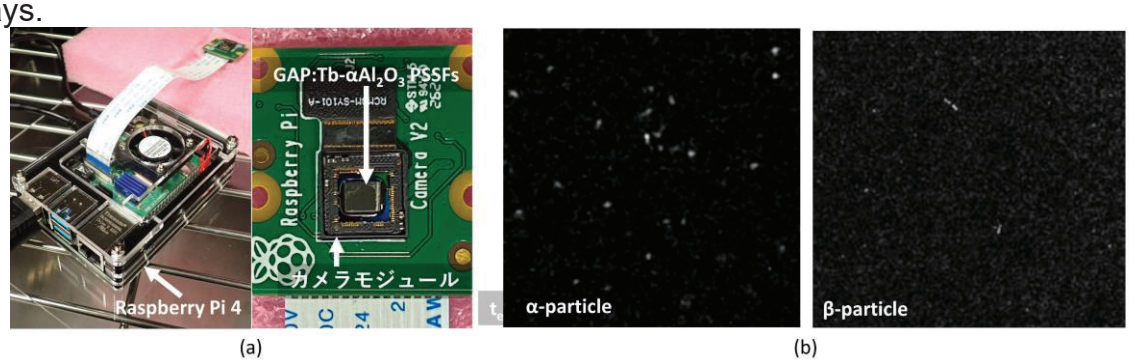

Fig. 1 (a) low-cost alpha-particle imaging detector, (b) Example image of alpha- and beta- paticle.

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ThO-4

Investigation of fusion breeder materials under neutron irradiation at WWR-K research reactor

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Lithium-based oxide ceramics are considered as a promising material for solid breeders in the blankets of future fusion reactors. To predict the behavior of the materials and justify the prospects of their use, it is very important to know the structural, thermal, and dynamic properties of the breeder material and their changes occurring in the material as lithium is burned out of it and numerous structural defects are formed. One of the main candidate materials is lithium metatitanate, Li_2TiO_3, due to the high rate of tritium release at relatively low temperatures (from 200 to 400°C) and chemical stability. Reactor experiments on irradiation of lithium-containing FR (fusion reactors) materials are usually aimed at determining the parameters of the processes of tritium generation and release. There are numerous publications in the literature related to the study of samples based on lithium ceramics, but scientific papers on experimental studies of such materials under reactor irradiation are insufficient, both because of the difficulty of organizing such studies and the limited access to research reactors in the world.

This paper presents the results of reactor experiments with samples of two-phase lithium ceramics of different molar composition and geometric sizes of pebbles. The experiments were performed at the research reactor WWR-K of the Institute of Nuclear Physics (Almaty, Republic of Kazakhstan) at neutron flux density of $5*10^{13}$ n/cm^2*s and sample temperature of 650-700ºC. In the process of irradiation mass spectrometric registration of tritium and helium release from samples at different temperature modes was carried out.

In this work, we would like to shown the basis of the received results of measurements the summarized data on rate of approach of process of equilibrium release of tritium-containing molecules from samples of investigated lithium ceramics are presented. The calculated values of the rate of tritium generation in the ceramic samples are given and their comparison with the released tritium fluxes in the experiment is carried out.

FrK-1

Photochromism and persistent luminescence in complex oxides: Unveiling the role of paramagnetic centres

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A variety of complex oxide materials exhibit fascinating properties such as photochromism and persistent luminescence upon excitation with ultraviolet radiation. These optical phenomena arise from processes involving the generation, transfer, trapping, and recombination of charge carriers. Electron paramagnetic resonance (EPR) spectroscopy-based techniques enable the detection and identification of paramagnetic centres which play a crucial role in these phenomena.

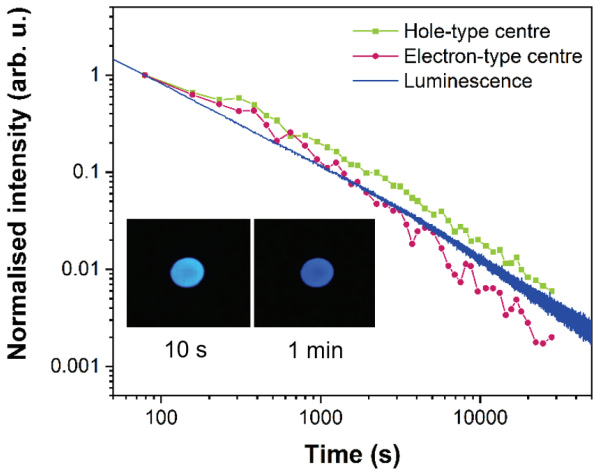

Fig. 1. Correlated decay of paramagnetic centres and persistent luminescence kinetics in Ca_2SnO_4: La^{3+} [1].

This presentation will overview the versatility and limitations of EPR spectroscopy for elucidating the origin of photochromism and persistent luminescence in complex oxide materials. The advantages of correlated EPR and optical spectroscopy experiments will be highlighted on recent results obtained in Ca_2SnO_4 [1], $Mg_3Y_2Ge_3O_{12}$ [2], $MgGeO_3$ [3], and $Ca_2Al_2SiO_7$ [4] complex oxide hosts.

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FrK-2

Near Field X-ray Optical Luminescence Scanning Probe Microscopy

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Near Field X-ray Spectromicroscopy is a fully new approach for the detailed investigation of nanostructures down to the nanometer level. The extremely high lateral resolution of Scanning Probe Microscopies (SPM, AFM, STM) makes them among the most largely used in nanoscience. However, these tools suffer of a lack in chemical sensitivity. On the other hand, far field X-ray spectroscopy probes the chemical and structural properties of materials. A combination of X-ray spectroscopies and SPM is the ideal answer to many problems in nanosciences.
The combination of XAS and scanning near-field optical microscopy (SNOM) as a local detector was proposed by Purans et.al. [1,2]. We have started with three types of experiments:
(i) XAS-AFM: X-ray excited secondary electrons detection by conductive tip in AFM mode;
(ii) XAS-SNOM: X-ray excited optical luminescence (XEOL) detection by SNOM in AFM mode;
(iii) XAS-SCM/AFM: X-ray excited capacitance or/and photoconductivity of sample detection by conductive tip in SCM, KFM or AFM mode. The new instrumentation developed within this project offers the possibility to carry out a selective structural analysis of the sample surface with the subwavelength spatial resolution determined by the SNOM probe aperture. The apex of the optical fibre plays the role of a topographic probe, and chemical and topographic mappings can be simultaneously recorded.

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FrK-3

Mechanisms of Aliovalent Codoping on the Timing Properties of the Multicomponent Garnet Scintillators

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Future high-energy physics experiments and medical imaging devices require substantial improvement in the timing properties of scintillation detectors. Aliovalent codoping by divalent Mg ions has been shown as an effective way to accelerate scintillation response of Ce-activated garnets. The improvement in scintillation timing properties is generally attributed to the stabilization of cerium ions in Ce^{4+} state and suppressing the influence of trapped electrons on the rise time of the scintillation response.

We present an extensive study of the effects of aliovalent codoping on the timing properties of the multicomponent GAGG:Ce, LuGAGG:Ce and LuAG:Ce scintillators codoped by Mg by utilizing transient absorption, time-resolved cathodoluminescence and photoluminescence techniques.

Study of photoexcitation relaxation processes exploiting transient absorption technique revealed that aliovalent cooping by Mg ions, both in GAGG:Ce and LuGAGG:Ce, supress the influence of shallow electron trapping centers that slows down the excitation transfer to the emitting Ce ions.

The idea of incorporation of gadolinium in the garnet-type scintillators is to diminish the thermal depopulation of the emitting $5d_1$ level of Ce^{3+}. However, the Gd ions build a sublattice, and part of excitations might reach the Ce^{3+} ions via that sublattice with a substantial delay deteriorating timing properties of the Ce activated scintillator. Our study of LuGAGG and LuAG scintillators exploiting time-resolved cathodoluminescence and photoluminescence techniques revealed that the deteriorating effect of Gd can be blocked by aliovalent codoping with Mg by channelling of the excitations in Gd sublattice via nonradiative recombination due to the spectral overlap of optical transitions in Gd^{3+} ions and the codoping-related absorption band.

On the other hand, our study demonstrates that heavy aliovalent codoping of Ce activated multicomponent garnets results in the coexistence of two types of emission centers: regular Ce^{3+} ions and Ce^{3+}+Mg^{2+} centers consisting of Ce ions located close to Mg ions. We revealed that latter centers exhibit a smaller energy barrier for thermal depopulation of the emitting level and introduce a barrier-free channel of nonradiative recombination resulting in a faster overall emission decay.

In conclusion, the aliovalent codoping is a powerful tool for improving the timing properties of the multicomponent garnet-type scintillators activated by Ce via several mechnisms, however, the scintillation decay is accelerated at the expense of light yield.

FrK-4

Low-temperature studies of transparent yttrium aluminum garnet ceramics doped with Sm^{3+} ions

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Properties of yttrium aluminum garnet doped with Sm^{3+} ions (YAG:Sm^{3+}) transparent ceramics, which theoretically meet all the cladding criteria for YAG:Nd^{3+} laser ceramics, were investigated. The phase formation, microstructure evolution, thermal properties, refractive index and spectroscopic properties of YAG ceramics with different concentrations of Sm^{3+} (1-10% at.%) were determined. In result, absorption, excitation, Raman spectra and thermoluminescence curves were measured and correlated with microstructural properties. Low-temperature experiments were also conducted to verify the feasibility of using these ceramic materials as cladding for YAG:Nd^{3+} also under cryogenic laser operating conditions. In the case of heavily doped YAG, not only the refractive index of these materials and the conductivity, but especially the concentration of defects can change, leading to unfavorable phenomena for the indicated applications, such as the formation of color centers, trap levels or non-radiative processes. Understanding these complex physical properties is an important step to designing ceramic laser materials that, in subsequent research steps, can already be fabricated as heterogeneous layered ceramics in the form of YAG:Nd^{3+} (lasing core) and YAG:Sm^{3+} (cladding absorber) and the construction of a laser optimized for low-temperature operation.

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FrK-5

Advances in persistent luminescence research - case of alkaline earth metal aluminates

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Persistent luminescence, commonly referred to as afterglow, is a phenomenon where materials continue to emit light after the excitation source has been removed. This intriguing property has widespread applications, from glow-in-the-dark safety signs to bioimaging. Recent years have seen significant advancements in the understanding and enhancement of persistent luminescence mechanisms, particularly within the family of alkaline earth metal aluminates. These materials are celebrated for their robust and long-lasting luminescent qualities under various conditions.

This talk will dive into the latest research developments surrounding alkaline earth metal aluminates, highlighting the synthesis, activation, and modification techniques that enhance their luminescent properties. Laboratory of Optical Materials, Institute of Solid State Physics, University of Latvia, has been studying persistent luminescent materials for over a decade [1]. Theoretical insights into the energy transfer mechanisms and trap distribution within the host lattice will also be discussed, providing a comprehensive understanding of how these materials store and release energy [2]. This talk will also outline our recent experiments of practical applications of these materials embedding the materials in glass [3], usage as 3d printable mechanoluminescent stress sensors [4] as well as usage as smartphone-readable anti-counterfeiting tags.

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FrO-6

Applications of YAG:Ce and LuAG:Ce crystal detectors for registration radiation activity of liquid wastes at Oncology Center in Bydgoszcz

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Thermoluminescence (TL) dosimetry is a versatile tool for the assessment of dose from ionising radiation. The crystals of Ce^{3+} doped $Y_3Al_5O_{12}$ garnet (YAG:Ce) with a medium density ρ=4.5 g/cm^3; Z_{eff}=35 was and $Lu_3Al_5O_{12}$ (LuAG:Ce) garnet with high density ρ=6.7 g/cm^3 and Z_{eff}=61 recently emerged as a possible alternative materials in radiotherapy applications due to its excellent radiation stability, high yield (~20-25 Ph/KeV) and good position of main TSL peak around 240-280 K [1]. Furthermore, the new types of composite TL detectors based on the YAG:Ce and LuAG:Ce single crystal and films were developed using the LPE growth method for simultaneous registration of the different components of ionization radiation [2]. Taking into account the resistivity of these oxide materials to direct contact with liquids and vapours, including aggressive substances, the practical goal of our activity is the testing developed TL detectors for simultaneous registration of the radiation activity in bunkers of liquid wastes, *containing α-* and *β-particles* and *γ-rays sources*, at cancer centres and other similar institutions producing radioactive sources.

In this work we have used the one set of YAG:Ce and two sets of LuAG:Ce TL detectors, prepared from Czochralski grown crystals, as tool for the registration of the ionising radiation dose (activity) of γ-rays ^{99m}Tc source. The detectors were directly placed in the containers with liquid solution of 0.9% NaCl with ^{99m}Tc eluate source from ^{99}Mo/^{99m}Tc generator with different activity levels: high (from 30 GBq to 3 GBq), medium (from 232 MBq to 6.6 MBq) and low (from 40 MBq to 5 MBq).

The first results are very promising (Fig.1). The results on YAG:Ce and LuAG:Ce detectors were compared in terms of selecting the best compositions for different levels of γ-rays activity. It was found that the YAG:Ce crystal detectors with medium density ρ=4.55 g/cm^3 and Z_{eff}=29 value is more suitable for the registration high-level activity (Fig.1a) when LuAG:Ce crystal detector with high density ρ=6.7 g/cm^3 and Z_{eff}=61 is more sensitive for medium and low-level activity (Fig.1b).

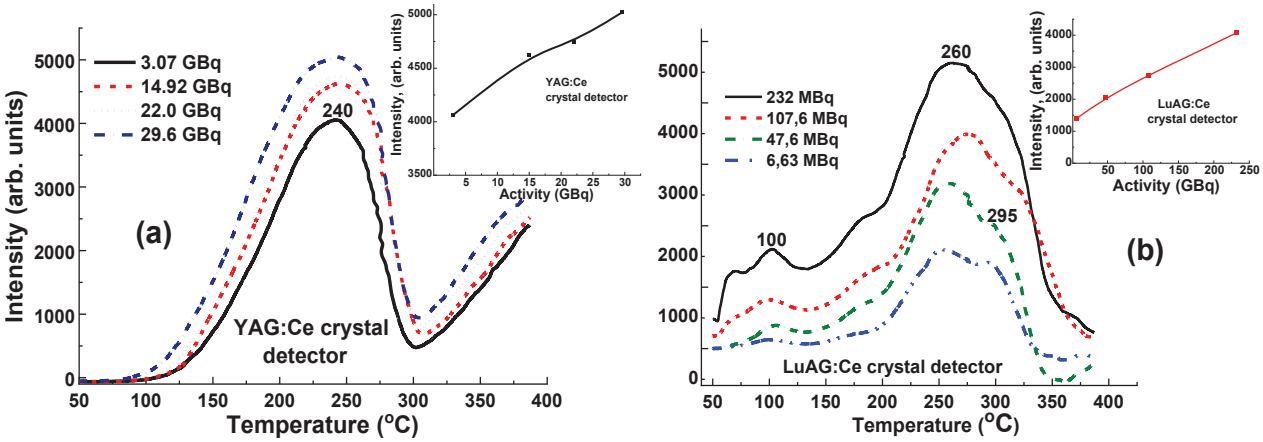

Fig.1. The result of in-situ dose measuring test in the Nuclear Department of Oncology Centers in Bydgoszcz. Dependence of the intensity of TSL glow peaks of YAG:Ce (a) and LuAG:Ce (b) crystal detectors with 10*10*0.5 mm and 5*5*1 mm size, respectively, on dose (activity) of γ-quanta radiation.

Acknowledgments. This work was performed in the frame of NCN OPUS 24 LAP 2022/47/I/ST8/02600 and Regional Excellence Initiative nr RID/SP/0048/2024/01projects.

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FrO-7

Persistent luminescence properties of Eu^{2+}, Dy^{3+} co-doped calcium aluminate synthesized by combustion method

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The $CaAl_2O_4$ co-doped has been obtained by different ways such as microwave-assisted chemical co-precipitation, [1] the solid reaction, [2] sol-gel, [3] combustion method [4] among others. We report photoluminescence, thermoluminescence and persistent luminescence properties of calcium aluminate synthesized by combustion method using urea as a fuel and co-doped with Eu^{2+} and Dy^{3+}. The synthesized samples displayed a characteristic XRD pattern show that it is a material composed of at least three different atomic arrangements of calcium aluminate (krotite, grossite and mayenite) where calcite additionally occurred, the presence of calcite is also consistent with the FTIR results. The photoluminescence spectrum showed a wide band from 380 to 530 nm with a maximum peaked at 438 nm. It corresponds to the allowed transition from $4f^65d$ to $4f^7$ levels of Eu^{2+} ion under excitation with 338 nm light. The $CaAl_2O_4$: Eu^{2+}, Dy^{3+} phosphor exposed to β particle radiation in the range of 0.8–10.6 Gy presents a wide glow curve with at least three overlapped peaks around 76, 136 and 196 °C. The phosphors exhibited persistent luminescence immediately after ceasing irradiation exposure with a time decay of the order of hours. The long-lasting luminescence was associated to the thermal emptying of the traps related to the low temperature TL peaks. The TL behaviour present a broad curve from 30 °C to 382 °C with similar maximums around 74, 202 and 308 °C, present in the doped material as the undoped.

Keywords: calcium aluminate, thermoluminescence, persistent luminescence.

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FrO-8

Cross-Luminescence in Doped BaF_2 Single Crystals for Detection of Gamma and X-ray Radiation with Picosecond Resolution

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Currently, a search is underway for scintillators that have ultrashort components in the luminescence decay. Overcoming a time resolution of 100 ps in modern detectors will make it possible to make a significant breakthrough in medical diagnostics, for example, time-of-flight positron emission tomography (PET-TOF) and time-of-flight computed tomography (TOF-CT). Detection of single gamma quanta with an energy of 511 keV or X-ray photons with an energy of 60 to 140 keV which have a time resolution of up to 10 ps is a necessary condition for the development of these technologies. Nowadays, inorganic scintillators based on lutetium orthosilicate LYSO:Ce, which have a relatively high density, are used in detectors for TOF tomography. However, LYSO:Ce and similar scintillators doped by cerium ions have the maximum achievable time resolution of approximately 100 ps.

Cross-luminescent scintillators will significantly improve the performance of modern time-of-flight detectors; they are also more cost-effective compared to orthosilicate crystals. In the future, this will make it possible to create larger PET scanners, for example for whole-body scanning, as well as to meet the high demand for materials expected with the introduction of TOF-CT.

This study presents the latest results on the study of cross-luminescence in barium fluoride (BaF_2) single crystals activated by lanthanum or cadmium ions. In these crystals, an ultrashort cross-luminescence component (<100 ps) was detected, the contribution of which increases with increasing activator concentration, which makes it possible to achieve a time resolution of approximately 50 ps.

The time-resolved spectra of this ultrafast component were measured at the photoluminescence endstation FINESTLUMI of FinEstBeAMS undulator beamline on the 1.5 GeV storage ring of the MAX IV synchrotron (Lund, Sweden). It was found that its maximum is shifted by 0.7 eV to the lower energies. First-principles calculations showed that this component may arise due to the excitation of the core levels of Cd or La.

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FrO-9

Luminescent Effect of Undoped and Chromium-doped MgGa2O4 Synthesized by Combustion

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Recent studies show the luminescent effect attributed to the chromium ion associated with emission bands in the red spectral region, with applications in imaging diagnostic, optoelectronic, dosimeters and signalization [1,2]. However, the luminescent effect has not been widely explored. In this work we reported synthesis and luminescent contribution of crystalline matrix $MgGa_2O_4$ and $MgGa_{2-x}O_4$: xCr^{3+} (x=0.001,0.005,0.01) by combustion method as an alternative to solid reaction [2]. The precursors were calculated from the stoichiometric reaction by introducing excess urea fuel. The nitrates were diluted with distilled water and placed in a preheated oven at 500 °C. After 5 minutes, the redox reaction leads to the formation of foam that is subsequently taken to cool and grind. The X-ray diffraction shows the presence of $MgGa_2O_4$ in its cubic form; PDF 00-036-0181. Photoluminescence of the undoped crystal matrix shows responses, highlighting emissions at 504 nm for the uncalcined sample and 688 nm for the calcined sample. Chromium-doped samples show emissions at 704 nm associated with Cr^{3+} [1]. Thermoluminescence (TL) was obtained with Risø TL/OSL reader model TL/OSL - DA-20 with ^{90}Sr-^{90}Y β radiation source. TL response was obtained in 0.0040 g of sample immediately after to 300 a 3600 s (26.6-314 Gy) of β radiation and show two notable curves at 98°C and 157°C.

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Abstracts
(Poster session A)

PA01

Preparation of gallium oxide (Ga_2O_3) nanowires in SiO_2/Si track template

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The preparation of nanomaterials from semiconductor oxides is a highly cost-effective and viable approach through solution phase methods. To apply this method, in order to direct the growth of the material to the required morphology, the use of templates or other additives is usually required [1]. As such templates for creating arrays of metal and semiconductor nanowires, we use nanoporous silicon dioxide grown on silicon wafers.

Our work presents the results of obtaining gallium oxide (Ga_2O_3) nanowires using the template synthesis method, which is based on the chemical and electrochemical deposition of materials into nanoporous SiO_2/Si substrates. Template synthesis has attracted great interest in recent years due to the possibility of tuning the physical and chemical properties of nanomaterials.

The III–VI semiconductor material gallium oxide (Ga_2O_3) attracts special attention due to its good chemical and thermal stability (up to 1400 C) [2]. It is a wide-gap material with a bandgap of 4.9 eV at room temperature [3]. Thermal stability makes it possible to use gallium oxide in the manufacture of high-temperature gas sensors [4], in addition, Ga_2O_3 is used in field-effect transistors [5] and solar photodetectors [6].

The research is related to the development of processes for the formation of gallium oxide nanowires in SiO_2/Si track templates. Such nanocomposites are of interest from the point of view of possible application in photonics and sensors.

