CHAPTER - ONE
1.1 An Introduction to ceramics:

Earlier, ceramic word is used for those inorganic solids, which are insulators. However, now a days, this category includes many other kinds of inorganic materials e.g., electronic materials, magnetic materials, optical materials.

Glass is a solid, which is made in solid form by rapid cooling of the melt. Due to rapid cooling, the atoms or molecules do not get sufficient time to come to minimum energy state, i.e., crystalline state. They therefore solidify in non-crystalline state. They are also considered analogous to and continuous to liquid state of that substance which has attained solid form due to high viscosity of the melt due to rapid cooling.

Glasses are known to the mankind for the last 2000 years and various kind of these glasses, e.g., silicate glasses, phosphate glasses, borate glasses etc, have been developed in past. The application of these glasses
was limited to optical applications, e.g., windows, panes, mirrors, lenses etc. Electrically they were all insulators as electronic conduction was absent in them. Even if they have some conductivity, it is ionic due to movement of alkali ions present as impurities.

The science and technology of materials are persistently undergoing vital changes. We have now entered into an age of materials science where-in materials go by a variety of alternative names such as smart, intelligent, high performance, hi-tech, tailored, engineered etc. The suitability of the materials for high technology applications requires additional information about the material in respect of optical, structural and electrical characterization.

Characterization of materials from optical, structural and electrical consideration involves the determination of features such as optical band gap, nature of band gap, crystallographic structure, chemical composition and current voltage characteristics of the materials. The information about these features is significant for the reproduction of materials.

Semiconductors are the basic components of the integrated circuits and are responsible for the starting rapid growth of the electronics
industry in the past fifty-to-sixty years worldwide. Because there is a continuing need for the faster and more complex systems for the information era, existing semiconductors are being studied for improvement, and new ones are being invented. Whether it is for higher speed, lower power, higher density, higher efficiency, or new functionality, the number and types of semiconductors have been growing steadily in the fascinating field.

It is difficult to have a clear quantitative definition of semiconductor. Based on conductivity, materials can be classified into three groups: (i) metal (ii) semiconductor and (iii) insulator. It is to be noted that the most important feature of the semiconductor is that it can be doped with impurities to different concentration levels, so every semiconductor material can cover a range of conductivity.

The earliest device, not necessarily made of semiconductor material, is probably the resistor, implied by ohm’s law back in 1826. Vacuum tubes started around 1904 and were the major electronic components in the early radio era through World War II. The real world of the semiconductors was in 1947 with the invention of the bipolar transistor.

According to their properties and behavior, materials can be classified as crystalline and non-crystalline solids. In a crystal, the atoms are
arranged in a periodic repeated pattern, whereas no such regularity occurs in non-crystalline material. Again crystalline solid can be divided into two as single crystal, where entire solid consists of only one crystal and polycrystalline, where the solid has an aggregate of many crystal separated by well defined boundaries.

Recent years have seen an upsurge in interest in the electronic properties of non-crystalline materials. These lack the simple structures and long range order that make crystals relatively easy to understand. The interest, both at Sheffield and worldwide have largely concentrated on amorphous silicon and its relatives. A wide variety of measurements have made along with the photoluminescence methods, for a broad understanding of the semiconductors. These materials are widely used in xerox copiers, photovoltaic cells and large area displays.

1.2 An Introduction to Chalcogenide Glasses:

For the last three decades, some glasses have been prepared from chalcogen elements (Se, Te, S) which show electronic conduction and have been used in semiconducting application widely. The electrical properties of these new glasses have therefore drawn more attention now a
days. Given below are some of the important properties and application of these glasses:

Glass formation of the above materials is relatively easy and many kind of glasses have been prepared by means of melt quenching, vacuum deposition and other less common methods such as spin coating and mechanical amorphization [1-4]. Among the glasses, only selenium vitrifies as an elemental glass, which is fairly stable at room temperature. Most of the stable binary glasses are compounds of chalcogen atom and group IV or V atom, such as Ge-Se and As-S, where atomic ratios can be varied widely. Ternary and more complicated glasses are of various kinds: these can probably be prepared by alloying with any kind of atom including cations such as sodium and metallic atoms such as erbium, although the concentration may be limited. Oxychalcogenide and Chalcogenide glasses can also be synthesized.

