IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Investigating The Structural Characteristics Of $Cu_5Se_{75}Te_{10}In_{10}$ Chalcogenide Glassy Composites For Advanced Applications

Ruchika

(M.Sc. and NET in Physics)

H. No.- 3822-P, Urban Estate, Jind (Haryana)

Abstract

Chalcogenide glassy composites, due to their unique structural and thermal properties, hold immense promise in various technological applications. This research paper delves into the study of $[(Cu_5Se_{75}Te_{10}In_{10})_{100-y}(CNT)_y]$nanocomposite materials, with varying carbon nanotube (CNT) concentrations (y = 0, 1%, and 2%), to uncover their structural properties. The investigation aims to elucidate the impact of CNT incorporation on the chalcogenide glassy matrix and its potential implications for advanced applications. Chalcogenide glasses have garnered considerable attention in recent years due to their exceptional properties, including high optical transparency, low thermal conductivity, and tunable electronic behavior. These attributes make them promising candidates for various applications, such as infrared optics, phase-change memory devices, and thermoelectric materials.The incorporation of carbon nanotubes (CNTs) into chalcogenide glassy matrices has emerged as a compelling avenue for enhancing their properties further. CNTs, with their outstanding mechanical, electrical, and thermal properties, can potentially impart new functionalities to chalcogenide glasses. This study focuses on the nanocomposite $[(Cu_5Se_{75}Te_{10}In_{10})_{100-y}(CNT)_y]$ where y represents the concentration of CNTs, to explore how the introduction of CNTs influences the structural characteristics of chalcogenide glasses.

In the present paper, nanocomposite samples were prepared using a melt-quenching technique. High-purity elemental copper (Cu), selenium (Se), tellurium (Te), and indium (In), along with multi-walled carbon nanotubes, were weighed according to the desired composition. The constituents were sealed in evacuated quartz ampoules, heated to their respective melting temperatures, and subsequently quenched in cold water to obtain the glassy composites. The CNT concentration (y) was varied systematically to investigate its impact on the material's properties.

Keywords: Chalcogenide, glassy, nanocomposite, quenched, CNT

1. Introduction

The exploration of amorphous chalcogenide glassy alloys holds profound significance in the realm of advanced technologies, encompassing a diverse array of applications, such as thermal imaging, memory switching, phase-change optical recording, threshold switching, environmental monitoring, X-ray imaging, electrophotography, biosensors, and a multitude of other semiconducting functionalities.

While selenium-doped chalcogenides exhibit unique phase transition properties, pure selenium suffers from drawbacks like limited sensitivity, short lifespan, and, notably, thermal instability. Within the Ge-Se system, extensive investigations have unveiled the composition-dependent variations in physical attributes. These Ge-Se systems exhibit superior mechanical characteristics, minimal internal resistance, and a broad range of transparency. The chalcogenide glassy Ge-Se system stands out as an exemplary glass former with covalently bonded atoms.

In this paper, we delve into an in-depth analysis of the structural characteristics of as-prepared ($Cu_5Se_{75}Te_{10}In_{10}$) glassy alloys, with the incorporation of 1 and 2 % multi-walled carbon nanotubes (MW-CNT). Our examination encompasses a comprehensive exploration of these materials, employing advanced techniques such as X-ray diffraction (XRD) and scanning electron microscopy (SEM). Additionally, we employ the Energy dispersive X-ray (EDX) technique to investigate the intriguing phenomena of glass transition and crystallization, all conducted under non-isothermal conditions.

2. Experimental Methods:

The synthesis of bulk glassy matrices containing ($Cu_5Se_{75}Te_{10}In_{10}$) alloy integrated with multi-walled carbon nanotubes (CNT) was executed with scrupulous precision. This process involved the utilization of high-purity elements, specifically Selenium (Se), Indium (In), Tellurium (Te), and Copper (Cu), each boasting an exceptional purity level of 99.9%. The CNT employed in this investigation exhibited dimensions ranging from 112 to 172 nm in diameter and 4 to 10μm in length, featuring a CNT content exceeding 92%.The initial formation of the bulk glass material was meticulously executed within a vacuum-sealed ampoule maintained at an ultra-low pressure of 10^{-6} Pa. To achieve proper homogenization, this sealed ampoule was subjected to a precisely controlled temperature of 800°C for a duration of 12 hours within a rocking furnace.

