Dynamics of Relaxor Materials of (1-x)$Pb(Mg_{1/3}Nb_{2/3})O_3$-x$PbTiO_3$ Studied by X-ray Scattering

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One of the most important topics of condensed matter physics is the effect of heterogeneous structure on physical properties. The relaxor ferroelectrics offer a playground for studying this issue, because it is believed that their physical properties are related to inhomogeneous domain structures from nanometer-to-micrometer spatial and THz-to-Hz time scales. Since $(1-x)\mathrm{Pb}(\mathrm{Mg}_{1/3}\mathrm{Nb}_{2/3})\mathrm{O}_3 - x\mathrm{PbTiO}_3$ (PMN $-$ xPT) of relaxor ferroelectrics consists of normal ferroelectrics PbTiO_3 (PT) and relaxor $\mathrm{Pb}(\mathrm{Mg}_{1/3}\mathrm{Nb}_{2/3})\mathrm{O}_3$, the solid solution made of these two materials results in an interesting phase diagram. This system has a morphotropic phase boundary (MPB: $x \sim 30\%$) between rhombohedral phase of low PT concentration and tetragonal phase of high PT concentration. The material shows anomalous physical properties, e.g. extremely high dielectric constants in the wide temperature range near MPB.

However, the domain structures and physical properties near MPB strongly depend on the sample conditions and histories (thermal or electrical etc.). Such features make it great obstacle to elucidate the properties near MPB in relaxor system. Therefore, we prepared a single crystal sample of PMN $-$ xPT with PT concentration gradient extending from 27.0% to 38.0% (0.27< x < 0.38)[1] along the rectangular axis of the crystal. By using this sample, we can perform systematic study near MPB by changing the position of incident beam spot on the sample without changing the experimental set up.

We measured X-ray diffuse scattering (XDS) at BL22XU of SPring-8. XDS is related to a polarization fluctuation in the domain of the PMN $-$ xPT system. The anisotropic correlation of polarization fluctuation could give the anisotropic pattern of XDS at reciprocal space. We observed the anisotropic pattern to change with PT concentrations at only small-q ($q \leq 0.15$ [r.l.u.]) region. We also performed an inelastic X-ray scattering measurement at BL35XU of SPring-8 with the same sample to investigate the dynamic component of XDS at small-q region. As shown in Fig.1, the line width (life time) of transverse acoustic mode (open circle) shows clear anomaly near MPB, while the energy (solid circle) shows no clear change.We speculate that the results should be related to the fluctuation of local polarization, and could explain the characteristic dielectric properties near MPB.

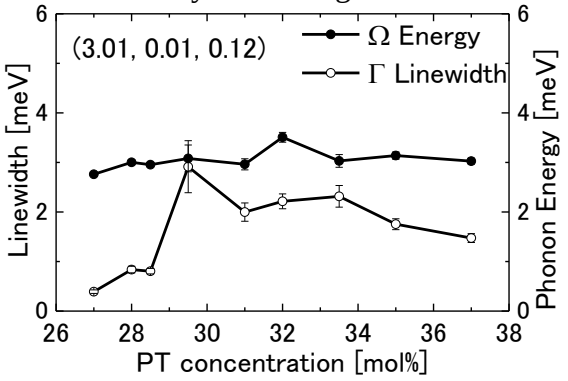

Fig.1 Line width and energy of TA mode

[1] M. Matsushita, et al. JFE technical report **8**, 43 (2005),