Growth of $(Lu_{1-x}Tb_x)_2O_3$ single crystals by the Optical Floating Zone

Padmanaban A.[1], Cajzl J.[1], Sidletskiy O.[1]*
*lead presenter: e-mail oleg.sidletskiy@ensemble3.eu
1 Ensemble3 Center of Excellence, Warsaw, Poland

Tb-containing materials are known as efficient Faraday rotators. The highest possible Tb content is necessary to miniaturize the devices, while single crystals should be transparent in optical band and possess a cubic lattice. While the commercially available $Tb_3Ga_5O_{12}$ accommodates 15 at% of Tb, the search is ongoing for other Tb-containing garnets [1, 2] with optimized transmission and optimized Verdet constant, while other alternatives such as TbO(OH) or $Tb_xYb_{(2-x)}O_3$ [3] are also considered. Terbium oxide Tb_2O_3 may potentially accommodate up to 40 at% of Tb. However, the process of obtaining Tb_2O_3 single crystals from melt is complicated by polymorph transitions and very high crystallization temperature of over 2500 ºC. The region of the polymorph transitions in sesquioxides may be bypassed when decreasing the size of the rare earth ion in Tb-containing solid solutions [4]. The issue of high temperatures may be resolved by using crucible-free methods, such as Optical Floating Zone (OFZ).

We report a study on the crystal growth of $(Lu_{1-x}Tb_x)_2O_3$ (x = 0–1) using the OFZ technique. Raw materials of the $(Lu_{1-x}Tb_x)_2O_3$ solid solutions were synthesized by solid state reaction route. Initially, the rare-earth oxides were preheated at 950 °C for 12 h to remove any moisture content on it. Then, the stoichiometric amount of material was reground and heated again at 1250 °C for 24 h several time to get the monophase composition. The synthesized powders were isostatically pressed at a pressure of about 70 MPa to have the feed and seeds rod for crystal growth. The rods were sintered at 1200 °C for 24-48 h.

Growth conditions like growth rate, feed and seen rod rotations, growth atmosphere, molten zone length were varied to yield crack free crystals. Initial growth runs were performed using sintered rods as seeds due to the non-availability of the single crystals. $(Lu_{1-x}Tb_x)_2O_3$ single crystals of 2-7 mm diameter and 30 to 50 mm in length were grown at a growth rate of 4-6 mm/h. The crystals were characterised using powder X-ray diffraction at room temperature. $(Lu_{1-x}Tb_x)O_3$ crystallized in cubic structure ($I2_13$ space group). Structural analysis carried out by Rietveld refinement of PXRD data demonstrated that the volume and lattice parameters increase with increasing Tb^{3+} substitution at Lu^{3+} site. Transparency over the entire visible spectrum was determined.

Authors acknowledge the support from the “ENSEMBLE3” project (GA no. MAB/2020/14) carried out within the International Research Agendas program of the Foundation for Polish Science and Teaming for Excellence project (GA no. 857543)”.

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