After the quenching process, the resulting alloy underwent a transformation into a finely powdered state, which was subsequently divided into three equal portions. One portion was meticulously preserved as the standard sample, while the remaining two portions were meticulously blended with 1% and 2% by weight of CNT, respectively. These amalgamated samples were then hermetically sealed within a vacuum environment and exposed to identical furnace conditions, involving heating up to 650°C for a duration of 10 hours.

2.1 Sample Preparation:

To facilitate the comprehensive analysis of the bulk samples, pellets with a precise diameter of 6 mm and a thickness of 1.6 mm were meticulously crafted by subjecting the powdered material to a controlled pressure of 5 tons. The structural attributes of the composite were subjected to rigorous examination utilizing X-ray diffraction (XRD). Additionally, the presence and specific characteristics of CNT contamination were methodically verified through Field Emission Scanning Electron Microscopy (FESEM). X-ray diffraction data were meticulously collected employing an X-ray diffractometer equipped with Cu-K_α radiation and utilizing a minimal step size of 0.04° for angle increments.Furthermore, the surface morphology of the specimens was comprehensively explored through Scanning Electron Microscopy (SEM), encompassing a magnification range of 50,000 X.

3. Results and Discussion

3.1 XRD Analysis

As illustrated in Figure 1 below, the X-ray diffraction (XRD) pattern of the synthesized composite denoted as ($Cu_5Se_{75}Te_{10}In_{10}$) CNT conspicuously manifests the conspicuous absence of well-defined and sharp peaks. This unequivocally corroborates the amorphous nature of the sample under scrutiny.

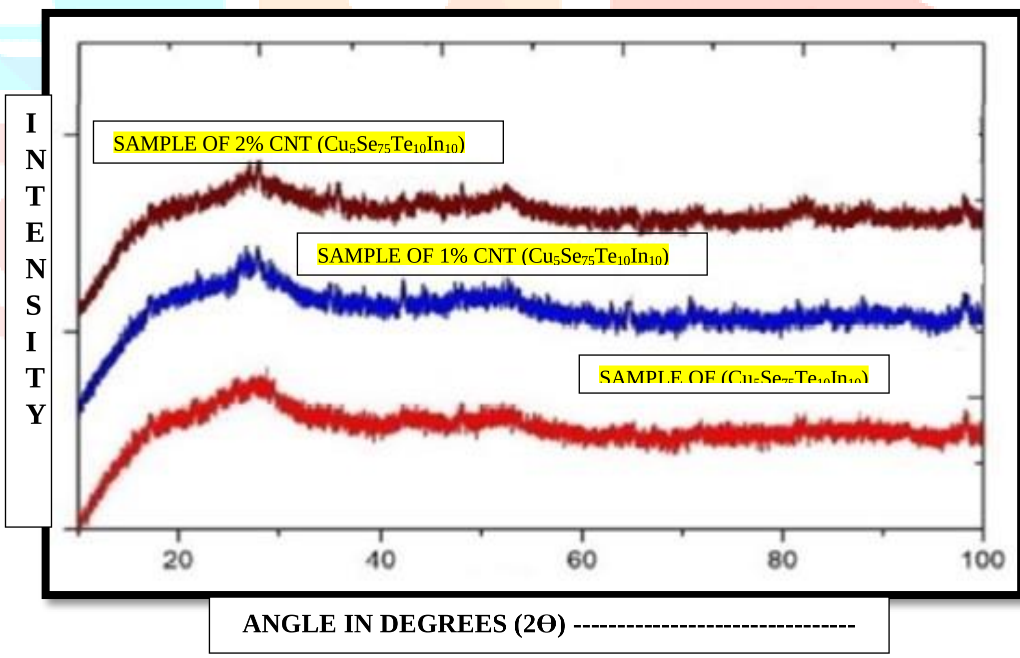

Fig. 1: XRD Pattern of glassy alloy sample havingy = 0, 1% and 2% CNT ($Cu_5Se_{75}Te_{10}In_{10}$)