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PA02

Synthesis of SnO_2 nanowires with activating impurities in track templates

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Increasing the sensitivity of sensor layers to detected gases is an urgent task in the development of gas sensors. To increase sensitivity, various methods are proposed, such as nanostructuring of gas-sensitive layers, the use of ultrathin layers with a high area-to-volume ratio, doping with various catalytic impurities, as well as other approaches. An interesting solution for obtaining SnO_2 layers with a high area-to-volume ratio could be the deposition of tin into SiO_2/Si track templates followed by heat treatment in an oxidizing environment. Track templates are obtained by irradiating SiO_2 structures with swift heavy ions, followed by chemical etching in a 4% aqueous solution of hydrofluoric acid (HF). Nanostructured metal oxide films doped with various impurities are promising for increasing the sensitivity of sensors. Developments are underway to integrate such sensor layers into integrated circuits, combine them with processors, etc., and these problems are being studied by many researchers [1-3].

This work presents the development of technological routes for the template synthesis of Sn, SnOx, SnO_2 nanowires and the study of the influence of metal impurities on the structure, electrical conductivity and electrical capacity of Me/SnO_2-NWs/SiO_2/Si compositions. Doping will make it possible to create nanowire heterostructures with tunable electronic properties.

The results obtained can be used in the development of highly sensitive gas sensors based on Sn oxides for the detection of explosive, flammable and toxic volatile substances.

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PA03

Luminescent properties of composite detectors based on $MgAl_2O_4$ doped with rare-earth and transition metal ions

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Composite scintillators and detector of phoswich-type (phosphor sandwich) are frequently being developed for registration of different components of ionizing radiation field, characterized by various penetration depths, e.g. heavy charged particles and gamma-rays [1, 2]. One of the important methods for manufacturing such detectors is liquid phase epitaxy (LPE), which enables growing single-crystalline films (SCF) with thickness from a few μm even up to about 100 μm, onto relatively thick crystal substrates [3]. The separation of the signals originating from both parts of a composite detectors can be realized in the *active mode of registration* using the differences in scintillation decay kinetics or also *in passive mode* of registration using thermoluminescence (TL) [4] and optically stimulated luminescence measurements (OSL).

The aim of the present work was to study the different luminescence characteristics of LPE grown epitaxial structures of magnesium aluminum spinel ($MgAl_2O_4$). $MgAl_2O_4$ with relatively low density ρ=3.58 g/cm^3 and effective atomic number Z_{eff}=9.97 is a widely used insulating oxide with applications in both electrical and optical fields. This study focuses on the different luminescence characteristics of $MgAl_2O_4$ based materials used in composite detectors. Rare earth Ce, Pr, Eu, Tb doped and transition metal Mn, Cr, Co and Ti-doped $MgAl_2O_4$ SCFs were grown using the LPE method on undoped $MgAl_2O_4$ crystal-substrates. The composite detectors, consisting of films and substrates with varying thickness, were irradiated with α- and β-particles, and their TL glow-curves and OSL decay curves were recorded both from film and substrate parts of detectors.

The investigation revealed distinct luminescence signals from the SCF and substrate, depending on the type of radiation. The obtained results suggest that the combination of specially selected materials in the composite detector based on the $MgAl_2O_4$ epitaxial structures is suitable for the separation of signals from mixed fields by using luminescence methods. These findings provide valuable insights into the properties and differences of luminescence signals in composite scintillator detectors, contributing to radiation detection tools.

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PA04

Luminescence of Sr^{2+}-activated $CsPbCl_3$ single crystals

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Efforts of numerous researchers are aimed at the search and development of scintillation materials with time resolution on the order of tens of picoseconds and light output around 100 000 ph/MeV, which would allow maximizing the capabilities of positron emission tomography in terms of spatial resolution. Among the objects of study are traditional crystalline systems, nanocomposites, and even metascintillators. We intend to draw attention to the potential of excitonic luminescence in perovskite crystals for the development of high-speed scintillators.

$CsPbCl_3$ single crystals excited by synchrotron radiation (λ_{ex} = 160 nm) at T = 10 K exhibit an excitonic luminescence band at 417 nm [1]. Activation of the $CsPbCl_3$ perovskite single crystal with Sr^{2+} ions lead to significant changes in the parameters of the excitonic luminescence of $CsPbCl_3$. The luminescence spectrum of $CsPbCl_3$-Sr (0.5 mol %) is modified, along with excitonic luminescence at 417 nm, additional narrow excitonic-like bands appear in the range of 417–424 nm. At Sr^{2+}-ions concentrations of 1 mol % the intensity of the edge luminescence increases by an order of magnitude at λ_{ex} = 160 nm (at 10 K). The position of the excitonic luminescence maximum shifts to 414 nm, the decay time constant changes from 0.2 ns to 0.4 ns, and the rise time of the kinetic curve is prolonged. The predominance of the edge excitonic luminescence intensity of the activated crystal over that of the pure crystal is maintained even at 80 K.

The observed changes of luminescence parameters are explained in terms of the ordering of the perovskite structure upon doping. Quantum-mechanical Density Functional Theory (DFT) calculations reveal a redistribution of the electronic density around the bottom of the conduction band and an increase in the bandgap width, a smaller Sr-Cl distance compared to the Pb-Cl bond. These theoretical results, alongside experimental evidence, suggest that doping induces the formation of shallow traps, which delay the rise time of the pulse and scatter excitons. The shorter Sr-Cl bond length reduces the probability of chlorine vacancies creation, which are primary quenchers of excitonic luminescence. The decrease in the number of such defects leads to the increase in the intensity of excitonic luminescence and the increase in the luminescence decay time constant.

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PA05

Synthesis and luminescence of nanocrystalline ZnS formed in ion track templates a-SiO_2/Si-n

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Over the past few decades, semiconductor nanomaterials have played a vital role in research due to their several promising applications in the fields of science and technology. Zinc sulfide (ZnS) is a well-known luminescent material for optoelectronic applications.

In this work, we present the results of template synthesis (electrochemical deposition) of ZnS nanocrystals into a track template a-SiO_2/Si-n. SiO_2/Si structures were irradiated with Xe 177 MeV ions to a fluence of 10^8 ions/cm^2 followed by chemical etching in a 4% aqueous HF solution; the etchant included m(Pd) = 0.025 g, etching time 10 minutes, etching temperature t = 20°C. Electrochemical deposition (ECD) of zinc sulfide into a-SiO_2/Si-n template was carried out at a voltage of 1.75 V, and pH=2, at room temperature. After electrochemical deposition, the morphology of the surface and transverse cleavage was studied using a JSM-7500F scanning electron microscope. SEM studies showed that most of the pores of the template are filled and the electrochemical precipitation method is excellent for growing with a controlled morphology and a high degree of orderliness.

In this work, we analyzed in detail the photoluminescence spectra of nanocrystalline ZnS depending on ECD time. A typical PL spectrum contains various spectral bands in the visible and ultraviolet ranges. It was shown that the luminescence spectra can be deconvoluted into five Gaussian curves with band maxima of 3.02 eV, 3.1 eV, 3.15 eV, 3.3 eV and 3.45 eV. The peak at the maximum of 3.1 eV corresponds to the lattice defects energy level. According literature analysis the band at 3.02 eV is due to the recombination of the donor associated with the sulfur vacancy and the valence band, and the peak at 3.15 eV can be associated with the sulfur vacancy and lattice defects of the interlayer sulfur. The maxima at 3.3 eV and 3.45 eV are associated with interstitial emission of sulfur and interstitial emission of zinc.

The work carefully analyzed the dependence of the luminescence spectra and the contribution of specific defects as a function of ECD time.

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PA06

Synthesis of copper selenide nanowires into SiO_2/Si track template

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This paper presents a study of nanowires obtained by template synthesis (electrochemical deposition) of copper selenide in the a-SiO_2/Si-p track template. Copper nanoparticles and nanowires have found wide application in the development of nanoelectronics elements and nanosensors, in catalysis and biomedicine, in the development of radiation-resistant materials, etc. [1-3].

Compared to traditional synthesis methods, the templated synthesis method allows effective control of morphology, particle size and structure in obtaining nanomaterials and is an efficient method for their synthesis.

The track template was prepared by irradiation of a-SiO_2/Si-p (amorphous SiO_2 on Si-p type substrate) with Xe ions of 200 MeV up to fluence $5*10^7$ cm^{-2} at accelerator DC-60 (Astana, Kazakhstan) followed by etching in aqueous solution of hydrofluoric acid.

$CuSe_2$ was deposited into track template by electrochemical method (ECD). ECD was carried out in potentiostatic mode at a voltage range of (1.75-2.5) V. Electrolyte composition: $CuCl_2$ - 1.7 g/ml, SeO_2 - 0.18 g/ml. The deposition time ranged from 10 to 30 min, at room temperature (20°C).

The morphology was observed by scanning electron microscopy and the crystalline parameters were studied by X-ray diffraction analysis. The formation of $CuSe_2$ nanowires with cubic crystal structure was found.

Thus, $CuSe_2$ nanowires were obtained by the method of template synthesis into the track template matrix and their properties were investigated.

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PA07

The impact of crystal structure on Tb^{3+} luminescence in double molybdates

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The present work shows a comparative study of Tb^{3+} luminescence in compounds possessing the same elemental composition but distinctly different crystal structures. The experimental results reveal the effect of crystal structure type on luminescence properties and energy transfer processes in $K_5Tb(MoO_4)_4$ and $KTb(MoO_4)_2$ representing the palmierite and scheelite types, respectively [1,2]. Various spectroscopic techniques were employed to obtain the emission and excitation spectra as well as luminescence decay curves for both crystals at different temperatures. Emission spectra revealed several bands of different intensities in the 380-640 nm range, corresponding to the intra-configurational 4f-4f transitions of Tb^{3+} ions in both materials. The emission bands of dissimilar structures in the green spectral range 480-640 nm are attributed to the $^5D_4$–^7F_J transitions. The observed structures allowed the estimation of site symmetries of Tb^{3+} ions in both materials. The relative intensity of the bands that appear due to the $^5D_3$–^7F_J transitions in the blue 380-440 nm region is shown to be dependent on the average distance between Tb^{3+} ions in the crystals. The excitation spectra measured in the VUV-Vis range showed similar band positions for the 4f-4f transitions for both structure types; however, a prominent difference of ~0.2 eV in the onset of the fundamental absorption edge was observed, indicative of different energy band gap values of the crystals studied. The decay kinetics study shows that the $KTb(MoO_4)_2$ crystal has a shorter luminescence decay time of green emission (~0.5 ms) as compared to that in $K_5Tb(MoO_4)_4$ (~1.7 ms), which is in line with the previous observation of the dependence of the decay time of the green emission on impurity concentration in Tb^{3+} doped oxides [3]. The shortening of luminescence decay time supports the idea of concentration quenching of Tb^{3+} in the crystal. Temperature-dependent investigations yielded insights into the luminescence quenching mechanism determining luminescence thermal stability in both materials. Based on the results, the processes of energy transfer to the Tb^{3+} luminescence center and the symmetry of these centers, which are dependent on the identified crystal structure, are analyzed in detail.

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PA08

Reinvestigation of TL properties of protective glasses of mobile phones for retrospective dosimetry using the red-emission range

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Mobile phones are useful proxies for assessing an absorbed dose after a radiological overexposure. There are many studies available in characterising different elements of mobile phones (i.e. electronic components, display or touch screen glass) for physical retrospective dosimetry. However, so far these techniques are frequently destructive. This implies that, in case of a dose assessment, the phones can no longer be used, which is a major issue in terms of the acceptance within the population due to the destructive loss of the mobile phone and potential emotional damage.

In order to overcome this problem, the use of optically stimulated luminescence (OSL) from the protective back-glass found on modern mobile phones with wireless charging capabilities was proposed [1]. Moreover, the protective glass, as an extra layer on the touchscreen of the mobile phone, has become an alternative material instead of other elements of mobile phones. This type of glass is readily available and cheap, has become very popular to protect the display screen surface of phones, can be easily replaced without complete destruction of an expensive smartphone and will thus find much greater public acceptance.

Systematic tests have shown the potential that this kind of glass is sensitive to ionizing radiation and the dosimetric properties were investigated in detail [2-3]. Further research was conducted by optimizing the thermoluminescence (TL) readout using a red-sensitive PMT in order to minimize the non-radiation induced signals [4]. Thus, the dosimetric properties, such as signal fading and optical stability had to be reinvestigated, which are the aims of this study.

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PA09 Luminescence decay characteristics of CdSe nanoparticles

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Keywords: quantum dots, luminescence decays, emission, time resolved spectroscopy

Abstract.

CdSe nanoparticles have gained special interest due to their unique optical and electronic properties [1], in many respects they can be considered as model research objects. In semiconductor quantum dots, the luminescence kinetics strongly depend on the nanocrystal size and surface properties. As a rule, the recorded optical responses decay within picoseconds, which is associated with exciton-phonon interaction processes. Auger recombination processes can also occur, leading to fast subpicosecond attenuation. Generally, multicomponent luminescence decays are observed, with time constants up to hundreds of nanoseconds, depending on the size of quantum dots.

The problem of practical application of quantum dots is aggregation of single objects into clusters. These effects are vividly manifested at obtaining nanocomposites. This process significantly suppresses quantum properties of nanoparticles, changes optical properties of nanoparticles, which makes it less attractive for application in optoelectronics.

To study this problem, we synthesized quantum dots in the form of CdSe nuclei, core-shell CdSe/CdS QDs, CdSe nuclei doped with copper impurities, core-shell CdSe/CdS QDs doped with copper impurities, as well as samples of CdSe QDs in a polymer matrix (nanocomposites). For each of the samples optical characteristics under steady-state and pulse irradiation were studied. The results were measured in Time-resolved luminescence spectroscopy which is commonly used as a quantitative tool for the analysis of the dynamics of photoexcitation in colloidal semiconductor quantum dots.

Here we present an interpretation of the luminescence attenuation of CdSe semiconductor quantum dots at room temperature in colloidal solutions.

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PA10 Enhancing photo- response in p-Si cells by luminescent down-shifting using different CdSe semiconductor nanoparticles

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Abstract: Luminescence down-shifting layers integration has been proven to be an efficient way to ameliorate the bad UV-blue spectral response and improve the power conversion efficiency for polycrystalline solar cells [1]. By employing a quantum dots/ polymer composite film (nanocomposite) as the LDS layer, we observed a clear enhancement in the efficiency (PCE) for silicon cells, predominantly in the UV-blue region. The combination of easy fabrication and low cost makes it a practical way to achieve photovoltaic enhancement of Si solar cells.

Here we present the results of studying the performance electrical characteristics of commercially available solar modules equipped with a luminescent solar concentrator based on CdSe semiconductor quantum dots with high photoluminescence quantum yield (QY), but of different types and nature. Optical properties of the synthesized quantum dots were characterized by absorption and PL spectroscopy. Structural and compositional properties were studied by X-ray diffraction, transmission electron microscopy and energy-dispersive analysis methods.

For better operation of the LDS, its technological parameters were optimized, such as layer thickness [2], concentration of nanoparticles [3], disclosure of the complex relations between the concentration of nanoparticles, rotation speed and optical transmittance [9999], application method [2], spectral coincidence of spectra and type of CT [4], optical-luminescent properties [5], combination of dyes [6], photostability of the film and the possibility of using it over a large area [7].

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PA11

Multicomponent nanoscintillators in radiotherapy and Alzheimer's disease treatment

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Multicomponent nanomaterials (MNs) consist of dense scintillating nanoparticles grafted by conjugated photosensitizers (PSs) generating cytotoxic singlet oxygen (SO) species. They can act as sensitizers agents for radiotherapy (RT) of cancer and mortal diseases upon X-ray irradiation. [1] Notably, the beneficial activity of these agents is prominent at delivered doses lower than those ones employed in standard protocols.

One fascinating MN is represented by hydrated magnesium silicate scintillating nanotubes (NTs) prepared by hydrothermal synthesis, which show biocompatibility and blood-brain barrier-permeability. Moreover, the outer surface of NTs has a positive Z-potential, allowing to bind to the surface a variety of negatively charged SO PSs. Here, we present the case of NT grafted by porphyrin moieties, whose efficiency as a coadjutant for RT has been tested in vitro, showing a striking efficacy in enhancing both the prompt cytotoxicity of the ionizing radiation and the long-term cytotoxicity given by radiation-activated apoptosis. Another recent outstanding result has been obtained by functionalizing the surface of NT by Chlorin e6 to develop specific drugs for the cure of Alzheimer's disease. Indeed, in this configuration and upon X-rays, the MNs interact selectively with Aβ oligomers - the neurotoxic species in Alzheimer's disease – and inhibit their formation. The reduction of the levels of Aβ oligomers enables to restore functional symptoms in transgenic C. elegans models. [2-3]

Despite the encouraging results in clinics, the mechanism of matter-ionizing radiation interaction in MNs considered to be responsible for SO production and pivotal to the therapeutic effect during RT protocols is debated. Thus, we have investigated the SO enhancement in MNs by exploring the energy partition process - non-radiative energy transfer between nanoscintillators and PSs and the harvesting of ionizing radiation by MN - in a series of Rhodamine Red C2 functionalized scintillating NT, where the non-radiative energy transfer yield has been tuned by the control of the NT-PS intermolecular distance. Our findings indicate that non-radiative energy transfer has a negligible effect on SO sensitization efficiency, thus opening the way to the development of a variety of architectures for innovative RT coadjutants to be tested in clinics. [4]

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PA12

$Mg_4Ga_8Ge_2O_{20}$: M (M = Cr^{3+}; Mn^{2+}) phosphors with multicolour persistent luminescence for advanced anti-counterfeiting applications

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Counterfeiting and reverse engineering involving banknotes, documents, artworks, technology, etc., are ever-growing problems that challenge companies, governments, and customers worldwide. Consequently, anti-counterfeiting, security, and identification solutions methods and products are highly demanded to minimise economic damage and protect public safety.

Luminescent materials, particularly those that respond to multiple stimuli like persistent luminescence phosphors, are becoming increasingly popular for advanced anti-counterfeiting purposes. Recently, invisible near-infrared emitting materials have spiked the scientific community's interest.

Our research unveils the unique properties of transition metal Cr^{3+} and Mn^{2+} doped and undoped $Mg_4Ga_8Ge_2O_{20}$ materials. These multi-stimuli-responsive phosphors hold promise for advanced anti-counterfeiting applications, marking a significant advancement in the field.

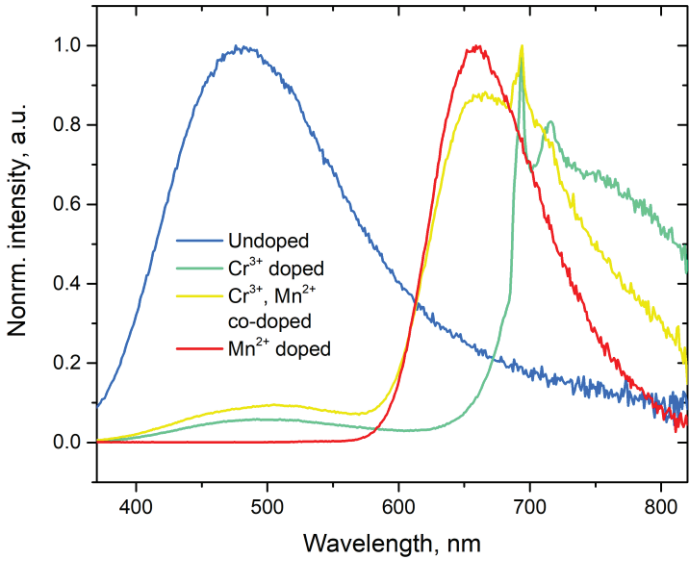

Fig. 1. Luminescence spectra of $Mg_4Ga_8Ge_2O_{20}$ materials, excited with UV.

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PA13

Three-fold enhancement of Eu^{3+} emission intensity in $BaYF_5$ nanoparticles by Bi^{3+} co-doping

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Luminescent nanoparticles are increasingly being used in LED technology to improve luminous efficiency, color rendering, and spectral characteristics, enabling the production of LEDs with customized emission spectra for a variety of applications, including lighting and displays. Photosynthetically active radiation (PAR) is the fraction of the light spectrum that plants use for photosynthesis, with wavelengths ranging from 400 to 700 nm. LEDs that convert electrical energy into the PAR spectrum have recently become quite popular.

$BaYF_5$ belongs to a growing group of rare earth fluoride host materials. The trivalent europium ion (Eu^{3+}), as the luminescence center, is well known for its strong luminescence in the red spectral region, particularly around 590 nm (orange-red), 615 nm (red) and 700 nm (deep-red), making it appropriate for producing LEDs for horticultural use. Furthermore, Bi^{3+} ions can act as a sensitizer in the host lattice, enhancing Eu^{3+} emission under UV and blue irradiation.

Herein, we report the photoluminescence properties of Bi^{3+}-sensitized $BaYF_5$: 10mol%Eu^{3+} phosphors. Samples with fixed Eu^{3+} and various Bi^{3+} were prepared by a solvothermal method. X-ray diffraction analysis showed that phosphors crystallize in a cubic structure with an Fm-3m (225) space group. Scanning electron microscopy clearly shows that samples are comprised of well-defined nano-sized spherical-shaped grains with an average size of around 36 nm. Upon 265 nm excitation photoluminescence spectra show characteristic Eu^{3+} red emission with CIE chromaticity coordinates (x, y) of (0.614, 0.386). The emission spectra are typical for Eu^{3+}, with extremely intense $^5D_0 \rightarrow {}^7F_4$ deep-red emission. The emission intensity increases with the increase of Bi^{3+} concentration up to 20 mol%, after which emission quenching occurs *via* electric multipolar interaction. The intensity of Eu^{3+} emission in the 20%Bi^{3+} co-doped $BaYF_5$ is three times larger compared to the Bi^{3+}-free sample. Our findings demonstrated that $BaYF_5$: Eu, Bi phosphors have considerable potential for application in plant lighting technology due to strong emissions in both red and deep-red spectral areas.

