

Scanning Electron Microscopy of $Zn_{1-x}Mn_xTe$ Thin-Films Prepared by Thermal Evaporation Method

Dinesh C.Sharma

Department of physics, Yagyavalkya Institute of technology, Jaipur, India

Email: dcsharma1970@gmail.com

Abstract: We report SEM measurements on $Zn_{1-x}Mn_xTe$ thin film were prepared onto glass substrate by thermal evaporation method under the vacuum of 10^{-5} Torr with thicknesses around 160 nm and 165nm.

Keywords: $Zn_{1-x}Mn_xTe$ thin films, Surface topography.

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I. INTRODUCTION

A wide class of semiconducting materials is characterized by the random substitution of a fraction of the original atoms by magnetic atoms, known as semi magnetic semiconductors (SMSC) or diluted magnetic semiconductors (DMS) [1]. Tunability of lattice parameter and band gap with respect to concentration (x) are the unique properties of DMS. Mn doped II–VI compounds, $Zn_{1-x}Mn_xTe$; $Zn_{1-x}Mn_xS$, $Zn_{1-x}Mn_xSe$ in bulk and thin film form, find potential applications in science and technology. Replacement of the group-II element with Mn leads to significant quantitative changes in the energy gap and optical properties. As Mn is substituted, the energy gap increases and the originally opaque material becomes as transparent as in visible region of electromagnetic spectrum. Tunability of lattice parameter and band structure parameters with concentration of Mn is excellent in fabrication of quantum well devices [2]. Distribution of Mn atoms in II–VI lattice exhibits interesting phenomena like negative magneto resistance, giant Faraday rotation and spin-glass behaviour. Nanostructured DMS have revolutionary applications in non-linear optics, fast optical switching and memory devices [3]. Several

authors reviewed different growth methods of II–VI DMS [4]. In $Zn_{1-x}Mn_xTe$ system ‘3d’ states of Mn are split into two groups of sub levels by a strong exchange interaction as spin up states located in the valence band region and the spin down empty states located in the conduction band region. At lower concentration of Mn, the Mn atoms can be considered as impurities and their ‘3d’ states are considered as well localized states and they split further into e_g and t_{2g} components by the tetrahedral crystal field and hence a prominent structure of peaks is observed. Increase of Mn concentration forms interaction between ‘d’ levels of Mn and ‘sp’ levels of II–VI host lattice. The ‘3d’ levels of Mn hybridize with Te energy levels as well as cation ‘s’ and ‘p’ levels and hence a further distortion in band structure is likely to occur. The shift observed in the spectra is a characteristic property of several Mn doped II–VI systems like HgMnTe [5], ZnMnTe, CdMnTe [6] and $Zn_{1-x}Mn_xTe$ [7].

The development of crystal growth techniques such as Molecular Beam Epitaxy (MBE) and Metal Organic Vapor Phase Epitaxy (MOVPE) in late 1970’s enabled the growth of high purity crystals, and new interest in II–VI semiconductor materials arose. However, the doping problem remained unsolved until 1991, when p-type doping of ZnSe was finally achieved. There were many theoretical approaches that explained the doping problem, one of the oldest and most popular is a self-compensation theory. According to this theory, some dopants may incorporate not only on the substitutional sites, but also on the interstitial sites. The latter creates structural defects such as vacancies and

leads to a self-compensation. Though the application of II-V semiconductors for LEDs is a main driving force for scientific research on these materials, the potential of their technical application is much broader. The applications include solar cells, X-ray detectors, photo resistors, electron beam screens, etc [8]. The II-VI semiconductors (ZnSe, ZnTe, CdSe, CdTe, ZnS etc.) have a direct band gaps with energies ranging from near ultraviolet to the far infrared, as a consequence, these materials should be useful in a wide varieties of electronics and optoelectronics devices [9,10].

