Electric Field Effect of Relaxor Ferroelectric $0.7Pb(Mg_{1/3}Nb_{2/3})O_3$-$0.3PbTiO_3$ Single Crystals Studied by Micro-Brillouin Scattering

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The relaxor ferroelectric single crystals $(1-x)Pb(Mg_{1/3}Nb_{2/3})O_3$-$xPbTiO_3$ (PMN-xPT) with the ABO_3-type perovskite structure have been studied last several decades due to its excellent piezoelectric and electromechanical responses [1,2]. From the technological point of view, the PMN-xPT single crystals with composition near the morphotropic phase boundary (MPB) are very interesting. Under dc electric field, they demonstrate a great variety of physical properties that will give the new insights into further applications. In the present study, the acoustic properties of PMN-30PT (x = 0.30) single crystals under the dc electric field along the [001] direction were investigated by using broadband Brillouin scattering. Under 0.5 kV/cm, the frequency shift of the longitudinal acoustic (LA) mode exhibits splitting below ~351 K (Fig. 1a). This is due to the coexistence of the ferroelectric macrodomain with the high-frequency LA mode (HLA) and the nanodomain state with the low-frequency LA mode (LLA) owing to the pinning of domain walls by the random field. Under 1.0 kV/cm, the LA mode splitting disappears by the complete switching of nanodomain to the single/macrodomain state (Fig. 1b). In the ferroelectric phase of the zero field cooling crystal (Fig. 2), a discontinuous transition of the LA velocity from a nonequilibrium nanodomain state (A) to an intermediate state (B) of coexisting nano- and macrodomains states was observed at 1.05 kV/cm. At 2.6 kV/cm, the state (B) changes into the equilibrium state (C). Similar behaviors were observed in the dielectric measurements. At 0.5 kV/cm, the Monoclinic (M) phase coexists with Tetragonal (T) phase. At 1.0 kV/cm, the M phase disappears and the T phase becomes stable. The critical end point (CEP) was observed at 1.2 kV/cm and at 398 K. At CEP the polarization rotation energy is decreased significantly [3]. Our results suggest that at the CEP, the transition from multidomain to a single domain state may be the origin of the maximum electric responses in the PMN-30PT single crystal near the MPB composition.

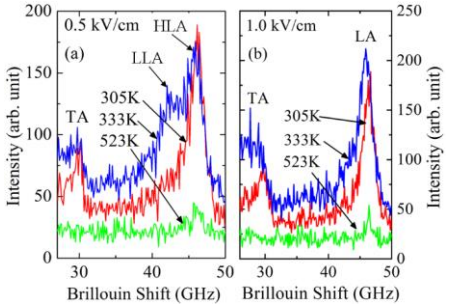

Fig. 1. Brillouin spectra measured under (a) E = 0.5 kV/cm and (b) E = 1.0 kV/cm on cooling.

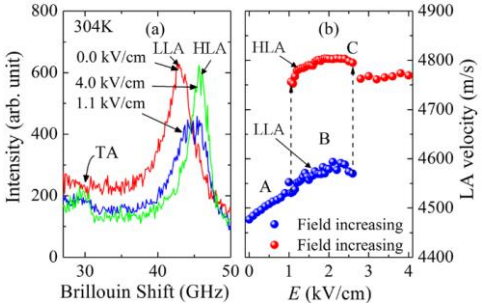

Fig. 2. Electric field dependence of (a) Brillouin spectra and (b) LA velocity at 304 K.

[1] E. Sun and W. Cao, Prog. Mater. Sci. **65**, 124 (2014).

[2] S. Zhang and F. Li, J. Appl. Phys. **111**, 031301 (2012).

[3] Z. Kutnjak, J. Petzelt, and R. Blinc, Nature **441**, 22 (2006).