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Hydrostatic Pressure Effect on the Dielectric Relaxation Time in Ferroelectric $AgNa(NO_2)_2$

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Ferroelectric $AgNa(NO_2)_2$ 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 $AgNa(NO_2)_2$ 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

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

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 $\alpha=9.3$ 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 $a=-(7.2\pm0.8)\times10^{-4}$K^{-1} from results at $p=0$ in a temperature region of 40~80°C.[3] The pressure coefficient b is estimated from the present experimental results to be about $+2\times10^{-2}$ 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.

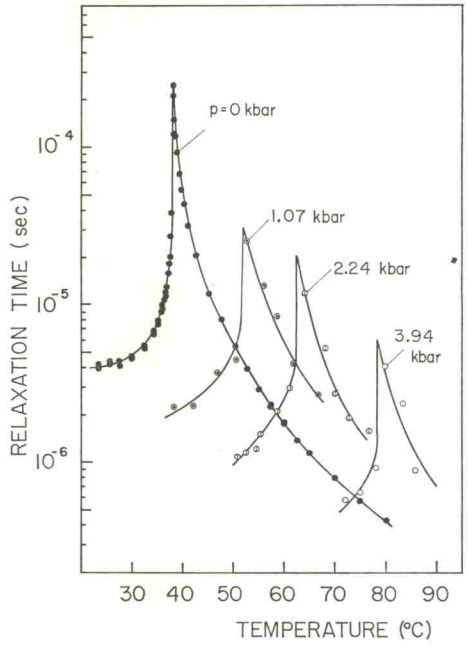

Fig. 1. Temperature dependence of dielectric relaxation time of $AgNa(NO_2)_2$ at different hydrostatic pressures.

References

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3) K. Gesi: to be published in Ferroelectrics.
4) K. Gesi and K. Ozawa: to be published in Phys. Status solidi **62.**