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A Review On Electrical Properties of Chalcogenide Thin Films

Imran Khan
Assistant Professor
Dept. of Physics
G.F College, Shahjahanpur,
MJP Rohilkhand University,
Bareilly, U.P., India

Abstract

Chalcogenides are compounds formed primarily from chalcogen elements such as sulphur, selenium or tellurium. Knowledge of the structural arrangement of atoms of a solid substance is an essential prerequisite to detailed understanding of other physical, chemical and electrical properties. However, despite the lack of periodicity, the structure of a-solids possesses a considerable degree of ordering. In order to provide a description of the structure of solids, it is convenient to consider the various types of structural or decreasing length scales in terms of ever-increasing n-body correlation functions. Hence,

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short-rang order (SRO), medium-range order (MRO) and long-range order (LRO) are concepts have been developed to understand the disorder in a-solids. It has been widely believed that there is no structural order in a-solids at a length scale says greater than 10Å from any given atom as origin. However, recent improvements in computing power have meant that very large structural models of a-solids can now be constructed out to 50Å or so [1,2,3]. Crystalline materials can be obtained by exploiting the periodicity of the crystal structure. Most of the textbooks on the theory of condensed matter ignore this type of materials most completely. The reason of this negligence is the lack of a coherent theoretical description.

We can find in the literature a widespread interchange of terms; liquid-like, non-crystalline, glass, vitreous, and amorphous. All of these are often taken as synonymous. The absence of long-range order is an essential aspect, which differentiates them from their crystalline counterparts. Adopting this aspect as a definition, the various terms can be taken as synonymous. Glasses are essentially amorphous solids (a-solids). However, all a-solids are not necessarily glasses – e.g. gels. The word glass has various meanings and in scientific language its definition is subject to evolutionary change. Chalcogenide glasses show glass transition, at various length scales.

To understand the relaxation effect and crystallization

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by heating the materials its structural order can be defined in a hierarchical manner. But it is usual to understand a glass as an amorphous solid formed by the process of solidification of liquid. By applying the quenching techniques we can find out the same composition of glassy materials. That's why nowadays most scientists termed glass as a solid and it depends on preparation methods.[4-6].

Chalcogenide glasses (ChGs) are based on selenium, sulphur, or tellurium or their compounds with As, Sb.Ge.Si.etc. These materials are prepared in vacuum so that reaction of the raw materials with oxygen is avoided. Typically, ChGs have densities in the order of 3 to 5 g/cm^3. ChGs can be characterized as covalent, metallic and ionic. For covalent ChGs the band gap is 2-3 eV and electrical conductivity in many of this group is governed by holes. Accordingly, these glasses can be regarded as a-semiconductors. In the rich-tellurium ChGs the bandgap is about 1 eV and it exhibits metallic characteristic. Finally, the Ag doped ChGs can be regarded as ionic glasses where the ionic conduction in many of these glasses governs the electrical conductivity [7]. ChGs exhibit some different features from hydrogenated a-semiconductors such as a-Si:H, a-Ge:H and their alloys. ChGs can be prepared as bulk material as well as thin films, whereas hydrogenated a-semiconductors can be obtained only as thin films and unlike hydrogenated a-semiconductors ChGs show glass transition. This remarkable difference obviously arises from different bonding coordination [8]. One

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of the most prominent features of a-solids is the localization of energy states. It is widely accepted in many cases that elementary excitations in a-solids are localized if the disorder is strong enough or/and the energy of the excitations is close enough to the band edges. A central problem in the understanding of the electronic structure of a-solids is the determination of when the electronic states are extended (delocalized) or localized and how this localization or delocalization depends upon the energy of the state, the degree of randomness in the system. To investigate the electrical characteristics of chalcogenide glasses, studies the dependence of the switching voltage and current on different material properties, such as composition, thickness, and pressure. It will help the investigators to understand the conduction mechanisms of the chalcogenide glasses. In this present work I have been studies the effect of thickness, composition, frequency and temperature on the I-V characteristics of chalcogenide glasses.

