

under $1/\epsilon_r=0$ versus pressure is obtained by replotting from Fig. 8(a) as shown in Fig. 7(b), then it is found that the characteristic temperature(T_0) decreases linearly with increasing pressure. Accordingly, T_0 is expressed as follows;

$$T_0 = a_2 - \beta_2 p \quad (30)$$

where $a_2=104^\circ\text{C}$ & $\beta_2=4.92^\circ\text{C/kbar}$ from Fig. 7(b). By putting eq. (30) into T_0 of eq. (23) & eq. (24), the following formulas are obtained;

$$\frac{1}{\epsilon_r} = -4C_0(T - a_2 + \beta_2 p) + \frac{\xi^2}{\zeta} \left\{ 1 + \sqrt{1 - \frac{4\zeta C_0}{\xi^2} (T - a_2 + \beta_2 p)} \right\} \quad (31)$$

$$P_s^2 = -\frac{\xi}{2\zeta} \left\{ 1 + \sqrt{1 - \frac{4\zeta C_0}{\xi^2} (T - a_2 + \beta_2 p)} \right\} \quad (32)$$

The temperature dependence of $1/\epsilon_r$ at pressure parameter $p=7.7, 10.3$ & 12.4 kbar is expressed as a solid line in Fig. 8(a) by putting the previous values of ξ & ζ at $T=23^\circ\text{C}$ and above values of C_0 , a_2 & β_2 into eq. (31). The temperature dependence of P_s is also expressed similarly as a solid line in Fig. 8(b) from eq. (32). Here, since the abscissa in Fig. 8(b) is the reduced temperature ($T - T_c$), the characteristic curves with each pressure parameter overlap as a one line. Comparable large difference between the measured value and the calculated one is observed in Fig. 8(a). This cause is considered to be based on the temperature & pressure dependence of the coefficients C_0 , ξ & ζ . Let's consider this effect subsequently. The pressure dependence of the transition temperature(T_c) must be same as that of the characteristic temperature(T_0) from eq. (25). However, the paper reports that there is some difference between $dT_c/dp=-5.5^\circ\text{C/kbar}$ and $dT_0/dp=-4.8^\circ\text{C/kbar}$ in experimental value⁶). Furthermore, though all curves which are the reduced temperature ($T-T_c$) versus spontaneous polarization with pressure parameters must overlap as a one line, the value of P_s decreases gradually with increasing pressure parameter like a dotted line (or the measured value) in Fig. 8(b). These facts suggest that the coefficients C_0 , ξ & ζ depend on pressure a little. However, the temperature dependence of the coefficient ζ of higher order of P_s in the expansion formula of the free energy is considered to be extremely small, and therefore, the pressure dependence of the coefficient ζ is also assumed to be extremely small. The slope C_0 is known to be independent of pressure from experimental results. Consequently, in this case, the pressure dependence of the coefficient ξ should be considered. Here, let's add the little quantity $\Delta\xi$ to the value of ξ to compensate ξ . In order to obtain the value of $\Delta\xi$, the following method is performed, that is, from eq. (21),

$$dP_s/dp = -g\zeta/2P_s \sqrt{\xi^2 - 4\zeta(u + gp)} \quad (33)$$

still more, by substituting $\xi + \Delta\xi$ for ξ in eq. (33)

$$dP_s/dp = -g\zeta/2P_s \sqrt{(\xi + \Delta\xi)^2 - 4\zeta(u + gp)} \quad (34)$$

First, let's put $p=7.7$ kbar and the previous values of u, g, ξ & ζ at $T=23^\circ\text{C}$ into eq. (33) & eq. (34), and put simultaneously the values of dP_s/dp obtained from the slope of the experimental curve (or the dotted line) & the calculated one (or the solid line) at $p=7.7$ kbar & $T=23^\circ\text{C}$ in Fig. 6(b), that is, $dP_s/dp=3.80 \times 10^{-3} \text{ C/m}^2 \cdot \text{kbar}$ (or the measured value) & $dP_s/dp=3.13 \times 10^{-3} \text{ C/m}^2 \cdot \text{kbar}$ (or the calculated value) into eq. (34) & eq. (33) respectively. Next, let's take the ratio eq. (34) to eq. (33) in order to find the value of $\Delta\xi$; $\Delta\xi=0.373 \times 10^9 \text{ m}^5/\text{F} \cdot \text{C}^2$. The compensated curve of $1/\epsilon_r$ versus T obtained by calculation is shown as a dot-dash-line in Fig. 8(a) by putting

