Measurement 58 (2014) 325–329

Contents lists available at ScienceDirect

Measurement

journal homepage: www.elsevier.com/locate/measurement

# Synthesis and characterization of Bi doped Se–Te nanostructured thin films

M.A. Alvi *, A.A. Al-Ghamdi, Jamal H. Madani

*Department of Physics, King Abdulaziz University, Jeddah 21589, Saudi Arabia*

ARTICLE INFO

*Article history:*
Received 13 April 2014
Received in revised form 11 July 2014
Accepted 28 August 2014
Available online 16 September 2014

*Keywords:*
Nano-chalcogenide
Thin film
X-ray diffraction
Optical constants

ABSTRACT

The nanostructure formation has been revealed in different types of materials and therefore an increasing interest has been witnessed in recent years to study the amorphous materials. Nano-structured materials show dramatic changes in their structural, optical and electrical characteristics due to the decrease in size below excitonic limit and provide new physical and chemical properties. In the present research work amorphous $Se_{80}Te_{20-x}Bi_x$ ($x = 3$ and 6) was prepared by melt quenching techniques. Nano-structured thin films of amorphous $Se_{80}Te_{20-x}Bi_x$ have been obtained using physical vapor condensation process on glass/Si wafer substrate. The morphology of amorphous $Se_{80}Te_{20-x}Bi_x$ films was scanned by employing field emission scanning electron microscope (FESEM). The optical absorption and reflection spectra of nano-structured films were inspected by UV/VIS/NIR spectrophotometer. The optical absorption analysis indicates the non-direct transitions predominate in nano-structured $Se_{80}Te_{20-x}Bi_x$ films. The extinction coefficient and absorption coefficient are found to decrease while optical energy band gap and the refractive index increase with Bi contents in Se–Te system.



## 1. Introduction

The fabrication of nano-chalcogenides thin films has witnessed great interest due to its exceptional properties as compared to the bulk materials. Due to decrease in size these materials exhibit excellent electrical, optical and chemical properties. These materials can be used in room temperature UV lasing and blue-UV light-emitting diodes. The semiconductor thin films based on selenium–tellurium (Se–Te) material are suitable for several device applications. Glassy alloys of Se–Te systems based on Se have become materials of considerable commercial, scientific and technological importance. They are widely used for various applications in many fields as optical recording media because of their excellent laser writing sensitivity, xerography and electrographic applications such as photoreceptors in photocopying, laser printing, infrared spectroscopy and laser fiber techniques. Se–Te form a continuous series of solid solution and the Se–Te system has an intermediate behavior between pure Se and pure Te. Se–Te alloys have greater hardness, higher crystallization temperature, higher photosensitivity and smaller aging effects. It has been pointed out that the addition of Se to Te improves its corrosion resistance. Therefore, Se–Te alloys are thought to be promising media, which can be used for phase change between amorphous to crystalline states.

The nano-structured chalcogenide thin films have several unique properties which has motivated the researchers to investigate the possibilities of these materials in different technological applications. Nano-chalcogenides offers new opportunities not only experimental but also a theoretical study of fundamental processes which help in the fabrication of new opto-electronic devices. The

* Corresponding author.
*E-mail address:* alveema@hotmail.com (M.A. Alvi).

http://dx.doi.org/10.1016/j.measurement.2014.08.046
0263-2241/

preparation of nano-structured materials in controlled manner is a vital success of nanotechnology. These technologies are based on the fabrication and designing of nanoscale opto-electronic devices [1,2]. The structure of the metal plays an important role in novel nanoelectronic devices. Amorphous materials, prepared by Se S, or Te with Ge, As, Bi, Ga, etc., are best known inorganic materials that show interesting properties such as low phonon energy, large linear refractive index and photo-induced aspect which are useful in optoelectronics. The most important research on chalcogenides is the possibility to examine properties on the basis of which the photonic circuit and data storage parts can be designed [3–7]. In the recent years research has been concentrated on preparation of polycrystalline compounds at nanometric scale due to their potentiality in the possible application in optoelectronic and optical memory devices. Now optical nano-recording is highly appreciated for large information storage. In the past number of phase change optical recording materials have been studied by different research groups. But presently extensive attempts have been made to build up phase change optical recording materials at nanometric scale because of their potential applications in nano-memory devices. Tintu et al. [8,9] have studied the reverse saturable absorption in nano-colloidal $Ge_{28}Sb_{12}Se_{60}$ chalcogenide glass and nanocomposite thin films of $Ga_5Sb_{10}Ge_{25}Se_{60}$ chalcogenide glass for different applications, Kolbjonoks et al. [10] have characterized the nanostructure formation using electron beam irradiation, Takats et al. [11] have examined the surface patterning on chalcogenide materials.