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PA14

About thermal stability of the F^+ centers in MgO single crystals irradiated by fast neutrons or energetic Ar ions

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Due to fascinating physicochemical properties and high tolerance to intense irradiation, MgO is exploited in different applications and considered as a promising material for projected deuterium-tritium fusion devises. Therefore, the radiation effects in MgO ceramics and single crystals exposed to fast neutrons and energetic electrons or ions have been studied for a long time. Optical and EPR characteristics of several radiation point defects have been determined [1-3]. However, there is still lack of information on thermal stability of the paramagnetic F^+ centers, the structure of which was determined via EPR by J.E. Wertz as an oxygen vacancy with one trapped electron. Note that interstitials are a mobile component in mutual recombination of Frenkel pairs during annealing procedure. However, a single oxygen interstitial, which is a complementary defect to vacancy-related defects from Frenkel pairs formed in irradiated metal oxides, has been detected yet only in a corundum crystal [4].

In the present study, the precise isothermal annealing of the F^+ EPR signal has been performed in a temperature range of 400-1100 K for a neutron-irradiated (dose of 2.7×10^{18} cm^{-2}) MgO crystal. The decay of the F^+ centers starts above 720 K and lasts until 950 K. For the first time, the F^+ EPR signal has also been detected in a MgO crystal exposed to 70-MeV Ar ions at room temperature (3×10^{14} cm^{-2}). The determined EPR parameters confirm same F^+ centers as in case of neutron irradiation, while the lines of hyperfine structure are broadened due to local disorder of the lattice within a thin layer (determined by ion range 11.3 μm) of an ion-irradiated MgO. At the same time, a decrease of the F^+ concentration begins at higher temperature (about 750 K) and ends at 1060 K, simultaneously with the total decay of the ~2.16-eV absorption band in the same ion-irradiated sample. Features in the F^+-EPR annealing kinetics confirm some difference in initial topology of Frenkel defects induced by fast fission neutrons or energetic ions.

The most confusing is the fact that the annealing of the Ar-ion-induced absorption band, undoubtedly ascribed in the literature to the F and F^+ centers, starts already above ~500 K (see also [3] for 230-MeV Xe-irradiated MgO), significantly below the changes in the F^+ EPR signal intensity. Note also that the decay of the EPR signal related to the association of oxygen interstitials with some additional defect occurs at 650-750 K [2]. Possible reasons of this discrepancy in the thermal behaviour of optical and EPR F^+-absorption are considered (in particular, on the basis of the decrease of optical absorption at around 5 eV in the temperature regions below and above the beginning of the EPR signal decay).

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PA15

Electron-hole recombination and exciton luminescence in the field of local lattice deformation by sodium impurity ions in KCl:Na single crystals

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The origin of sodium-related luminescence bands at 2.8 and 3.1 eV has been elucidated in KCl:Na single crystals under excitation by X-rays, providing creation of electron-hole (*e-h*) pairs, or by VUV photons, which selectively form various electronic excitations (free and bound anion excitons, correlated *e-h*) [1, 2]. It has been proved that these emissions are connected with the radiative decay of exciton-like formations created in the field of local lattice deformation nearby singe and pair Na^+ impurity ions either directly (photoexcitation at helium temperatures) or *via* the *e-h* recombination.

The temperature dependences of sodium-related luminescence at the excitation of KCl:Na(1000 ppm) by 7.6 eV photons (bound excitons nearby single Na^+) or 6.6 eV photons (excitations nearby Na^+-Na^+) show that the thermal quenching of these exciton-like emissions occurs at significantly higher temperatures than that for the 2.3 eV emission of self-trapped excitons, which is quenched by 40 K. In particular, the quenching of the 2.8 eV emissions lasts till 200 K, while the 3.1 eV luminescence can be detected at room temperature, where its intensity is by 6-10 times lower than that at 10 K.

It is worth noting that the yield of X-ray luminescence in KCl:Na increases with temperature (80→ 300 K), and at room temperature it exceeds that in classic CsI:Na scintillators (see also [1, 2]). According to our data, just recombination creation of exciton-like formations nearby Na^+ and Na^+-Na^+ is responsible for such amplification of scintillation yield with temperature. Note also that the analysis of the spectra of time-resolved cathodoluminescence gives the life-time of the emissions at 2.8 and 3.1 eV in the time range of 1-10 ns at helium temperature, whereas the values even shorten till 0.3 ns at room temperature, the operation temperature for many scintillators.

It is well-known that solid solutions of small-radius sodium ions in KCl are structurally unstable in time due to the removal of Na^+ from the regular cation sites with the formation of nanosized clusters. However, thermal quenching (up to 600-700 °C) of stored KCl:Na leads to the incorporation of Na^+ back into the cation sites. Such restoration of impurity distribution (up to 80-90 %) is proved *via* the reappearance of the characteristic optical absorption bands at 3.5 and 6.3 eV and X-ray luminescence at 2.8 and 3.1 eV.

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PA16

Accumulation of oxygen interstitial-vacancy pairs under irradiation of corundum single crystals with energetic xenon ions

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Corundum (α-Al_2O_3) demonstrates various fascinating properties and is widely exploited in different technological applications. In particular, α-Al_2O_3 single crystals and ceramics are in the list of promising window materials for projected *D-T* fusion devises. The degradation of optical materials under intense irradiation (fast neutrons, energetic electrons and ions) is caused by the creation of interstitial-vacancy pairs of Frenkel defects and their aggregations. Up to now, the characteristics of oxygen-vacancy-related defects (single vacancies with two or one trapped electrons − *F* and F^+ centers, F_2 dimers in different charge states) are mainly determined in corundum [1]. Recently, a charged single oxygen interstitial − a complementary defect to the F^+ from a Frenkel pair − has been detected in a neutron-irradiated corundum by the EPR method [2]. The thermal annealing of these crystals reveals the correlation of the F^+ EPR signal and optical absorption band at 5.6 eV, while further modelling of the annealing kinetics for the *F* and F^+ centers allows to suggest that the 6.6-eV optical absorption band could be related to neutral oxygen interstitials [2-4].

In the present study, the spectra of radiation-induced optical absorption at 1.5-8.3 eV in a set of corundum crystals (a broad polished side perpendicular to the *c* crystal axis) exposed to 231-MeV ^{132}Xe ions with six fluences of $\Phi = 5\times10^{11}–1\times10^{14}$ ions/cm^2 have been analyzed. The spectra have been decomposed into elementary Gaussians (as in the case of neutron irradiation [2-4]), the integrals of which represent the concentration of a certain defect type. The defect concentrations (including charged/neutral oxygen interstitials tentatively responsible for the 5.6-eV and 6.6-eV bands) clearly increase with ion-irradiation fluence thus undoubtedly confirming their radiation-induced origin. The concentration of paramagnetic F^+ centers has been detected by the EPR method using a special Bruker program.

In addition, the accumulation of single and dimer *F*-type defects have been analyzed via the cathodoluminescence spectra (CL, 6 K, 10-keV electrons) of the same Xe-ion irradiated crystals. Because of rather different lifetime of the characteristic emission for different *F*-type defects (a few nanoseconds for the F^+ center emission and dozens of milliseconds for the *F*-luminescence), the spectra of both steady-state and time-resolved (time windows) CL have been measured. The limitations of the use of specific CL bands for the detection of radiation damage are considered (see also a similar study of a neutron-irradiated corundum [5]).

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PA17

Development of composite scintillators based on epitaxial structures of garnet compounds for medical application

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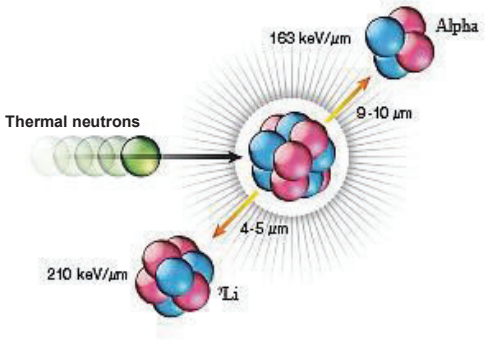
This work is the next step in the development of ***multilayered composite scintillators*** of *phoswich-type* (phosphor sandwich) based on the single crystalline films (SCFs) and single crystals (SCs) of garnet compounds using the liquid-phase epitaxy (LPE) growth method [1]. Such composite scintillators comprise *multilayered epitaxial structures* containing SCF scintillators, LPE grown „step-by-step" onto substrates of SC scintillators. Film and substrate parts of composite scintillators were fabricated from efficient scintillation materials with different scintillation emission spectra or/and decay kinetic achieved by doping by different cations and varying host composition [1].

The basic application of the developed composite scintillators is the radiation monitoring in mixed ionization fluxes, i.e. simultaneous registration of various types high energy particles and photon fluxes [1]. Meanwhile, composite scintillators can be also as a very important tool for medical application, namely for study of the effects of secondary radiation in Boron-Neutron Capture Treatment (BNCT) (Fig.1) and measuring the dose absorbed by tissues from various types of ionizing radiation (α-particles, ^{7}Li ions and γ-quanta) [2]. In such composite scintillators, the thickness of the top film materials can be selected according to the attenuation length of ^{7}Li quanta and α-particles when the lower bulk part of the scintillators comprises thick enough and heavy materials intended to absorb high-energy γ-rays.



In this work, we present results of LPE growth of these composite scintillators, based on the two single crystalline films of Ce^{3+}, Pr^{3+} and Sc^{3+} doped $Y_3Al_5O_{12}$ (YAG) and $Lu_3Al_5O_{12}$ (LuAG) garnets with thickness of 4-5 μm and 8-12 μm, respectively, and bulk crystal-substrates of Ce^{3+}, Pr^{3+} and Sc^{3+} doped LuAG with thickness of 0.5 mm. Their absorption and luminescent properties of these epitaxial structures were studied. Several types of composite scintillators based on the epitaxial structures of garnet compounds for real-in-time dose measuring of BNCT procedure were proposed. Their scintillation properties of were examined as well under selective excitation with α-(^{239}Pu) particles and γ-quanta (^{192}Ir) sources. The results were compared and analyzed in terms of selecting the best composition for BNCT performance in laboratory conditions.

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PA18

Investigation of emission properties in $YA_{1-x}Ga_xG$:Ce scintillators with different gallium content

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YAG:Ce scintillators, known for their superior light yield and robust mechanical and chemical properties, have found widespread application in diverse fields, including X-ray CCD cameras for medical imaging, radiation level monitoring, and nuclear safety inspections. However, YAG:Ce scintillators do not meet the growing requirements for fast performing in high energy physics experiments. A significant delay in luminescence response is caused by electron trapping at shallow traps. It is shown that the shallow traps can be buried in the conduction band by introduction of gallium in the lattice.

We report on the results of a detailed study of the influence of Ga content in $Y_3(Al_{1-x}Ga_x)_5O_{12}$:Ce on the luminescence properties of this scintillator. Eight samples with different Ga content ranging from $x = 0$ to 1 grown using the Czochralski method were studied by time-resolved spectroscopy in the temperature range from 80 K to 700 K. Yb:KGW laser, emitting 250 fs pulses at 1030 nm, equipped with harmonics generators and optical parametric amplifier to tune the laser photon energy for resonant excitation of Ce^{3+} ions to energy levels $5d_1$ and $5d_2$ were exploited. Photoluminescence spectra were recorded by CCD camera and time-correlated single photon counting system with a 200 ps temporal resolution was used to measure the time evolution of luminescence. Quantum yield of scintillators was measured using a 6-inch integrating sphere.

A continuous change in the luminescence properties at increasing Ga content was observed only in the samples with up to 60% of gadolinium. In these samples, the temperature dependence of both photoluminescence intensity and decay time can be properly described by the Arrhenius formula evidencing that the thermal depopulation of the emitting level $5d_1$ of Ce^{3+} occurs via a single barrier. The barrier height strongly decreases from 0.75 eV down to 0.35 eV as the Ga content increases up to 60%. At further increase of Ga content, the thermal quenching can not be described by a single channel. The results are interpreted by assuming involvement of defect-related level providing additional channel for thermal quenching. The quantum efficiency increases with increasing Ga content up to ~50% and sharply decreases afterwards.

PA19

Mobile phone screen protector glass for radiation accident dosimetry: a TL investigation of the intrinsic background signal in the red detection window

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The dosimetric properties of mobile phone materials (electronic components and display glass in particular) have been extensively studied by luminescence methods [1] over the last decade with the aim of using these items as emergency dosimeters in the event of a radiological accident. However, to date, these methods require the destruction of the mobile phone and alternative non-destructive approaches need to be sought.

Mobile phone screen protectors in glass, which are placed over the touchscreen to protect its surface from physical damage, are generally cheap and could be easily removed and replaced in case of a dose assessment. Their dosimetric properties were investigated using thermoluminescence (TL) in recent studies [2, 3, 4]. For the moment, the main limitation to the use of this dosimetry method in case of a radiological accident is the intrinsic background signal, that partially overlaps with the radiation-induced TL signal. The reconstructed dose could be overestimated if it is not properly considered.

A preliminary study [4] has shown a reduction in the intrinsic background dose when measuring in the red detection window. In addition, a chemical treatment of the glass surface with concentrated hydrofluoric acid, as proposed for display glass, could reduce the contribution of this confounding signal [4, 5]. Further measurements were carried out on a larger set of screen protectors in order to confirm these observations. The results of this study are presented and discussed in this work.

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PA20

Reconstructing the trap filling process in multiple trap systems using the dose-response curve measured for a single OSL trap

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The dose response curve (DRC) of the optically stimulated luminescence (OSL) signal is the basis for dose determination in dosimetry and OSL dating. By measuring DRC in the laboratory, we aim to reproduce the changes in trap filling with environmental dose. The DRC shape depends on the parameters of the traps and recombination centres [1]. Previous studies showed that when the OSL signal is complex, the DRC correctly reproduces the dose dependence of the trap filling only within a limited range of these parameters [2]. This worsens the accuracy of dose reconstruction, especially if the traps have different thermal stability or sensitivity to optical bleaching. If OSL complexity is causing the problem, the solution should be to limit the signal creating the DRC to a single OSL component. For this purpose, one can take advantage of the strong dependence of optical cross-section on the stimulation light wavelength and use recently proposed methods that allow for more efficient separation of components [3]. However, limiting the signal used for DRC construction to the component originating from a single type of trap does not prevent other traps from participating in luminescence processes.

Based on computer simulations, this presentation will compare the DRC measured for a complex OSL signal and OSL from a single trap. This comparison is intended to show whether, when multiple OSL traps are present in the material, using an isolated signal from one of them improves the reconstruction of the changes of filling this trap during irradiation. Simulations of the DRC construction procedure with sensitivity correction were carried out for a kinetic model, including two traps that are the source of OSL, a third trap that is thermally and optically inactive in the modelled processes, and two recombination centres. The simulations reproduced the processes associated with the irradiation, the OSL measurement, and the signal reset at elevated temperatures. These steps were repeated for the test dose to correct the sensitivity.

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PA21

2D OSL dosimetry based on MgB_4O_7 prototype foils - facilitating the high-resolution proton radiotherapy

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Modern radiotherapy (RT) techniques, such as proton radiotherapy, have enhanced the geometrical accuracy and complexity of the delivered dose distributions. Thus, spatial two-dimensional (2D) or even three-dimensional (3D) resolved measurements are required to validate complex treatment plans properly. These also imply the development of new kinds of dosimetry techniques and materials. One of the new and very promising dosimetry approaches developed at the IFJ PAN, is based on technology consisting of a flat and flexible sheet made of a polymer, with embedded optically-stimulated luminescence (OSL) material. With the appropriately designed optical read-out system, consisting of an illuminating light source (LEDs) and a highly sensitive digital camera, direct 3D dosimetric verification can be obtained, also in proton radiotherapy applications [1,2].

In the present work, the 2nd generation of the optical readout system was optimized for 2D OSL readouts of the newly developed prototype foils made from the silicone and MgB_4O_7 (MBO) embedded OSL material. The stack of prototype MBO foils in different dimensions was irradiated parallel and perpendicular to the monoenergetic proton beam, allowing the visualisation of the spatial proton beam. The results were also compared with the EBT3 gafchromic films. The presentation will show the initial results of the spatial proton depth dose distribution obtained for the irradiated MBO foils and other OSL characteristics, including the OSL luminescent efficiency response of the MBO materials to protons relative to gamma rays. The measurements were realized by exploiting the 60 MeV proton beam of the AIC-144 cyclotron in the Proton Eye Radiotherapy Facility at IFJ PAN.

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PA22

Performance of various TL/OSL detectors after irradiation with gamma-rays and protons at different dose rates

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In the dosimetric applications of thermoluminescence (TL) and optically stimulated luminescence (OSL) it is commonly assumed that detector performance is independent of radiation dose rate. However, there is no theoretical basis to exclude the possibility of dose rate effects, and several TL/OSL models predict their existence. Experimental data on possible dose rate effects are rather limited and often inconclusive. One of the reasons might be a technical difficulty in ensuring, that the possibly observed effects are due to varying dose rates and not due to other factors, like e.g. different doses.

The goal of the present work was to study several types of luminescent dosimeters for the presence of dose rate effects. The list of the investigated materials included the most widespread TL (LiF:Mg,Ti and LiF:Mg,Cu,P) and OSL (Al_2O_3:C and BeO) detectors, as well as a new promising OSL material MgB_4O_7:Ce,Li. Irradiations were carried out with gamma-ray sources (Cs-137 and Co-60) and 60 MeV proton beam (AIC-144 cyclotron at IFJ PAN Kraków). The dose rates ranged from 0.1 mGy/h up to 40 Gy/s.

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PA23

Luminescence and TSL study of ScF_3 single crystals under UV-VUV and electron beam excitation

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ScF_3 has a simple cubic ReO_3 type structure down to at least 10 K and exhibits a rare property of isotropic negative thermal expansion (NTE) over a large temperature range. ScF_3 crystals, along with other fluorites, can be considered as promising scintillators

In order to explore its luminescent properties more deeply as well as to reveal the manifestations of the NTE effect in optical spectra, we have performed the following investigations:

(a) cathodoluminescence analysis of ScF_3 single crystals, when crystals was excited by electrons with energy 10 keV.

(b) VUV-luminescence excitation using synchrotron radiation at MAX-Laboratory in Lund,

(b) Thermally stimulated luminescence (TSL) study between 80 and 350 K, excited by an electron-beam with energy10 keV or VUV radiation.

From the TSL data analysis and the comparison with other metal fluorites [1], we can conclude that in ScF_3 there is the effective self-trapping of holes in the form of V_k centres and their thermal destruction occurs at about 100 K. From the creation (excitation) spectra of several TSL peaks as well as the VUV-luminescence excitation spectra, we can conclude that the value of band gap energy in ScF_3 exceeds 11 eV.

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PA24

Influence of Ce^{3+} doping and crystallization rates on the structural, optical and photoconversion properties of the Al_2O_3-YAG:Ce eutectic

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A commonly used type of white light-emitting diode (WLED), currently based on a blue LED chip combined with yellow-emitting YAG:Ce phosphor converters (**pc**) that are embedded into resin or silicon matrix. However, the lack of sufficient thermal conductivity and stability under the high level of blue light irradiation doesn't allow to development of a converter for high-power WLED. . To address this limitation, alternative converter materials have been considered, among which Ce^{3+}-doped YAG-Al_2O_3 eutectic stands out as a promising candidate for **pc** in high-power WLEDs [1, 2].

This work is devoted to the study of the structural, luminescent and photoconversion properties of Ce^{3+}-doped Al_2O_3-YAG eutectic samples synthesized by horizontal directional crystallization (HDC) [3], while changing the Ce^{3+} concentration (0.25, 0.5, 1% 5 wt. %) and crystallization rates (5, 15, 30, 50 mm/h).

Various characterization methods were used in this study to assess the structural and optical properties of Ce^{3+} doped Al_2O_3-YAG eutectic samples. Structural analysis was conducted using X-ray microtomography (SkyScan 1272 spectrometer) with a resolution of 0.5 μm, optical microscopy (Keyence VHX-7000), electron microscopy (SEM, JSM-6390L) and X-ray diffraction (XRD). Luminescent properties were assessed through cathode- and photoluminescence (CL and PL) as well as PL spectroscopy of eutectic samples under excitation by the synchrotron radiation with energy in the 3.5-12 eV range. The photoconversion properties (CCT, CRI, color coordinates) of Ce-doped YAG-Al_2O_3 eutectics were investigated under excitation by a 450 nm blue LED chip.

The XRD pattern and microtomography show the samples were predominantly composed of the YAG and Al_2O_3 phases with minor traces (below 1%) of the YAP:Ce perovskite phase detected through PL spectra within the Al_2O_3-YAG:Ce matrix. Remarkably, the eutectic morphology exhibited a unique stripe-like channel structure, showcasing a random arrangement of the garnet and sapphire phases, which is distinguished depending on the growth rate.

The luminescence behaviour of the eutectic samples showcased a dominant Ce^{3+} emission band within the garnet phase, contrasting with the relatively weak luminescent activity of Ce^{3+} in the sapphire phase. Moreover, notable energy-transfer processes were observed among Ce^{3+} ions in both the Al_2O_3 and YAG garnet phases, manifesting under intense excitation conditions, including excitation within the UV Ce^{3+} absorption bands of sapphire.

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PA25

Energy transfer in $CsPbCl_3$:Yb and $CsPbCl_3$:Yb,Er single crystals

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Lead-halide perovskites are perspective materials for optoelectronic devices due to their remarkable properties, such as high luminescence quantum yield, narrow excitonic emission band, and large product of carrier lifetime and their diffusion length. Ytterbium-doped perovskites are characterized by exceptionally high luminescence output in compare with the most advanced commercially available scintillators that allows exploiting them for the registration of X-ray radiation. Also, those materials are known as a high-performance γ-ray detector.

