Functional Materials

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Characterization of cerium-doped LYSO scintillating crystals

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During the last decade, scintillating crystals have become of particular interest as promising candidates for applications in energy physics, security, diagnostic and medical imaging. Many oxyorthosilicate based materials showing high scintillating properties have been studied in the past.

Among them lutetium-yttrium oxyorthosilicate cerium-doped crystals are largely employed for positron emission tomography (PET) and single-photon emission computed tomography (SPECT).

Even though lutetium oxyorthosilicate (LSO) appears to be the best scintillating material for PET application, it has some characteristics that makes it unsuitable for mass production process such as high melting temperature and high cost of the oxide Lu_2O_3 (starting material). The addition of yttrium, leading to the $Lu_{2(1-x)}Y_xSiO_5$ (LYSO) system is able to reduce both the growth temperature and the material cost. Moreover, the addition of cerium as a dopant to the LYSO system, leads to crystals with a comparable light yield and a slightly longer time of decay (50 ns) to LSO, making this system the perfect candidate for scintillating applications. Lutetium yttrium oxyorthosilicate is considered a solid solution of two different silicates, Lu_2SiO_5 and Y_2SiO_5, and in the formation of the final compound, the concentration of the solid solution can be indicated as percentage of the Y/Lu ratio. Mechanical properties have a great importance in the exploitation of scintillating crystals at industrial scale, since they provide the designer a degree of workability in terms of cutting, shaping, mounting and assembling [1]. Aim of the present work is to correlate the microstructure of twelve lutetium-yttrium oxyorthosilicate cerium-doped $Lu_{2(1-x)}Y_{2x}SiO_5$:Ce with x=0.1 (LYSO) crystals to their mechanical behaviour. In particular, this work reports the very preliminary results obtained by transmission electron microscopy (TEM) observations and X-ray diffraction (XRD) techniques on samples submitted to thermal annealing and mechanical testing. X-ray diffraction measurements were carried out by a Bruker D8 Advance diffractometer, using Cu-Kα radiation in Bragg-Brentano geometry, while a Philips CM200 transmission electron microscope at 200 kV was used for TEM observations. Samples for TEM investigations were prepared by the conventional thinning procedure. Six out of the twelve samples were submitted to an annealing treatment in air consisting of the following steps: a) a linear temperature increase (1°C/min) from room temperature to 300°C, b) an isothermal treatment for 10 h at 300°C and c) slow cooling at a linear rate (0.5°C/min) down to room temperature. The ultimate tensile strength (σ_{UTS}) and the Young modulus (*E*) of all the samples were measured by applying a four-point bending load [2]. Mechanical testing showed a slightly decrease of the mechanical properties for the annealed samples. XRD measurements performed on the not-annealed samples showed peaks exclusively attributable to the LYSO matrix (Figure 1.). On the contrary, a TEM observation performed on an annealed sample evidenced the presence of small coherent precipitates uniformly distributed inside the sample, as reported in Figure 2. taken in two beam condition close to the [010] zone axis orientation. Further TEM investigations and X-ray diffraction measurements are in progress, in order to obtain a complete correlation between crystals mechanical properties and their microstructure.

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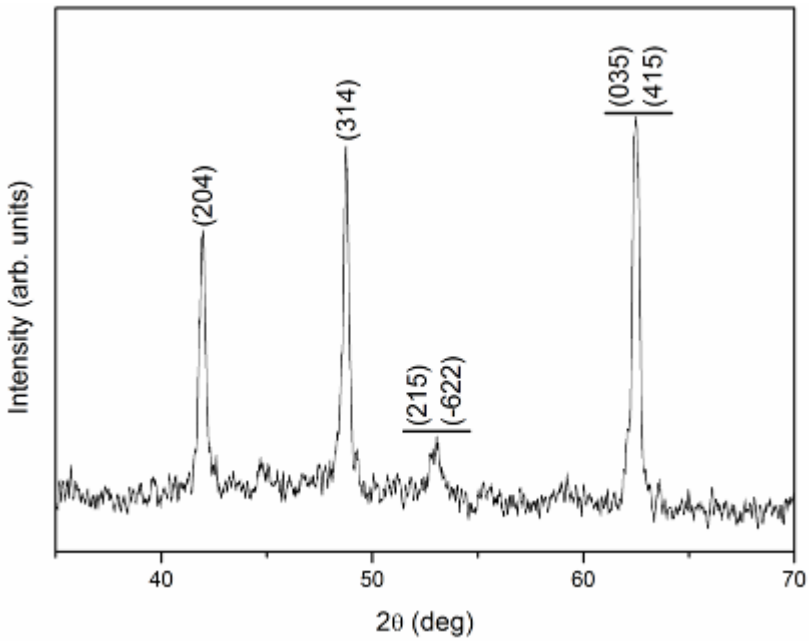

Figure 1. XRD spectrum of a not-annealed LYSO crystal.

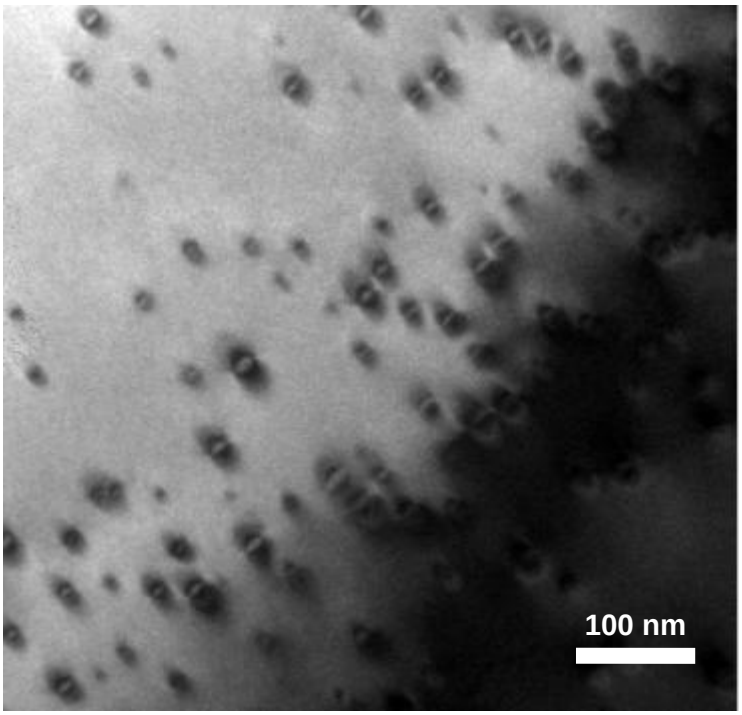

Figure 2. TEM micrograph of an annealed sample.