Experimental:

We can use different methods to produce a solid from a liquid phase such as melt quenching, precipitation and co-precipitation reactions, polymerization reactions. The important historically method to prepare amorphous materials is the melt quenching method. The melt-quenching technique was adopted to prepare the entire glassy systems understudy. The melt-quenching technique was adopted to prepare all compositions of the investigated glassy systems. The

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electrical properties were studied on samples in vacuum at different temperature with subsequent quenching by the rapid cooling of the obtained melt in air at room temperature prepared in form of pellets. The quenched glassy alloys have been grounded and the fine powder was compressed under a pressure of 5 Ton. The thickness of the pellet is ~1.5 mm and the diameter is 1cm. The pellets were coated on two opposite sides with silver paste for good electrical contact with the electrodes of the sample holder.

The metallic samples holder was used for DC and AC measurements. The samples holder consists of two parts; the upper part contains two steel electrodes passes through teflon feed, between which the pellet samples were mounted via a spring arrangements. The lower part contains a heating element in the bottom to heat the sample. Electrical measurements the samples were heated to 500 C and kept there for 15 mins. It was then slowly cooled to room temperature. To avoid any effect of moisture absorption, both DC and AC measurements were maintained under vacuum of the order 10-3 Torr in the sample holder. The temperature was measured by mounting a copper constantan as thermocouple near the sample. The DC conductivity was measured using a Keithley 617 *C* electrometer where a DC voltage 1.5 V was applied across the sample. The capacitance *C* and dissipation factor *D* measurements were carried out in the frequency range 0.12–100 KHz for several temperatures in the range from room temperature up to 390 K by means of Keithley

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3330 programmable LCZ meter. A programmable Kiethly electrometer model 6517 was used to measure the I –V characteristics.

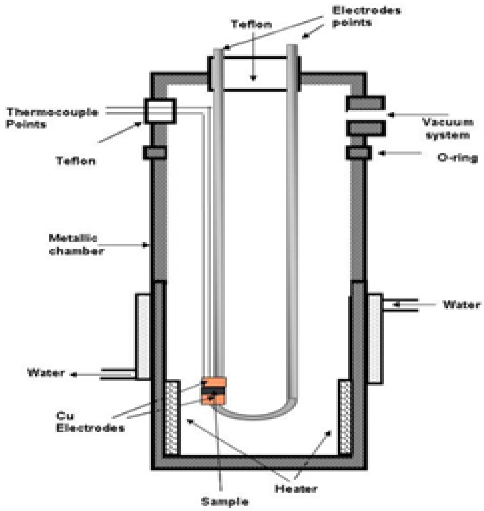

Fig: 1 Schematic diagram of sample holder

Fig: 2 Keithley picoammeter Model-6485

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Electrical Studies

Semiconductors are the materials that has an electrical conductivity between that of a conductor and an insulator, that is, generally in the range 10^3 Siemens per centimeter to 10^{-8} S/cm. Devices made from semiconductor materials are the foundation of modern electronics, including radio, computers, telephones, and many other devices. Semiconductor devices include the various types of transistor, solar cells, many kinds of diodes including the light-emitting diode, the silicon controlled rectifier, and digital and analog integrated circuits. Solar photovoltaic panels are large semiconductor devices that directly convert light energy into electrical energy. An external electrical field may change a semiconductor's resistivity. In a metallic conductor, current is carried by the flow of electrons. In semiconductors, current can be carried either by the flow of electrons or by the flow of positively-charged "holes" in the electron structure of the material. Electrical conductivity or specific conductance is measure of material’s ability to conduct an electrical current. When an electrical potential is placed across a conductor, movable charge flow, gives an electric current. The conductivity σ is defined as the ratio of current density J to the electric field strength E. $J = \sigma E$ Conductivity is reciprocal of electrical resistivity (ρ) and has the SI unit of Siemens per meter ($S.m^{-1}$). $\sigma = 1/\rho$ The system which was used to characterize the Semiconductor has been shown in figure. Electrometers can measure low currents very accurately, but

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the circuitry needed to measure extremely low currents, combined with functions like voltage, resistance, and charge measurement, can increase an electrometer's cost significantly. The Model 6485 Picoammeter combines the economy and ease of use of a DMM with low current sensitivity near that of an electrometer.