In present work, we study the effect of Yb and Yb-Er dopants on the optical and photoelectric properties of $CsPbCl_3$ single crystals grown by the Bridgman method. In $CsPbCl_3$:Yb single crystal emission band at 417 nm corresponds to the luminescence of free excitons, as observed in the undoped crystal. On the other hand, the bands observed in the range of 970–1030 nm are characteristic for Yb^{3+} ion emission [1]. It should be noted that the intensity of Yb^{3+} luminescence in this sample is nearly five times higher compared to the excitonic luminescence.

The position of the main energy level of Yb^{3+} and Er^{3+} ions relative to the energy band was determined. Our studies reveal a non-uniform distribution of dopants in the $CsPbCl_3$ that results in the increase of the band gap within the regions with higher dopants concentration. The dopants together with Pb vacancies form electrically neutral $(2Yb_{Pb}+V_{Pb})^0$ complex. We found that ytterbium ions in $CsPbCl_3$ single crystals exist in two states, namely Yb^{3+} and Yb^{2+} [1]. The key role of the Yb^{2+} ions in the quantum cutting effect is clearly demonstrated. It was established that the absolute quantum yield of ytterbium luminescence in $CsPbCl_3$:Yb single crystals in the near-infrared region at Yb concentration of 2 mol.% reaches 86%. In the case of doping with Yb and Er ions both types of ions comprise the same complex. It has been reported previously, $(2Yb_{Pb}+V_{Pb})^0$ complex appears in two forms: linear and right-angle one [2]. We observed resonance energy transfer from Yb to Er ions within a single complex. Shorter distance between ions in the right-angle complex facilitates the resonance energy transfer. Due to the low phonon energy in lead halide perovskites, they exhibit a low probability of non-radiative transitions, which is very desirable for the effective emission in the mid-infrared region. A significant number of energy levels of Er ions and, therefore corresponding radiative transitions greatly enhances the efficiency of scintillations registration.

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PA26 RADIATION RESISTANCE OF GALLIUM OXIDE THIN FILMS TO THE ION IMPACT

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Monoclinic gallium oxide (β-Ga_2O_3) has attracted much attention of many researchers as a promising semiconductor material for various electronic and optoelectronic devices, including UV photodetectors [1]. Being thermally and chemically stable, β-Ga_2O_3 is well known for its wide forbidden bandgap (~4.9 eV) and high critical electric field strength (~8 MV/cm). According to the potential application of β-Ga_2O_3, the radiation resistance and stability of optical and photovoltaic properties after exposure to ionizing radiation fluxes are of significant importance.

In this work, β-Ga_2O_3-based thin films were deposited by reactive RF-magnetron (13.56 MHz) sputtering method from Ga_2O_3 targets onto polished α-Al_2O_3 (0001) sapphire substrates. Films with two different microstructures - amorphous (as-deposited) and crystalline (after annealing in air) have been researched.

Short-pulsed ion irradiation [2] of the samples was carried out using a TEMP-4M accelerator with the following parameters: accelerating voltage U = 160 - 200 V, pulse duration - 90-100 ns, beam composition - carbon ions (> 85%) and protons (< 15%), current density on the target - up to 10-15 A/cm^2.

Irradiation with heavy ions (oxygen and krypton) was carried out using a DC-60 accelerator [3] at Astana branch of the Institute of Nuclear Physics of the Ministry of Energy of the Republic of Kazakhstan. Parameters of irradiation with heavy ions: irradiation energy for $^{84}Kr^{15+}$ - 147 MeV and $^{16}O^{3+}$ - 28 MeV; smeared current density for $^{84}Kr^{15+}$ - 15 nA/cm^{-1} and $^{16}O^{3+}$ - 37.5 nA/cm^{-1}; irradiation temperature – 300 K. Irradiation time was varied to get the similar damage level (in dpa terms) in the films after irradiation with krypton and oxygen ions. A comparative analysis of the irradiation effect on the main physical properties of β-Ga_2O_3-based thin film in the short-pulse and heavy ion exposure modes will also be made.

The report will present the results of the investigation of the patterns of short-pulse and heavy ion effects on the structure, optical and photovoltaic characteristics of the deposited β-Ga_2O_3-based thin films.

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PA27

Mechanical properties of Y_2SiO_5-Lu_2SiO_5 solid solutions from *ab initio* calculations

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Y_2SiO_5 (YSO) is a scintillator material successfully employed in the Compact Muon Solenoid (CMS) detectors at the Large Hadron Collider (LHC). Within the LHC's CMS detectors, scintillation crystals are pivotal for detecting and quantifying the energy of particles resulting from high-energy collisions. YSO's composition can be altered by substituting the Y^{3+} ion with the Lu^{3+} ion, resulting in $Lu_xY_{1-x}SiO_5$ (LYSO) and Lu_2SiO_5 (LSO). Furthermore, the Ce^{3+} impurity can be introduced into the crystalline lattice in varying concentrations. Both YSO and LYSO are prime candidates for these applications, attributed to their impressive light output, swift response time, and resistance to radiation. The elastic properties of scintillation materials are important in determining their strength, reliability, and effectiveness in various applications. These properties become especially important when scintillators are integrated into detectors or other structures, subjecting them to various mechanical loads.

In this work, first-principle calculation CRYSTAL23 program with the PW-GGA exchange-correlation functional with the addition of 20% exact exchange and triple-zeta valence polarized (TZVP) Gaussian-type basis sets were utilized to obtain 76 symmetry independent structure of YSO-LSO solid solutions. For every configuration, after full geometry optimization, elastic properties were calculated. Cell parameters, relative stability and mixing energies of various configurations were analysed and compared with available experimental data.

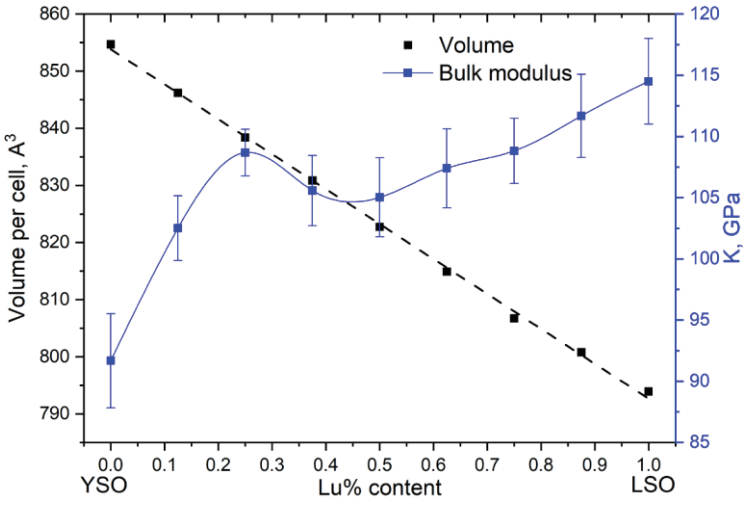

Figure 1. Crystallographic cell volume and averaged Hill bulk modulus for structure including various %Lu content. Upper and lower limits of error bars for bulk modulus are calculated by Voigt (upper) and Reuss (lower) approximations. Data refer to LYSO crystallographic cell with 32 atoms with 8 cation positions.

PA28

Netron radiation defect EPR analysis in gadolinium gallium garnet

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Understanding the permanent defects induced by ionizing radiation in scintillator materials is crucial due to their detrimental effects on material functionality.

Gallium gadolinium garnet (GGG) stands out as one of the most extensively examined garnet materials, prized for its optical and scintillator capabilities when doped with rare earth (RE) ions. These characteristics make it valuable for applications such as solid-state lasers and scintillator detectors. GGG, belongs to the garnet crystal family, and shares similarities in properties with various similar materials known for their excelent optical characteristics due to transparency and the ability to incorporate RE ions. GGG exhibits excellent optical and mechanical properties, chemical inertness, and thermal stability compared to alternative materials.

While radiation-induced centers have been previously reported [1], the mechanisms governing their formation remains elusive. Analysis of EPR spectra concerning defects induced by neutron radiation in GGG is performed in this study. These defects exhibit highly anisotropic g-factors, an anomaly for materials of this kind. Two distinct types of radiation-induced defects have been identified in GGG, prompting discussions regarding their formation mechanisms.

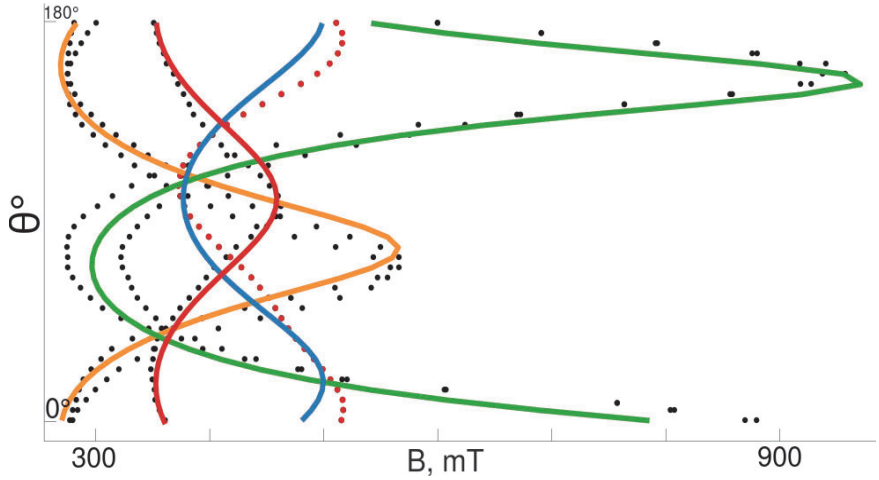

Figure 1: EPR resonance angular dependence rotating GGG around one of the principal crystal axes. Dots are experimental points and lines represent simulations.

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PA29

The attempt to reconstruct a dose after irradiation with gamma source of unknown dose rate using KCl dietary supplements

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Encountering unexpected accidents evolving ionizing radiation requires evaluation of potential hazard to citizens. As professional personal detectors are not household items other materials need to be used for such estimations [1-4]. One of them are dietary supplements based on potassium chloride while KCl has good OLS properties like linear dose response for dose range from 25 mGy to 1 Gy under green light (520-532 nm) stimulation [5-8].

The work will present the attempt to reconstruct an unknown dose with potassium supplements as dosimeters. The pills and capsules were exposed for three different doses by irradiation (^{137}Cs 370 MBq) through three different time durations. Readouts of OSL signals were done 1 and 7 days after irradiation in order to approximate the realistic situation of exposure of public. As supplements show sensitization, procedure with test dose of 200 mGy was used for dose reconstruction. Heating in 175^{o}C or irradiation with green light was used for bleaching to background level. BeO detectors ware used as reference material to check the procedure of dose reconstruction.

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PA30

Radiation-stimulated optical and luminescent effects in ZrO_2 ceramics

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The paper presents the results of determining structural defects arising as a result of low-energy, high-dose irradiation with He^{2+} ions in the surface layer of ZrO2 ceramics. Due to the shallow penetration depth of He^{2+} ions, which is about 300 – 400 nm, traditional methods for assessing structural defects associated with changes in the processes of radiation-induced deformation and accumulation of implanted He^{2+} ions are impossible, which does not allow us to fully determine the kinetics of degradation of the near-surface layer of ceramics. which is the most susceptible to external influences. However, the use of optical analysis methods, including UV-Vis and Raman spectroscopy, luminescence, makes it possible to accurately determine the relationship between the accumulation of structural distortions caused by irradiation and changes in the optical characteristics of ceramics, in particular, optical density, electron density distribution, band gap, concentrations of defective inclusions and oxygen vacancies.

In the course of the experiments, the dependences of changes in optical density were established, according to which the most pronounced changes characterizing the accumulation of structural deformation distortions are observed at irradiation fluences above 10^{17} ions/cm^2. At the same time, the use of the Raman spectroscopy method made it possible to determine that the characteristic deformation distortions occurring in the damaged layer are of a tensile type, characteristic of deformation tensile stresses, the formation of which is due to the accumulation of implanted He^{2+} ions and their agglomeration.

PA31

Assessment of prospects for the use of optical and luminescent methods for determining the density of latent tracks in polymer film detectors

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The work is to determine the prospects of using the proposed methods of optical UV spectroscopy to determine the radiation density of the daughter products of radon decay - α-particles recorded using polymer track detectors. The use of optical methods for assessing structural effects in polymers caused by the impact of charged particles is one of the most promising non-destructive testing methods, which make it possible to determine the dynamics of the accumulation of radiation-induced defects in polymer dielectric films without chemical etching. At the same time, the use of a set of optical methods makes it possible to determine with sufficiently high accuracy changes associated with isolated structural changes, even in the case of high-dose exposure.

This paper presents the results of experiments on detecting daughter products of radon decay - α-particles in a room on various floors for a fairly long time, the choice of which made it possible to determine not only the concentration dependences (increase in the density of recorded α-particles) over time, but also to determine the lower limit for recording changes in the optical spectra of film detectors used to register α-particles. During the experiments, good convergence of the results of structural changes determined by optical spectroscopy and X-ray diffraction methods was established. These changes are caused by the processes of interaction of α-particles with a polymer detector, characterized by deformation distortion of the molecular chains of the polymer, leading to the formation of defects that affect changes in optical and electron density.

PA32

Improving the method of detecting α-particles with film polymer detectors using optical analysis methods

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The paper presents the results of evaluating the applicability of optical spectroscopy and X-ray diffraction to determine the density of latent tracks of α-particles emitted by the Am-241 source.

UV spectroscopy and X-ray diffraction were used as the main research methods for assessing changes in solid-state nuclear track detectors exposed to the daughter products of radon decay.

To determine the influence of the accumulation of the absorbed dose and caused by the interaction of α-particles with the polymer structure of the nuclear track detector on the optical properties, a technique was used to assess changes in the transmission of optical spectra in a wide range of wavelengths. Based on the obtained data of the optical transmission spectra, the optical characteristics of the studied samples were determined depending on the accumulated radiation dose.

During the studies, the dependences of changes in optical characteristics, such as optical density, band gap (fundamental absorption edge), refractive index depending on the density of latent tracks and the structural consequences caused by them in the molecular structure of the polymer, were established. The dependences of changes in structural characteristics associated with deformation distortions of molecular chains and, therefore, changes in the electron and charge density in the material depending on the density of latent tracks are determined. The sensitivity thresholds for determining the density of latent tracks were determined using X-ray diffraction and optical spectroscopy methods.

The proposed methods for registering the total activity of alpha-emitting radionuclides, as well as determining the absorbed dose, will increase the accuracy of determining these values for long exposure times, as well as determine the dynamics of changes in the background radiation in selected areas of study.

PA33

The influence of radiation damage on the band gap, optical and luminescent properties of CoZn/CoZnO nanostructures

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The work shows the results of the influence of radiation damage, as well as the associated ionization and athermal effects caused by irradiation on the change in the optical properties of CoZn/CoZnO nanostructures obtained by electrochemical synthesis. Ionic modification associated with irradiation of the resulting nanostructures with O^+, Ar^+ and Kr^+ ions with energies of 28, 31.5 and 147 MeV was carried out at the DC-60 heavy ion accelerator, located in the Astana branch of the Institute of Nuclear Physics (Astana, Kazakhstan). Irradiation was carried out by placing samples of ZnO/CoZn nanostructures synthesized in polymer templates in such a way on the target holder that the passing ions could interact with maximum efficiency. For this purpose, samples of CoZn/CoZnO nanostructures were placed on a target holder parallel to the ion beam. Irradiation fluences (10^{10}-10^{11} ions/cm^2) were chosen to achieve maximum efficiency of ion modification, without the destructive effect that occurs with high-dose irradiation.

In the course of the studies, relationships were established between changes in structural features caused by ion modification, as well as their influence on the optical and luminescent properties of CoZn/CoZnO nanostructures. Critical doses of damage have been determined at which irreversible structural damage is observed, leading to amorphization and softening.

PA34

Quantum Dots as a Precondition for the $ZnCr_2Se_4$ Spinel Formation in ZnSe:(Fe, Cr) Laser Crystal Matrixes

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Significant progress has been made in mid-infrared (mid-IR) laser technology based on Fe- and Cr-doped $A^{II}B^{VI}$ crystals. Infrared lasers utilizing the ^5D intra-term transitions are now commercially available [1]. However, there are still a few unresolved issues that need to be addressed to achieve future practical tasks such as electrically pumped ZnSe:(Cr, Fe) structures, miniaturized laser structures or new pumping schemes for $A^{II}B^{VI}$ -based lasers. In particular, establishing a correlation between the spectral characteristics of the active ions and the host structure can be difficult due to the peculiarities of the Fe and Cr doping process and their temperature behaviour. The main challenge relates to the formation of Frenkel defects, such as $ø = (Fe,Cr)_i + V_{Zn}$. This process is usually associated with the change in charge state of Fe and Cr, which is strongly temperature dependent and leads to the charge transfers $Fe^{2+} \leftrightarrow Fe^{3+}$ and $Cr^{2+} \leftrightarrow Cr^{3+}$.

Herein we report on co-doped ZnSe:(Cr, Fe) laser crystals that have been studied with an approach that includes both optical spectroscopy and theoretical modelling using the Modified Crystal Field Theory [2]. In particular, temperature dependent EPR, photoluminescence (PL) and absorption spectra have been measured in both samples. A theoretical model has been developed to explain the observed temperature evolution of the optical spectra. The types and values of distortions of the Cr- and Fe-based coordination complexes are determined. We found that the Jahn-Teller distortions are crucial for modelling the temperature-dependent changes of the optical spectra, and concentrations of Cr and Fe up to 10^{18} cm^{-3} are optimal for obtaining a homogeneous solid solution in designing laser crystals. Higher dopant concentrations lead to the formation of clusters with spinel $ZnCr_2Se_4$ structure in the ZnSe matrix. The Cr ion incorporates as a pair of Cr^{3+} ions occupying edge-sharing octahedral sites generated by formation of three Zn ion vacancies in the sphalerite lattice to charge compensate the QD [3]. The obtained PL spectra indicate that the formation of QDs prevents the formation of inclusions with the spinel $ZnCr_2Se_4$ structure.

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PA35

Influence of crystal structure on luminescence of Pr^{3+} doped barium lutetium fluoride nanocomposite

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In recent years, ternary fluoride compounds have gained significant attention for their potential applications as scintillators offering ultrafast response times crucial for medical imaging in time-of-flight positron emission tomography, as well as for high-energy physics calorimetry and X-ray photodynamic therapy [1]. Among these materials, ternary fluoride compounds doped with Pr^{3+} ions have particularly sparked interest due to their ability to exhibit either strong $4f^15d^1 \rightarrow 4f^2$ emissions in the UV region or a cascade of the $4f^2 \rightarrow 4f^2$ emissions in the visible region, depending on the crystal field strength influencing the position of the $4f^15d^1$ state in the electronic band structure of the compound [2]. To explore the potential of such compounds, we focused on synthesizing Pr^{3+} ion doped barium lutetium fluoride composite material via a hydrothermal process. X-ray diffraction and scanning transmission electron microscopy analysis showed that the composite material comprised two phases: orthorhombic phase ($BaLu_2F_8$, 89%) with spherical morphology, and cubic phase ($BaLuF_5$, 11%) with elongated plate-like morphology.

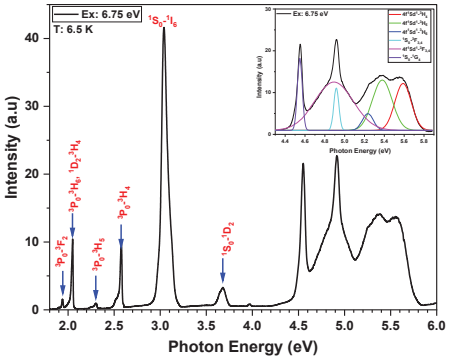

Figure 1: TI photoluminescence spectra of Pr^{3+} doped barium lutetium fluoride nanocomposite under excitation to the Pr^{3+} $4f^15d^1$ state (6.75 eV) at 6.5 K.

Time-integrated (TI) photoluminescence spectroscopy conducted under vacuum ultraviolet (VUV) photon excitation at the FinEstBeAMS beamline revealed following results. In the orthorhombic phase of the nanocomposite, the Pr^{3+} $4f^15d^1$ bands were found to be positioned below the $4f^2$ $^1S_0$ energy level, whereas in the cubic phase, it remained above the same energy level. Consequently, upon the high-energy (45 eV) and Pr^{3+} $4f^15d^1$ excitation (6.75 eV), the nanocomposite demonstrated broad UV emission bands from the orthorhombic phase, attributed to the $4f^15d^1 \rightarrow {}^3H_{4,5,6}$ transitions (4.4 to 5.8 eV), as well as narrow lines in the UV-visible region from the cubic phase, arising due to a two-step photon cascade emission process involving the $^1S_0 \rightarrow {}^1I_6$ (3.04 eV) and $^3P_0 \rightarrow {}^3H_{4,5,6}$ (2.68 eV–1.80 eV) transitions. Additionally, decay kinetics studies indicated a fast decay of the emissions related to $4f^15d^1 \rightarrow {}^3H_{4,5,6}$ transitions from the orthorhombic phase (τ~11 ns), contrasted with a relatively slow emissions from $^1S_0 \rightarrow {}^1I_6$ transitions from the cubic phase (τ~102 ns). These findings underscore the potential of this composite material to generate both UV and visible emissions, highlighting its potential for applications in various medical applications. The relaxation processes leading to various emissions in the mixed phase composite will be discussed on the basis of experimental data analysis.

