ABM 8P CHARGE TRANSPORT MECHANISMS IN QUATERNARY GLASSY S –Te BASED THIN FILMS

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Several compositions of quaternary materials in the As-S-Ge-Te system were synthesized by melt-quenching technique and the respective thin films have been fabricated. Shown by AFM, SEM and X –ray analysis the nature of the films was predominantly amorphous. In order to elucidate the mechanisms of charge transport in these films, the DC and AC conductivities have been carried out in the 10 -200 ^{0}C temperature range and 5 – 10^7 *Hz* respectively. Direct current - voltage characteristics were measured at different temperatures in normal air ambient conditions, using a priory established electrically transparent (ohmic) Ag contacts. Applying these data, the temperature dependence of DC conductivity has been highlighted. Being presented as $ln\sigma$ versus $10^3/T$ it consists of two straight lines with different slopes, which gives evidence that the charge transport occurs by different mechanisms, ether via non localized (extended) states above mobility edges or by phonon assisted hopping via tails of localized states, close to mobility edges.

Respectively, the entire conductivity in mentioned above temperature range can be expressed as:

$$\sigma = \sigma_{ext} + \sigma_{hopp} = C_1 \exp(-\frac{E_1}{kT}) + C_2 \exp(-\frac{E_2}{kT}) \qquad (1)$$

Here:

$$C_1 = \sigma_{\min} \exp(-\frac{\gamma}{k}) \quad (2)$$

where $\sigma_{\min}$ is the minimum metallic conductivity, that is the conductivity by charge transport exactly on the mobility edge; γ - is the temperature coefficient of gap edge broadening, which is approximately a half of temperature coefficient of the optical gap. Following the Mott and Davis model of de density of states in disordered materials [1] the minimum metallic conductivity and the mobility gap of glassy materials in question have been estimated. At temperatures lower than 80 ^{0}C (at list up to 10 ^{0}C) the electrical conductivity is released by phonon assisted hopping via tails of localized states, close to mobility edges. The AC conductivity has been found to depend on frequency as:

$$\sigma_{\omega} = A\omega^{n} \quad (3)$$

with $n \approx 0{,}7$ and A a constant. In the $10^3 - 10^6$ *Hz* frequency range, the AC conductivity was observed to be temperature dependent, while in the higher frequency region it appeared to be nearly independent on temperature. It is assumed [2] that in the frequency range until 3 *kHz* the AC conductivity is due to charge hopping between tail localized states. AC is higher than DC conductivity: at 3 *kHz* and room temperature their ratio being of $\sigma_{\omega}/\sigma \approx 3$. This ratio, increases further at frequencies higher than 3 *kHz,* but itself σ_{ω} becomes less and less temperature dependent, along with a stronger frequency dependence. Such behavior is interpretable in terms of transition to a mechanism of hopping that includes the states $N(E_F)$ in the middle of the mobility gap. Using the theoretical formula derived by Austin and Mott for such a conductivity [3], the composition dependent density of states $N(E_F)$ has been estimated. For $As_2Te_{13}Ge_8S_3$ it appears to be in the range of $N(E_F) \cong 1{,}3 \cdot 10^{21} eV^{-1}cm^{-3}$.

[1] N. F. Mott and E.A. Davis, Electron processes in non-crystalline materials, Clarendon Press, Oxford, (1979).
[2] P. Nagels, Electron transport phenomena in amorphous semiconductors, in: M.H.Brodsky (Ed), Amorphous Semiconductors, Springer-Verlag, Berlin, Heldeiberg, New York, (1979).
[3] I.G. Austin and N. Mott, Adv.Phys. 18 (1969) 41.