Retųjų žemių elementų jonais legiruotų naujų stiklų ir granatų tyrimas

Investigation of novel glasses and garnets doped with rare earth ions

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Due to their low price and unsophisticated production method two component glasses are an attractive material platform for rapid prototyping of novel scintillators. The amorphous structure of glass also enables reaching high doping concentration leading to efficient excitation transfer and short emission decay lifetimes. Meanwhile, garnets are a very flexible class of materials that allows for engineering of the excitation transfer process and luminescence properties by creating solid solutions with lighter cations. The garnets composed of lighter ions are preferable for harsh radiation environments in high energy physics experiments.

Two sets of samples were investigated in this study. The first set consists of two-component silicate glasses doped with different rare earth ions. Cerium, terbium, dysprosium, and europium were used to dope barium, lithium, calcium, and strontium glasses. The influence of heat treatment on luminescence properties of glass samples was investigated. The second set of samples consists of modified cerium-doped yttrium aluminum garnets. Magnesium or calcium atoms were used to partially substitute yttrium atoms in the base garnet, meanwhile germanium was used to partially substitute aluminum atoms: $Y_2MgAlGe(AlO_4)_3$:Ce and $Y_2CaAlGe(AlO_4)_3$:Ce .

Confocal photoluminescence (PL) spectroscopy was used to study the samples. A WITec Alpha 300 S microscope system coupled via fiber to a thermally cooled CCD camera and 405 nm and 442 nm laser light sources were used. Equipping the microscope system with a high-numerical-aperture objective allowed us to perform spatially-resolved measurements with sub-micron in-plane resolution. Measurements of photoluminescence excitation spectra and XRD crystal structure investigation were also performed.

The results of studying the first set of samples showed that different rare earth ions are affected by composition of the glass matrix in different ways. Europium-doped glasses strongly depend on the composition of the glass matrix, while cerium-doped glasses show little sensitivity to the matrix composition. The emission spectra of other combinations of rare earth ions and glass hosts are also presented and discussed.

Investigation of garnet samples revealed that the partial substitution of yttrium by magnesium or calcium and aluminum with germanium does not result in any significant distortion of the crystal lattice (Fig. 1).

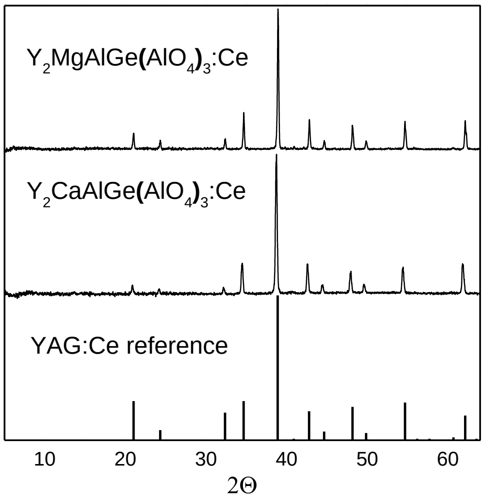

Fig. 1. XRD patterns of YAG:Ce garnets with Mg, Ca and Ge substitution and YAG:Ce for reference.

The study of emission spectra with spatial resolution revealed that all the aggregates exhibit similar PL spectra. This is an indication of good structural quality of the novel garnets. We observed that incorporation of magnesium into the garnet structure results in a red shift of the cerium ion emission by 7 nm in respect to that in garnets where calcium was used instead of magnesium. Thus, the emission wavelength of cerium is tunable by garnet composition, while the incorporation of magnesium and calcium does not result in formation of structural phases other than the garnet-type single crystal, provided that the growth conditions are optimized.

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