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PA36

Radiation processes in YAG single crystals irradiated with swift heavy Xe^{132} ions

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Yttrium aluminum garnet ($Y_3Al_5O_{12}$, YAG) is one of the most significant optical materials. Acting as a matrix for various rare-earth impurities, YAG has found various applications in laser technology, scintillation detectors, phosphors etc. During operation, this material is exposed to ionizing radiation. Therefore, the processes of radiation defect creation have been studied for a long time in YAG single crystals and ceramics exposed to various types of radiation such as fast fission neutrons, protons, electrons, gamma-rays, etc. However, only few studies are dedicated to examining the processes caused in YAG by irradiation with swift heavy ions [1].

In this study, synthetic YAG single crystals were irradiated at room temperature (RT) by 231-MeV Xe^{132} ions with fluences of $\Phi = 10^{12}$-10^{14} ion/cm^2. Optical absorption spectra, measured at RT, exhibit complex bands at 3-6.5 eV. Based on literature data [2], a rather weak broad band peaked around 4.9 eV could be partly connected with the F^+ centers (an oxygen vacancy with one trapped electron), while clearly increasing with fluence absorption above 5.5 eV is related to neutral F centers (two electrons trapped in an oxygen vacancy). Because of high values of optical density, the F-absorption band peaked at 6.3 eV is clearly distinguished only in the spectrum of radiation-induced optical absorption (absorption of a pristine sample is subtracted) for the sample with the lowest fluence $\Phi = 10^{12}$ ion/cm^2.

In the spectra of X-ray luminescence (25 kV, 10 mA, RT), a broad band peaked around 3.65 eV is observed in both pristine and Xe-irradiated samples. The main part of this complex band is tentatively connected with the radiative decay of bound excitons − excitons nearby anti-site defects (an Y^{3+} ion located at an Al^{3+} site) [3]. The low-energy wing of the band could be related to the emission of the F and F^+ centers, while a set of narrow luminescence bands at 1.5-2.2 eV typical of several impurity ions is observed as well. Note that a clear continuous attenuation of all X-ray luminescence bands with irradiation fluence is detected.

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PA3

Characterization of IRSL decays of copper-doped potassium sulfate

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The purpose of this research is to explore the dosimetric properties of a newly developed phosphor, potassium sulfate doped with copper. K_2SO_4:Cu is highly sensitive as a radiation detector in the infrared stimulated luminescence (IRSL) method [1], allowing dose measurements even in the μGy range when using a sufficiently sensitive luminescence reader. The equipment used for IRSL measurements was OSL reader Helios (Zero-Rad, Czestochowa, Poland) with infrared (850 nm) stimulation and detection in range 300-600 nm, which has been optimized for the material's luminescence emission range. The studies of IRSL decay curves depending on the type of sample (powder, pellet, silicone foil), absorbed dose and storage time after irradiation were carried out. Particular attention was paid to the optimization of dosimetric properties in terms of selecting the appropriate form of the sample-detector. The study examined the decay of IRSL under different conditions. By deconvoluting the IRSL signal into individual exponential curves, valuable insights into kinetic parameters such as the lifetimes of charge carriers responsible for luminescence can be obtained. Notable differences in decay parameters were observed in various types of samples. It was examined whether the type of sample influenced the change in the fading characteristics, which for pellets is visible a few days after irradiation.

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PA38

Determination of the effect of ZrO_2 doping with magnesium oxide on the optical and luminescent properties of ceramics used as fuel cells

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The paper presents the results of assessing the effect of changes in the phase composition of ZrO_2 ceramics on resistance to radiation damage in the case of irradiation with heavy ions comparable in energy to fission fragments. As objects of study, samples of ZrO_2 ceramics doped with MgO were chosen, variation in the concentration of which leads to acceleration of the processes of polymorphic transformations during thermal sintering, as well as the formation of a structure of the ZrO_2/MgO type with inclusions in the form of MgO grains. In the course of the studies, it was established that variation in the concentration of MgO leads to the initialization of processes of polymorphic phase transformations of the type m – ZrO_2 → t – ZrO_2 and t – ZrO_2 → c – ZrO_2, as well as an increase in the resistance of ceramics to external influences (increased mechanical strength). In the course of determining the optical and luminescent properties, it was found that the formation in the structure of phase transformations of the type m – ZrO_2 → t – ZrO_2 and t – ZrO_2 → c – ZrO_2 leads to the formation of additional absorption bands, the presence of which causes a change in the concentration of vacancy defects. In this case, there is a general tendency for a change in the fundamental absorption edge and optical transmission, which indicates a decrease in transmission and a change in the electron density of the ceramic.

PA39

Analysis of Positron Trapping Defects through Free-Volume Study in Chalcogenide Glass

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Chalcogenide glasses (ChG) offer numerous advantages for potential applications such as optical modulators, frequency converters, efficient laser hosts, and fiber-optic amplifiers in the infrared spectral region. The incorporation of gallium significantly enhances the solubility of rare-earth ions in these glasses, leading to structural modifications in the GeS2 network. While various techniques can be employed to study the atomic arrangement in such ChG, the characterization of atomic-deficient distribution remains challenging due to limited available probes. Positron annihilation lifetime (PAL) spectroscopy emerges as a powerful technique capable of probing fine free volumes within these materials.

In this study, we utilize PAL spectroscopy to investigate extended free-volume defects in $GeSe_2$-Ga_2Se_3 and GeS_2-Ga_2S_3-CsCl ChG systems, employing a two-states trapping model. PAL spectra were recorded using a conventional fast-fast coincidence system (ORTEC) with a resolution of 230 ps at a temperature of T = 22°C and relative humidity of RH = 35% [1]. The measured PAL spectra were analyzed]1using the standard LT 9.0 computer program, fitting the obtained curves with two components characterized by lifetimes (τ_1, τ_2) and intensities (I_1, I_2), where (I_1+I_2=1).

Since the τ_1 and I_1 components lack strong physical significance within the accepted two-state positron trapping model, our focus lies on the second (τ_2, I_2) component. The τ_2 lifetime directly correlates with the size of free-volume defects (trapping centers), while the intensity I2 is proportional to the number of such defects. Analysis of PAL fitting parameters for the $80GeS_2$-$20Ga_2S_3$ system (τ_1 = 0.234 ns, I_2 = 0.67, τ_2 = 0.481 ns, I_2 = 0.33) reveals that the size of free-volume trapping defects in this system is greater compared to $80GeSe_2$-$20Ga_2Se_3$ glasses (τ_2 = 0.439 ns). Weak increases in I_2 intensities indicate a growing trend in the number of corresponding free-volume entities.

Furthermore, structural changes induced by CsCl additives in the $80GeS_2$-$20Ga_2S_3$ system suggest a relatively unchanged nature of the corresponding free-volume defects responsible for positron trapping in the studied glasses. However, the concentration of these traps undergoes significant changes with variations in composition.

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PA40

Exploring Luminescence Spectra of Eu-Doped $BaGa_2O_4$ Ceramics through Synchrotron Studies

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The incorporation of europium (Eu) dopants into the $BaGa_2O_4$ host is of significant practical importance owing to its luminescent properties. By introducing europium impurities into the $BaGa_2O_4$ lattice, the material gains the potential for efficient light emission and the ability to tailor its optical characteristics [1]. Europium]ions serve as luminescent centers, giving rise to characteristic emission peaks within the visible spectrum. The controllability of the Eu dopant concentration provides avenues for precise adjustment of optical properties. Furthermore, the high melting point and resistance to chemical reactions with diverse substances render Eu-doped $BaGa_2O_4$ suitable for utilization in demanding operational environments.

To elucidate the luminescent behavior of pure and Eu-doped (1%, 2%, 3%, and 4% Eu) $BaGa_2O_4$, thorough investigations into their luminescence and luminescence excitation spectra are conducted [2]. The excitation characteristics of both $BaGa_2O_4$ and its Eu-doped variant are meticulously examined to gain insights into their optical properties and their potential for efficient light emission. Luminescence excitation spectra are recorded across excitation wavelengths ranging from 220 to 550 nm, while the emission responses are monitored at 390 nm, 594 nm, and 616 nm.

A comparative analysis between the excitation spectra of pure $BaGa_2O_4$ and Eu-doped $BaGa_2O_4$ sheds light on the influence of europium dopants on the host material's properties. These excitation spectra offer valuable insights into the absorption and energy transfer mechanisms, thus facilitating a deeper understanding of the luminescent behavior exhibited by $BaGa_2O_4$.

This comprehensive investigation significantly advances the understanding of luminescence excitation in both $BaGa_2O_4$ and Eu-doped $BaGa_2O_4$, laying a solid foundation for further optimization and development of these materials for advanced applications in optoelectronics.

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Abstracts
(Poster session B)

PB01

The nature of high-temperature peaks of thermally stimulated luminescence in NaCl, NaC:Li, KCl and KCl:Na crystals

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In ionic crystals, low-temperature (4.2 K-300 K) peaks of thermally stimulated luminescence (TSL) that are associated with reorientation, delocalization and recharging of primary radiation-induced defects have thoroughly been studied for a long time. At the same time, there is still lack of information on the nature of high-temperature TSL peaks, which serve as the main probe of ionizing radiation in several thermoluminescent dosimeters on the basis of ionic crystals.

In this regard, the nature of high-temperature TSL peaks at 300-800 K (until the irradiated crystals are completely discolored, i.e. radiation defects are totally destroyed) has been investigated in X-ray irradiated NaCl, NaCl:Li, KCl and KCl:Na single crystals using the Harshaw model 3500 thermoluminescent dosimetric system (Thermo Fisher Scientific, USA).

In all crystals studied, high-temperature TSL peaks were recorded in two temperature ranges, which will further be conventionally denoted as Type *I* peaks (from 360 K to 400 K) and Type *II* peaks (from about 500 K till 620 K). Type *II* TSL

In NaCl:Li crystals, the light sum of Type *II* peaks increases with the concentration of lithium impurity ions. In particular, TSL light sum in case of Li concentrations of 400 ppm exceeds that in undoped NaCl by three orders of magnitude and is even 10 times higher than in TLD-100 dosimeter. A similar effect of Type *II* TSL amplification was also observed for a KCl:Na (1000 ppm) crystal.

A thermal quenching (up to 600-700°C) significantly stabilizes a solid solutions of small-sized (light) impurity cations in KCl:Na and NaCl:Li due to reincorporation of these impurity ions into regular cation sites. The latter process can be proved *via* the amplification of Type *II* TSL, the intensity of which is decreased in "decayed" doped crystals because of removal with time of impurity ions, initially located in regular cation sites, into nanosized clusters.

The emission spectra in Type *II* TSL peaks in NaCl:Li crystals have the maxima at 3.5 eV and coincide with those in the spectra of X-ray luminescence and tunnel luminescence (phosphorescence) of the same crystals. The same coincidence of the maxima (at 2.8 eV and 3.1 eV) in X-ray, tunnel and Type *II* peak luminescence spectra has been detected in KCl:Na crystals.

In the temperature range of 500-600 K, we tentatively detect an "explosive" dissociation of halogen aggregations, more complex than trihalide quasi-molecules decaying in KCl at 380-400 K [1, 2]. As a result of such "explosion", a flow of unrelaxed "hot" holes and electrons is formed (a certain similarity with the case of crystal excitation by X-rays), which recombine in the field of local lattice deformation by light impurity ions (Li, Na) *via* partial creation of luminescent exciton-like formations (see also [1, 2]).

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PB02

Studying the prospects for using photosensitive ACdSe (A – Co, Ni) thin films

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Interest in ACdSe (A – Co, Ni) thin films in the field of their use as detection systems for determining harmful contaminants in aquatic environments, as well as their subsequent disposal, is due to the optical properties of these structures, as well as their band gap, which varies over time. due to changes in the phase composition of films when adding magnetic elements in the form of cobalt or nickel to cadmium - selenium. As a result of such modifications, structures of the substitution type are formed, the change in structural features in which is due to the formation of phases of the type CoSe, NiSe, CoCd, etc. Moreover, the formation of such structures in the composition of films has a significant impact on the change in optical properties, as well as a decrease in the band gap, which makes it possible to generate a photocurrent when exposed to visible or sunlight.

The paper examines the prospects for using ACdSe (A – Co, Ni) thin films as a basis for creating catalysts for the detection and purification of wastewater from organic dyes and heavy metals. Samples of thin films were obtained by electrochemical deposition by varying the composition of the electrolyte to obtain structures based on cadmium-selenium compounds with nickel or cobalt. In the course of the studies, it was found that partial replacement of CdSe with nickel or cobalt leads to an increase in the photoactivity of films and acceleration of the photodegradation processes of organic dyes.

PB03

Application of optical analysis methods to assess destructive changes in the surface layer of SiC ceramics exposed to high-dose irradiation

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The paper presents the results of determining the structural features associated with helium swelling of the surface layer in SiC ceramics using optical and Raman spectroscopy methods.

Interest in these types of ceramics is due to their great prospects for use as structural materials for nuclear power, as well as for use in the creation of protective structures for long-term storage of spent nuclear fuel. During the study, the dependences of changes in the structural, mechanical, strength, and morphological characteristics of SiC ceramics depending on irradiation fluence were obtained. It has been established that the greatest changes in the strength properties are associated with the dominance of the crystal lattice swelling effect in the structure due to an increase in the concentration of implanted helium, and its further agglomeration with the formation of vacancy complexes of the He-V type. A model for changing the structural properties of ceramics irradiated with low-energy He^{2+} ions based on the change in the contributions of the dislocation density concentration, anisotropic distortion of the crystal lattice, and the effect of swelling as a result of implantation is proposed.

Based on the data obtained, a model was proposed for estimating the contributions of various structural changes to the degree of radiation damage in SiC ceramics with a hexagonal type of crystal structure. At irradiation fluences of 10^{15}-$5x10^{16}$ ion/cm^2, the main contribution to radiation damage is made by changes in the dislocation density and anisotropic deformations of the crystal lattice. At irradiation fluences above 10^{17} ion/cm^2, the dominant effect is the swelling of the crystal lattice and a change in its volume as a result of the accumulation of implanted helium in the structure of the damaged layer.

PB04

First principles calculations of the structure, electronic structure, elastic properties, and processes of formation of some defects in the Na_2SO_4-V crystal

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It is known that Na_2SO_4 crystals belong to ionic crystals with a complex anion with a tetrahedral structure. Na_2SO_4 crystals have 5 phase states. We are studying Na_2SO_4-V – thenardite with unit lattice parameters a=5.858 Å, b=12.299 Å, c=9.814 Å, belonging to the orthorhombic system [1]. Ab-initio calculations of the properties of the Na_2SO_4-V crystal were carried out using the DFT method included in the CRYSTAL23 program [2]. The functionals used were B3LYP, B3PW, PWGGA, PBE, PBESOL, LDA, HSE06 and SCAN. The results of calculations of a unit cell consisting of 2 formula units Na_2SO_4-V showed that the cell volume is 175.25 $Å^3$, density is 2.69 g/cm^3. The upper part of the table shows the values of the total energy and band gap corresponding to the functionals. Depending on the functional used, the band gap varies from 4.94 eV to 7.89 eV. We have optimized the geometric parameters of Na_2SO_4-V. The results obtained are shown at the bottom of the table.

Functional	B3LYP	PWGGA	PBE	PBESOL	LDA	B3PW	HSE06	SCAN
E_{tot}(AU)	-2047.47	-2042.12	-2046.56	-2043.32	-2027.39	-2047.48	-2046.64	-2047.86
Eg, eV	7.56	5.47	5.45	7.89	4.94	7.72	7.3	6.08
after optimization								
a, Å	5.959	6.198	5.994	5.877	5.892	5.969	5.930	5.866
b, Å	12.484	13.082	12.618	12.316	12.421	12.51	12.443	12.333
c, Å	9.951	10.432	9.964	9.741	9.779	9.952	9.865	9.723
V, $Å^3$	740.38	845.82	753.61	705.08	715.69	743.18	727.93	703.41
ρ, g/cm^3	2.547	2.229	2.502	2.674	2.634	2.537	2.590	2.680
E_{tot}(AU)	-2.047.49	-2042.21	-2046.6	-2043.33	-2027.43	-2047.5	-2046.66	-2047.88
E_g, eV	6.93	3.96	4.63	7.78	4.32	7.14	6.86	5.69

The results of studies of elastic properties and defect formation processes in the Na_2SO_4-V crystal will also be reported.

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PB05

DFT STUDY OF STRUCTURAL, ELECTRONIC AND ELASTIC PROPERTIES OF c-ZrO_2

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Crystals of ZrO_2 is a ceramic material that has found numerous technological applications due to its thermal, dielectric, mechanical, chemical, and biological properties. Pure zirconium dioxide has three polymorphic modifications: monoclinic (P21/c), tetragonal (P4/nmc), and cubic (Fm3m) symmetries under atmospheric pressure. In this article, we have discussed the structure, electron structure, and elastic properties of ZrO_2 with cubic structure (c-ZrO_2). The lattice constant for c-ZrO_2 is 5.129Å [1], and the band gap width is 6.10 eV [2].

Calculations of the structure, energy band structure and elastic properties of c-ZrO_2 were performed using density functional theory (DFT) approximation included in the CRYSTAL23 computer code [3]. In the cubic modification of ZrO_2, zirconium atoms form a face-centered cubic structure with a lattice parameter of 5.11 Å, while oxygen atoms occupy tetrahedral positions in this lattice. The elementary rhombohedral cell has an edge length of 3.61Å and contains three atoms with the following coordinates in the Zr (0, 0, 0); O1 (0.25, 0.25, 0.25); and O2 (0.75, 0.75, 0.75) crystalline coordinate system. All Zr-O distances are equal and are 2.21Å. The parameters of the elementary cell of ZrO_2 were optimized using density functional theory (DFT). Hybrid functionals B3LYP, B3PW, and HSE06, which include accurate exchange energy calculations based on the Hartree-Fock method, were used in this analysis. Using hybrid functionals B3LYP, B3PW, and HSE06, the following results were obtained: a = 5.10 Å, ρ = 6.104 g/cm3, V = 132.65 Å3, and the band gap energy was E_g = 5.75 eV, E_g = 5.73 eV, and E_g = 5.51 eV, respectively. It can be observed that the band gap width varies depending on the chosen functional. After lattice parameters optimization, they were as follows: for B3LYP - 5.13 Å, for B3PW - 5.09 Å, and HSE06 - 5.08 Å, with volumes of 134.77 $Å^3$, 131.93 $Å^3$, and 131.21 $Å^3$, respectively. Meanwhile, the band gap width of c-ZrO_2 for these functionals was E_g = 5.7 eV, E_g = 5.75 eV, and E_g = 5.51 eV, respectively. Calculations of the elastic properties of c-ZrO_2 showed that the Young's modulus is E = 328.83 Pa, and the Poisson's ratio is μ = 0.28. The obtained results of first-principles calculations of the structure, electronic structure, and elastic properties of c-ZrO_2 are in good agreement with the results of experimental studies and theoretical calculations.

Ongoing calculations include modeling the structure of c-ZrO_2 with oxygen vacancies and the introduction of impurities such as CaO, etc.

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PB06

Investigating novel double half-Heusler Alloys: a study of electronic, magnetic, elastic properties and their Implications

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Half-Heusler alloys have emerged as a compelling class of materials with promising prospects for various technological applications, owing to their distinctive amalgamation of properties [1,2]. In this study, the computational analysis of the double half-Heusler compounds Ti2Pt2ZSb (Z=Al,Ga,In) was conducted by integrating two density functional theory (DFT) methodologies, namely the Generalized Gradient Approximation (GGA) and the meta-Generalized Gradient Approximation (metaGGA-SCAN).

Continued investigation into synthesis methodologies, fundamental characteristics, and application-specific optimizations of double half-Heusler compounds holds substantial promise for unveiling novel opportunities and driving the advancement of cutting-edge technologies [3]. Figure 1, presented below, illustrates the electronic properties of the Ti2Pt2AlSb double half-Heusler compound.

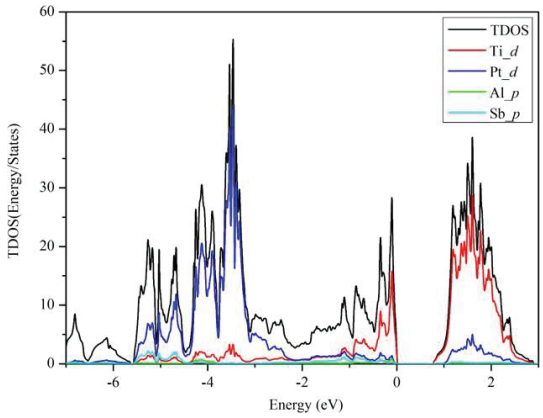

Fig. 1 Density of states (DOS) for Ti2Pt2AlSb double half-Heusler alloy

In conclusion, the investigated alloys have demonstrated stability and exhibited favorable electronic, magnetic, and elastic properties. Their versatile characteristics render them applicable across various scientific disciplines.

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PB07

First principles calculations of the advanced phosphor materials

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In this study, we present the results of first-principles calculations of potassium hexafluorosilicate (K_2SiF_6) advanced phosphors, both defect-free and doped with the Mn atoms ($K_2SiF_6:Mn^{4+}$, substitution of Si with Mn). It is well known, that this material is capable of supporting efficient red emission from the Mn^{4+} activator ions [1–3].

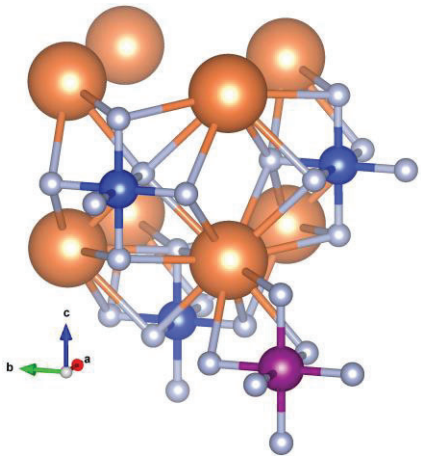

Fig. 1. Mn impurity in K_2SiF_6. K atoms — orange balls, Si — blue, F — grey, Mn — violet.