Thermal stability depends upon the glass. When heated, stable glasses such as As$_2$S$_3$ exhibit only the glass transition, some glasses such as selenium undergo glass transition and crystallization and tellurium glasses are likely to crystallize directly.
In covalent chalcogenide glasses, it has been argued that there exist some transition at $<N> = 2.4$ and $2.67$ [2,5]. Here, $<N>$ is the average coordination number of atoms, which is defined as $<N> = \sum x_i N_i$ where $x_i$ is the atomic fraction $\Sigma x_i = 1$ of constituent elements and $N_i$ is the atomic coordination number which is two for chalcogens.

Philips and Thorpe have interpreted the transition at 2.4 as follows [5]: In a glass with $<N> < 2.4$ the structures is floppy, and there exist so called zero- frequency vibrational modes. That is supposing only the bond length and the bond angle provide structural constraints, there remain free (zero frequency) vibrational modes. At $<N> = 2.4$ the structures becomes just regid, and stable glasses can be prepared. Above this point the structure is over constrained, and glass formation becomes difficult.

However, the compositional dependence of some physical properties such as the density and the optical energy gap manifest extrema and/ or the threshold also at $<N> = 2.67$ [5]. Tanaka assumes that this is a signature of a topological phase transition from two dimensional ($<2.67$) to three dimensional ($>2.67$) structures. However, some physical properties such as the glass transition temperature increase monotonically with $<N>$. Further compositional studies are needed to obtain universal insights. It
should be noted that such \(<N>\) dependence studies are inherent to covalent glasses, which can be varied continuously in atomic compositions.

Chalcogenide glasses possess electrical and optical bandgaps of 1-3eV and accordingly they can be regarded as amorphous semiconductors. The gap decreases in the sequence of sulfur, selenium and tellurium, reflecting the enhanced metallic character.

The electronic structures of a chalcogenide glass is essentially the same as that of the corresponding crystal [2, 3, 6]. That is, in covalent glasses with the chalcogen coordination number of two, the top of the valence band is composed of lone-pair p-electrons of chalcogen atoms, and the bottom of the conduction band is composed of anti-bonding states covalent bonds. The bandgap energy is similar (\(\sim \pm 10\%\)) to that in the corresponding crystal.

Electrically, however glasses exhibit smaller conductivities than the corresponding crystals [1-3, 7]. This is because the electronic mobility is suppressed by band tail and gap states, which are manifestations of disordered structures. Specifically, sulfide glasses such as As\(_2\)S\(_3\) and GeS\(_2\) behave as insulators, the conductivity being smaller than \(10^{-15}\text{ S cm}^{-1}\). On the other hand, the carrier density of intrinsic semiconductors is governed by the
band gap energy, and accordingly it is assumed to the similar to that in the corresponding crystal.

After the discovery of an optical phase-change phenomenon by Ovshinsky et al. in 1971 [8], extensive studies have been made on photoinduced phenomena in chalcogenide glasses [2, 9-11]. The phenomena can be grouped into three categories. The photon mode, in which the photoelectronic excitation directly induces atomic structural changes; the photothermal mode in which photoelectronic excitation induces some structural changes with the aid of thermal activation and the heat mode in which the temperature rise is induced by optical absorption. Interestingly, these three kinds of phenomena are likely to appear in sulfide, selenides, and tellurides, respectively.

Four kinds of applications are commercially available or practically utilized. These rely upon the unique features of chalcogenide glasses: quasistability, photoconductive properties infrared transparency and ionic conduction.

The first is the phase-change phenomena used is erasable high-density optical memories [8]. The product utilizes semiconductor lasers and chalcogenide films such as Ge-Sb-Te with the thickness of ~ 15 nm. The
reflectivity change between amorphous and crystalline phases is monitored with the weak line beam. The present memory capacity is about 5 GB/disk, which is still increasing [12].

The second category is photoconductive applications such as photoreceptors in copying machines and X-ray imaging plates [2 - 3, 8]. In a photoconductive target in vidicons, avalanche multiplication in amorphous selenium films is employed, which substantially enhances the light sensitivity so that star images can be taken.

The third application is purely optical [2 - 4]. That is, since chalcogenide glass is transparent in IR regions, it can be utilized for IR optical components such as lenses and windows. It can also be utilized for IR transmitting optical fibers. Fibers have also been employed as a matrix incorporating rare earth ions, such as Er$^{3+}$. Such rare earth ion doped chalcogenide glasses are promising for preparing functional fibers such as optical amplifiers.