3.2 Scanning Electron Microscope (SEM) & Energy Dispersive X-Ray (EDX) Analysis

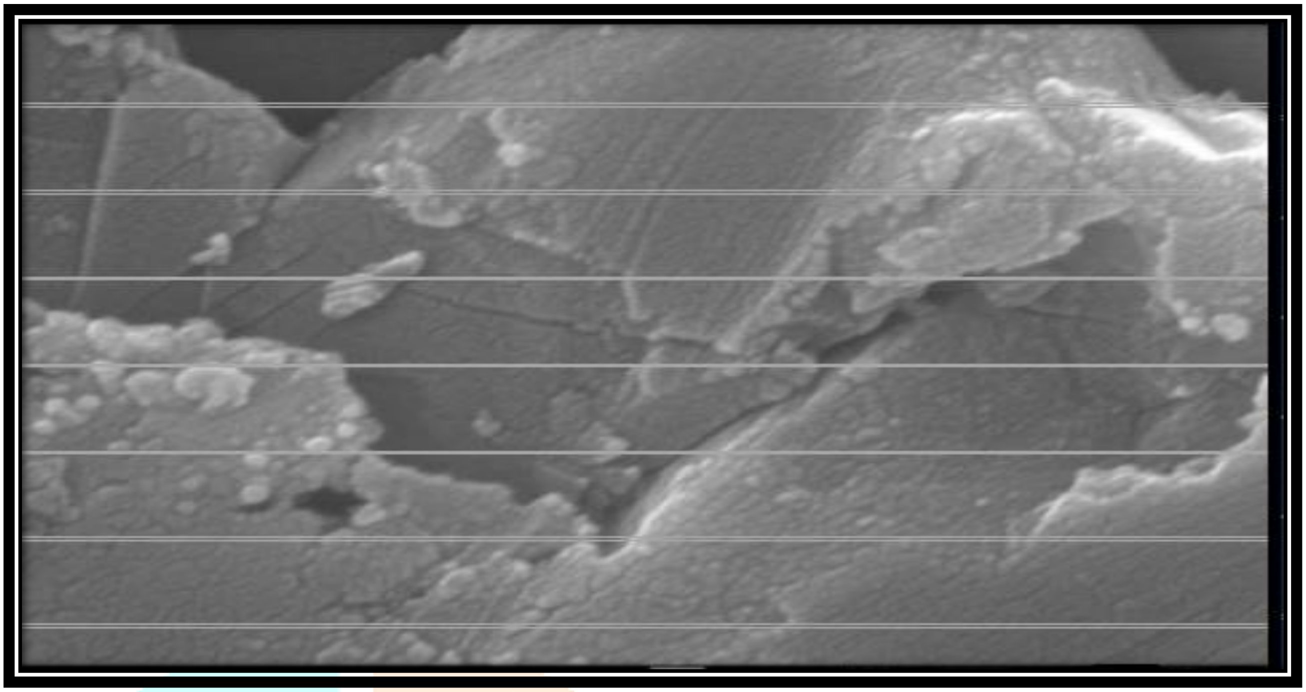

Fig. 2 : **SEM Analysis of sample $Cu_5Se_{75}Te_{10}In_{10}$ having y = 0% CNT chalcogenide glasses**