The structural, electronic and elastic properties of perfect and doped materials are considered in detail. The simulations were performed using the CRYSTAL17 computer code [4] within the linear combination of atomic orbitals (LCAO) approximation of the density functional theory (DFT). To define an optimal combination of basis set and functional for the calculations, at the beginning we simulated pure K_2SiF_6 using two types of basis sets and four different functionals (three advanced hybrid exchange-correlation and one LDA functionals) and compared obtained results with available experimental data. Further, for selected basis set and finctional, the dependence of mentioned properties of pure K_2SiF_6 on pressure (0–20 GPa) was evaluated and the simulation of $K_2SiF_6:Mn^{4+}$ was performed. Defective system was considered by means of supercell (SC) calculations (two sizes of SC were used: 36 and 288 atoms). The structural changes due to an inclusion of the Mn^{4+} ions into K_2SiF_6 hosts (Fig. 1) as well as positions of defect levels in the band gap are studied in detail.

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PB08

DFT study of ternary zinc based pnictogenides ($ZnAX_2$) with chalcopyritic structure

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Chalcopyritic II-IV-V compounds are widely utilized compounds in non-linear optics applications [1] and are potential candidates as photovoltaic materials due to a band gap tunable by chemical composition as well as owing to the success of ternary chalcopyrite thin-film solar cell technology [2]. Recent research also studied a high pressure phase transition of $ZnSiP_2$ to a superconducting state albeit with a simultaneous shift of the crystal structure to a rock-salt symmetry. [3] Another possible application is photoluminescence, as some chalcopyrites show luminescent properties due to naturally formed lattice defects. [4]

In this work we present a DFT study of pnictogen based chlacopyrites with a general formula $ZnAX_2$ with X = N, P, As and A = Si, Ge, Sn. Recent ab initio research while focusing on the different chemical composition of zinc based chalcopyrites [5] ignored the effect of pnictogen substitutions on the material properties. Hence, we focus on the systematic description of the role pnictogen has in determining the properties of a given chalcopyrite.

We use plane wave based approach as implemented in Quantum Espresso [6] code to obtain the relevant wavefunctions that correctly capture the crystal structure and band gap of the material group by tuning both the functional and basis sets used for calculation.

Consequently, we compute and report the electronic properties of the material as well vibrational and optical spectra that respectively link to the non-linear optical and photovoltaic applications of the material group. Additionally, we assess the possible luminescent properties of the compounds in question. Results are analyzed and interpreted as pointing to the prospective usefulness of the discussed applications.

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PB09

Predictions of $LiInSe_2$ scintillating properties from DFT calculations

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Lithium Indium Selenide ($LiInSe_2$) is a material with proven scintillation properties for neutron detection applications [1] and applications in non-linear optics [2]. Although garnering noticeable interest from experimentalists the material is relatively poorly studied theoretically with most prominent works focusing on a thermodynamically less stable chalcopyritic phase [3], and the nature of the scintillating mechanism still not having a definite explanation [4].

In this work we present the results on the *ab initio* calculated properties of the $LiInSe_2$ crystal. The calculations were performed using CRYSTAL17 code [5] and employing a hybrid functional approach. This method ensures an accurate representation of the lattice structure and the band gap of the material. We compare the results with experimental data and present the electronic property features in form of band diagrams

Furthermore, we computed the vibrational properties including phonon dispersion and simulated Raman spectra that are directly comparable to the experimentally available results.

Our theoretical study of $LiInSe_2$ not only deepens our understanding of its fundamental properties but also enables us to predict scintillating behaviors. The average energy necessary to generate an electron-hole pair was estimated using the methodology described by Robbins [6].

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PB10

Thermal stability of color centers in lithium fluoride crystals irradiated with electrons and N, O, Kr, U ions

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The formation of radiation defects during irradiation is a complex outcome of sequential and independent events, including the creation of primary pairs, the spatial separation of their components, and their transformation into stable forms under experimental conditions. In ion crystals, particularly alkali halide and alkali earth metal fluoride crystals, the generation of initial defects is highly efficient. When temperatures are sufficiently high, the primary pairs are spatially separated through the thermally activated movement of the mobile component, which is also highly efficient.

The LiF crystals were irradiated with electron and ion (O, N, Kr, U) beams at room temperature. Electron irradiation parameters for the pulse accelerator included a pulse duration of 10 nanoseconds, an average electron energy of 250 keV, and an energy density of the initiating pulse of 15 mJ/cm^2. The electron range was 0.2 mm, and the absorbed single pulse energy in the LiF crystal was 8xE2 Gy. For O, N, Kr ions irradiation, we employed the DC-60 accelerator (Astana) with a 10-80 μm range. Uranium ion irradiation was conducted at the GSI accelerator (Darmstadt) with a 94 μm uranium ion range.

We have conducted studies of the thermal stability of color centers created in a LiF crystal upon irradiation with various doses and types of radiation. As the heating temperature of the sample increases, F centers are destroyed and F_n aggregate centers are not created. The stability of color centers induced by irradiation with hard radiation in LiF crystals increases with increasing irradiation dose. Color centers induced by small (up to 1.0xE4 Gy) doses are destroyed when heated to 300°C. Color centers induced by large (over 1.0xE6 Gy) doses are destroyed when heated above 450°C.

The thermal stability of color centers accumulated in LiF crystals upon irradiation with electrons depends on the irradiation dose and increases with increasing pre-irradiation dose. Irradiation with oxygen and uranium ions with doses up to 2.0xE10 Gy leads to the induction of color centers in LiF crystals, the thermal stability of which is higher than that of crystals subjected to preliminary irradiation with electron fluxes with doses up to 2.0.E3 Gy. The increase in the stability of induced color centers is presumably associated with the formation of hole color centers in the crystal, which have the structure of a molecular fluorine ion in the interstices.

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PB11

Use of optical and luminescent methods for detecting radiation damage in $ZrO_2 – Al_2O_3$ ceramics

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The article discusses the possibility of using optical methods for determining structural distortions and deformations that occur during hydrogenation of the surface layer of ZrO_2 - Al_2O_3 ceramics in the case of proton irradiation. To synthesize ceramics of the cer-cer type based on zircaloy compounds doped with aluminum oxide, micron-sized ZrO_2 and Al_2O_3 powders purchased from Sigma Aldrich (USA) were used.

The choice of protons with an energy of 1.5 MeV as ionizing radiation is due to the possibility of modeling the processes of radiation-induced damage characteristic of the effect of hydrogenation of the damaged layer, comparable to the real processes of hydrogenation of ceramics during operation of fissile nuclear fuel during nuclear reactions, as well as the operation of ceramics in the core at their interaction with coolants.

During the experiments, it was established that changing the phase composition of ceramics due to the formation of solid solutions of the ZrO_2/Al_2O_3 and $ZrO_2/Al_2O_3/AlZr_3$ type leads to an increase in resistance to swelling by 3–5 times in comparison with monoclinic ZrO_2 ceramics. A general analysis of changes in the optical parameters of ceramics depending on the irradiation fluence for ceramics with different phase compositions showed a direct dependence of changes in structural deformations on the concentration of vacancy defects and structural distortions caused by irradiation.

PB12

Thermoluminescence study of neutron-irradiated $MgAl_2O_4$ crystals doped with rare-earth ions

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Rare-earth (RE) - doped MgO - $2Al_2O_4$ single crystals were grown using the Verneuil method. The corresponding concentration of the RE ions was determined by neutron activation analysis. All samples exhibited complex TSL glow peak at 490-520 K. All TSL glow curves were analysed by using two software packages GlowFit and TLD-MC, and were deconvoluted into four single peaks by first-order kinetics.

Corresponding activation energies were also determined for each obtained peak. The concentration of hole traps was also determined for each dopant. The sample activated by terbium has the largest concentration of traps among rare earth activated spinels.

The observed TSL peaks and the corresponding activation energies are in full agreement with previously obtained data, which indicates, despite the different stoichiometry of the crystals, the same structure of point defects.

PB13

XANES analysis sheds new light on the structural properties of up-converting TiO_2 nanoparticles doped with rare earth elements

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The design and engineering of luminescence up-converting nanoparticles are gaining an increasingly important role in biomedicine for precision drug delivery, labeling, and imaging of target cells and molecules, military and aerospace due to their ability to emit visible light upon infrared (IR) radiation [1, 2]. Successful implementation of up-converting nanoparticles in the listed applications requires an in-depth understanding of their structure and surface physics, as well as the development of fabrication technologies that ensure confident reproducibility of the nanoparticle properties at the nanometer level. Nanoparticles of wide-gap oxides with photocatalytic activity doped with rare earth elements (REE) are of particular interest due to their pronounced antimicrobial feature and the ability to luminesce in the visible range when exposed to IR radiation. In this work, we report the sol-gel and hydrothermal formation and comprehensive characterization of erbium- and ytterbium-doped TiO_2 nanoparticles in comparison with the pure TiO_2. It is found that TiO_2 nanoparticles of a 20-70 nm size when doped with REE tend to decrease in diameter by 10-20%. At the same time, the REE introduction helps to impart up-conversion luminescent properties to nanoparticles, namely, the emission of light in the red and green ranges when exposed to a 980 nm laser. For the first time, the X-ray absorption near-edge structure (XANES) analysis of Er/Yb-doped TiO_2 nanoparticles is carried out, which suggests that their surface is depleted of REE ions over time.

By comparing XANES O K-edge spectra and peaks related to O(2p) and Ti(3d) hybridization states of the samples produced by sol-gel, hydrothermal, and extraction-pyrolytic methods we revealed the dependence of electronic and structural properties on the fabrication regimes and techniques, which is vital for selection of the optimal approach for the TiO_2:REE synthesis.

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PB14

Exploring Luminescence Spectra of Eu-Doped $BaGa_2O_4$ Ceramics through Synchrotron Studies

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The incorporation of europium (Eu) dopants into the $BaGa_2O_4$ host is of significant practical importance owing to its luminescent properties. By introducing europium impurities into the $BaGa_2O_4$ lattice, the material gains the potential for efficient light emission and the ability to tailor its optical characteristics [1]. Europium]ions serve as luminescent centers, giving rise to characteristic emission peaks within the visible spectrum. The controllability of the Eu dopant concentration provides avenues for precise adjustment of optical properties. Furthermore, the high melting point and resistance to chemical reactions with diverse substances render Eu-doped $BaGa_2O_4$ suitable for utilization in demanding operational environments.

To elucidate the luminescent behavior of pure and Eu-doped (1%, 2%, 3%, and 4% Eu) $BaGa_2O_4$, thorough investigations into their luminescence and luminescence excitation spectra are conducted [2]. The excitation characteristics of both $BaGa_2O_4$ and its Eu-doped variant are meticulously examined to gain insights into their optical properties and their potential for efficient light emission. Luminescence excitation spectra are recorded across excitation wavelengths ranging from 220 to 550 nm, while the emission responses are monitored at 390 nm, 594 nm, and 616 nm.

A comparative analysis between the excitation spectra of pure $BaGa_2O_4$ and Eu-doped $BaGa_2O_4$ sheds light on the influence of europium dopants on the host material's properties. These excitation spectra offer valuable insights into the absorption and energy transfer mechanisms, thus facilitating a deeper understanding of the luminescent behavior exhibited by $BaGa_2O_4$.

This comprehensive investigation significantly advances the understanding of luminescence excitation in both $BaGa_2O_4$ and Eu-doped $BaGa_2O_4$, laying a solid foundation for further optimization and development of these materials for advanced applications in optoelectronics.

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PB15

Quasi-equilibrium conditions in the model of semi-localized transitions (SLT)

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One of the most general models describing thermoluminescence (TL) and optically stimulated luminescence (OSL) phenomena is the semi-localized transitions model (SLT), formulated in 2005 by A. Mandowski [1]. According to the SLT model the recombination processes responsible for luminescence can be both local (i.e. taking place in the vicinity of the trap) as well as delocalized, i.e. taking place through transport bands.

The SLT model is quite complex mathematically which makes it difficult to directly apply to the analysis of TL and OSL phenomena – in particular to the estimation of trap parameters. Nonetheless, there are some interesting features that allow to simplify the equations. In this paper the quasi-equilibrium relations between states $H^1{}_0$ and $H^0{}_1$ and well as $E^1{}_0$ and $E^0{}_1$ are studied. It is shown that the relation holds for a variety of heating rates and physical parameters of traps and recombination centres as shown in Fig.1.

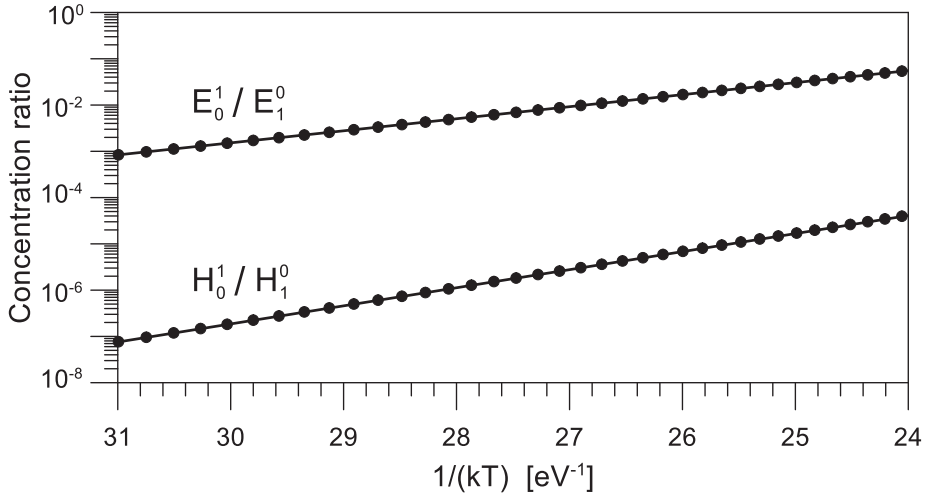

Fig. 1. Comparison of concentration ratios during TL measurement with theoretical quasi-equilibrium predictions.

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PB16

Studies of optically stimulated luminescence of the $YAlO_3:Mn^{2+}$ crystals grown by the floating zone and Czochralski methods

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Mn^{2+}-doped $YAlO_3$ (YAP) crystal is a good candidate for thermally stimulated (TSL) or optically stimulated luminescent (OSL) dosimetry of ionising radiation [1]. This material has a high effective atomic number (Z_{eff} ~ 31.4), making it particularly useful for estimating the energy range of unknown photon radiation fields [2, 3]. However, the optically stimulated luminescence and the effect of optical bleaching in this material have not yet been thoroughly investigated. It is necessary to establish the optimal conditions for measuring the OSL response of this material for use in dosimetry.

To achieve this, the Mn^{2+}-doped crystals, in particular $YAlO_3$, $(Y\text{-}Gd)AlO_3$ and $(Y\text{-}Lu)AlO_3$, were grown by the floating zone (FZ) and the Czochralski (CZ) methods and studied in detail.

In our experiments, it was investigated the influence of the intensity and wavelength of optical stimulation on the kinetics of the OSL response. Besides the influence of the time parameters of pulse stimulation on the form of the OSL kinetics has been studied. The effect of host material composition on the TSL and OSL properties, including the activation energy of shallow traps and the main dosimetric TSL peak at about 200 °C, was determined.

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PB17

Optical properties of multi-site $CaAl_{12}O_{19}$ phosphors doped with Cr^{3+}, Fe^{3+}, or Mn^{2+}

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Multi-site phosphors are attractive materials for applications in luminescence thermometry, and in visible and near-infrared lighting. Magnetoplumbite type calcium hexaaluminate ($CaAl_{12}O_{19}$) contains five unequal Al crystallographic sites with different degrees of local symmetry that are suitable for incorporation of transition metal ion activators.

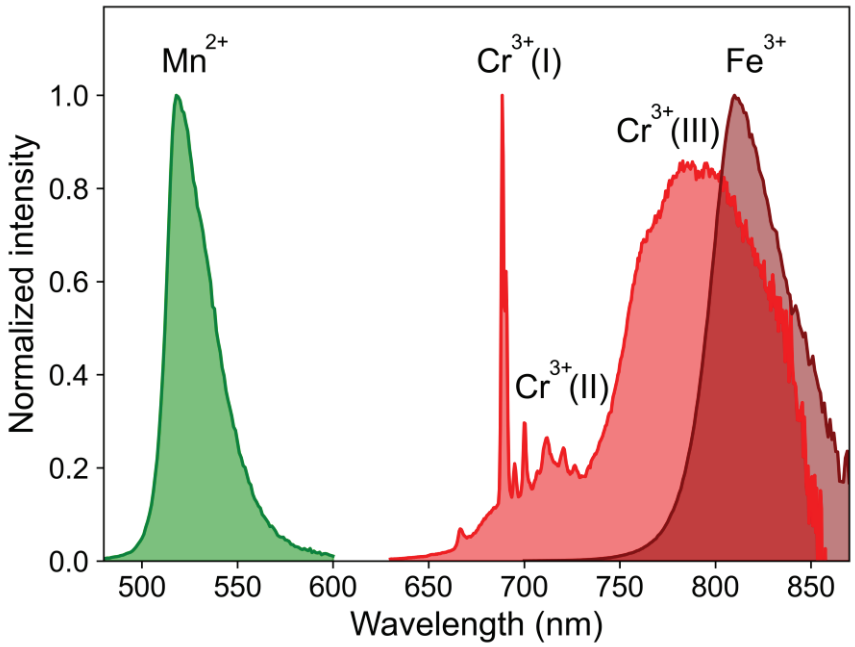

Figure 1. Photoluminescence of Mn^{2+}, Cr^{3+} or Fe^{3+} in $CaAl_{12}O_{19}$ under blue excitation.

In this work, we report optical properties of Cr^{3+}, Fe^{3+}, and Mn^{2+} doped $CaAl_{12}O_{19}$ phosphors. Our findings indicate the presence of three different Cr^{3+} luminescence centres residing in octahedral Al sites that generate two red narrow-band emissions with maxima at 689 nm and 700 nm, and broadband emission peaking at 785 nm [1]. Fe^{3+}-doped $CaAl_{12}O_{19}$ exhibits near infrared emission with maximum at 810 nm [2], while Mn^{2+} doped phosphors emit green light with maximum at 518 nm.

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PB18

Characterization and enhancement of UV-C persistent luminescence in $Ca_2Al_2SiO_7:Pr^{3+}$

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In recent years, as a subfield of persistent luminescence (PersL), the UV PersL research and characterization has emerged. This is due to the new potential applications of UV persistent phosphors such as disinfection, anti-counterfeiting, photocatalysis in the dark, etc. The practical application of such materials requires an understanding of their structure and the PersL mechanism. One of the materials that shows high intensity UV-C PersL is $Ca_2Al_2SiO_7:Pr^{3+}$. Structural properties and PersL characterization of this material was carried out using various spectroscopic techniques [1].

Based on these results, changing the synthesis conditions and adding different coactivators is done in the present study to increase the UV PersL intensity of $Ca_2Al_2SiO_7:Pr^{3+}$. The synthesised materials were studied using several spectroscopic techniques such as thermostimulated luminescence and photoluminescence. Based on the obtained results, the dependence of $Ca_2Al_2SiO_7:Pr^{3+}$ UV PersL on synthesis conditions and coactivators is discussed.

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PB19

Thermoluminescence and optically stimulated luminescence properties of some gemstones

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Contemporary approaches to designing new dosimeters increasingly draw inspiration from the wealth of nature. Natural materials, such as fluorite, have been widely used in dosimetry for years. Their properties can vary depending on the place of origin and thus the content of impurities [1,2]. The aim of the study was to assess the dosimetric properties of gemstones using thermoluminescence (TL) and optically stimulated luminescence (OSL) measurements, as well as their preliminary evaluation for potential application in individual, environmental, or retrospective dosimetry.

Qualitative and quantitative analysis was carried out for 22 samples of gemstones from 15 different locations. The tested materials were exposed to ionizing radiation from a ^{137}Cs source (0.39-0.42 Gy) and an Elekta linear medical accelerator (0.5–2.0 Gy). TL signal measurements were performed at heating rates of 1, 2, 3, 5 and 10°C /s, and readings were taken up to a maximum temperature of 350°C or 450°C. OSL signals were measured in LM-OSL mode using blue, green, or IR LED diodes with powers of 50, 70 and 80 mW/cm^2. TL and OSL signal measurements were performed using TLD RA'94, TLD RA'04 and *lexsyg* research TL/OSL readers.

Dosimetric properties were demonstrated by 6 out of 22 tested natural materials. Promising dosimetry results were obtained for fluorite (Strzegom, Poland), barite (Jebel Ouichane, Morocco), zircon (Pailin, Cambodia), microcline (Piława, Górna, Poland), topaz (Volodarsk Volynski, Ukraine), topaz (Sherlova Gora, Russia), for one (TL or OSL) or both phenomena (TL and OSL). Confirmation of differences in dosimetric properties resulting from the extraction locations of the material through chemical analysis is necessary.

Out of the 22 tested materials, 6 manifested promising dosimetric properties. The dosimetric properties of materials depend on their extraction locations and origin, suggesting differences in chemical composition. Further research is necessary to identify the chemical composition and conduct a deeper analysis of the dosimetric properties for the most promising materials.

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PB20

Temperature Behavior of Luminescence in LYSO:Ce Single Crystals under Synchrotron Radiation Excitation in VUV Range

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A solid solution of lutetium and yttrium orthosilicates doped with cerium, $Lu_{2(1-x)}Y_{2x}SiO_5$ ($(Lu,Y)_2SiO_5$ or LYSO) is one of the most promising scintillators due to its unique combination of properties required for modern applications. However, there is still a significant gap in fundamental knowledge about the final stage of energy relaxation processes in this material, which is critical for assessing scintillator performance for modern applications such as the new compact muon solenoid detector at CERN. One of the most important factors affecting the operation of a scintillator is the efficiency of energy transfer from the crystal lattice to the luminescence center (Ce^{3+}). As a rule, energy transfer processes involve the migration of charge carriers to luminescence centers and, therefore, depend on temperature. Thus, the goal of this work is to study the temperature dependences of the luminescent properties of intrinsic and impurity centers in LYSO single crystals.

