Summary of Thesis

ELECTRICAL PROPERTIES OF Se-Te BASED CHALCOGENIDE GLASSES

by

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Amorphous semiconductors due to their scientific and technological importance are an interesting field of study in Solid State Physics. The preparation of amorphous material is much easier than growing single crystals. The easy fabrication in thin film and bulk form without the use of any sophisticated technology has contributed to the world wide interest of scientists, engineers and electronic industries in amorphous semiconductors.

Amorphous semiconductors consisting of chalcogen elements of group VI of the periodic table are called chalcogenides. Materials prepared by melt quench technique exhibit glass transition phenomenon and hence are called glasses. Chalcogenide glasses have found wide and varied applications such as in solar energy conversion, infrared lenses, optical and mass memory, imaging, electro photography, I.C. technology, optical fibers etc.

Se-Te glassy alloys are widely used for various applications in many fields as optical recording media because of their excellent laser writer sensitivity, xerography and electrographic applications such as photoreceptors in photocopying and laser printing, infrared spectroscopy etc.

The effect of additives in binary chalcogenide glasses has always been an interesting area of study in chalcogenide glasses from the application point of view. So, the effect of Indium and Germanium additives on electrical and dielectric properties of $Se_{85}Te_{15}$ glass has been reported.

This thesis presents details of material & sample preparation of $Se_{85-x}Te_{15}A_x$ (A=In,Ge) glasses and various models to explain their electrical and dielectric properties alongwith the study of electrical and dielectric behaviour of these glasses.

Chalcogenide glasses of different compositions are prepared by weighing the elemental constituents (5N pure) in desired atomic weight percentages. The weighed materials are sealed in quartz ampoules under a pressure ~10^{-5}Torr. The ampoules are kept inside the rocking furnace at a temperature of about 50^0C above the highest melting point of constituent element for nearly 24 hours. Then the ampoules are quenched in ice water/

liquid nitrogen. Then the samples are removed from the ampoules, ground and characterized for amorphous nature using X-ray diffraction (XRD) technique. Bulk samples in the form of circular pellets are made from finely ground powder of the glassy materials under a pressure ~ 10^6 Kg m^{-2} using hydraulic press. Pellets are annealed in vacuum below their glass transition temperature to reduce the effect of grain boundaries before doing measurements.

For dc conductivity measurements, a constant voltage is applied across the sample using dc power supply and the resulting current is measured with digital having least count of 0.1nA. For frequency and temperature dependent ac conductivity and dielectric constant measurements of the materials, general radio bridge (Model 1620-A) is used. The bridge consist of an audio oscillator (Model 1311-A), a tuned amplifier (Model 1232-A) and a null detector, which permits balance to a resolution of one part in million. This bridge is designed for the precise measurements of capacitance and conductance. Its direct read-out system minimizes the reading errors and permits rapid operation.

dc conductivity measurements yield valuable information about transport mechanism in the amorphous materials. Keeping this in mind, temperature dependent dc conductivity measurements have been carried out on the circular pellets (thickness~1mm) of $Se_{85-x}Te_{15}In_x$ (x=0, 2, 6, 10, 15) and $Se_{85-x}Te_{15}Ge_x$(x = 0, 2, 6, 10, 15) chalcogenide glasses using the sample holder. dc conductivity results of $Se_{85-x}Te_{15}In_x$ show that dc conductivity increases with increase in Indium and is maximum for x=10. The study of dc conductivity of $Se_{85-x}Te_{15}Ge_x$(x=0, 2, 6, 10, 15) shows that for the series, dc conductivity decreases appreciably with addition of Germanium in $Se_{85}Te_{15}$. The dc conductivity of $Se_{85-x}Te_{15}A_x$(A=In,Ge) is singly activated in the entire temperature range investigated and increases with increase in temperature for each composition.Meyer –Neldel (MN) rule is obeyed for the whole series of $Se_{85-x}Te_{15}Ge_x$ glasses and is obeyed for $Se_{85-x}Te_{15}In_x$ (x = 0, 2, 6, 10, 15) if we exclude $Se_{75}Te_{15}In_{10}$ from the series. For the series $Se_{85-x}Te_{15}In_x$ (x=0, 2, 6, 15), Meyer – Neldel characteristic energy (E_{MN}) and MN pre exponential factor (σ_{00}) are 17.04meV & $1.678*10^{-9}$ Sm^{-1}respectively. For the whole series of $Se_{85-x}Te_{15}Ge_x$ glasses, Meyer - Neldel characteristic energy (E_{MN}) & MN pre exponential factor (σ_{00}) come out to be 40.67 meV and $3.78*10^{-4}Sm^{-1}$ respectively.

