PROC. JSSF-2, KYOTO, 1980
J. PHYS. SOC. JPN. **49** (1980) SUPPL. B, p. 59.

Dielectric Properties of Dirty Ferroelectric SBN

Shoziro KURODA, Taiji KOHIGASHI, Hikaru TERAUCHI, Kanji KUBOTA and Kohji YOSHIMISTU

Faculty of Science, Kwansei Gakuin University, Nishinomiya 662

Diffuse phase transition of a rare earth ion-doped SBN40 ($Ba_{0.4}Sr_{0.6}Nb_2O_6$; Pr^{3+} or Nd^{3+}) has been carefully examined by the measurements of the spontaneous polarization P_s, the dielectric constant ε and X-ray diffraction. P_s decreases gradually with increasing temperature and ε has a broad maximum near the transition temperature T_c. With increasing rare earth ion concentration M, 1) the broadening of ε increases, 2) the temperature dependence of P_s becomes more diffuse, 3) T_c and T_p (the inflexion point of P_s) decrease in proportion to M^{-1}. In order to discuss the temperature and M dependence of P_s and ε, we adopt the order parameter expansion of the free energy including odd powers as well as even powers of the polarization and the expansion of the reciprocal susceptibility in terms of $T-T_c$ which was introduced by L. Benguigui:[1)]

$$\chi^{-1}=\chi_0^{-1}+B_2(T-T_c)^2+B_3(T-T_c)^3. \quad (1)$$

B_2 and B_3 are the expansion coefficients, and were determined by the method of least square. It turned out that B_2/B_3 is proportional to M^{-1}. The calculated values of χ^{-1} are in good agreement with the experimental results in the temperature range of $T_c \pm 5$°C for pure SBN40, and $T_c \pm 15$°C for the samples with the rare earth ion. However, except the above temperature regions, χ^{-1} is a linear function of temperature. The ratio of the slopes of the χ^{-1} vs T curve at low and high temperature regions is about 2:1 in our experiments. Figure 1 shows the temperature dependence of P_s. Marks show the calculated values and the lines are the experimental results. The calculated values of P_s agree with the experimental results in the temperature range of $T_c \pm 20$°C for the samples containing the rare earth ion. Furthermore, by using the expressions for B_2 and B_3,[1)] we can write the inflexion point as

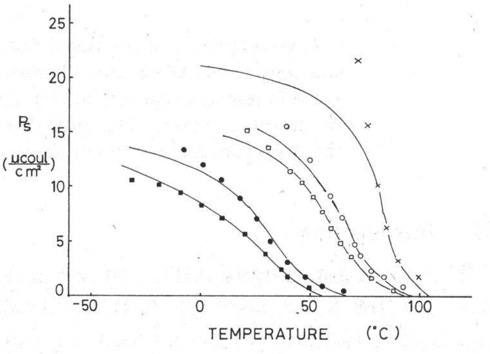

Fig. 1. Temperature dependence of the spontaneous polarization P_s and the calculated values of P_s for various samples. The lines show the experimental results. ×: pure SBN40, ○: SBN40+Pr^{3+} (0.3 wt%), ●: SBN40+Pr^{3+} (1.0wt%), □: SBN40+Nd^{3+} (0.3 wt%), ■: SBN40+Nd^{3+} (1.0 wt%)

$$T_p=T_c+B_2/6B_3. \quad (2)$$

It is clear that the calculated values of T_p given by eq. (2) agree with the experimental values within 5% error in all samples. As mentioned above, in the case of the rare earth ion-doped SBN40, temperature dependence of the dielectric properties is well explained by the order parameter expansion of free energy and the expansion of χ^{-1} in terms of $T-T_c$. Furthermore, X-ray experiments were carried out to clarify the microscopic mechanism of the diffuse phase transition. The equi-intensity contour of X-ray critical diffuse scattering around (0 0 4) reflection in SBN40+Pr^{3+} (0.3wt%) shows a strongly anisotropic distribution. Considering the piezoelectric coupling in χ^{-1}, we can explain the strong anisotropy near T_c in SBN40+Pr^{3+} (0.3wt%).

Reference

1) L. Benguigi: Solid State Commun. **14** (1974) 669.