Journal of Radiation Research and Applied Sciences 8 (2015) 311–316

HOSTED BY ELSEVIER

Available online at www.sciencedirect.com

ScienceDirect

Journal of Radiation Research and Applied Sciences

journal homepage: http://www.elsevier.com/locate/jrras

Optical and electrical properties of γ irradiated $In_{1-x}Mn_xSe$

S.A. Gad

Solid State Physics Dept., National Research Centre, 33 El Bohouth St. (former El Tahrir st.), Dokki, Giza, P.O.12622, Egypt

ARTICLE INFO

Article history:
Received 25 February 2015
Received in revised form
19 April 2015
Accepted 27 April 2015
Available online 11 May 2015

Keywords:
In_{1-x} Mn_xSe
γ-irradiation
Optical
Electrical properties

ABSTRACT

In_{1-x} Mn_xSe thin films prepared by thermal evaporation technique. The effect of γ-irradiation on the optical and the electrical properties were studied. The optical parameters were calculated from the transmittance and reflectance. The absorption coefficient decreased with increasing the γ-irradiation doses. The direct allowed band gap increased as the γ-irradiation doses increased. As the γ-irradiation increased the electrical conductivity and the activation energy decreased.

1. Introduction

A few III–VI DMS systems have been investigated such as, Ga_{1-x} Mn_xS (Fuller et al.,2002; Pekarek et al., 2000; Tracy et al.,2006), In_{1-x} Mn_xS (Franzese et al., 2005; Tracy et al., 2005) In_{1-x} Mn_xSe (Pekarek, Arenas, Miotkowski, and Ramdas et al., 2005; Pekarek, Ranger, Miotkowski, and Ramdas et al., 2006) Ga_{1-x} Mn_xSe (Pekarek, Crooker, Miotkowski, and Ramdas et al., 1998) $Ga_{1-x}Fe_xSe$ (Pekarek et al., 2001) Ga_{1-x} Mn_xS and In_{1-x} MnxS are well understood at this time. Diluted magnetic semiconductors, doped with magnetic ions such as Mn, have attractive magnetic properties for spintronic applications. The increasing interest in transition metal containing chalcogenides arises from their attractive structural features (Yaghi, Sun, Richardson, & Groy, 1994) and also as a result of their potential applications in semiconductors, non linear optics, ion exchange, photocatalysis. Also, they are considered important technological materials because of their electrical, optical, magnetic and transport properties which have found applications in spintronics devices (Heulings, Huang, Yuen, Lin et al., 2001; Lei, Tang, & Zheng, 2006; Wolf et al., 2001).

Among them, alloys of manganese attract the attention of many researchers due to their excellent combination of semiconductivity and magnetism (Verwey, 1939; Zhang and Satpathy, 1991).

Indium Selenide is one of the promising materials of chalcogenide alloys from the III–VI group semiconductor, which have a low density of dangling bonds (Parlak and Ercelebi, 1999) and is the suitable material to form a heterojunction with a very low density of interface states. Chalcogenide compounds are responsive to external influences, such as γ-irradiation, because of their adaptable structure.

E-mail address: samiagad2000@yahoo.com.

Peer review under responsibility of The Egyptian Society of Radiation Sciences and Applications.
http://dx.doi.org/10.1016/j.jrras.2015.04.004

According to the previous studies, the role of γ-irradiation is to create some microstructural changes in film and bulk materials (Kavetsky, Vakiv, & Shpotyuk, 2007; Mansour, Gad, & Mohamed Eissa, 2015; Shpotyuk and Kovalskiy., 2002; Shpotyuk, Kovalskiy, Kavetsky, & Golovchak, 2003). Moreover, transport measurements are studied by electrical conductivity to cast more light on the value of the activation energy and band gap. No previous efforts have been done to measure the electrical conductivity and the optical properties of the different compositions of In_{1-x} Mn_xSe. The objective of this work is to investigate the effect of γ-irradiation doses on the optical and electrical properties of In_{1-x} Mn_xSe.

2. Material and methods

Indium, Manganese and Selenium (99.999%) were purchased from Aldrich Chem. Ltd. The powders were mixed with stoichiometric proportions and then prepared by direct fusion method. The thin films were evaporated by thermal evaporation.