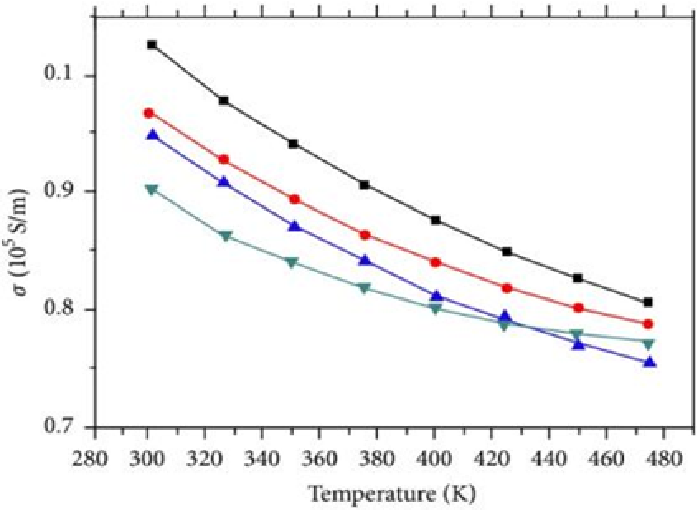

Fig: 3 Conduction mechanism in chalcogenide

Conclusion:

Bulk sample has been deposited on ultra clean glass substrate at room temperature by thermal evaporation technique. The measured values of electrical parameters like dc-conductivity (σ_{dc}), pre exponential factor (σ_0) and activation energy (ΔE) suggest the investigated amorphous semiconductor thin film is suitable for electronic devices. It is clear that conductivity is less with temperature, this can be

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attributed to the fact that charge carriers are frozen at low temperatures, however as soon as the temperature increases the degree of charge carrier ionization of impurities increases results in rapidly increase in conductivity. The electronic applications of chalcogenide glasses have been an active topic of research throughout the second half of the 20th century and beyond. For example, the migration of dissolved ions is required in the electrolytic case, but could limit the performance of a phase-change device. Diffusion of both electrons and ions participate in electro migration widely studied as a degradation mechanism of the electrical conductors used in modern integrated circuits. Thus, a unified approach to the study of chalcogenide, assessing the collective roles of atoms, ions and electrons, may prove essential for both device performance and reliability (9, 10).

References_

1. *R. Zalin, The physics of amorphous solids (Wiley-VCH, 1998).*
2. *S. Elliott, Physics of Amorphous Materials (Longman Scientific & Technical, 1990)*
3. *S. Elliott, in "Properties and applications of amorphous materials", edited by M. Thorpe and L. Tichy (Springer, 2001) p1-12.*
4. *J. Bosnell , Physics in Technology, 4 (1973)113*
5. *J. Zarzycki, W. Scott, C. Massart, Glasses and the Vitreous State (Cambridge University Press, 1990)*
6. *J. Shelby, Introduction to Glass Science and*

ISBN: 978-81-951728-4-9

Technology (Royal Society of Chemistry, 2005)

7. *K. Tanaka, in "Photo-Induced Metastability in Amorphous Semiconductors", edited by A. Kolobov (Wiley-VCH, 2003) p69-90,*
8. *M. Popescu, in "Photo-Induced Metastability in Amorphous Semiconductors", edited by A. Kolobov (Wiley-VCH, 2003)p1-22.*
9. *K. Morigaki, Physics of amorphous semiconductors (World Scientific, 1999)*
10. *Ovshinsky, S.R. (1968). "Reversible Electrical Switching Phenomena in Disordered Structures". Phys. Rev. Lett.* ***21*** *(20): 1450–3*
11. *Adler, D.; Shur, M.S.; Silver, M.; Ovshinsky, S.R. (1980). "Threshold switching in chalcogenide‐glass thin films". Journal of Applied Physics.* ***51*** *(6): 3289–3309*