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Scanning Electron Microscopy of ZnTe/Cr Thin-Films Prepared by Thermal Evaporation Method

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Abstract **- We report SEM measurements on ZnTe/Cr thin film were prepared onto glass substrate by thermal evaporation method under the vacuum of 10^{-5} Torr with thicknesses around 150 nm and 155nm.**

Keywords **- ZnTe:Cr thin films, Surface topography.**

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I. INTRODUCTION

Modern day materials science depends largely on semiconductors which may be elemental systems such as Si and Ge, or compound semiconductors such as GaAs, ZnTe and InP, or alloys such as Si-Ge or aluminium gallium arsenide. This large family also consists of a smaller sub-set of wide bandgap semiconductors (band gap ~ 2 to 3.5 eV) which have electronic band gaps larger than 1.7 eV. Wide bandgap materials are often utilized in applications in which high-temperature operation is important. One of the most important II-VI wide band gap semiconductors, which is a hot topic of research in the 21st century is ZnTe. Wide-bandgap II-VI semiconductor materials attract attention of many scientific and industrial research groups throughout the world. Materials of this group pose such a broad range of bandgaps that they are capable of emitting nearly every color in the visible light spectrum. If the ternary II-VI compounds are included, the range of band gaps becomes even more continuous. Therefore, in the field of communication and data transfer they are very promising candidates for development of short wavelength light emitting diodes (LEDs) and diode lasers. The main advantage of short wavelengths resides in the increased storage density for the laser recording devices.

Binary semiconductors are considered to be important technological materials because of their potential applications in optoelectronic devices, solar cells, IR detectors and lasers [1, 2]. Binary compounds of group IIB and group VIA elements, commonly referred to as II-VI compounds, have technologically important applications. Among these compounds, only CdTe and ZnSe can be prepared in both n- and p-type forms [3]. Some of the mixed compound have definite band structure and behave exactly like binary or ternary semiconductors. With mixed compounds it is possible to prepare a semiconductor almost with a specific band structure. The entire band structure between the two limits is determined by the two compounds and it may be obtained by adjusting the ratio of two individual compounds. These practical characteristics of mixed semiconductors have greatly increased the potential of compound semiconductors.

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The extensive research of II-VI semiconductor materials started in 1920’s with the investigation of luminescence and optical properties of ZnS [4]. Later attempts to dope other II-VI semiconductors were not successful. In the 1950's it was found that materials such as Zones, Zones, CdS and CdSe exhibit an intrinsically strong preference to n-type doping, while others such as ZnTe show the opposite characteristic. The doping problem imposed serious limitations on their use for LED applications and slowed down the research on these materials. 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 [5]. 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 [6,7]. It is difficult to grow bulk II-VI materials that area good structurally and chemically pure because these materials have high melting points, and a tendency to form non-stoichiometric compounds.

The II-VI semiconductors thin films are deposited by several techniques. The choice of the deposition method was based on quality of the films required for specific applications. The II-VI compound semiconductors can also prepared by stacked elemental layer (SEL) techniques. This process was originally developed to produce copper indium diselenide thin films [8] but has been also used to produce CdTe films [9,10]. It consists of sequentially depositing Te and Cd layers and then annealing the resulting stack in order to form the compound. It is particularly suitable for deposition of compound semiconductor films, as it provides good control of compositions. In present work we prepared $Zn_{1-x}Cr_xTe$ thin films by thermal evaporation techniques and characterized them.

II. DEPOSITION OF THIN FILMS

The ZnTe:Cr thin films were prepared using a vacuum coating unit (Hind High Vacuum Company, Bangalore) Model 12A4D. High purity Zn (99.99%), Te (99.99%) and Cr (99.99%) metal powder were taken in the stoichiometric proportion for the preparation of $Zn_{1-x}Cr_xTe$ alloys with varying Cr composition with x = 0.1 and 0.2. Each material of ZnTe:Cr 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. The material (~ 100 mg) was placed into molybdenum boat and it was heated indirectly by passing current through the electrodes. Cleaned glass slides were used as a substrate. The deposition has been done at vacuum of 10^{-5} torr.

III. RESULT & DISCUSSION

A. Scanning Electron Microscopy

The surface of the thin films was analyzed with SEM, “the technique that permits the observation and characterization of heterogeneous organic and inorganic materials on a nanometer to micrometer scale [11]. SEM employs a finely focused electron beam to raster the surface of the specimen. Many signals are produced as the result of this beam-specimen interaction, including secondary electrons, backscattered electrons, characteristic X-Rays and photons of various energies. Secondary and backscattered electrons are commonly used for imaging because these signals vary, depending on the topography. As a result, a three dimensional-like image is achieved due to the large depth of field of SEM and the shadow relief effect of the secondary and backscattered electron contrast. The surfaces of the ZnTe thin films were analyzed with SEM.

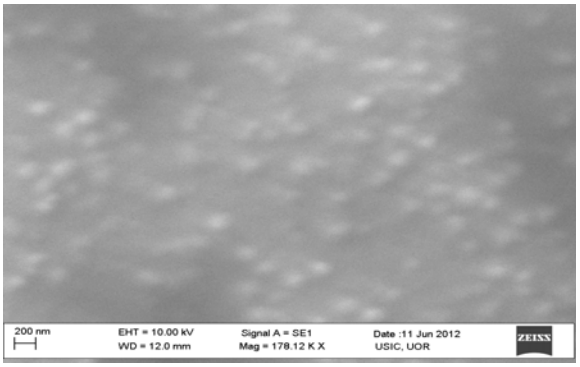

Fig. 1 SEM image of $Zn_{0.8}Cr_{0.2}Te$ thin film.

The surface morphology and grain size analysis of the thin films have been estimated by SEM measurements as shown in Fig.1. This measurements shows that thin film surface exhibits spherical granular structure distributed uniformly along the surface. The average grain size has found to be ≈ 11 0 nm

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