Contribution ID: **136** Type: **Poster presentation**

Improved cathodoluminescence performance of Mg-doped LuAG:Ce(GdGa) single crystalline films

Thursday, 21 September 2017 10:32 (1 minute)

Cerium activated lutetium aluminum garnet (LuAG:Ce) is a perspective material for applications in detection of X-rays, gamma radiation or high energy particles. However, the luminescence response of LuAG:Ce suffers from structural defects (mainly anti-site defects) that create unwanted slow microsecond-component in decay characteristics. Concentration of these defects decreases with decreasing growth temperature. Therefore, single-crystalline films grown by liquid phase epitaxy have recently attracted a lot of attention because their growth temperature is about half of that of the bulk single crystals grown by the Czochralski method. As shown earlier [1], the proper admixture of Gd and Ga into the garnet structure eliminates the effect of remaining anti-site defects and thus resulting in almost complete suppression of the slow decay component. In addition, such material has exceptionally high light yield (LY) exceeding 50 kph/MeV and its cathodoluminescence (CL) decay is dominated by a fast component with decay time of 50-80 ns. However, this decay time can be still too high, for example, for some special SEM applications where very fast e-beam scanning is required. Thus, new materials with faster decay have to be found. Recently, Mg^{2+}-doped garnet films have been intensively studied, primarily using photoluminescence and radioluminescence [1] but X-rays have high penetration depth in garnets. Consequently, unwanted substrate information is also recorded. The CL solves this problem because electrons having energy of 10 keV don't penetrate deeper than 1 µm under the surface. Therefore, CL was selected as the optimal tool for specimen characterization.

For the purpose of this work, set of Mg^{2+}-doped LuAG:Ce and set of Mg^{2+}-doped LuAG:CeGdGa multicomponent epitaxial films (thickness around 17 µm) with different Mg concentration (0-700 ppm) were grown from lead-free BaO-B_2O_3-BaF_2 flux. The films were excited by an e-beam with energy of 10 keV using a specialized CL apparatus [2]. The CL spectra, CL decays under nanosecond and millisecond excitation and thermoluminescence glows in the temperature range between 100 and 490 K were obtained.

Firstly, it was shown for both sets of specimens that the CL decay time of the fast component related to the 5d-4f transition at Ce^{3+} sharply decreased with increasing concentration of Mg^{2+}. For LuAG:CeGdGa with the highest concentration of Mg^{2+}, the decay time was only 28 ns. Secondly, considerable reduction of the afterglow (signal at 1 µs after e-beam cut off) for highly Mg^{2+}-doped specimens was observed. The afterglow of 3.1 % for Mg^{2+}-free LuAG:Ce was reduced down to 0.037 % in case of highly Mg^{2+}-doped LuAG:Ce, and even down to 0.015 % in case of highly Mg^{2+}-doped LuAG:CeGdGa. This is the best afterglow value ever reported for garnets so far. Finally, Mg^{2+}-doping has no influence on the start of thermal quenching, i.e. the quenching start is determined by the host composition, mainly by the Ga/Al ratio. Unfortunately, all these observations come at the expense of LY, however, the LY is still comparable to that of YAG:Ce.

Acknowledgement: The research was supported by Czech Science Foundation (GA16-05631S), by MEYS CR (LO1212), its infrastructure by MEYS CR, EC (CZ.1.05/2.1.00/01.0017) and by CAS (RVO:68081731).

[1] P. Průša *et al*, Adv. Optical Mater. 5 (2017) 1600875.

[2] J. Bok *et al*, Rev. Sci. Instrum. 82 (2011) 113109.

Has accepted

Primary author: Mr LALINSKÝ, Ondřej (Institute of Scientific Instruments of the CAS)

Co-authors: Dr SCHAUER, Petr (Institute of Scientific Instruments of the CAS); Dr LUČENIČOVÁ, Zuzana (Charles University, Faculty of Mathematics and Physics); Prof. KUČERA, Miroslav

Presenter: Mr LALINSKÝ, Ondřej (Institute of Scientific Instruments of the CAS)

Session Classification: Poster Session 3

Track Classification: P5_characterization