Single Crystal Growth and Solidification Characteristics of PIN-PMN-PT Ferroelectrics

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Due to the superior piezoelectric properties compared to polycrystalline ceramics, such as the ultrahigh piezoelectric coefficients (d_{33}>1500pC/N) and electromechanical coupling factors (k_{33}>90), the ferroelectric perovskite single crystals are regarded as the potential new materials used for electroacoustic, or ultrasonic transduction devices. The ternary $Pb(In_{1/2}Nb_{1/2})O_3$-$Pb(Mg_{1/3}Nb_{2/3})O_3$-$PbTiO_3$ (PIN-PMN-PT) crystals were reported to possess improved properties at higher temperature when compared to the binary $Pb(Mg_{1/3}Nb_{2/3})O_3$-$PbTiO_3$(PMN-PT) crystals, due to the high Curie temperature (~200^{o}C). In this presentation, crystal growth of the ternary PIN-PMN-PT ferroelectric materials was introduced, and some solidification characteristics of this ternary ferroelectric crystal were announced. Large size crystal boules grown with <011> and <001> orientation were analyzed as well as the di/piezoelectric properties along the growth directions. The thermal stability of the as-grown crystals was inspected and the composition segregation along axial and radius direction were investigated. Finally, the crystalline quality and defect density were checked as a basis of device fabrication. The results indicated that the large size boules were successfully grown from melts, di/piezoelectric properties varied in relation with structural phases due to composition segregation. The melting/solidification behavior were collected and no decomposition was found in sealed containers. The segregation coefficients varied from 0.83 to 0.91 depending on the diameters of the boules and implied the general composition inhomogeneity within a millimeter area. It is found that there exist ferroelectric domains, residual stress and microstructural defects in the crystal boules, and the defect density of the PIN-PMN-PT crystals grown from melts is in the magnitude of 10^{10} cm^{-2}.