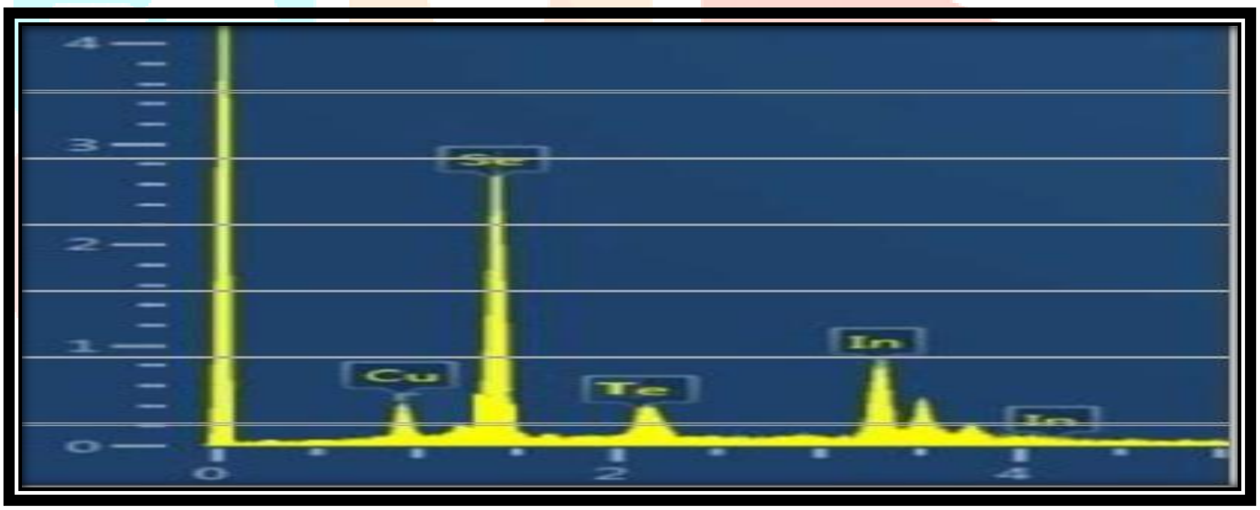

Fig. 3: **EDX Analysis of sample $Cu_5Se_{75}Te_{10}In_{10}$ having y = 0% CNT chalcogenide glasses**

Scanning Electron Microscopy (SEM) emerges as an indispensable tool for the meticulous examination of the surface morphology within the multi-walled CNT $Cu_5Se_{75}Te_{10}In_{10}$ chalcogenide glass. Notably, the density of nanotubes experiences a discernible augmentation with the progressive increase in the MW-CNT concentration, as clearly delineated in Fig.2 to 7 shown here. The corroborative evidence provided by Energy-Dispersive X-ray (EDX) analysis, coupled with SEM, serves to validate the presence of essential elements such as Copper (Cu), Selenium (Se), Tellurium (Te), Germanium (Ge), and Carbon (C, attributable to CNT). Furthermore, it unequivocally illustrates the conspicuous absence of any extraneous or unwanted elements.

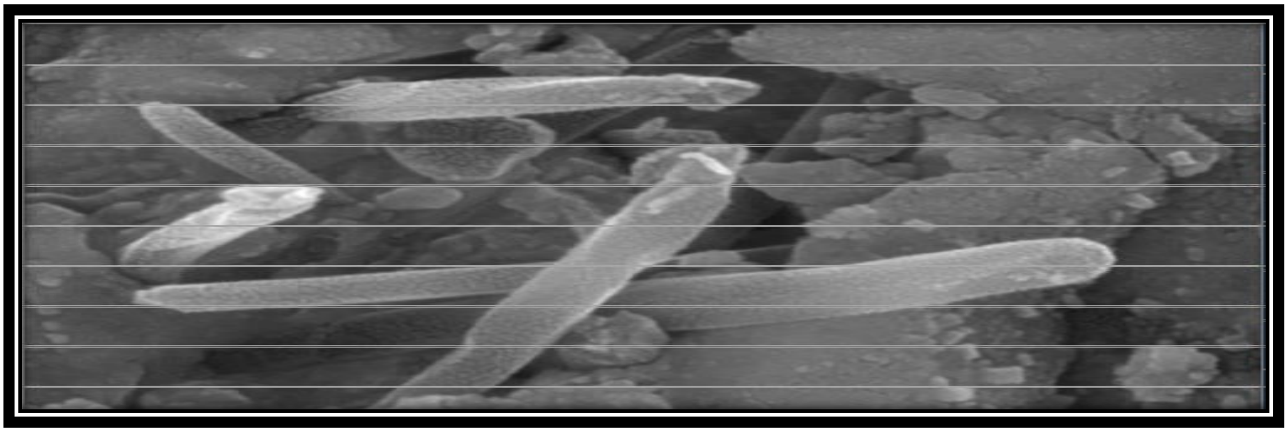

Fig. 4 SEM Analysis of sample $Cu_5Se_{75}Te_{10}In_{10}$ having y = 1% CNT chalcogenide glasses

