A study of Relaxor based Ferroelectric Pb[(Zn1/3Nb2/3)]0.91TI0.09O3 Crystals by Micro-Brillouin Scattering

©金 度漢1, 高 在賢2, 小島 誠治（筑波大学、物質工学系）
Do Han Kim1, Jae-Hyeon Ko2 and Seiji Kojima (Univ. Tsukuba, IMS)

1. Introduction

Lead based perovskite oxide materials such as Pb(Zr1/3Ti2/3)O (PZT), Pb[(Zn1/3Nb2/3)]1-xTi3O3 (PZN-xPT) and Pb[(Mg1/3Nb2/3)]1-xTi3O3 (PMN-xPT) etc. have been focused by researchers because they have high piezoelectric properties. And they are considered as good candidate materials for electromechanical application because of those. So, they are also trying to clarify the origin of piezoelectric properties about PZT, PZN-PT and PMN-PT.1-3) They undergoes a ferroelectric phase transition rhombohedral (R) into tetragonal (T) phases in the low temperatures such as Fig. 1. (b) There are thermal hysterisis between heating process and cooling process. Dielectric constants of PZN-xPT crystals undergo a first order phase transition. But PZN-xPT still has relaxor properties below T_{max}. 5)

Brillouin scattering has been used to investigate acoustic properties of condensed matters because laser source and Fabry-Perot interferometer (FPI) have been developed. We investigated the phase transitions as temperature dependence of acoustic phonon researched in a PZN-9%PT crystal using Brillouin scattering.

2. Experimental

A 3+3 pass tandem Fabry-Perot Interferometer (FPI) has been used to measure the Brillouin scattering spectra. 6) An Ar ion laser was used to excite the sample with a wavelength 514.5nm and power of 100 mW. A conventional photon counting system and a multi-channel analyzer were used to detect and average the signals. Samples were put in a cryo-stat cell (THMS 600) with the temperature range -200-600°C and the stability of ±0.1°C. An optical microscope (OLYMPUS BH-2) was combined with

![Micro-Brillouin scattering system.](image)

Fig. 2. Micro-Brillouin scattering system.

---

1 Corresponding author e-mail addresses: dhkim@ims.tsukuba.ac.jp, hanie@hanmail.net
2 Present address: Samsung Corning R & D Center, Paldal-gu, Sin-dong 472, 442-390, Suwon-si, Gyeonggi-do Province, Korea
FPI to achieve a focal point of 1-2 μm for the backward scattering geometry. The sample cell with X-Y-Z adjustable stage was put on the stage of an optical microscope. The propagation of phonon direction was [100] in the backward scattering geometry. Fig. 2. shows the block diagram of micro-Brillouin scattering system.

3. Results

Micro-Brillouin scattering were measured with a free spectral range (FSR) of 75 GHz and a scan range of ±60 GHz for both heating and cooling processes. We measured VH spectra and VV spectra separately. Fig. 3. shows micro-Brillouin scattering spectra of VV and VH components respectively. There was strong longitudinal acoustic mode (LA-mode) peak and central peak at VV geometry. Frequency shift was about 43 GHz. And there were LA-mode, transverse acoustic mode (TA-mode) and central peak at VH geometry. But intensities were very weak. It was difficult to fit TA-mode. On heating, they were almost disappeared around 90 °C except central peak. This central peak was keeping during tetragonal phase and disappeared with high temperature in the cubic phase.

![Intensity vs Frequency](image)

---

Density \( (\rho) \) is 8.71 g/cm\(^3\) that was calculated by lattice parameters and refractive index \( n \) was taken 2.5. On heating processes, \( C_{33} \) is 168.36 GPa at room temperature.

![Temperature vs Density](image)

---

Fig. 4. The temperature dependence of Brillouin frequency shift and FWHM.

4. Conclusions

The temperature dependence of Brillouin spectra of PZN-xPT crystals were investigated at a backward scattering geometry. We calculated elastic stiffness coefficient \( C_{33} \) related with LA-mode. In VV geometry, the central peak disappeared the cubic phase. Thermal hysteresis was observed Brillouin scattering as well dielectric measurements.

References