$\xi + \Delta\xi = -0.96 \times 10^9 \text{ m}^5/\text{F} \cdot \text{C}^2$ into ξ of eq. (24). In this case, the compensated quantity $\Delta\xi$ is 28% of the previous value of ξ , and the calculated value of $1/\epsilon_r$ approaches to the measured value by about 36% in comparison with the previous case.

(ii) The electric field dependence of the permittivity; The temperature dependence of the reciprocal relative permittivity of the ceramic ($\text{PbTiO}_3 25\% + \text{PbSnO}_3 75\%$) at atmospheric pressure obtained by the authors is shown as a dotted line in Fig. 9(a). The slope C_0 of $1/\epsilon_r$ to T in

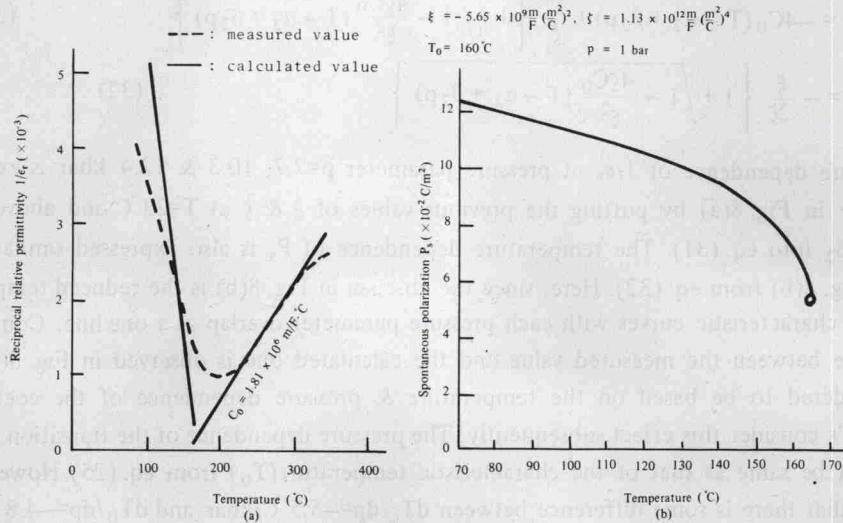


Fig. 9. The temperature dependence of (a) the reciprocal relative permittivity & (b) the spontaneous polarization of $\text{Pb}(\text{Ti}(25\%)+\text{Sn}(75\%))\text{O}_3$ at 1 bar.

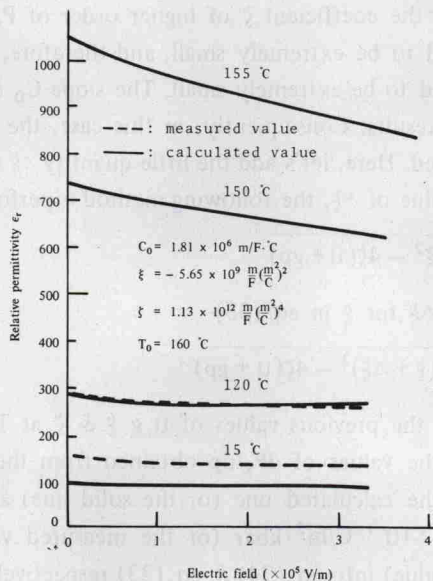


Fig. 10. Effect of external electric field on the relative permittivity of $\text{Pb}(\text{Ti}(25\%)+\text{Sn}(75\%))\text{O}_3$ under various temperatures.