RSC Advances

PAPER

Cite this: *RSC Adv.*, 2015, **5**, 69400

Electronic excitation induced structural, optical and electrical properties of $Se_{85}S_{10}Zn_5$ thin films and applicability of a single oscillator model

Shabir Ahmad,[a] Mohd. Nasir,[a] K. Asokan,[b] Mohd. Shahid Khan[a] and M. Zulfequar*[a]

Received 25th May 2015
Accepted 5th August 2015

DOI: 10.1039/c5ra09815g

www.rsc.org/advances

The effect of electronic excitation induced by 120 MeV Ag^{9+} ion irradiation on the structural, optical and electrical properties of $Se_{85}S_{10}Zn_5$ thin films has been investigated at various ion fluencies. Thin films of $Se_{85}S_{10}Zn_5$ have been prepared by vacuum evaporation technique with thickness ~250 nm on cleaned glass substrates. X-ray diffraction (XRD) patterns confirm that preferred crystallite growth occurs in the (100) plane corresponding to the hexagonal phase structure. XRD analysis also shows that the crystallite size decreases with increasing ion fluence. This post irradiation change was also supported by morphological studies carried out by scanning electron microscopy (SEM) which indicate the grain fragmentation process has been taking place due to excessive energy deposition during the passage of ion beams. The optical parameters calculated from optical transmission spectra in the wavelength range 200–1000 nm show the reduction of the optical band gap and an enhancement in absorption coefficient after ion irradiation. The data from refractive index dispersions of the thin films before and after irradiation fit well with a single oscillator model. This post irradiation change in the values of optical parameters suggests that the investigated material may have industrial applications for various optoelectronic devices. Electrical properties such as dc conductivity of investigated thin films were carried out in the temperature range 309–370 K. Analysis shows that the value of the activation energy decreases with the increase of ion fluence indicating that the density of defect states increases after swift heavy ion irradiation.

1. Introduction

Chalcogenide semiconductors have technical importance in various optoelectronic device applications such as solar cells, IR detectors and non-volatile memory devices[1–3] *etc.* Among chalcogenide glasses, Se based alloys are mostly preferred for optical and electrical memory devices because of their unique property of reversible phase transformation. The operating principle of memory devices is based on the ability of the active material to undergo very fast transformation between amorphous and crystalline phases which results in significant change in the physical properties of these materials.[4] The performance of these devices strictly depends upon the material properties. Many disadvantages were found in pure Se based chalcogenides, such as low photosensitivity and short life time. Different additives are used in order to improve the material properties.[5] The present study investigates the effect of addition of S to the Zn–Se system and changes in their lattice parameters, electronic properties, and values of the energy gap. Especially, the application of bandgap engineering to $Se_{85}S_{10}Zn_5$ ternary alloys is likely to give the desired optical properties for optoelectronic and photonic devices with high performance.[6,7] However, there are also different irradiation techniques like laser irradiation, gamma-ray irradiation, swift heavy ion (SHI) irradiation *etc.*, that are used to modify the material properties at microscopic levels and thus enhancing the performance of devices. SHI forms as a special form of ion beam radiation wherein particles are accelerated by particle accelerators to very high energies, typically in the range of few tens of MeV or GeV range and have sufficient energy and mass to penetrate into solids. These irradiations play a vital role in the field of materials science research,[8,9] and useful for modification of the material properties like structural, optical, electrical properties *etc.* of thin films, foils and surface of bulk solids in order to enhance the performance of various technological devices. The extent of damage formation and property modification depends mainly on energy, mass and charge state of the ion, ion fluence and target density. The ions with velocity comparable to or higher than the velocity of lattice atoms, the energy deposition takes place through electronic excitation and ionization. This high energy deposition leads to interesting phenomena like sputtering of target atoms, amorphization, re-crystallization, grain fragmentation, production of defects, surface and interface

[a]Department of Physics, Jamia Millia Islamia, New Delhi-110025, India. E-mail: mzulfe@rediffmail.com; zulfequarphy@rediffmail.com

[b]Materials Science Division, Inter University Accelerator Centre, New Delhi-110067, India