Lastly, Chalcogenide glasses containing group I elements such as silver are used as high sensitivity ionic sensors [2, 3]. Some lithium-containing glasses can also be utilized as solid state electrolytes in all solid batteries.
The electrical conductivity of ceramic materials encompasses a wide range of values, which characterize insulators, semiconductors and metallic conductors. The electrical behavior is usually strongly dependent upon temperature and composition. For example, a small change in the composition may transform an insulating ceramic into a semiconductor. When the resistivity is high, conduction may occur by both ionic and electronic processes.

Since the electrical conductivity of a single-phase material depends upon the type, concentration and mobility of charge carriers, the electrical conductivity will be uniquely determined when the temperature and composition are fixed, provided the mobility is a function of temperature and composition only. This is generally true if the effect of defects is negligible. If structural defects exist, they play an important role in determining the electrical conductivity [13].

The interest in glass ceramics is perhaps two folds. Firstly, there is the material science aspect; a wide diversity of materials can be rendered in glassy form. This is in sharp contrast to the knowledge of the average layman for whom the word glass signifies only to transparent materials which are used in windows, e.g., silicate glasses made from silica
with the addition of a few alkali oxides. But, now a days, glasses have wide range including metallic glasses, semiconducting glasses and of course insulating glasses.

The second interest in glass ceramic materials is in the fundamental physics of such systems: Why widow glass is transparent when the conventional solid state explanation of transparency lies in term of band gap which depends crucially on the periodicity of the lattice? Furthermore, the semiconducting behavior of glassy materials is also astonishing if the band gap is due to long range order in solids. Glassy semiconductors exhibit many properties, which are unique to them and are not found in their crystalline counterparts [14].

In view of the above interesting problems, the present candidate has decided to work on some glass ceramics, which do not contain oxygen but contain other six group elements. These non-oxide glasses are found to have semiconducting properties, which are being studied by various workers for the last two decades but many unsolved problems are left in this area.

1.3 Electrical Conduction in Chalcogenide glassy Semiconductors:

By semiconductor we mean a substance, which has conductivity in between that of a conductor and an insulator. The distinction
between an insulator and semiconductor is difficult to draw. However, normally a substance having conductivity less than $10^{-14}$ ohm$^{-1}$ cm$^{-1}$ does not fall under the category of semiconductor. The distinction between metal and semiconductor is quite sharp not by the conductivity range but by the temperature coefficient of resistivity which is positive in case of metals and negative for semiconductors. According to the band of theory of solids, the properties of semiconductors are described in terms of valence band, conduction band and forbidden gap.

The electrons in an isolated atom have the discrete energy levels. A solid contains a large number of atoms arranged in a lattice at a very small distance. The energy bands in a solid are produced due to spread of atomic energy levels. The band in which available states are occupied by valence electrons is known as valence band. On the other hand in conduction band, available states are occupied by electron, which can participate in electrical conduction. In semiconductors, these bands are separated by forbidden band. The energy difference between the highest filled valence band and the lowest empty conduction band is known as the band gap.

At absolute zero of temperature, the valence band of a semiconductor is completely filled and conduction band is completely
empty. Due to thermal energy at any temperature other than absolute zero, a number of electrons become free. In terms of bands, one can say that electrons are excited to the conduction band and contribute to the conductivity. The empty state left in the valence band is known as a hole, which can also contribute to the conduction process. The conductivity of a semiconductor therefore has two components as follows:

$$\sigma = n e \mu_n + p e \mu_p$$

Where $n$ and $p$ are the density of electrons and holes respectively. $\mu_p$ and $\mu_n$ are their respective mobilities.

When impurities are added to an intrinsic semiconductor, the conductivity increases by several orders of magnitude. The impurity levels in a semiconductor can be of donor type (n type), which donate electrons to conduction band or can be acceptor type (p type) which accept electrons from valence band.

When an electron comes from valence band to an acceptor level, a hole is produced in valence band, which can contribute to conductivity. Similarly electrons which are donated to conduction band by donor levels contribute to the conductivity of the semiconductor which increases in both the cases.
It must be noted that the donor and acceptor states in a semiconductor are localized in space because the impurity atoms occupy certain atomic sites in the structure. Because of this, donor and acceptor states are frequently called localized states.