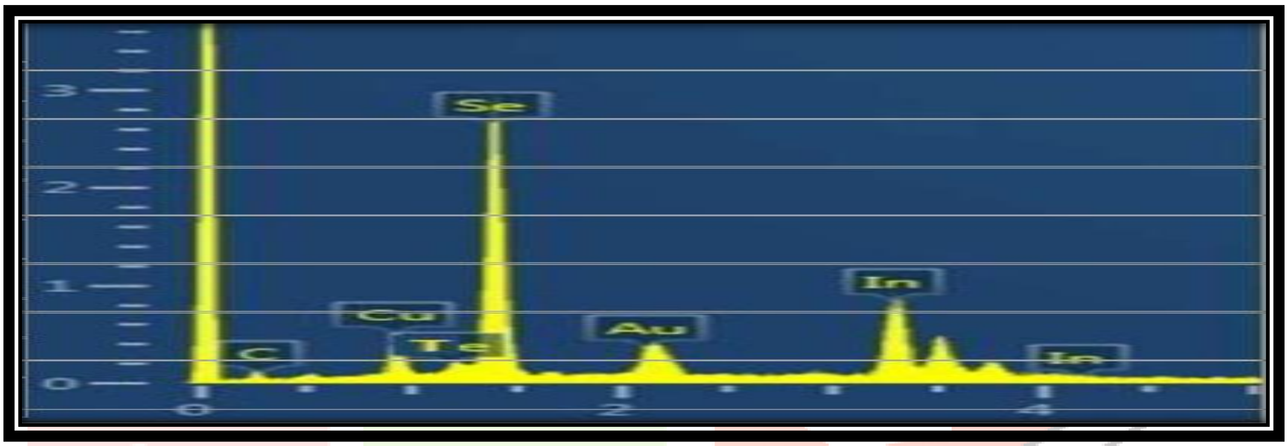

Fig.5 SEM Analysis of sample $Cu_5Se_{75}Te_{10}In_{10}$ having y = 1% CNT chalcogenide glasses

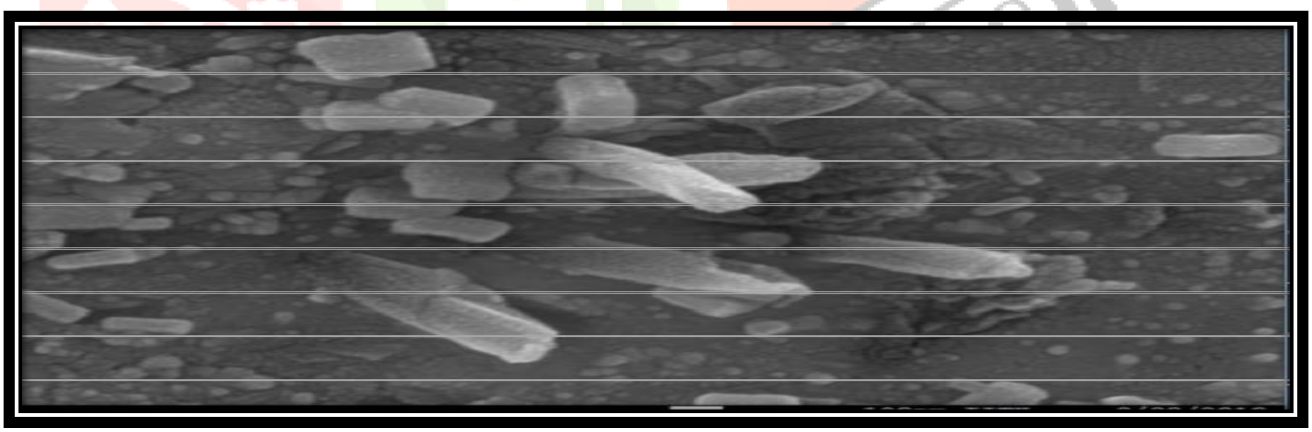

Fig. 6 SEM Analysis of sample $Cu_5Se_{75}Te_{10}In_{10}$ having y = 2% CNT chalcogenide glasses

