Investigation of Relaxor-PT Single Crystals for Device Applications

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Several large size and high quality of relaxor-PT single crystals (PMN-PT, PIN-PMN-PT etc.) have been successfully grown by the Bridgman techniques in SICCAS since 1997. These relaxor-PT single crystals exhibit not only extra high piezoelectric performances, but also excellent opto-electric and pyroelectric performances. From our experiences on various device applications, these relaxor-PT single crystals still need to improve some their performances to meet the requirements in different device applications.

For an example, PMN-PT crystals are now commercially utilized in medical ultrasonic transducers in many companies. However, they still need to increase Curie temperature to enhance applied electric field and temperature stability for the transducer applications, to exceed convectional PZT transducers not only in bandwidth and sensitivity but also stability in working duration. PIN-PMN-PT crystals are new good candidates for the next generation of ultrasonic transducer applications.

For sensor applications, Mn-doped relaxor-PT crystals have been improved to reduce noise and increase signal-to-noise ratio for their low dielectric loss. Dipole defect $(Mn_{Ti}^{2+})'' - V_o^{\bullet\bullet}$ were found in in Mn-doped PMN-PT and PIMN-PMN-PT single crystals, where Mn^{2+} is in the B-site of perovskite ABO_3. The dipole defects pin the domain movements and reduce DC conductivity, resulted to lower dielectric loss and higher coercive field Ec.

By using our relaxor-PT crystals, several high performances of devices have been fabricated. The medical transducer shows 96% bandwidth at the insertion loss of 6dB, and loop sensitivity -70.39dB in 2.7MHz single crystal phase array transducer, higher than 78% bandwidth and -71.16dB loop sensitivity in PZT transducer. The special detectivity reaches at 3.01×10^9 cmHz$^{1/2}$/W@4Hz and 2.21×109 cmHz$^{1/2}$/W@10 Hz in the charge mode of single element of Mn: PMN-PT infrared detector, 4-6 times higher than conventional LiTaO3 infrared detectors. The magnetic anomaly sensors were fabricated by ME laminated composites, and the detectivity reaches at 5pT/Hz$^{1/2}$@1Hz, 1pT/Hz$^{1/2}$@10Hz, 0.1pT/Hz$^{1/2}$@1kHz and 10 fT/Hz$^{1/2}$@EMR.