Y-stabilized hafnia as a potential scintillating material for ionizing radiation detection

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Beside the improvement in performance of already applied scintillators, the research focuses on finding new scintillating materials and further characterizing less known materials. One of the potential, yet not fully investigated, materials is hafnia (HfO_2). Due to its high density it can be employed as a heavy matrix with high stopping power and therefore suitable for high energy physics, for example. Hafnia has three polymorphs. The monoclinic phase is the low-temperature polymorph that transforms into the tetragonal phase at 1800 °C and, upon further heating, the cubic phase is obtained at 2630 °C; the band-gap of the cubic phase was reported to be around 6.03 eV. Based on the similarity with zirconia and the stabilization of its cubic structure at lower temperatures by yttria doping, the stabilization of the hafnia cubic phase by Y doping was reported. The amount of Y necessary for the stabilization of the cubic phase depends on the preparation method and may vary from 6 to 24 % of Y. Depending also on the synthesis method, ferroelectric orthorhombic phase may be formed if not enough yttrium is doped.

HfO_2 was studied as a host for selected rare earths photoluminescence; however, Ce-doped Y-stabilized single crystals have never been studied for either scintillation applications or any other purposes. To close this knowledge gap, the purpose of this work was to prepare sintered ceramic rods that will be later used in Optical Floating Zone (OFZ) processing of single crystals of Y,Ce:HfO_2 and characterize the luminescence in this material. Due to the high melting point of HfO_2, OFZ method is perspective for research of such a material. Single crystals of the cubic HfO_2 stabilized by 20 % Y were recently prepared for ferroelectricity studies by this method. Nevertheless, our goal is to study the relation between the content of cerium and yttrium in the hafnia matrix, and scintillation properties.

First, feed and seed ceramic rods were prepared. The precursors to our samples of yttria-stabilized HfO_2 (nominal composition: $Y_{y\text{-}x}Ce_xHf_{2-x}O_{1.9}$; y = 0.11, 0.12, 0.2 and x = 0, 0.01, 0.001) were prepared by a solid state reaction. The powders were then pressed isostatically into rods which were subsequently sintered at 1650 °C for prolonged time. The phase composition and microstructure of these rods were characterized by XRD and SEM. Cross sections of these samples were then post-annealed in inert (N_2) or reducing ($5H_2/95Ar$) atmospheres and radioluminescence was measured to evaluate the luminescence of cerium. Prepared rods were subsequently used for the OFZ growth of single crystals which are now being characterized.

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