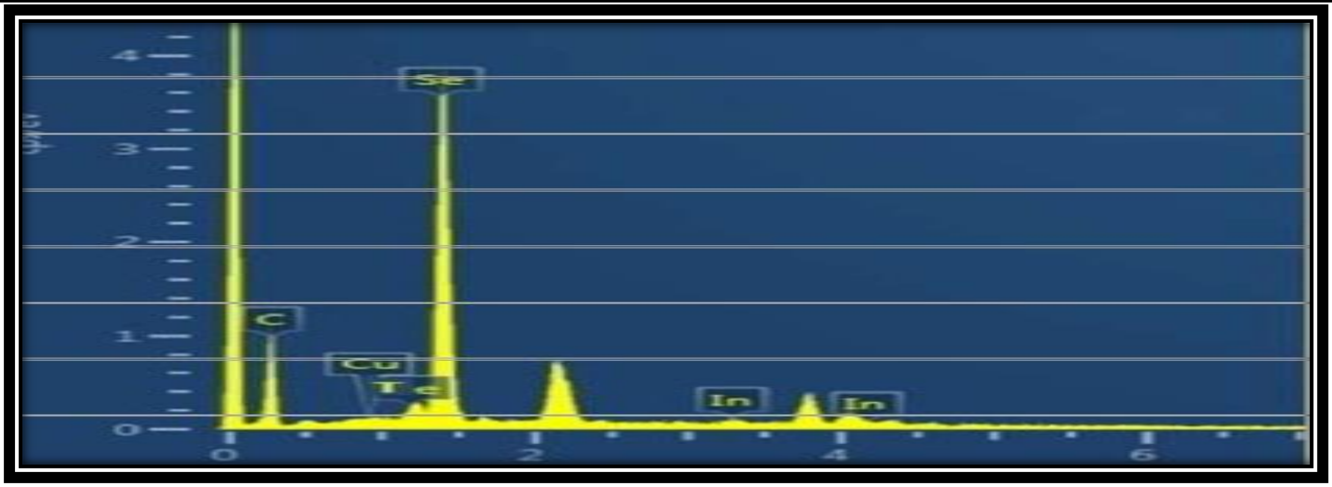

Fig.7 EDX Analysis of sample $Cu_5Se_{75}Te_{10}In_{10}$ having y = 2% CNT chalcogenide glasses

5. Conclusion

In conclusion, we have successfully synthesized multi walled CNT $Cu_5Se_{75}Te_{10}In_{10}$ glass composite through the meticulous melt quench technique. Our investigation focused on elucidating the impact of varying CNT concentrations on the structural properties of the composite.XRD analysis of the composite revealed an absence of discernible diffraction peaks, signifying the complete absence of any crystalline phase in both the as-prepared $Cu_5Se_{75}Te_{10}In_{10}$ glassy composite. Further examination of the surface morphology via SEM, with a magnification of 50,000x, reaffirmed the purity of the alloy, as evidenced by EDX analysis, which corroborated the absence of impurities. The observed bending of the incorporated CNTs is attributed to the inherent strains developed during the preparation and quenching processes. Consequently, the studied material exhibits promise as a viable candidate for applications in Phase Change Memory (PCM) technology, underlining its potential significanceThese findings open up exciting opportunities for tailoring the properties of chalcogenide glasses for diverse applications, including optical devices, sensors, and thermoelectric materials.

6. Future Directions

Future research in this area could explore the electrical and optical properties of the $Cu_5Se_{75}Te_{10}In_{10}$ nanocomposites to gain a comprehensive understanding of their potential for advanced electronic and optoelectronic applications. Additionally, further studies could investigate the influence of different types and structures of carbon nanotubes on the properties of chalcogenide glassy matrices, providing valuable insights into materials design and optimization.

7. References:

i) W. H. Zachariasen, The atomic arrangement in glass , J. Am. Chem. Soc.,V-65.

ii) D. I. Bletskan, "Glass-formation and crystallization in the system Ge-Te." Chalcogenide Lett. 2005, V-2(12), pp. 110-122.

iii) N. F. Mott. Conduction in non-crystalline materials: III. Localized states in a pseudo-gap and near extremities of conduction and valence bands PhilosMag., vol.XXV.

iv) R. Zallen The physics of amorphous solids John Wiley & Sons; 2008.

v) D. Adler, in Amorphous Semiconductors , CRC Press, Creveland, Ohio 1971

vi) B. T. Kolomiets, "Vitreous semiconductors (I)",Phys Status Solidi B.,Vol.-7(2)

vii) N. F. Mott, E. A. Davis, and R. A. Street. "States in the gap and recombination in amorphous semiconductors", Philos. Mag., Vol-32(5)

viii) R. A.Street., and N. F. Mott. "States in the gap in glassy semiconductors." Phys. Rev.Lett. pp. 1123.

ix) S. C. Agarwal, "Nature of localized states in amorphous semiconductors a study byelectron spin resonance." Phys.Rev.B., V.7(2).

x) R. Fairman, and U. Boris, eds. Semiconducting Chalcogenide Glass I