In this work, cerium-doped LYSO single crystals were studied using luminescence spectroscopy in the temperature range from 7 to 300 K. To excite luminescence, synchrotron radiation in the vacuum ultraviolet (VUV) region was used. The experiments were carried out at the Finestlumi end station [1] of the FinEstBeAMS beamline [2] at the MAX IV synchrotron facility (Lund, Sweden).

It is important to note that a new, previously unpublished luminescence band at 250 nm was detected. The excitation spectra of this band, its temperature behavior, as well as time characteristics allow us to attribute this emission to the singlet component of a self-trapped exciton in LYSO [3]. In addition, it was found that the increase in Ce^{3+} luminescence intensity above 50 K correlates with thermal quenching of excitonic emission bands, which confirms the excitonic mechanism of energy transfer from the lattice to the Ce^{3+} ion.

It is also shown that both types of Ce^{3+} centers (seven and six coordination) are excited at any energy used in this work. It was concluded that, independently on the coordination of Ce^{3+}, the same processes of energy transfer from the main lattice to impurity ions occur [4].

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PB21

Study of Swift Heavy Ion Induced Radiation Defects in Relevant Garnet Crystals by VUV Excitation of Synchrotron Radiation

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Single crystals with garnet structure are important optical materials and nowadays they supposed to be prospective optical components for utilization in aggressive radiation environment (fusion applications, space applications, detectors of ionizing radiation, etc.). In these cases crystals are naturally subject to radiation influence. Therefore, the predictable functionality of their parameters under ionizing radiation and in a radiation environment is mandatory. From the physical point of view, the problem is to study the deterioration mechanisms of the material optical transparency and of the luminescence yield.

The radiation defects in the set of relevant undoped garnet single crystals $(Gd_3(Ga,Al)_5O_{12}$ (GAGG), $Y_3Al_5O_{12}$ (YAG), $Tb_3Ga_5O_{12}$ (TGG) and $Gd_3Ga_5O_{12}$ (GGG) have been produced by the irradiation of 156 MeV Xe ions to fluences $6.6\cdot10^{10}$ of $2\cdot10^{13}$ cm^{-2} at the DC-60 heavy ion accelerator (Astana, Kazakhstan). Such irradiation is capable to produce radiation defects similar to those generated by neutrons i.e. it is a good alternative to neutron irradiation, which needs a significantly longer time for samples' relaxation after neutron treatment. Therefore, it is suggested that the irradiation of swift heavy ions produces stable radiation defects in the lattice of the garnet crystal. The irradiated crystals have been studied by means of optical and luminescence spectroscopy including vacuum ultraviolet (VUV) excitation spectroscopy under synchrotron radiation. For these purposes two experimental setups have been actively utilized. The first one is the photoluminescence endstation (Finestlumi) [1] installed on the FinEstBeAMS beamline [2,3] of 1.5 GeV storage ring of MAX IV synchrotron facility (Lund, Sweden). Another one is a new Superlumi endstation [4] which has been recently installed on PETRA III storage ring of DESY synchrotron center (Hamburg, Germany). Both experimental setups provide a number of experimental advantages allowing to get new insights into radiation damages in relevant garnet crystals.

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PB22

Temperature dependence and dynamics of luminescence of gallium oxide single crystals

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Gallium oxide has garnered immense interest in optoelectronics as a phosphor, scintillation material, etc., due to its unique characteristics in terms of optical and radiation resistance. Single crystals of gallium oxide grown in different locations possesses varying characteristics due to different growth conditions. Accordingly, studies on the temperature dependence of luminescence and the kinetic characteristics of luminescence were conducted, as well as comprehensive investigations into the structure and optical properties. Crystals of gallium oxide (Ga_2O_3) were obtained from Tamura in Japan.

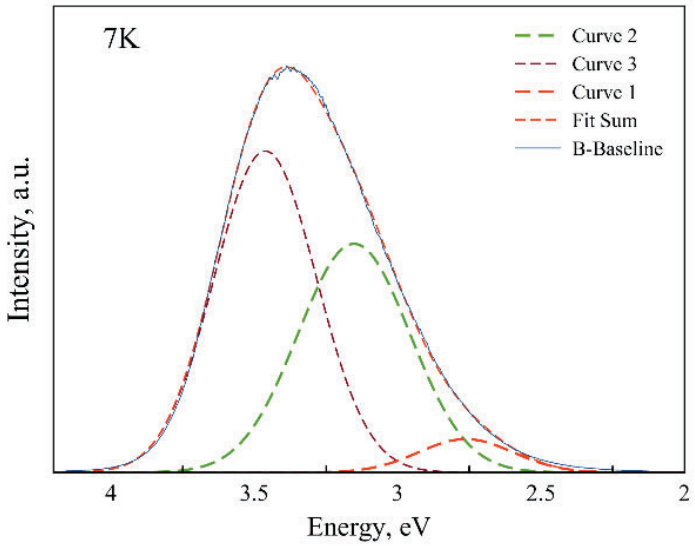

Fig.1. Lumiescence spectra at 7 K of Ga_2O_3 single crystals

The temperature dependence of luminescence was conducted in the range of 7-300K, and the luminescence excitation spectrum was studied in the range of 4.5-11 eV. The band gap was estimated to be 4.65 eV using the Tauc method. Luminescence spectra decompose into three Gaussians at 300K – 3.3, 3, and 2.6 eV; at 7 K – 3.5, 3.1, and 2.7 eV (Fig.1). The excitation spectrum at 7K on bands – 3.5, 3.1, and 2.7 eV shows a consistent trend, with excitation starting at 4.6 eV and sharply rising to 4.88 eV, then leveling off up to 11 eV. At 300K, with a peak at 4.11eV, excitation begins at 4.3eV, reaches a maximum at 4.75 eV, then drops sharply to 6 eV and further to 11 eV. A broad band at 1.77eV, not related to chromium impurities, which are an unintentional impurity for this material, was discovered for the first time. With characteristic decay times of 90, 307, and 1100 ns. The nature of this emission is being investigated.

PB23

Optimizing Ga_2O_3:Ce for Advanced Optoelectronic Applications: Synthesis and Properties

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Cerium (Ce) doped Gallium oxide (Ga_2O_3) represents a promising material for optoelectronic applications, including use as scintillators. Variations in cerium concentration allow control over not only the structural but also the optical properties of the material, which can significantly enhance its application in various technological fields. The ceramics were synthesized using a solid-phase synthesis method at 1500°C. The ceramics have the following structural parameters obtained by diffraction method: a(A) 12.265062, b(A) 3.049797, c(A) 5.822340. An increase in cerium content from 0.5% to 2% was observed to decrease the cell parameters and volume, indicating changes in the microstructure. The luminescence decay decreased to 900 nanoseconds compared to pure gallium oxide, where decay lasts up to 5 microseconds. Adding cerium to gallium oxide leads to a significant reduction in luminescence decay time, making Ga_2O_3:Ce particularly suitable for use in scintillators, where a fast response time is a critical parameter. This discovery expands the potential use of modified Ga_2O_3 in optoelectronics and solar-blind sensors.

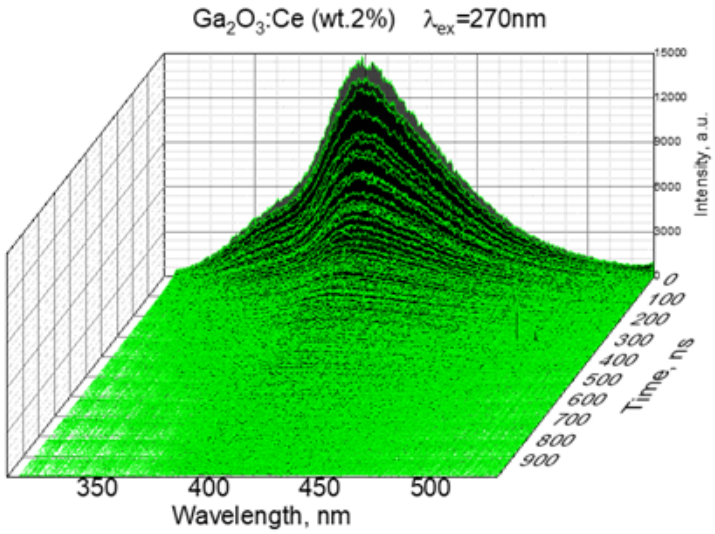

Fig. 1. Time resolved luminescence Ga_2O_3 ceramics exited with 270 nm pulsed laser at 300 K.

PB24

Effects of High-Energy Ion Irradiation on Luminescent Properties of Gallium Oxide Crystals

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Crystals of gallium oxide (Ga_2O_3), tin-doped (Ga_2O_3:Sn), and iron-doped (Ga_2O_3:Fe) obtained from Tamura in Japan irradiated with krypton and xenon ions with 147 MeV and 231 MeV energies, respectively, with the ion fluences varied from E10 to E13 ions /cm^2. Irradiation with ions was carried out at the Astana DC60 facility in Kazakhstan.
Subsequent luminescence analysis was performed on these crystals under vacuum ultraviolet (VUV) photon excitation between 11 eV and 4.5 eV at the MAXLAB IV synchrotron's FinEstBeam line.

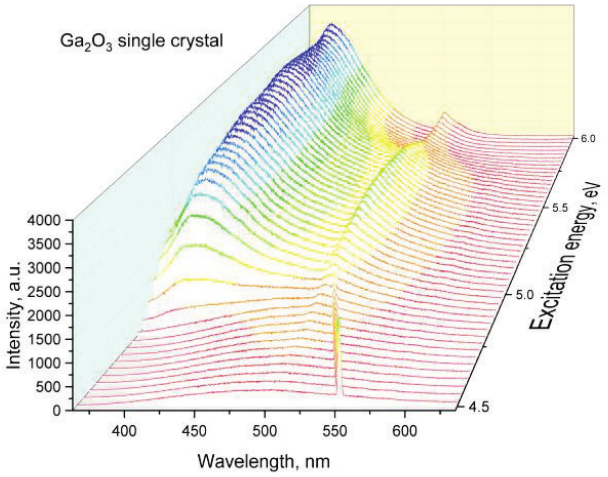

Fig. 1. 3D spectra of the luminescence/excitation spectra of ion irradiated Ga_2O_3 single crystal at 7 K.

In the crystals that had been ion-irradiated, an additional luminescence band was detected, peaking at 2.25 eV, which was only observable at the low temperature of 7 K and was excited by photon energies in the 4.5-5.5 eV range, with maximum excitation occurring at 5 eV. Radiation-induced defects in the crystal structure affect the electronic properties of the material. Oxygen and gallium vacancies can act as traps for electrons or holes, changing local energy levels in the bandgap. These changes in the energy structure may be responsible for the appearance of new luminescence bands.

PB25

Enhanced Luminescence in YAG Ceramics Doped with Eu, Cr, and Er

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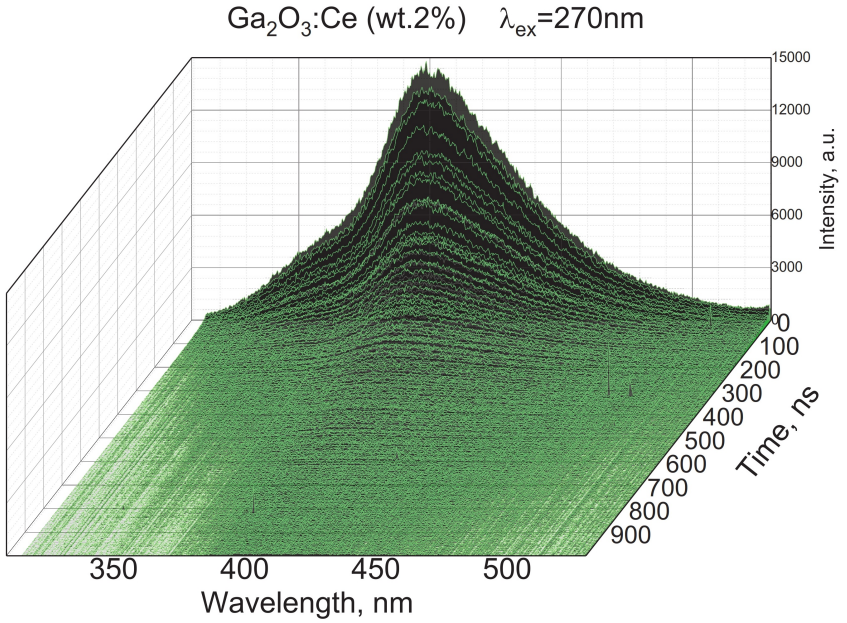
This study provides an in-depth examination of the luminescent properties of Yttrium Aluminum Garnet (YAG) doped with Europium (Eu), Chromium (Cr), and Erbium (Er), synthesized using an electron-beam assisted technique. The study aimed to uncover how these dopants influence the optical characteristics of YAG crystals and explore their potential applications in optoelectronics and photonics. Detailed photoluminescence (PL) and photoluminescence excitation (PLE) spectra were measured for this purpose.

Notably, YAG:Eu ceramics, when excited at a 250 nm wavelength, emitted at 588 nm ($^5D_0 \rightarrow {}^7F_1$), 614 nm ($^5D_0 \rightarrow {}^7F_2$), 653 nm ($^5D_0 \rightarrow {}^7F_3$), and 683 nm ($^5D_0 \rightarrow {}^7F_4$). Additionally, YAG:Cr ceramics emitted at 704 nm ($^3A_2 \rightarrow {}^3T_1$) and 788 nm ($^3A_2 \rightarrow {}^3T_2$) under the same excitation conditions. YAG:Er ceramics exhibited emissions at 402 nm ($^2H_{11/2} \rightarrow {}^4I_{15/2}$), 471 nm ($^4F_{7/2} \rightarrow {}^4I_{15/2}$), 526 nm ($^4S_{3/2} \rightarrow {}^4I_{15/2}$), 539 nm ($^4F_{9/2} \rightarrow {}_4I_{15/2}$), 552 nm ($^4I_{9/2} \rightarrow {}^4I_{15/2}$), 616 nm ($^4I_{11/2} \rightarrow {}^4I_{15/2}$), and 792 nm ($^4I_{13/2} \rightarrow {}^4I_{15/2}$).

Our findings indicate that incorporating Eu, Cr, and Er dopants significantly alters the luminescent properties of YAG. A detailed analysis of the PL spectra showed that each dopant creates unique luminescent centers with distinct emission peaks corresponding to their specific transitions. Thus, the electron-beam assisted method has proven to be highly effective in producing YAG ceramics with customized optical properties.



PB26

Luminescence of Unintentional Impurities in $Gd_3Ga_5O_{12}$ Crystals

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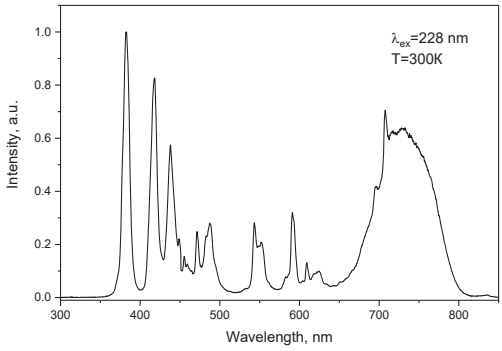
$Gd_3Ga_5O_{12}$ monocrystals were grown using the Czochralski method from an iridium crucible in a mildly oxidizing atmosphere. A mixture of argon (98%) and oxygen (2%) was used as the growth atmosphere. Pure oxides (99.99 wt%) Gd_2O_3 and Ga_2O_3 were used as raw materials. It is known that the presence of tetravalent impurity ions (Si, Zr) in the raw materials leads to the formation of vacancies in the cation sublattice and the occurrence of screw dislocation growth of rare-earth gallium garnet crystals. Undoped GGG single crystals exhibit weak luminescence of gadolinium and uncontrollable impurities, which do not exceed 10^{-3} mass%. The spectra of pulsed photoluminescence are excited by a 228 nm pulsed laser with a 50 μs step. Peaks: 382 nm ($^5D_3 \rightarrow {}^7F_6$), 418 nm ($^5D_3 \rightarrow {}^7F_5$), 438 nm ($^5D_3 \rightarrow {}^7F_4$), 487 nm ($^5D_4 \rightarrow {}^7F_5$), 543 nm ($^5D_4 \rightarrow {}^7F_6$), 583 nm ($^5D_4 \rightarrow {}^7F_4$), 622 nm ($^5D_4 \rightarrow {}^7F_3$) are associated with transitions in Tb^{3+} ions. Transitions 483 nm ($^3P_0 \rightarrow {}^3H_4$), 559 nm ($^3P_1 \rightarrow {}^3H_5$), 616 nm ($^3P_0 \rightarrow {}^3H_6$) are attributed to transitions in Pr^{3+} with a duration of up to 2.5 ms. Peaks associated with transitions in Eu^{3+} ions include: 581 nm ($^5D_0 \rightarrow {}^7F_0$), 591 nm ($^5D_0 \rightarrow {}^7F_1$), 609 nm ($^5D_0 \rightarrow {}^7F_2$), 696 nm shoulder ($^5D_0 \rightarrow {}^7F_4$), 707 nm ($^5D_0 \rightarrow {}^7F_4$). A broad luminescence band at 728 nm ($^5E \rightarrow {}^4A_2$) is associated with Cr^{3+} ions [1]. Terbium and Europium centers have a photoluminescence duration of 5-8 ms. Chromium centers fade quicker, within 500 μs. Luminescence at 750 nm is associated with the lattice luminescence. A large Stokes shift between the absorption and emission of lattice luminescence indicates that the lattice luminescence of GGG is created due to the excitation of free holes and/or electrons in the bands. The temperature dependence of luminescence and lifetime (7-300K) of all identified unintentional impurities was measured.



[1] Akihiro Yamaji et.al. Luminescence Properties of $Gd_3Ga_5O_{12}$:Cr Single Crystals//IEEE Transactions on Nuclear Science – 2014. – Vol. 61(1). – P. 320-322

PB27

Phosphate matrix-based phosphors for luminescence in UV spectral range

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Materials with luminescence in the ultraviolet (UV) region are a very active and promising field of research due to their potential applications in photocatalysis, photochemistry, and medicine [1]. For short-wave UV luminescence, a matrix and an activator with appropriate electronic levels are required. UV-C light emission is usually associated with wide-band gap matrices doped with rare earth elements, such as Pr^{3+} and Bi^{3+}. Phosphates are attractive candidates for UV luminescence due to their wide band gap and chemical stability.

Phosphate materials were synthesized using solid-state synthesis and material chemical composition was determined using x-ray diffraction (XRD). Additionally, electron paramagnetic resonance (EPR) and photoluminescence measurements were carried out to determine the possible UV luminescence mechanisms.

The presentation highlights the use of phosphate matrices doped with Pr^{3+} and Bi^{3+}, which have shown promising results for UV emission.

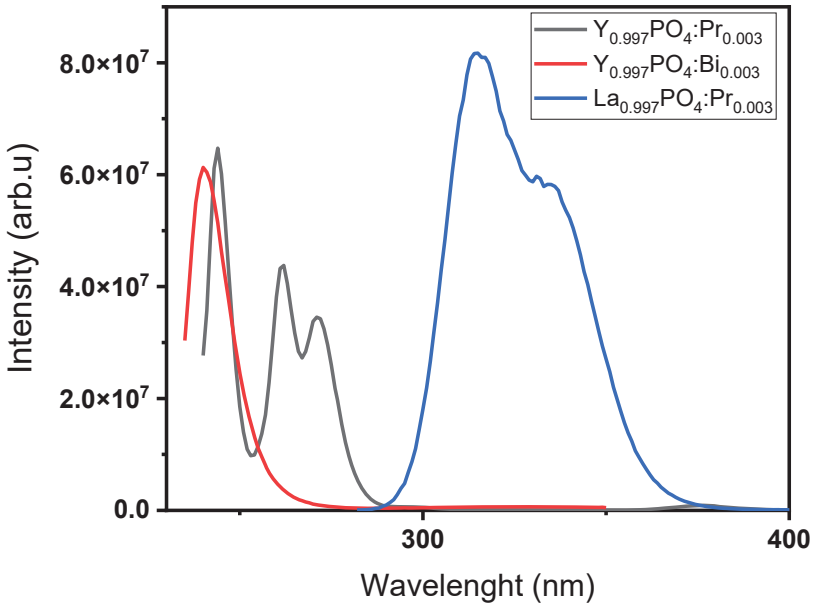

Fig. 1 Luminescence spectra of YPO_4 and $LaPO_4$ materials doped with Pr^{3+} and Bi^{3+}

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[1] Sharma, S.K.; James, J.; Gupta, S.K.; Hussain, S. UV-A,B,C Emitting Persistent Luminescent Materials. *Materials* **2023**, *16*, 236.

Latvian Council of Science, project “Defect engineering of novel UV-C persistent phosphor materials”, project No. LZP-2021/1-0118 is gratefully acknowledged.

PB28

Swift Heavy Ions Induced Defects Influence on Optical and Luminescent Properties of $Gd_3Ga_2Al_3O_{12}$ Single Crystals

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Scintillators, or detectors of ionizing radiation, are utilized in high-energy physics and fusion applications. The research and development of scintillator materials and devices for the detection of ionizing radiation is one of the priorities of CERN. Cerium-doped $Gd_3Ga_2Al_3O_{12}$ (GGAG:Ce) is a promising scintillator material with a high light yield and high density. Its relatively long afterglow of Ce^{3+} emission has been found to be countered by co-doping GGAG:Ce with divalent ions, such as Mg^{2+} which accelerate the Ce^{3+} emission.