2.1. *Experimental*

In_{1-x} Mn_xSe thin films were prepared by evaporating In_{1-x} Mn_xSe (x = 0, 0.05, 0.1 and 0.15) compounds. The compounds were kept in Molybdenum boat and then deposited on ultrasonically cleaned unheated glass substrates under the vacuum pressure of 10^{-5} torr using Edward E306 A coating units. Thickness of the films was measured using an optical multibeam interfotmeter. The X-ray diffraction (XRD) patterns of the prepared thin films were investigated by Emprean (pananlytical) diffractometer. Ni-filtered CuKα radiation at 45 kV and 30 mA was used showing that the amorphous nature and the composition were determined by (EDAX) Philips (XL30 attached with EDX unit). Transmittance (T) and reflectance (R) of the as-deposited thin films on precleaned glass substrates were determined at normal incidence using a Jasco (V-570) spectrophotometer from 500 to 2500 nm to determine some optical parameters of $In_{1-x}Mn_xSe$. The optical measurements were carried out at room temperature. Electrical conductivity was measured by Keithley (6517 A Electrometer/High Resistance Meter) over the temperature range from (300–488) K. Electrical measurements were done under a vacuum of 10^{-3} Torr. Irradiation for thin films with doses (40 and 120 KGy) was performed using a Co^{60} gamma ray source.

3. Results and discussion

3.1. *Optical properties of unirradiated and irradiated thin films*

It is known that, the absorption of γ-radiation in chalcogenide glasses for bulk and thin films depends strongly upon their electronic structure which in turn changes by the interaction with photons. To investigate the effect of irradiation on energy gap of the prepared samples, In_{1-x} Mn_xSe (x = 0, 0.05, 0.1 and 0.15), transmission T and reflection R at normal incidence in the spectral range 500–2500 nm were measured for a thin film of thickness 750 nm, subjected to different doses (40 and 120 KGy). The representative examples of transmission T for unirradiated and irradiated InSe and $In_{0.9}Mn_{0.1}Se$ are shown in Fig. 1(A & B). It is observed that the transmittance increases with increasing γ-irradiation. The absorption coefficient (α) for $In_{1-x}Mn_xSe$ of the as deposited thin films and the irradiated films at 40 and 120 KGy were calculated from the transmission (T) and reflection (R) data using the relation:

$$T = (1 - R^2)\exp(-\alpha t) \Big/ (1 - R)^2 \exp(-2\alpha t) \tag{A.1}$$

where t is the film thickness.

The spectral behavior of α as a function of photon energy, hν, for as-deposited and irradiated films for InSe and the representative example $In_{0.9}Mn_{0.1}Se$ is illustrated in Fig. 2(A & B). From these figures it is clear that, the absorption coefficient has values in the order of 10^4 cm^{-1}. It is also obvious that the absorption coefficient decreases with increasing the irradiation doses. In this treatment, the absorption data follows a power law, which is given by (Bardeen, Blatt, & Hall, 1965):

$$\alpha h\upsilon = A(h\upsilon - E_g)^n \tag{A.2}$$

where A is the parameter that depends on the transition probability, E_g is the characteristic energy of the transition and

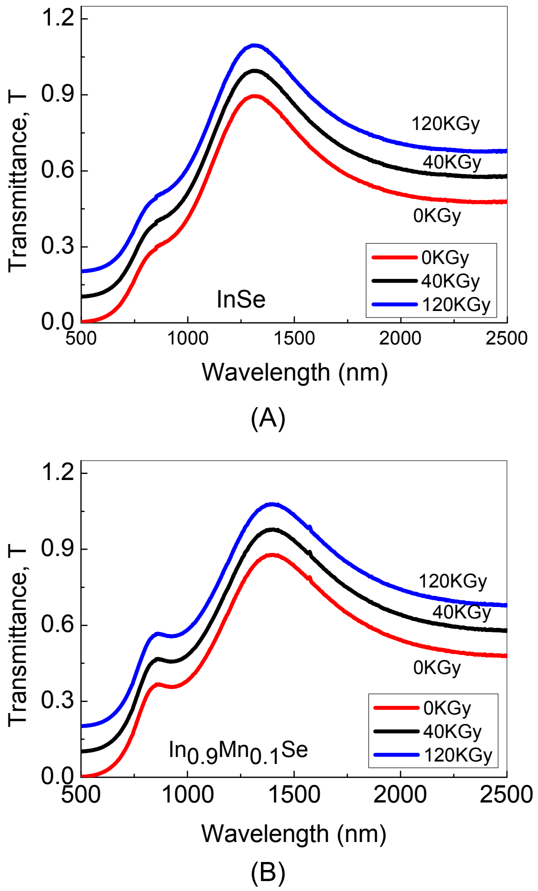

Fig. 1 – (A): Transmission spectra of unirradiated and irradiated InSe at 40 and 120 KGy (B): Transmission spectra of representative curve $In_{0.9}Mn_{0.1}Se$, unirradiated and irradiated InSe at 40 and 120 KGy.