In addition to donor or acceptor states, other kinds of defects in semiconducting crystals can also be produced. Each type of defects has a definite energy and produced localized states at that energy. These localized states can act as traps for electrons or holes. When probability of capturing electrons and holes become equal, a localized state can act as a recombination center.

Generation and recombination of charge carriers are simultaneous in a semiconductor. In thermal equilibrium, equal number of like charges appear and vanish per unit time. The conductivity of a semiconductor depends upon these equilibrium electron and hole densities.

The structure of all non-crystalline semiconductors lack long-range order and far way from a site seems to be randomly distributed but short-range does exist. The state of material may be regarded as a supercooled liquid. Chalcogenide glassy materials are heated to melt in the form of a liquid and at the same instant freeze the position of every atom by
quenching. Even in this freezeed position they retain short-range order and the position of nearest neighbour remains nearly same. For instant in non-crystalline germanium, four nearest neighbour surrounds each atom. This can be arranged in two different ways one that the atom at the opex of the tetrahedron and the other at the center of new tetrahedron.

In non-crystalline germanium both arrangements occurs with essentially equal likely hood and it leads to disorder in second nearest neighbours. As the process is extended further and further away for original atom, the numbers of the possible position multiply rapidly resulting in complex disorder at long range. This type of disorder is termed as positional disorder and prevails in all non-crystalline elemental semiconductors like germanium, silicon, selenium and tellurium.

In binary non-crystalline semiconductors besides positional disorder, compositional disorder also exists. For example in non-crystalline Ge or Te the structure becomes such that there becomes equal probability of finding Ge or Te atoms at any position. This is compositional disorder and exists in other binary non-crystalline semiconductors like $\text{As}_2\text{S}_3$ and others.

The carriers in amorphous systems are strongly affected by the randomness of atomic arrangement due to the absence of long-range order.
Mott has argued that the spatial fluctuation in the potential, caused by the configurational disorder in amorphous materials may lead to the formation of localized states, the valence and conduction bands do not have sharp cut off but have a tail above and below the normal band. The extent of these tailing is expected to be enhanced in alloys, which contain compositional disorder in addition to positional disorder.

The conduction in localized states take place, by hopping process, with the help of thermal energy. At absolute zero of temperature, no conduction is expected in localized states. The mobility of charge carriers therefore changes suddenly from finite value to zero in the band tails.

Cohen, Fritzsche and Ovshinsky first suggested that in the case of disordered covalent alloys, such as chalcogenide glasses, the valence and conduction band tails overlap each other close to the center of the forbidden gap. The mobility of the carriers has finite value in high density states but it decreases abruptly in tail states. These boundaries are called mobility edges. The critical energies at mobility edges define a mobility gap.

Davis and Mott [15] proposed that there is a narrow band of compensated localized states, which is in the Fermi level between the two
tails. This model suggests that hopping conduction can take place in the localized states near the Fermi level.

Mott and his collaborators [16] further elaborated the model of gap states in chalcogenide glasses. They considered the states near Fermi level due to defects, e.g., dangling bonds. Two electrons are shared in a chemical bond between atoms. In some structural configuration, the atoms are not able to share the electrons and the bond is broken. This is called a dangling bond. A dangling bond is neutral (d^0) when occupied by a single electron. In some cases, dangling bond can attract an electron, and become negatively charged (d'), or attract a hole and become positively charged (d^+). They based their model on the assumption that paired electron states are preferred in chalcogenide glasses.

In general it is accepted that the localized states in amorphous semiconductors do not correspond to a single energy but have an energy distribution. Various methods, e.g., field effect, space charge limited conduction, deep level transient spectroscopy, barrier capacitance measurement and thermally stimulated currents have been employed to study the localized states in amorphous semiconductors.
The most accepted model for the density of localized states assumes a continuous distribution of localized states having its minimum value near Fermi level. The density of localized states varies with energy on both sides of the Fermi level towards conduction and valence bands.

The essential features of the Davis and Mott model for the band structure of amorphous semiconductors are the existence of narrow tails of localized states at the extremities of the valance and conduction bands and further more of a band of localized levels near the middle of the gap. This leads to three basically different channels for conduction.

1.3.1 Extended State Conduction:

The conductivity in this case is given by

\[ \sigma = \sigma_0 \exp \left[ - \frac{(E_c - E_F)}{kT} \right] \]

Where \( \sigma_0 \) is called pre-exponential factor and lies in the range 10^3 to 10^4 ohm^{-1}cm^{-1}.

