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Lithium di-silicate Li2O·2SiO:Tb bright scintillation glass for thermal neutron detection

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Among the variety of scintillating inorganic materials glasses hold a unique position. They are transparent, easly handled, environmentally friendly, cheap to produce, and can be easily obtained in different forms in short times: from bulk to fibers. However, the disordered structure of the atoms in a glass and the presence of structural defects cause low efficiency transfer of electronic excitation to emitting centers preventing the achievement of a high scintillation yield. So far, encouraging results have been obtained with sol-gel SiO_2 doped with Ce [1] and with other glasses with stoichiometric composition, in particular di-silicates [2].

Lithium di-silicate system, with $Li_2O{\cdot}2SiO_2$ (DSL) composition and doped with Ce ions, can be obtained in the form of glass ceramics which have advantages with respect to glasses. Glass-ceramics, in fact, combine the luminescent properties of rare-earth ions in crystallites with the morphological ones of the remaining mother glass. Indeed, partially crystallized DSL glass, doped by Ce ions, and containing nano-crystallites of $Li_2Si_2O_5$ displays a light yield of more than 7000 ph/neutron and provides energy resolution for thermal neutrons better than 8.5%.[2]

In the present work, photo- and radio-luminescence properties of DSL glass doped with Tb ions were studied. DSL glasses doped by Tb^{3+} ions were obtained by heat treatment of a mixture of Li_2CO_3, SiO_2 and Tb_4O_7 in a gas furnace (in CO atmosphere) at a maximum temperature of 1450 °C for 2 h. Tb concentration was set to 0.6 at. % with respect to Li ions. The obtained samples were annealed at 500 °C for 4 h in a muffle furnace to reduce stress. Bulk glass was found to be colorless. The samples for this study were cut from the synthesized blocks in 1mm thick plates and polished.

Both photo- and radio-luminescence spectra showed bright narrow bands corresponding to $^5D_4 \rightarrow {}^7F_j$ Tb^{3+} electronic transitions (490, 545, 590 and 620 nm respectively for j = 6, 5, 4 and 3). The integrated radio-luminescence emission intensity of DSL:Tb glass was found to be two times higher than that of a BGO single crystal reference, measured at room temperature and in the same experimental conditions. So, the light yield was estimated to be 25000 ph/neutron. Although the scintillation kinetic is rather slow due to the forbidden nature of the Tb^{3+} 4f-4f transitions, its high light yield still makes DSL:Tb a very promising material for applications in threshold neutron detectors, where the sensitivity to neutrons is particularly important.

[1] A. Vedda e al., Chem. of Materials, 18, 6178 (2006).
[2] P. Lecoq, A. Gektin, M. Korzhik, Inorganic Scintillators for Detector Systems: Physical Principles and Crystal Engineering, Springer International Publishing (2016).

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