As scintillators are naturally subjected to radiation damage, their influence on the material properties should be thoroughly studied. Radiation damage strongly influences the stability of scintillator parameters under ionizing radiation. The aim of this work was to evaluate the influence of swift heavy ions on GGAG:Ce,Mg single crystals, which were irradiated with several different fluences in the range $6.6 \cdot 10^{10} - 1 \cdot 10^{14}$ cm^{-2}. The irradiation of the crystals have been carried out using the DC-60 heavy ion accelerator (Astana, Kazakhstan). Optical and luminescence spectroscopy was utilized to study the induced radiation defects in GAGG. Special attention was paid on the study of luminescence properties of irradiated crystals under vacuum ultraviolet (VUV) excitations of synchrotron radiation. Synchrotron based experiments have been conducted on two European synchrotron facilities: P66 beamline at DESY (Hamburg, Germany) and FinEstBeAMS beamline at MAV IV Laboratory (Lund Sweden).

Induced optical absorption bands have been detected in all crystals studied. Detailed analysis of the induced absorption bands and their thermal stability allows us to attribute them to F-type centers. Furthermore, it was found the induced radiation defects are responsible for the non-radiative losses during the thermalization of charge carriers, which leads to the strong degradation of the excitation spectra in VUV range. Physical mechanisms of the energy absorption and the generation of electron-hole pairs in the conversion stage as well as energy transfer processes in highly irradiated crystals will be proposed and discussed. In addition, in the case of doped materials it will be shown that the induced radiation defects can modify the charge state of the impurities, which leads to the significant alteration of the luminescence properties of the doped materials and degrades their scintillating performance. The change in the oxidation state of cerium ions in irradiated GGAG:Ce,Mg was confirmed by monitoring XANES spectra.

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PB29

The study of $Ag^+(Cu^+)$ center creation in α-quartz crystals by thermal annealing at 1200°C in O_2 atmosphere from metallic Ag and Au

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Previously, the effect of treatment in oxygen at high temperatures on copper luminescence centers in α-quartz was discovered [1]. In this work, we investigated the effect of such treatment on silver centers in α-quartz, known previously [2]. Also, a series of non-activated crystalline α-quartz samples were thermally annealed at 1200◦C in an O2 atmosphere together with metallic Ag.

A characteristic Ag^+ luminescence center with a band at 260 nm was discovered for α -quartz samples thermally annealed in oxygen and initially not containing silver. It is likely that at high temperatures an oxygen-silver complex is formed, which can diffuse into previously no activated samples, and modification of the existing aluminum-alkali metal center occurs, probably due to the replacement of the alkali ion (Me^+) by Ag^+.

An attempt was made to introduce gold into α-quartz by such treatment in oxygen. Both high-purity gold and gold containing parasitic impurities of silver and copper were used. In the latter case, we obtained Ag^+ and Cu^+ luminescence centers but were unable to identify the luminescence of centers associated with gold. When using high-purity gold, neither centers associated with copper and silver nor centers that could be associated with gold were found.

The luminescence center associated with gold was not identified when using pure gold and when attempting to introduce gold by electrolysis.

References:

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PB30

Characteristics of rhombohedral $BaTiO_3$/Graphene (111) surface

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Combined 2D graphene films and transition metal oxides, 2D van der Waals (VdW) materials demonstrate various physicochemical properties at the interfaces of structural elements, forming completely new types of promising properties for various technological needs. Thus, they are promising materials for systems based on heterostructures with base states with tunable responses that are absent in modern VdW materials, including energy-controlled topological states, spin–orbit induced spin states and superconductivity [1].

Design and research of new multifunctional VdW structures of 2D films based on combination transition metal oxides and graphene will lead to fundamentally new and unidentified processes, patterns at the interface of structural elements, creating a new base for multifunctional materials in the nanoscale range. Reproduced rhombohedral phase bulk band gap presented in Fig. 1.

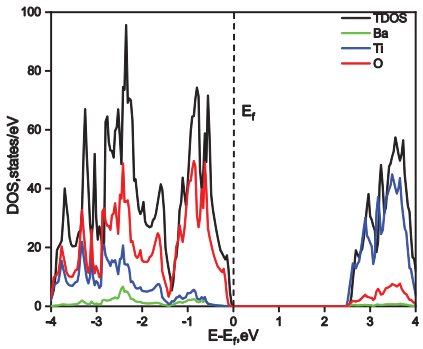

Fig.1. The electronic DOS of a rhombohedral phase of $BaTiO_3$. The Fermi level is taken equal to zero

As we can see from Fig.1, the BaTiO3 calculated optical band gap is equal to 2.5 eV. It is worth to notice, that by Evarestov et al. [2] by means of the DFT PBE functional calculated band gap for the BaTiO3 bulk is 2.7 eV, so our result good agreement with this. Reproduced band gaps of BaO_3- and Ti-terminated rhombohedral phase $BaTiO_3$ (111) surfaces band gaps are 2,33 eV and 0,63 eV, respectively.

It is seen from results of theoretical research that at an graphene layered BaO_3 terminated $BaTiO_3$ (111) surface strongly reduced the band gap and vanishing. Demonstrated the sensitivity of the electronic properties of $BaTiO_3$ (111) surface on combination of low dimensional systems. The main source of energetic diversity is most likely caused by charge redistribution between ions of surface and graphene.

References:

[1] Liu, Y., Van der Waals Heterostructures and Devices. *Nature Reviews Materials,* Vol.1, **2016,** 16042.

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PB31

Luminescence and ESR characterisation of quartz extracted from granite source rocks and the derived sediments used for provenance studies

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Quartz luminescence sensitivity as well as some ESR signals have been proposed as potential indicators for the provenance of sediments. For a signal to be useful for determining provenance it must be stable or reach a quantifiable steady equilibrium level that corresponds to the same level as attained in the host rock. On the other hand, for a signal to be used as a sediment tracer it must change in a predictable and quantifiable way during transport. Luminescence sensitivity of quartz is conventionally defined as luminescence emitted in response to a given dose per unit mass. While it is largely believed to be acquired by Earth surface processes, recent studies bring empirical evidence that sensitisation processes are a function of source geology or a combination of both.

Some ESR signals, such as the heat-treated E', the native E', peroxy or Al and Ti related defects have been proposed to have such properties, but a field study necessary to test that hypothesis by directly comparing the properties of sediments to those of the source rock has not been conducted so far.

Here we investigate the luminescence (OSL and TL) and ESR properties of quartz extracted from granite rocks and their related sediments that show different sensitization behaviour. Sampling was focused on simple catchments draining a single granite lithology of known age. Catalina granite and the derived sediments were collected from the Basin and Range geology in southeast Arizona, USA. Retezat granite and sediments were collected from the Retezat Mountains in Romania.

The natural sensitivity of quartz extracts is similar for Catalina and Retezat granite. We observe that the sediments derived from Catalina granite are up to 250 times more sensitive than the source rock while the Retezat granite and the derived sediments have similar sensitivity. Laboratory sensitization experiments comprising 159 cycles of irradiation and optical bleaching induce a ~ 5 times increase in the luminescence signal displayed by the quartz extracted from the Catalina granite whereas the sensitivity of quartz from Retezat granite is unchanged. The derived sediments have a similar behaviour to their source rock. As such, we propose that sensitization first requires a “potential” given by the existence of the precursors of the activated traps that can be enhanced by the effect of environment. This is investigated by looking at the ESR signals. E’ and peroxy are higher in Retezat granite while the saturated Al-h is higher in Catalina granite. No visible Ti is identified Retezat granite.

Further analyses on the capacity on the luminescence and ESR signals to carry genetic information from the granite parent to the sediment are required. These investigations will contribute to the development of a quartz fingerprint method that can have a significant impact on quantitative provenance studies.

Keywords: OSL, TL, E’, peroxy, quartz, granites, sediments

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PB32

Study of the influence of varying compositions for producing lithium-containing ceramics on changes in structural and optical properties determined using optical spectroscopy and luminescence methods

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The work examines the influence of variations in the compositions of components for the production of lithium-containing ceramics based on lithium metazirconate, obtained by the method of mechanochemical grinding and subsequent thermal sintering. To vary the components, two compositions containing zirconium dioxide (ZrO_2) and two different types of lithium-containing components, lithium perchlorate ($LiClO_4 \cdot 3H_2O$) and lithium carbonate (Li_2CO_3), were used, changing the concentration of which made it possible to obtain two-phase types of ceramics with different contents of impurity phases. Using the methods of optical and Raman spectroscopy, in combination with X-ray diffraction, it was found that the use of $LiClO_4 \cdot 3H_2O$ leads to the formation of a monoclinic phase Li_2ZrO_3 with impurity inclusions in the form of the orthorhombic phase LiO_2, and in the case of using Li_2CO_3, the resulting ceramics are a mixture of two phases Li_2ZrO_3 and Li_6Zr2O_7. In the course of the studies, it was established that the formation of impurity inclusions in the composition of ceramics leads to an increase in the stability of strength properties with varying mechanical test conditions, as well as stabilization of thermophysical parameters and a decrease in thermal expansion during long-term high-temperature tests. It has been established that in the case of two-phase ceramics $Li_2ZrO_3/Li_6Zr_2O_7$ in which the dominance of the Li_6Zr2O_7 phase is observed, during high-temperature mechanical tests a more pronounced decrease in resistance to cracking is observed, due to thermal expansion of the crystal lattice.

PB33

Hardening effect and structural changes in $ZnWO_4$ crystals irradiated with swift ^{6}C, ^{8}O, ^{36}Kr and ^{54}Xe ions

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Formation of ion-induced defects and modification of optical and other properties in advanced materials was a topic of active studies in recent decades [1]. In the present report, the ion-induced effect on the hardness and structure of $ZnWO_4$ crystals irradiated with light 19 MeV ^{6}C and 28 MeV ^{8}O ions and heavy 147 MeV ^{36}Kr and 231 MeV ^{54}Xe ions was investigated. $ZnWO_4$ crystals were selected as a promising material for modification of optical and related properties [1] and as a material exhibiting suitable cleavage property. The variation of hardness and structure along the ion path was investigated on profile surfaces prepared by cleaving of ion-irradiated $ZnWO_4$ samples. Indentations were performed by Vickers hardness tester ensuring vibration damping [2]. The size of imprints was measured by AFM.

The results show that all studied ions produce a hardening effect in the $ZnWO_4$ crystal.

The effect appears at $10^{13} cm^{-2}$ fluency for investigated light ions and 10^{11} cm^{-2} fluency for heavy ions. Such fluencies correspond to the initial stage of ion track overlapping. ^{6}C ions showed the highest hardening effect. Its value at fluency of 10^{14} $^{6}C/cm^{2}$ was 100%, while the maximum effect observed for the other ions was 40-58%. Further increase of fluency leads to increase of brittleness and even to decomposition of samples. The values of threshold energy loss and average absorbed energy for hardening were determined.

Structural study of profile surfaces for irradiated samples revealed the trend to produce layered or columnar structures along the ion path containing submicron size clusters. In several cases, the structure resembling helical screw type dislocations was observed. Such dislocations were revealed earlier in $Gd_3Ga_5O_{12}$ crystals. Irradiation at high fluencies leads to formation of a brittle small-grained structure cracking and destructing under indentation.

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PB34

Time-Resolved Luminescence of Embedded Mixed-Halide Perovskite Nanocrystals

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Lead-halide perovskites have unique optical properties, such as a direct-bandgap, large absorption and emission coefficients, narrow luminescence bands, defect-tolerance, and the possibility to shift the optical properties throughout the entire visible region by mixing halogens in the composition and changing their sizes [1]. Thereby, many potential applications of the perovskites have been proposed. However, among others the application as scintillators is especially interesting, because perovskite nanocrystals have short luminescence decay time in nanosecond and subnanosecond range [2,3].

In current research we synthesized mixed-halide perovskite nanocrystals $CsPb(Br_xI_{1-x})_3$ with several different Br/I ratios, which are embedded into borogermanate glass. Time-resolved luminescence properties of obtained nanocrystals have been studied under vacuum ultraviolet (VUV) excitation in wide temperature range (10-300K). The experiments have been carried out at Superlumi beamline at Photon Science Division of DESY synchrotron facility.

The average lifetime of the series of the embedded perovskite nanocrystals was in the range of 100 ps – 21.5 ns and consisted of two to three components. The trends of the change of quantum yield and average lifetime with the change of perovskite nanocrystals composition appeared to be the same, that is these quantities increased with Br/I ratio decrease in the mixed nanocrystals. In addition, it was shown that the synthesized embedded perovskite nanocrystals can be used as an effective wavelength shifter for ultraviolet ultrafast luminescence for instance cross-luminescence in BaF_2.

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PB35

Optical absorption, photoluminescence and Raman scattering of $LiNbO_3$ single crystals irradiated by $^{84}Kr^+$ ions

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The experimental results of the irradiation effect by $^{84}Kr^+$ ions with an energy of 1.75 MeV/nucleon up to fluences 10^{13}-10^{14} cm^{-2} on the spectra of optical absorption, photoluminescence, and Raman scattering of $LiNbO_3$ will be presented. The plane-parallel plates with dimensions of 15(X)×10(Y)×3,6(Z) mm^3 were made of a single crystal and were used for investigation. All faces of these plates were polished. The ions flux was directed along the crystallographic direction Z. After irradiation of the specimens, two bands can be distinguished in the induced absorption spectra of crystals, – one with a maximum near 320 nm (adjacent to the fundamental absorption edge) and another – wide band with a maximum near 450 nm. The magnitude of the induced changes in the spectra increases with the increase of ion fluence. Furthermore, the luminescence in a wide band with a maximum near 450 nm is also significantly enhanced after irradiation. The luminescence was excited in the region of the $LiNbO_3$ fundamental absorption at a wavelength of 280 nm. In addition, it was found that Raman scattering spectra from the irradiated crystal surface differ from those in the undamaged part of the sample. Depth profiles of changes in Raman spectra from the irradiated surface to the depth of the crystal were obtained. It has been established that the spectra take the form characteristic of an undamaged crystal at a distance of no more than 5 μm from the irradiated crystal surface. Comparative investigations of changes in Raman spectra distribution profiles and theoretical calculations of the stopping power distribution profile of incident krypton ions in $LiNbO_3$ target were performed. The nature of the observed changes in the properties of the crystals after irradiation is discussed

PB36

Thermostimulated luminescence properties of neutron and thermochemically-reduced $Y_3Al_5O_{12}$

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$Y_3Al_5O_{12}$, single crystals are known for their interesting properties such as high radiation-resistance, high melting point and high thermal conductivity. Consequently, they are candidates to several technological applications such as fusion energy devices and nuclear applications. Irradiation of single crystal $Y_3Al_5O_{12}$ in the reactor (i.e. fast and thermal neutrons and gamma radiation) produces many color centers (such as F-type center, interstitials [1-5] and many others) in the material. Similar defects are also formed by heavy ion irradiation or by fast electrons, while only electronic processes are important in the case of UV, X-ray and low energetic electron irradiation..

In this presentation we report the results of the thermostimulated luminescence measurements, performed between 300 and 720°K of the stored energy in $Y_3Al_5O_{12}$ single crystals, irradiated by fast neutrons with fluences of 2.1×10^{17} or 2.18×10^{19} n/cm^2, or also by 1.8 MeV electrons, or thermochemically reduced.

A clear pronounced dose effect was found and analyzed. In particular, four TSL peaks were observed in $Y_3Al_5O_{12}$ samples subjected 2.18×10^{19} n/cm^2, while in sample subjected 2.16×10^{17} n/cm^2, only three TSL peaks were detected. A comprehensive kinetic analysis of the glow peaks in $Y_3Al_5O_{12}$ is performed. As usual, each TSL peak is characterized by the appropriate activation energies, which both crystals are 0.8 – 1.3 eV. The obtained values are compared with the appropriate activation energies for F-type center annealing in neutron- and heavy-ion irradiated $Y_3Al_5O_{12}$ as well as also with similar TSL data for Al_2O_3 and $Y_3Al_5O_{12}$ [2-5]. Furthermore, we have also performed a comparative analysis of the photoluminescence properties of a series of neutron-irradiated and non-irradiated $Y_3Al_5O_{12}$ single crystals.

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PB37

Are color centers possible in ceria?

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The color *F* centers (electron trapped in the halide vacancy) are very common defects in alkali halides, identified by means of the ESR and optical absorption/luminescence. In particular, their properties in fluorites (CaF_2, SrF_2 and BaF_2) are very well studied and understood in detail. However, the manifestation of similar defects in binary oxides with fluorite structure (CeO_2 or UO_2) is debated for a long time.

Recently, we successfully applied the Mollwo-Ivey rule (correlation between lattice constant and optical absorption energy) to explain similarity of optical properties of the *F*-type centers in alkali halides, alkaline earth oxides and sulfides with NaCl lattice structure [1]. In this study, we have performed similar comparative analysis of the *F*-type centers in alkaline earth halides and oxides with fluorite structure supported by detailed analysis of the literature. Special attention is paid to oxygen vacancies in CeO_2. Obtained results and conclusions are supported by the first principles calculations of the atomic and electronic structure of defective oxides.

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PB38

Analysis of the self-trapped hole center mobility and recombination in alkali halides and complex metal halides

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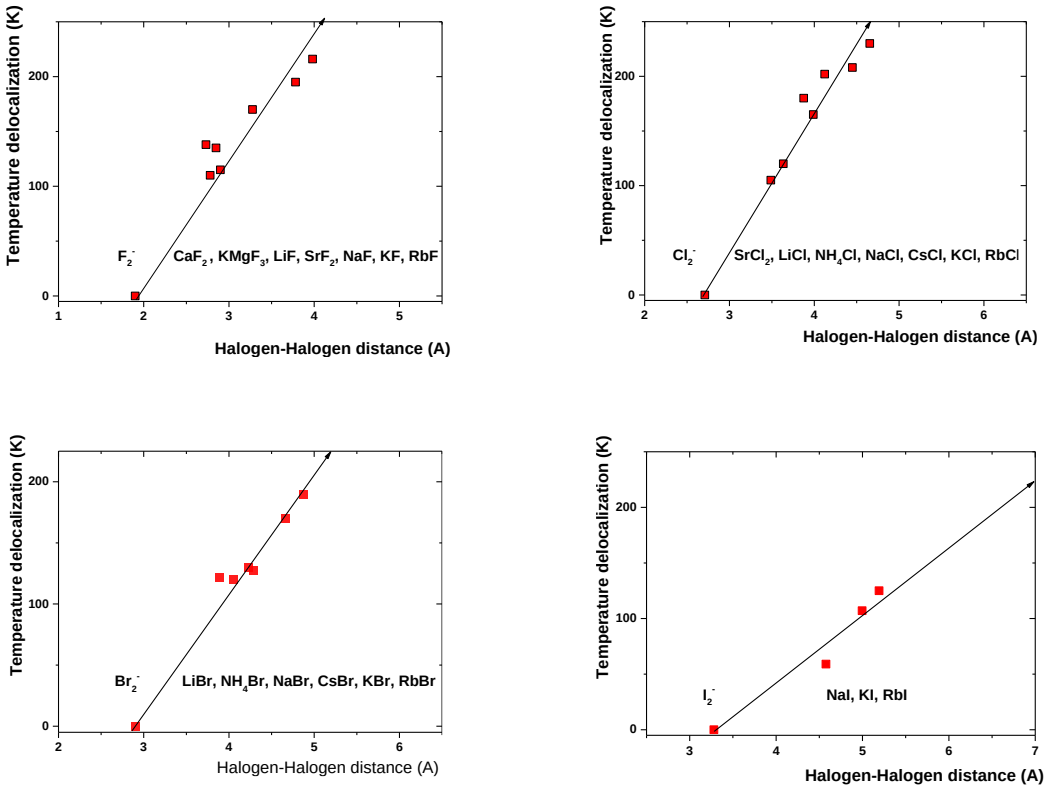
The self-trapped hole polarons (called also V_k centres) where a hole is shared by two nearest halogens, X_2^-) are very common color centers created in alkali halides and alkaline-earth halides under all kinds of irradiation (UV light, electrons, gamma rays, neutrons, heavy swift ions). Their stability controls the secondary reactions between electron and hole defects and thus radiation stability/sensitivity of materials.



In this report, we review and analyse the self-trapped hole center migration temperatures for a series of alkali halides and more complex halides, such as perovskite halides, ammonium halides, as a function of halogen-halogen distance in a regular crystalline lattice as well as of halogen-halogen distance in isolated molecular ions. The results discussed here are especially important for clarification of the self-trapped holes in, for example, large family of perovskite halides and more complex halide materials.

PB39

Thermoluminescence Spectral Properties of feldspars

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Feldspars are minerals commonly used to date Quaternary sediments using long lived luminescence caused by natural ionizing radiadion. These minerals exhibit strong optically (OSL) and thermally stimulated luminescence (TL). Typical OSL and TL glow curves measured both after natural and laboratory applied irradiation are very complex. This suggests a complex structure of the trap levels responsible for the charge carrier capture and recombination.

Spectrally resolved thermoluminescence (SRTL) provides a comprehensive information relating population and energy distribution of trap levels as well as recombination centers in dielectric solids. Advanced measurement, using a sensitive cooled CCD camera combined with a spectrograph, allows to record spectral distribution of luminescence during heating. As a result it provides a three-dimensional diagram - the surface of intensity as a function of wavelength and the temperature. This is important to determine the energy distribution of recombination centers and recombination mechanisms related to TL phenomenon. SRTL requires an advanced theoretical and numerical approach for extracting model parameters from experimental data

Spectrally resolved TL analysis is particularly important in application and analysis of a very complex materials, such as feldspars. The paper presents selected spectral properties of a special feldspar - a microcline from the Strzegom Massif. The mineral was irradiated using a $^{90}Sr/^{90}Y$ beta source with doses up to several kGy. Spectral distribution of the emitted light shows several broad peaks in the range of 340-640 nm. This is interesting that the results could not be directly related to the discrete or continuous distribution of energy levels. Therefore several theoretical models are considered to explain luminescence properties of the mineral.

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