II EXPERIMENTAL

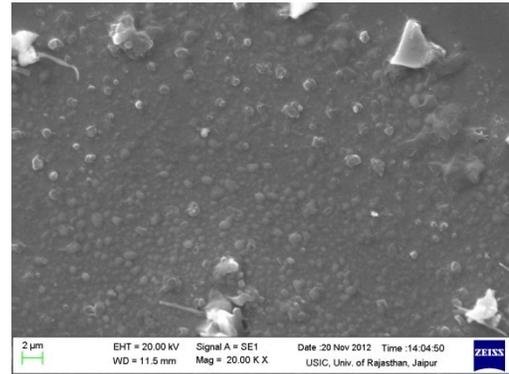
The $Zn_{1-x}Mn_xTe$ thin films were prepared using a vacuum coating unit (Hind High Vacuum Company, Bangalore) Model 12A4D. High purity Zn (99.998), Te (99.998) and Mn (99.998) metal powder were taken in the stoichiometric proportion for the preparation of $Zn_{1-x}Mn_xTe$ alloys with varying Mn composition with $x = 0.1, 0.2$ and 0.3 . Each material of $Zn_{1-x}Mn_xTe$ was weighed by an electronic balance which has a resolution of ± 0.0001 g, according to percentage of composition to be used. Then the materials were mixed and ground together using an agate mortar and pestle and then prepare their pallets for evaporation purpose. The pallets were prepared using hydraulic press at the pressure of 10 ton. The pallets were placed into molybdenum boat and it was heated indirectly by passing current through the electrodes. The glass substrate was placed in substrate holder above the boats carrying the materials. Cleaned glass slides were used as a substrate. The deposition has been done at vacuum of 10^{-5} torr. In present work we have deposited three different film system viz. ZnTe, $Zn_{0.9}Mn_{0.1}Te$ and $Zn_{0.8}Mn_{0.2}Te$.

III RESULT & DISCUSSION

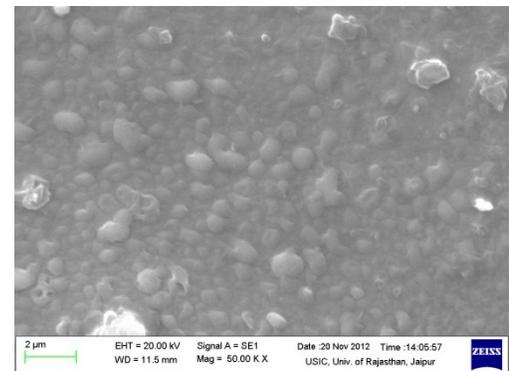
Scanning Electron Microscopy

The surface morphology and grain size analysis of the thin films have been estimated by SEM measurements using ZEISS E.V.O. 18 model. Fig.1 (a) shows the image of $Zn_{0.9}Cr_{0.1}Te$ SEM with magnification = 20.00 KX, Fig.1 (b) shows the image of $Zn_{0.9}Cr_{0.1}Te$ SEM with magnification = 50.00 KX, Fig.1(c) shows the

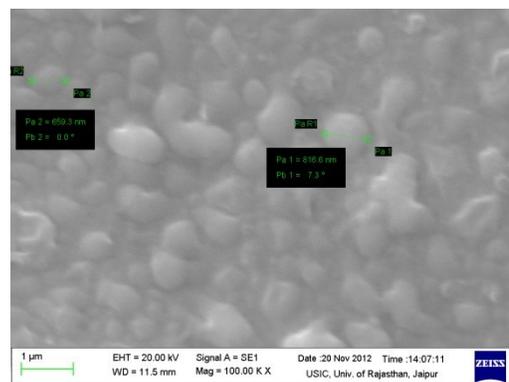
image of $Zn_{0.9}Cr_{0.1}Te$ SEM with magnification = 100.00 KX, Fig.1(d) shows the image of $Zn_{0.9}Cr_{0.1}Te$ SEM with magnification = 150.00 KX, these surface shows that thin film surface exhibits spherical granular structure distributed uniformly along the surface. The average grain size has found to be about ≈ 152 nm.



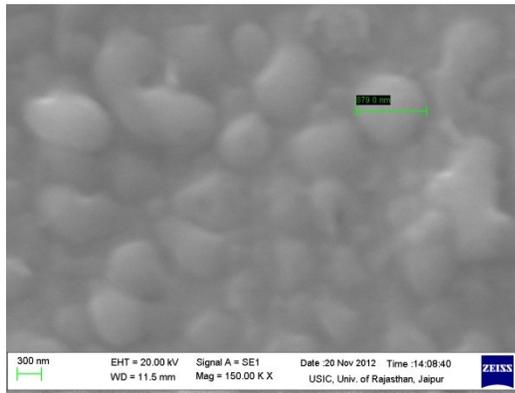
a



b



c



d

Fig.1 SEM image of $Zn_{0.8}Mn_{0.2}Te$ thin film.

IV. ACKNOWLEDGEMENT

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