4-6 Some Aspects of the Reversible Optical Effect in (Se,S)-Based Chalcogenide Glasses

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In a previous paper[1)] we have reported a reversible change in optical properties, transmission and refractive index, observed in the Se-based glass. As a continuation of the work we describe here some interesting features concerning the reversible effect.

Sample Preparation. All the samples investigated were thin films deposited on transparent glass plates by an rf sputtering. The sample composition here reported is 40 % As, 25 % Se, 25 % S, and 10 % Ge, which was chosen as a representative from our preliminary study.

Heating Effect. As has been reported, heating causes the absorption edge shift to shorter wavelengths. Amount of the shift depends on the temperature reached by the sample. This shift occurs rapidly. However, once the sample was heated up to a high temperature $T_1 (\lesssim T_g)$, succeeding heating of the sample at a lower temperature T_2 does not cause any more significant shift of the edge. This implies that the state of material established by heating is determined only by the highest temperature the material was brought to.

Absorption Edge. The absorption constant is expressed well by the equation , in the region of large α ,

$$\alpha = A(h\nu - E_{go})^2/h\nu \quad , \qquad (1)$$

where E_{go} is the optical gap and A is a constant[2)]. Figure 1 shows the $(\alpha h\nu)^{1/2}$ plotted against $h\nu$. As seen in the figure, the linear portion of the curves, one for the heated and the other for the irradiated cases, are parallel, indicating that the optical gap changes without affecting the constant A. According to Davis-Mott theory, A is proportional to $\sigma_0/\Delta E$, where σ_0 and ΔE are electrical conductivity and spread of the localized state density, respectively. Since the con-

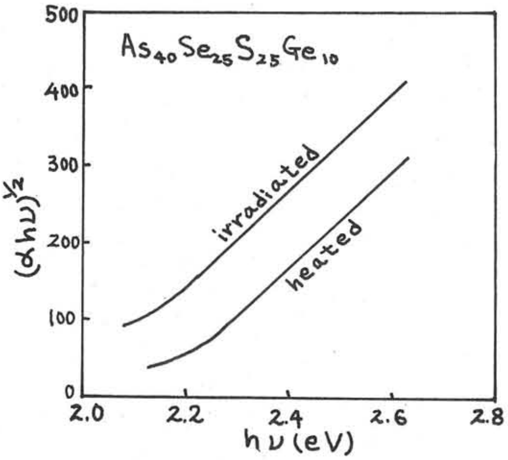

Fig.1. $(\alpha h\nu)^{1/2}$ vs $h\nu$

ductivity of the heated sample is smaller than that of the irradiated sample, constancy of A means ΔE becomes smaller upon heating.

Irradiation Effect. Accompanying the above-mentioned edge shift, the refractive index is also changed when the sample is heated or irradiated. We measured the index change by employing a holographic technique; a beam from a Kr laser was divided into two beams, which were shed on the sample to form interference fringe. It is recorded in the sample as a grating. Light from a He-Ne laser(6328 Å) is used to monitor the formation of the grating during irradiation. Figure 2 shows growing behavior of the index change, Δn, as a function of the exposure time. The stronger is the irradiation power, the larger is the growing rate. The behavior of Δn is approximately expressed as

$$\Delta n \propto (1 - e^{-\beta t}), \qquad (2)$$

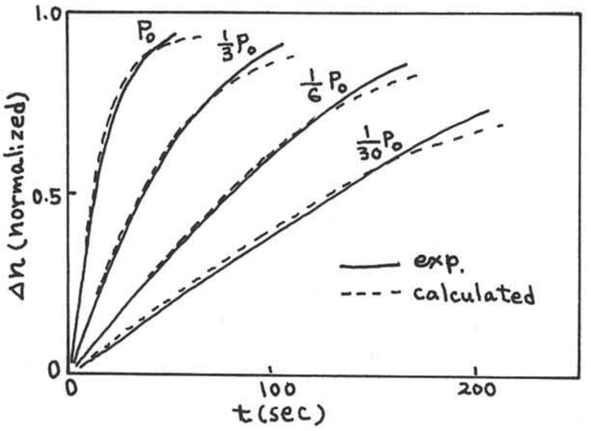

Fig.2. Δn vs time

which is the same functional form as the change of the absorption constant[1]. If we assume single oscillator Sellmeir's dispersion relation of the refractive index[3] and Eq.(1), the index change, Δn, is reasonably related with the absorption constant change.

Summary. Our measurements indicate that the change in the optical properties in our system of glass is explained by the rigid variation of the optical gap. How this is interpreted from a viewpoint of the change of atomic structure of the material requires further investigation.

1. T.Igo and Y.Toyoshima, J.Non-Crystalline Solids 11(1973) 304.
2. See, for example, Mott-Davis, " Electronic Processes in Non-Crystalline Materials ", Clarendon Press, 1971.
3. Born and Wolf, " Principles of Optics ", Pergamon Press,L964.