Electrical Transport Properties And Noise in Amorphous Semiconductor

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Abstract : The electrical transport properties of amorphous materials are given in the literature since several decades. Several problems are related with the band gapes, mobility edges and band structure of the amorphous semiconductor. The spontaneous fluctuation in the current or voltage across a circuit or sample give a source of noise in amorphous semiconductor.

***IndexTerms* - Electrical transport properties, Amorphous semiconductor, Band gapes, Mobility edges, Band structure, Noise.**

I.Introduction

The amorphous semiconductors are characterised by the absence of long-range order in the arrangement of atoms with compared to their crystalline counter parts are known as amorphous semiconductor. The amorphous semiconductor insists of chalcogenide glasses and tetrahydral coordinated material such as Ge and Si. The physical properties of amorphous semiconductor is now a days active field in the solid state Physics. The attention of research workers is attracted significantly by understanding the nature of electronic transport in amorphous materials. They interest in studies are developed point of view of the fundamental research and technology. Their properties are widely applicable to have a great deal of interest in the development of further research area in the electronics and optoelectronics.

It is very difficult to give the appropriate time with accuracy when mankind firstly fabricated its own glass. Some resources for this event go back to 10,000 years before in time. The silica is the glassy materials from which man has been manufacturing from thousands a year before. The much larger history is involved in the glass for its application as synthetic crystals. The modern reported investigations are started by the research workers in 28th century. The meaningful applications (3,13,18,19).

This are the examples for the back historical background of the amorphous semiconductor since the beginning of the human civilizations. Unfortunately, the scientist began to explore and understand the physical properties of the amorphous semiconductors just a few decades ago. The interest of the technological importance of this materials has developed over the past few years only. As a matter of fact, the amorphous materials had been exploited in diverse applications such as solar energy conversion, image processing, Xerography, memory switching devices, computer and telecommunication technology, thermo electric power, IR transmitting devices in many other important applications. (1,2,3,4,10,11,12,14,16,18,19).

II. Electron Transport Mechanism

The electronic transport properties are amorphous semiconductors are much more strongly affected by the potential fluctuations. In crystalline semiconducting materials, the long-range order in the lattice is present and the special averages of the transport parameters and the current carriers may be applied for a larger carrier mobility. In the case of the Alpine model shown in fig. (1.1) for an amorphous material, the conductivity of the material is calculated by the addition of conductivity slices σ (E) for a well defined value of each electron energy E. The analytical expression for the conductivity becomes

$$\sigma = \int \sigma\,(E)\,dE$$

where a constant energy slice cuts is obtained through the regions of different conductivity. The electrons are allowed in certain region and excluded in others. The allowed electron energy region from isolated pockets in a low energy slice. The allowed channel regions at a higher energy value present in the allowed packets. One side of the sample is connected with the other through the allowed channel regions. Some exceptional cases for isolated forbidden islands are observed in the lattice.

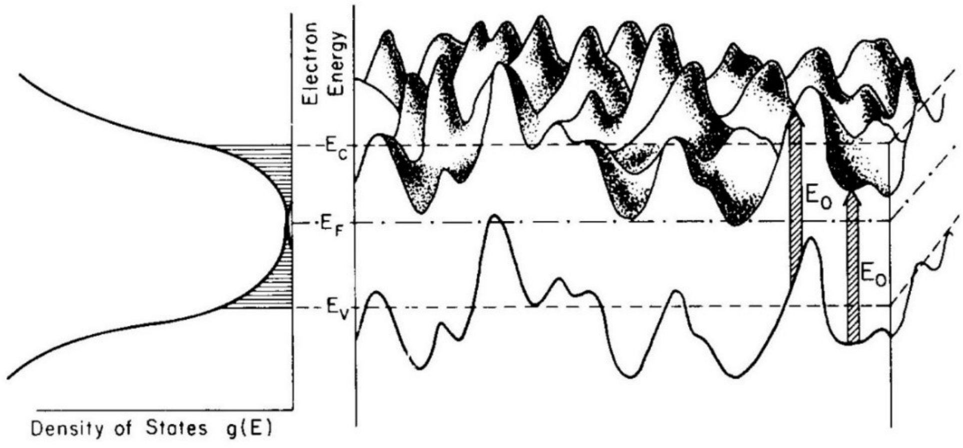

Figure 1.1 ALPINE model for the band structure of an amorphous semiconductor.

