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

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

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

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

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

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

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

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