Short Notes

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Hydrostatic Pressure Effect on the Dielectric Relaxation Time in Ferroelectric AgNa(NO₂)₂

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Ferroelectric AgNa(NO2)2 shows a dipolar dielectric dispersion in a low frequency region below 1 MHz.¹⁾ The fact enables us to measure hydrostatic pressure effect on the dielectric relaxation in AgNa- $(NO_2)_2$ by a conventional bridge technique. Single crystals of AgNa (NO₂)₂ were prepared by slow cooling of aqueous solution. Silver paste was attached as electrodes. The high pressure apparatus system used was described elsewhere.2) Pressure transfer fluid was kerosene. At a constant pressure, temperature was raised stepwise, and at a fixed temperature real and imaginary dielectric constants were measured with a transformer ratio bridge, TR-1B of Ando Denki Co., Ltd., as functions of frequency. The dielectric relaxation time τ_0 is obtained as $\tau_0 = 1/(2\pi f_m)$ where f_m is a frequency at which the imaginary dielectric constant takes the maximum value.

Figure 1 shows temperature dependence of the dielectric relaxation time at different hydrostatic pressures. At atmospheric pressure, the relaxation time shows a sharp λ -type maximum at the Curie point on account of the dielectric critical slowing down. The maximum value of τ_0 at p=0 in the paraelectric phase is about 2.5×10^{-4} sec. As pressure increases the transition point shifts to higher temperature side accompanied with decreasing of the maximum value of τ_0 .

The pressure dependence of dielectric relaxation time can be mainly attributed to increase of the Curie point. The dielectric relaxation time above the Curie point is expressed from a rate process theory as

$$\tau_0 = \frac{h}{k(T-\theta)} \exp\left(\Delta U/kT\right),$$

where θ , and ΔU are the paraelectric Curie temperature and the activation energy for flip-flop motion of a molecular dipole, respectively. The hydrostatic pressure dependence of the paraelectric Curie temperature can be expressed by a linear relation of $\theta = \theta_0 + \alpha p$ with $\alpha = 9.3 \text{ K kbar}^{-1.4}$ The activation energy ΔU would be dependent both on temperature and on pressure. Assuming a linear relation of $\Delta U(T, p) = \Delta U(T_0, 0)$ $(1+a(T-T_0)+bp)$, where T_0 is some base temperature, one can obtain $a = -(7.2\pm0.8) \times 10^{-4} \text{ K}^{-1}$ from results at p=0 in a temperature region of $40 \sim 80^{\circ} \text{ C.}^{-3}$ The pressure coefficient b is estimated from the present experimental results to be about $+2 \times 10^{-2}$ kbar⁻¹ for pressures up to 2 kbar. The fact that the sign of b is opposite to a suggests that pressure and temperature variation of activation energy ΔU is mainly caused by change in lattice parameters.

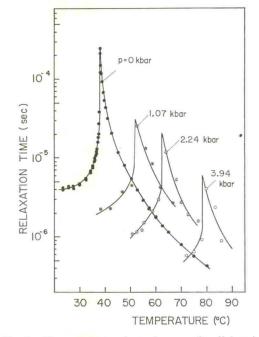


Fig. 1. Temperature dependence of dielectric relaxation time of AgNa (NO₂)₂ at different hydrostatic pressures.

References

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