The fig. (1.2) is given for the schematic illustration of the expected influence of varying degrees of disorder on the band structure of an amorphous materials which ultimately electrical conductivity . At high levels of disordered in a solid, the localisation is extended well into the energy bands of amorphous materials. In such materials the various defects are associated with the additional localized states which are broadly distributed is the energy gap. The extended electronic states are completely disappeared in a completely disordered material.

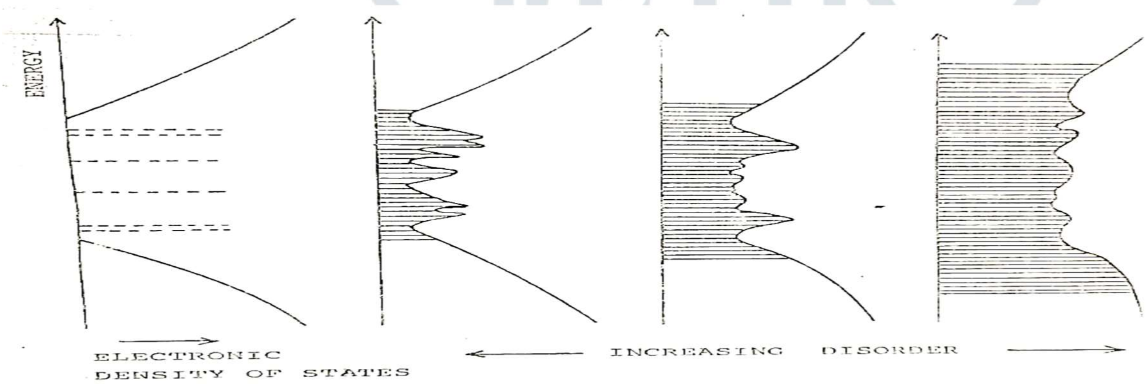

Figure 1.2 Band structure of an amorphous semiconductor with the effect of a progressively increasing degree of disorder.

The various aspects of the electronic property in real amorphous semiconductors are described in terms of a number of varients. Cohen et al. (1) had doveloped a model of complex multidesh component chalcogenides. This model is shown in fig. 1.3(a). The band structure is explained as the density distribution of localised states verses energy. It shows a sufficient degree of disorder in amorphous materials. In general this model is applicable to various amorphous semiconductors. As a matter of fact, such a band model has a limited success. Due to the fact that a considerable degree of short range order is observed in the simple compound amorphous semiconductor.

In advance alternative idealised model is developed by Mott and Davis (18,19) as shown in fig. 1.3 (b) This fig. has a comparatively limited tails of localised electronic states, which is postulated to present at the band edges. The Localised electronic states are approximated to give a linear variation of localised electronic state concentration with energy. It gives the simplified analytical treatment. In many, amorphous semiconductors, the Pinning of fermi levels is observed closure to the center of energy gap in such materials. The resistance to doping suggest such facts. In fig. 1.3(b), a group of localised electronic states are introduced at the gap center.

A different approach from the described above has been developed by the several workers (6). The presence of concentrations of localised electronic states at various reasonable well defined energy is the basis of their considerations. It is observed by the various experimental transport properties of chalcogenide semiconductor as, shown by the band model in fig. 1.3 (c).In the case of technological important amorphous silicon (a-Si), the similar conclusions are obtained by Spear and Coworkers as shown in fig.

1.3(d). In this fig. the density of states is shown in algorithmically due to the peaks in the distribution of electronic states. They are quite well defined in a linear plot.

