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Defects and Strain Configuration of “Ordered” Langasite Structure Compounds by SWBXT

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Beamline(s): X19C

Introduction: As the developments of research on LGS, LGN and LGT, two major disadvantages of those materials have been perceived. First, high Ga_2O_3 content among the raw materials makes the crystal cost much higher than quartz, $LiNbO_3$ and $LiTaO_3$. Second, more importantly, the crystal structure of those compounds is “disordered”. The “disordering” results primarily from the fact that two of the cations in each compounds randomly share the same sites in the unit cell, for LGS, Ga^{3+} and Si^{4+} sharing the same two small tetrahedral sites; for LGT and LGN, the Ga^{3+} and Ta^{5+} or Ga^{3+} and Nb^{5+} sharing the same single octahedral sites. This causes randomly distributed distortion to the crystal structure, affecting the material uniformity and reproducibility and leading to lower than ideally achievable acoustic Q and electromachanical coupling. Based on the “order-disorder” argument, several completely “ordered” Langasite structure compounds have been developed, including $Sr_3TaGa_3Si_2O_{14}$ or STGS, $Ca_3TaGa_3Si_2O_{14}$ or CTGS, $Sr_3NbGa_3Si_2O_{14}$ or SNGS and $Ca_3NbGa_3Si_2O_{14}$ or CNGS. Here, some preliminary SWBXT results of STGS boule are presented.

Methods and Materials: The whole curved surface of the STGS boule was examined by SWBXT with reflection geometry.

Results: There are no clear striation contrasts, which can be observed in most of the topographs, Figure 1. Wavy contrast features, A, in Figure 2 are caused by the ridges on the surface running along the length of the boule. Possible precipitate contrasts, P, can be observed throughout the whole boule. And other contrast due to surface roughness can also be observed. This new STGS crystal tends to have very strong facet formation during crystal growth. Vertical white contrast features, F, are produced due to risers on faceted steps on the boule, which block the diffracted beam thereby causing bands of white contrast. Some striation-like contrast can be observed in the facet area, but, in this case, it is not clear if it is from striations or due to surface features. Figure 3 clearly shows this unique contrast feature differing it from LG*X* crystals.

Conclusions: Surface X-ray topography of STGS boule was successfully carried out. Defects, such as precipitates can be observed. No clear striation contrast can be observed. Topographs are dominated by contrast related to surface features. X-ray topography of the surface of as-grown boule enable one to observe the true microstructure developed during the crystal growth process, and is imperative for understanding the nature and distribution of imperfections.

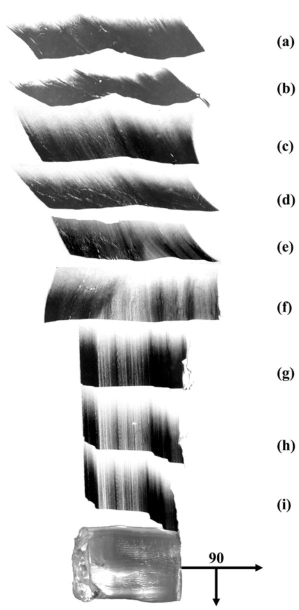

Figure 1. SWBXT images of STGS Boule recorded from reflection geometry

Figure 2. X-ray topograph showing no striations contrast, precipitates, P, wavy surface feature, A, and other surface features can be observed

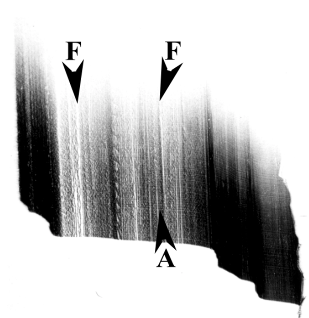

Figure 3. X-ray topograph showing wavy surface feature, A, and vertical white contrast facet features, F, along with some striation-like contrast