The work on synthesis and characterization of Ag–S nanoparticles by Anthony [12], characterization of $Bi_2S_3$ nanorods by Phuruangrat et al. [13], synthesize of nano $Cd_xZn_{1-x}S$ by Zu et al. [14], characterization of nano-amorphous inorganic/organic particles by Senna and Nakayama [15], high energy radiation on different properties of nano-crystalline cobalt phathalocyanine by El-Nahass et al. [16], preparation of nano-crystalline Si films by Kang et al. [17], characterization of nano-crystalline structures by Gracin et al. [18] are also worth to be acknowledged. Literature shows that several authors [19–31] have also studied the nano-structured films for various applications. Keeping in view the importance of nanochalcogenides, we are in this paper presenting the synthesis and characterization of Bi doped Se–Te nano-structured thin films.

## 2. Experimental

Uncontaminated with 99.999% purity Se, Te and Bi were weighted into quartz ampoules pursuant to their atomic percentage magnitude. The ampoules were then sealed under vacuum of $10^{-5}$ Torr and placed in a computerized furnace in which the temperature was increased at 4 K/min to a maximum of 1173 K and fixed at that temperature for 16 h. To achieve homogeneity of the mixture the shaking of the ampoules were also done simultaneously. The ampoules containing melt elements were rapidly quenched into ice water tub. Amorphous state of the synthesized materials was confirmed by X-ray diffraction. Nano-structured thin films of amorphous $Se_{80}Te_{20-x}Bi_x$ materials were prepared by physical vapor condensation technique (PVCT) under the vacuum of $10^{-6}$ Torr on a glass/Si wafer substrates pasted on the $LN_2$ cooled substrate. Argon gas was purged in the vacuum chamber after attaining a vacuum of $10^{-6}$ Torr. The amorphous $Se_{80}Te_{20-x}Bi_x$ materials were started evaporating for the deposition of the thin films. The thickness of the films was measured by a quartz crystal monitor (Edward model FTM 7) attached with the Edward Coating Unit E-306. The earthed face of the crystal monitor was facing the source and was placed at the same height as the substrate. The evaporation was controlled by using the same FTM 7 quartz crystal monitor. The morphology of these nanostructured $Se_{80}Te_{20-x}Bi_x$ films was explored by field emission scanning electron microscope (FESEM). The optical absorption and reflection of these nano-structured films were studied by using JASCO UV/VIS/NIR spectrophotometer.

## 3. Results and discussion

### 3.1. Structure studies

A Regaku X-ray diffractometer Ultima IV was engaged for examining the structures of synthesized nano-structured $Se_{80}Te_{20-x}Bi_x$ thin films. The copper target as X-ray source with $\lambda = 1.54178$ Å (Cu K$\alpha_1$) was used. The angle of scan was from 10° to 80° having scan speed of 2°/min and a chart speed of 1 cm/min. Fig. 1 represents the X-ray diffraction traces (taken at room temperature). No significant structural peaks have been observed in the XRD patterns, which indicate the amorphous nature of the nano-structured thin films.

The surface microstructure of nano-structured $Se_{80}Te_{20-x}Bi_x$ thin films grown on Si (1 0 0) wafer substrates was studied by FESEM (QUANT FEG 450, Amsterdam, Netherlands). Fig. 2(a and b) represents the FESEM of nano-structured $Se_{80}Te_{20-x}Bi_x$ thin films. It is obvious from FESEM image that the whole matrix consists of spherical particles in the range 30–60 nm with diverse shapes and sizes. As expected the contrast of nanoparticles was uniform for the amorphous structure.

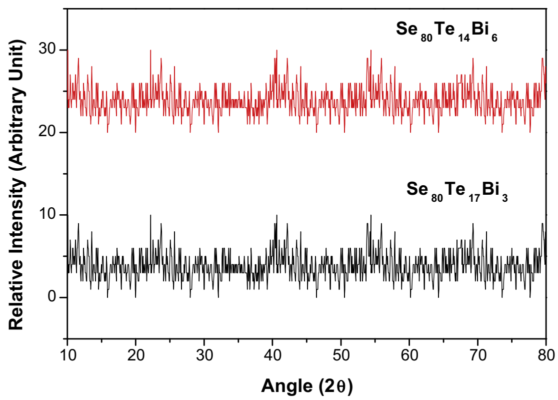


**Fig. 1.** X-ray pattern of nano-chalcogenide $Se_{80}Te_{20-x}Bi_x$ thin films.