1.3.2 Conduction in Band Tails:

If the wave function are localized, so that \( \sigma(E) = 0 \), conduction can only occur by thermally activated hopping. Every time an electron moves from one localized state to another it will exchange energy with a
phonon, it may be expected that the mobility will have a thermally activated nature.

\[ \mu_{\text{hop}} = \mu_0 \exp \left[ - \frac{w(E)}{kT} \right] \] ........(1.2)

The pre-exponential \( \mu_0 \) has the form

\[ \mu_0 = \frac{1}{6} \nu_{\text{ph}} \left( \frac{eR^2}{kT} \right) \] ........(1.3)

where \( \nu_{\text{ph}} \) is the phonon frequency and \( R \) is the distance covered in one hop.

According to the above theory the conductivity is given by

\[ \sigma_{\text{hop}} = \sigma_{0\text{hop}} \left( \frac{kT}{\Delta E} \right) C_1 \exp \left[ - \left( \frac{E_A - E_F + W}{kT} \right) \right] \] ........(1.4)

where

\[ C_1 = 1 - \exp \left( -\frac{\Delta E}{kT} \right) \left[ 1 + \frac{\Delta E}{kT} \right] \] ........(1.5)

1.3.3 Conduction in Localized States at Fermi energy:

Mott's treatment of variable range hopping leads to a temperature dependence for the conductivity of the form

\[ \sigma = \frac{1}{6} e^2 R^2 \nu_{\text{ph}} N(E_F) \exp \left( - \frac{A}{T^{1/4}} \right) \] ........(1.6)

or

\[ \sigma = \sigma_0(T) \exp \left( - \frac{A}{T^{1/4}} \right) \] ........(1.7)
1.4 Selection Of The Problem:

As we know, solids are of two types; crystalline and non-crystalline. Crystalline are those in which atoms or molecules are arranged in an orderly pattern. However, in non-crystalline, atom or molecules are in their higher energy states as they are prepared by the rapid cooling of the melt. Therefore a non-crystalline solid comes to thermodynamically equilibrium state, i.e., when it crystallizes. Thus, in this process of transformation, the excess energy is liberated which appears as exothermic peak in thermo-analytical measurements. Such exothermic peaks are observed by the dsc experiment. When the sample is brought quickly to a temperature above the glass transition temperature ($t_g$) and heat evolved during the process is recorded as a function of time, the process is called as isothermal transformation. Similarly, for the non- isothermal transformation, a fixed heating rate is employed to heat the sample and heat evolved is recorded as a function of temperature.

In fact, when the change of state takes place, various other properties, like electrical, optical and thermal, also change. According to theoretical analysis, isothermal method of transformation is more accurate but in
practice, it is difficult to maintain a constant temperature therefore non-isothermal transformation method is generally preferred for experiments.

Any physical parameter, which changes drastically upon crystallization, can be measured as a function of time during amorphous to crystalline transformation. As the electrical conductivity of amorphous semiconductors increases several orders of magnitude on crystallization, this parameter has been used widely by various workers to evaluate the degree of crystallization as a function of time.

In chalcogenide glasses the electrical conductivity, in general, is found to increase drastically when glass crystallizes on annealing at temperatures close to crystallization temperature. Time dependence of conductivity measurements show an increase in conductivity with time followed by saturation after some time when crystallization becomes complete. The total time of crystallization is found to depend on temperature of annealing [17]. The effect of light shining during crystallization is also found to have effect on total time of crystallization [18]. The results of crystallization are explained by considering bulk crystallization and crystallization kinetic parameters have been calculated using Avrami's theory of isothermal transformation. On the other hand, some workers have
explained their results in terms of the theory of surface crystallization. This shows that a more systematic study is required on this problem.

These glasses have found application in resistance switching which can be used as ON and OFF switch if switching is threshold type. However, they can be used as memory if switching is memory type. Such a memory effect is being used in computer memories marketed by Energy Conversion Devices Inc., U.S.A.

Chalcogenide glasses show resistance-switching behavior in which sample goes from high resistance state to a very low resistance state at a particular voltage called threshold voltage. The switching is of two types, namely threshold and memory. In threshold switching, the sample comes back to high resistance state if the voltage is reduced to zero. However, in case of memory switching, sample remains in low resistance state when voltage reduces to zero or is reversed. The high resistance state can, however, be obtained if one applies a high current pulse of short duration.

