Thin-Film Oxide Scintillators

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In scintillators, the high energy particles (electrons, protons, neutrons, alpha particles) or photons (X- rays or gamma rays) excite electrons in atoms, which thereafter return to the ground state accompanied by emission of visible or UV photons. These photons are easily detected by existing photodetectors. The de-excitation can be prompt (in nanosecond time scale) or delayed (milliseconds up to hours).

The films with thickness of several micrometres are used in high resolution electron or X-ray screens and in various applications for imaging of microscopic objects with submicron spatial resolution. The single crystalline film scintillators have found applications in many synchrotron X-ray light sources where luminescence image of a scintillation screen is coupled to a CCD digital camera.

The single crystalline films can be grown by the liquid phase epitaxy (LPE) from the flux. The LPE is a versatile method suitable for the growth of films of typical thickness from submicron to tens of microns on single crystal substrates. The method is more flexible as compared to the growth of bulk single crystals by Czochralski or Bridgman methods and is often used in material research for development of new scintillators.

Here we focus on oxide scintillator films, particularly aluminium garnets, perovskites, and oxyorthosilicates doped with rare earth ions, especially Ce^{3+} and Pr^{3+}. Their luminescent and scintillation properties will be reviewed and discussed in comparison with bulk single crystal counterparts. Special attention will be paid to recently discovered high efficient multicomponent garnets $(LuGd)_3(GaAl)_5O_{12}$:Ce (GAGG:Ce) due to their particularly high light yield (up to 58000 photon/MeV) approaching their theoretical limit and good energy resolution reaching 4.2% at 662 keV [1]. The scintillation characteristics of this garnet system are further improved by intentional co-doping by divalent Mg^{2+} or Ca^{2+} ions which results in significant reduction of the afterglow signal and thermoluminescence signal [2-4]. These results demonstrate significant suppression of shallow electron traps which otherwise result in parasite delayed emission or non-radiative recombination channels with negative influence on scintillation properties. The favorable role of Mg^{2+} doping of GAGG:Ce is mostly caused by creation of tetravalent Ce^{4+} ions as effective electron trap center which successfully compete with the intrinsic electron traps [2].

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