Contribution ID: **40** Type: **Oral presentation**

Comparative study of rare-earth aluminate scintillation crystals fabricated under different conditions

Friday 22 September 2017 09:15 (15 minutes)

Currently, Ce- or Pr-doped rare-earth aluminates with the garnet and perovskite structures, Y3Al5O12 (YAG), Lu3Al5O12 (LuAG), YAlO3 (YAP), as well as Al/Ga substituted garnets are the candidates for a range of scintillation applications, including future HEP experiments at colliders. High melting temperatures of garnets and the need for expensive Ir crucibles and shields stimulates the development of less costly crystal fabrication technologies. For instance, garnets and perovskites have been successfully grown in Mo and W crucibles under the reducing Ar+H2 atmosphere conditions by the Bridgman [1] and Czochralski [2] methods. The reducing atmosphere is necessary to avoid Mo(W) oxidation and melt contamination by its products.

This report represents a novel fabrication process of undoped, and Ce3+, Pr3+, Sc3+-doped YAG and LuAG, as well as perovskite crystals (YAlO3, CeAlO3) by the Czochralski and EFG methods in Mo and W crucibles under the reducing Ar+CO atmosphere. This method has potential advantages over the growth under H2, namely, avoiding the use of explosive H2, as well as substitution of expensive ZrO2 and corundum heat insulation with graphite.

Optical and scintillation properties of the crystals fabricated by the different methods are discussed. Creation/elimination of point defects, or change of valence state of admixtures, which act as electron or hole traps, are the cause of garnet crystals coloration. Therefore, the reversible coloration/discoloration of YAG grown under neutral atmosphere (Ar) is controlled by post-growth thermal annealing in reducing/oxidizing atmosphere, correspondingly. Meanwhile, the coloration of garnet crystals grown under Ar+CO can be eliminated irreversibly by the oxidizing or reducing high-temperature annealing. This is an evidence of more complex mechanisms of defect formation in YAG grown under the Ar+CO involving carbon and/or Mo(W) admixtures. Carbon is introduced into garnets due to interactions of melt and crystal with Ar+CO atmosphere. The carbon concentration in as-grown YAG determined by the element analysis is ˜10-2 wt%. As carbon oxidation state may vary from -4 to +4, it may act as an active electron trap and compete with color centers for electron capture. This explains why an expected increase of concentrations of oxygen and Al vacancies in YAG:C under the reducing annealing not results in formation of color centers. A similar mechanism of trap decoration by hydrogen and elimination of trapping at cation vacancies in YAG crystal grown under H2 atmosphere was suggested [3].

From the practical point, such features of crystals grown under Ar+CO open new possibilities to optimize the scintillation properties of rare-earth aluminates. The presence of active electron traps makes it possible to transfer activators (Ce, Pr, or Nd) into the optically active lower valence state by the reducing annealing thereby increasing a quantity of luminescence centers without a loss of crystal transparency.

The work is supported by the H2020-MSCA-RISE-2014 Project No. 644260 (INTELUM).

[1] A. Petrosyan, J.Cryst.Growth139 (1994) 372.

[2] J. Houžvička, K. Bartoš, Patent US 9,499,923 B2 (2016).

[3] F. Selim, C. Varney, M. Tarun, et al, Phys. Rev. B88 (2013)174102.

Author: SIDLETSKIY, Oleg (ISMA)

Presenter: SIDLETSKIY, Oleg (ISMA)

Session Classification: Crystal growth

Track Classification: S14_Crystal growth 2 (Oral)