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

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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.

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