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Shaped crystal growth of novel oxide scintillators by the edge defined film fed growth method

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Scintillator materials are used for radiation detection applications such as medical imaging techniques, high energy, homeland security, well loging, nuclear physics detectors, etc. In the last two decades, great R&D effort brought several novel scintillator material systems[1-4], namely the Ce-doped orthosilicates as Lu2SiO5 (LSO), Y2SiO5 (YSO), pyrosilicates based on(La,Gd)2Si2O7 (La-GPS), aluminum perovskites as LuAlO3 (LuAP), YAlO3 (YAP) and garnets as Lu3Al5O12 (Ce:LuAG), Y3Al5O12 (Ce:YAG), Ce:Gd3(Al,Ga)5O12(GAGG). These scintillator single crystals are commercially produced by the Czochralski method using Ir crucibles because of their high melting point around 1900-2130 ℃. At the production higher material costs of Ir crucibles and their repairing costs occupy most of the crystals costs.
Scintillator crystals are used mainly as rectangular shaped pixels which are processed from 3-4 inch diameter bulk single crystals. These processing costs are substantially an economic burden, too.
Up to now, shaped crystal growth of sapphire single crystal with shapes of tube, plate, fiber, etc was commercially developed by Edge defined Film Fed Growth (EFG) method [2]. Recently a few companies are producing shaped sapphire single crystal by EFG method using Mo crucible and die. Mo is several hundreds times lower cost material than Ir. Shaped growth by the EFG method using the low cost Mo crucible and die is a today's factor of cost reduction of sapphire. In this study, possibility of mass production of above mentioned oxide scintillators by the EFG method using Mo crucible and die is investigated.
At the beginning of this study, reactivity and contact angles of these oxides melts and Mo were investigated. A EFG furnace equipped with a graphite resistive heating unit and shields was used for these investigation under Ar atmosphere. Each oxides powder are melted in Mo crucibles. Radioluminescence, Mo contamination measurements by ICP and powder XRD are performed to check the reactivity. Mo dies are designed according to the contact angles. For example, Ce doped LuAG and YAG were grown using 1 x 30 mm Mo dies at a growth rate of 0.3mm/min under Ar atmosphere using <100> LuAG seeds. 1 x 30 x 50mm plates of Ce doped LuAG was successfully grown by the EFG method. Ce3+ 4f5d emission was observed 500 nm. Light yield was comparable to a Cz standard sample and around 18000 photon/MeV. Mo contamination was around 52 ppm. There is no harmful effect from the usage of Mo for the growth of Ce:LuAG scintillator. Furthermore 10 x 10 x 30mm Ce:YAP, Ce:La-GPS, Ce:YSO, Ce:LSO crystals were grown by the EFG method. In our presentation, details on reactivity, contact angles, Crusible and die designs, growth conditions, Mo contamination, chemical composition analysis, optical and scintillation properties of the grown crystals will be discussed.

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