In the band model for structure of disorder solids has a new complexity, which is connected with the position of the expected energy distribution of localised electronic states. Several workers (17) have suggested that the charge exchange phenomenon gives a new type of valency alternation defects which are obtained from the correlation effects between the localised electronic centers. The Transient photo conductive response of amorphous films are studied for this important aspect of the suggestion. The relaxations are associated with such electronic states plays an important role in such studies

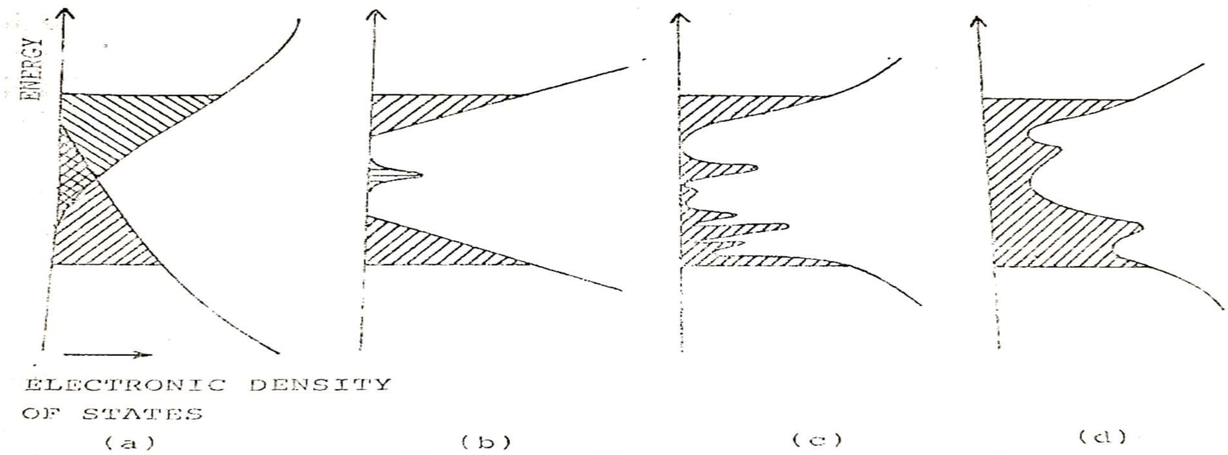

Figure 1.3 Different band structure models of amorphous semiconductors.

III. Noise in Amorphous Solid:

The spontaneous fluctuation in the current or voltage across a circuit or sample give a source of noise in amorphous semiconductor. The particular nature of current carriers by such fluctuations give the different noise source which have the statistical behaviour essentially. The fluctuations effects, investigations are generally useful to estimated the physical parameters such as trapped concentration and life time. The usefulness of a device depends on the noise level which is sufficiently low to a practical limit so that the device may be used. Therefore, the noise sets a lower limit for the device application and a knowledge of the factors and parameters are responsible for noise may helps to optimum operation of working of device.

The four categories are available in the literature for the semiconductor noise: (a)diffusion noise which is generally identified by Johnson or thermal noise (8,23) (b) drift noise which is normally associated carrier current flow in shot effect (c) generation recombination (g-r) noise associated with the carrier kinetic and electrical conductivity fluctuations, (d) $\frac{1}{f}$ noise (58) which is universally present in all circuits in electronic devices. The detailed review work of fluctuations in semiconductor is available in the literature (7,8,9,10,11,15,5716,18,19,20,21,22,23,24,25).

The work on the noise measurement and noise theory are not reported sufficiently in the research area of amorphous semiconductor by the workers of the field (9,15,18,19). The conductivity fluctuations gives the noise in the DC current when the external source is connected across the sample. The noise estimated in terms of spectral distribution for current s_i (f), where f is the frequency. The mean values of the physical quantities are represented by the subscript zero and Δ represents the departure the mean value. The mean square noise current across the sample follows (14).

$$\overline{\Delta I^2} = I_o \frac{\Delta P^2}{P_o} \qquad (1.1)$$

Where, ΔP and P_o are the carrier numbers in a given material and ΔP^2 is the hole number varience.