A time of about a few microseconds is required to obtain the memory effect. This time is known as lock in time. If voltage pulse is of less duration than this time, then a memory switch behaves as threshold switch. An extensive study has been made on the mechanism of switching and it is
generally believed that in addition to electronic processes thermal processes, i.e., joule heating is also responsible for this phenomena. In some cases electronic processes starts the process of switching which is taken over by thermal process and in some case vice versa happens.

Crystallization studies may be useful in predicting the switching behaviour in these glasses as type of switching (threshold or memory) depends upon the rate of crystallization. Apart from this application, chalcogenide glasses have found application in erasable phase change optical recording also. It is difficult to write and erase if the amorphous to crystalline transformation rate is not sufficiently high. For this reason also, the study of crystallization is important for development of new materials for such an application.

Apart from the technical importance mentioned above, the knowledge of the crystallization process is important for the better understanding of the short range order in these materials.

For the study of crystallization kinetics two methods can be used. One method is called isothermal technique while other is called non-isothermal technique. In isothermal technique, sample is brought near to crystallization temperature very quickly and then any physical quantity, which changes
drastically, is measured as a function of time. However, in non-isothermal technique sample is heated at a constant heating rate and the properties are measured as a function of temperature near crystallization temperature. In non-isothermal measurements, therefore, uniform temperature programming throughout the sample body is required for a successful determination of kinetic parameters.

A lag in the temperature may occur between the furnace and the sample. Moreover, the kinetic analysis of non-isothermal data is impossible if the reaction kinetics changes with the temperature range under consideration. The reaction mechanism can, therefore, not be accurately determined and hence the uncertainty in determination of activation energy of crystallization is possible. On the order hand, the theoretical analysis of isothermal crystallization is simple and easy to explain. However, isothermal measurements are more difficult to perform under ideal conditions. Also in isothermal measurements, sample may undergo some reaction to reach the desired temperature.

In view of the above discussion, crystallization kinetics have been studied by isothermal annealing near crystallization. The conductivity
variation with time is measured at various fixed temperatures under isothermal condition.

Odelevsky has suggested a power formula to calculate the conductivity of a mixture (\( \sigma \)) during the amorphous to crystalline transformation. According to him,

\[ \sigma' = \alpha \sigma_c + (1 - \alpha) \sigma_a \]

where \( \sigma_c \) and \( \sigma_a \) are the conductivities of crystalline and amorphous phases having volume fraction \( \alpha \) and \((1-\alpha)\), respectively. For the power \( l = 1 \) the measured conductivity \( \sigma \) at a particular time during crystallization can be written as

\[ \sigma = \alpha \sigma_c + (1 - \alpha) \sigma_a \]

On the other hand, when \( \ln \sigma \) is considered to represent the sensitive parameter characterizing the conductivity content dependence, an empirical power formula can be written in the following form as suggested by E.L. Monsly and Borisova:

\[ \ln \sigma = \alpha \ln \sigma_c + (1 - \alpha) \ln \sigma_a \]

Extensive investigation of the crystallization process from conductivity data for the amorphous phase of selenium and of selenium based alloys have shown in the valid equations, subject to the limitation that
σ changes by a large value during the growth stage. Kotkata et al. [17] have used these equations to calculate the extent of crystallization in some Se-based chalcogenide glasses and found that this equation is more satisfactory as σₐ - σₐ is quite large in these glasses.

In the present systems also, conductivity increased by several orders of magnitude on crystallization and hence equation 5 can be used to calculate α by measuring σ as a function of time during isothermal annealing at temperature near the crystallization temperature.

Some of the useful properties of amorphous Se-Te are well known. The addition of Te to Se changes the properties of glassy Se drastically, for example, the crystallization temperature and photosensitivity of Selenium increases while aging effect of Selenium reduces and xerographic application of Selenium improves. It proofs that Se-Te alloys are far superior to Se itself.

In the present work, we are interested to study the effect of incorporation of third element to the Se-Te alloys. Various workers have investigated the effect of incorporation of Sb, Ge and Cd on the electrical properties, However, the kinetic glass transition and crystallization has not
been studied in detail. For the above study, we have chosen two glassy series, i.e., $\text{Se}_{70}\text{Te}_{30-x}\text{Sbx} \quad (0 \leq x \leq 10)$, and $\text{Se}_{80-x}\text{Te}_{20}\text{Inx} \quad (0 \leq x \leq 15)$. 

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