The values of E_{MN} & σ_{00} for the two series following MN rule lie in the range suggested by Shimakawa and Abdul- Waheb for chalcogenide glasses. So it is concluded that inter layer tunnelling of holes through interlayer potential barriers may dominate the dc transport in the two systems.

ac conductivity measurements provide information about the conduction mechanism in the given material. Measurement of ac conductivity is a powerful tool to probe the presence of defect states in the disordered systems as it is assumed that they are responsible for this type of conduction. So, the frequency and temperature dependent ac conductivity studies have been made on the thin pellets (thickness~1mm) in the frequency range 2 kHz to 50 kHz and temperature range 213 K to 293 K for $Se_{85-x}Te_{15}In_x$ (x=0, 2, 6, 10, 15) and $Se_{85-x}Te_{15}Ge_x$(x = 2, 6, 10, 15) in the temperature range 263 K to 333 K and frequency range 2kHz to 50kHz in vacuum of 10^{-4} to 10^{-5} Torr inside the sample holder. The frequency dependence of ac conductivity for $Se_{85-x}Te_{15}In_x$ follows well known relation $\sigma_{ac}=A\omega^s$ at each temperature for each composition. The value of s comes out to be less than 1. The value of frequency exponent s is decreasing slowly with rise in temperature for each glass. The ac conductivity behaviour of $Se_{85-x}Te_{15}In_x$(x = 0, 2, 6, 10, 15) has been explained by CBH model in the studied temperature and frequency range. The frequency and temperature dependent behavior of ac conductivity of the studied materials is predominantly due to bipolar on hopping. W_M follows the pattern followed by the activation energy. The value of defect states and dielectric constant appear to increase with increase in Indium concentration.

The frequency dependence of ac conductivity for $Se_{83}Te_{15}Ge_2$ also follows the well-known relation $\sigma_{ac}=A\omega^s$ at each temperature and this behaviour has been explained well by CBH model. CBH model establishes that ac conductivity of $Se_{85}Te_{15}Ge_2$ is due to single polaron hopping in the studied temperature range. But higher addition of Germanium as impurity in $Se_{85}Te_{15}$ leads to the formation of simple pairs in the band gap which contribute significantly to the ac conductivity in addition to the polaron hopping as suggested by CBH model. So the ac conductivity behaviour of $Se_{85-x}Te_{15}Ge_x$ (x= 6, 10, 15) has been explained well by taking into account both CBH and simple pair model. Also, it has been found that the value of defect states and dielectric constant decreases with increase in Germanium concentration.

The study of dielectric behavior of chalcogenide glasses is useful to reveal structural information which can be used to understand conduction mechanism in these glasses. In addition, the study of temperature dependence of dielectric permittivity particularly in the range of frequencies where dielectric dispersion occurs can be of great importance for understanding the nature and origin of losses occurring in these materials which may be helpful to determine the nature of defects in the solids. So, the origin and nature of dielectric losses in these materials is an area of interest. In view of this, the dielectric studies have been made on the thin pellets of materials in the temperature range 213 K to 293 K for $Se_{85-x}Te_{15}In_x$ (x=0, 2, 6, 10, 15) and in the temperature range 263 K to 333 K for $Se_{85-x}Te_{15}Ge_x$ (x = 2, 6, 10, 15) for the frequency range 2 kHz to 50 kHz.

From the dielectric studies of $Se_{85-x}Te_{15}In_x$ (x=0, 2, 6, 10, 15) and $Se_{85-x}Te_{15}Ge_x$ (x= 2, 6), we find that dielectric constant (ε') and the dielectric loss (ε'') are temperature and frequency dependent. Dielectric constant and dielectric loss increases with increase in temperature, the increase being different at different frequencies. For each sample, dielectric constant and dielectric loss decrease with increase in frequency at a given temperature. The dielectric loss (ε'') follows power law $\varepsilon''=A\omega^m$ and m comes out to be negative. The frequency dependence of dielectric loss in the studied temperature range has been interpreted in terms of hopping of charge carriers over a potential barrier between charged defect states (D^+ and D^-) and follows Guintini's model for dielectric dispersion in chalcogenide glasses.

The dielectric constant (ε') and the dielectric loss (ε'') are found to increase with increase in Indium content for $Se_{85-x}Te_{15}In_x$ which may be interpreted in terms of increase in defect states in the Se-Te glassy system with the increase in Indium content. From the results of dielectric properties of $Se_{85-x}Te_{15}In_x$ glasses, it may be concluded that bipolaron hopping takes place in all the samples in the studied temperature range.

For $Se_{85-x}Te_{15}Ge_x$ (x= 2, 6), dielectric constant (ε') and dielectric loss (ε'') decrease with increase in frequency at a given temperature which may be interpreted in terms of decrease in defect states in the Se-Te glassy system with the increase in Germanium content. The decrease in defect states with the increase of Germanium content has also been predicted by CBH model of ac conductivity. For $Se_{85-x}Te_{15}Ge_x$ (x=10, 15), the temperature dependence of dielectric constant (ε') and dielectric loss (ε'') show peaks which has been explained on the basis of dipolar relaxation. The dielectric constant (ε') is found to decrease with increase in Germanium content which may be interpreted in terms of decrease in defect states in the Se-Te glassy system with the addition of Germanium.