The above mention work on noise is expected to give some new theories on noise in amorphous semiconductors.

IV.Conclusion:

The modern development in the area of electrical transport properties and noise in amorphous semiconductor have developed the active field in solid state electronic physics. It gives the valuable information about structure of the material, disorder effect, transport coefficient states present in the band gap, noise and other electronic properties in amorphous semiconductor. Amorphous semiconductors some important applications are in the field of optical wave guide, switching and memory devices, holography, imaging and xerography photoreceptors.

References :

1. Cohen, M.H., Feritzsche, H. and ovshinsky, S.R., Phys. Rev. Lett. 22, 1065 (1969).
2. Emin, D., Electronic and Structural Properties of Amorphous Semiconductors, ed. P.G. Le Comber and J. Mort (New York : Academic) PP. 261-328 (1973).
3. Fritzsche, H., A Review of Some Electronic Properties of Amorphous Substances. In the book, "Electronic and Structural Properties of Amorphous Semiconductors". (Edited by P.G. Le Comber and J. Mort) Chapter 2. Academic Press, New York (1973).
4. Greenwood, D.A., The Electronic Density of States in Amorphous Materials. In the book, "Electronic and Structural Properties of Amorphous Semiconductors." (Edited by P.G. Le Comber and J. Mort) Chapter 3. Academic Press, New York (1973).
5. Henisch, H.K., "Rectifying Semiconductor Contact", Oxford, Clarendon Press (1957).
6. Hill, R.M. Phys. State. Sol. (a) 24, 433 (1974).
7. Hussain, S.A., Sharma, Y.K. and Sharma, N.K., Ind. Jour. Pure and Appl. Phys. 25, 80 (1987).
8. Johnson, J.B., Phys. Rev. 32, 97(1928).
9. Koehler, M., Luz. Da Mge Hiimmelgen Journal of Physics D : Applied Physics 33 (17) 2096, 2000.
10. Kolomiets, B.T., Phys. Stat. Solid 7, 359 and 713 (1964).
11. Kumar, G., Sharma, Y.K. and Chaudhary, A.K., Proc. Nat. Acad. Sci. India 59, (a) III 503 (1989).
12. Kumar, G., Sharma, Y.K. and Nagayach, A.V., Current Science 59, 965 (1990).
13. Lampert, M.A. and Mark, P., "Current Injection in Solids" Academic Press, New York (1970).
14. Lecomber, P.G., Madan, A. and Spear, W.E., J. Non-Cryst. Solids 11, 219 (1972).
15. Madan, A., Lecomber, P.G. and Spear, W.E., J. Non-Cryst. Solids 20, 239 (1976).
16. Marshall, J.M., Phil. Mag. 36, 959 (1977).
17. Mort. J. and Lakatos, A.I., J. Non-Cryst. Solids 4, 117 (1970).
18. Mott., N.F., and Davis, E.A., "Electronic Processes in Non-Cryst. Materials" (Oxford : Clarendon) 1st Edn. (1971).
19. Mott., N.F., and Davis, E.A., "Electronic Processes in Non-Cryst. Materials" (Oxford : Clarendon) 2nd Edn. (1979).
20. Sharma, Y.K., Solid State Electronics 17, 762 (1974).
21. Sharma, Y.K., Phys. Rev. B10, 3273 (1974).
22. Sharma, Y.K., Solid State Electronics 17, 762 (1974).
23. Vander Ziel A., Fluctuation Phenomena in Semiconductors, Academic Press, New York (1959).
24. Vander Ziel. A., Solid State Electronics 9, 899 (1966).
25. Vender Ziel, A., Solid State Physical Electronics. Prentice Hall, Inc. Englewood cliffs, N.J. (1968).