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Effect of Mn-Doping on Optical Properties of ZnTe Thin Films

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***Abstract*-. The II-VI compound semiconductor ZnTe has a direct transition at 2.26 eV. Therefore, ZnTe is capable of green light emission at 550 nm, i.e. in the spectral region corresponding to the maximum sensitivity of the human eye. This makes ZnTe an appealing candidate for the production of bright light-emitting diodes (LEDs) and diode lasers. The optical properties of the nanostructured ZnTe/Mn thin films deposited by thermal evaporation method were investigated. Thickness of these thin films is determined by ellipsometric measurements.**

Keywords: Nanocrystalline, ZnTe:Mn thin films, Uv-Vis spectroscopy, optical properties.

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I. INTRODUCTION

Ternary compound ZnTe/Mn is a promising material for photovoltaic application. In recent years, many conductive oxides have investigated immensely due to their wide range of applications in semiconductor devices particularly in gas sensing area. ZnTe/Mn is the most popular, profitable and promising member of II-VI family due to its attractive electrical, optical and piezoelectric properties [1-3]. In addition, it possesses many interesting other properties, such as a wide energy band-gap, large photoconductivity, and high excitonic binding energy [4-6]. high-quality nanostructured ZnTe films are widely used in various fields such as light emitting diodes [7-9], photodetectors [10], laser diodes [11], gas sensors [12,13], field emission [14], and solar cells [15,16]. Nanomaterials have received much attention by worldwide material scientists for their uncommon properties compared to bulk phase in the last 10 years. Great efforts have taken for the preparation of metal oxides with various nanostructures for their wide application [17-22]. ZnTe/Mn nanostructures have been synthesized by many methods such as chemical vapour deposition [23], r.f. magnetron sputtering [24], reactive magnetron sputtering [25], CVD [26], sol-gel process [27], laser ablation [28] and spray pyrolysis [29] using different precursors [30-33]. . Bhahada *et al.* [34] have synthesized uniform ZnTe thin films by the thermal evaporation method.. Out of these techniques, thermal evaporation method has many advantages such as simplicity, safety and cost affordability of equipment and raw materials. In this paper, we present the deposition of nanocrystalline ZnTe/Mn thin films using thermal evaporation method. ZnTe has the appearance of grey or brownish-red powder, or ruby-red crystals when refined by sublimation. Zinc telluride typically had a cubic (sphalerite, or "zincblende") crystal structure, but can be also prepared as hexagonal crystals (wurzite structure). Irradiated by a strong optical beam burns in presence of oxygen. Its lattice constant is 0.61034 nm, allowing it to be grown with or on aluminium antimonide, gallium antimonide, indium arsenide, and lead selenide. With some lattice mismatch, it can also be grown on other substrates such as GaAs, and it can be grown in thin-film polycrystalline (or nanocrystalline) form on substrates such as glass, for example, in the manufacture of thin-film solar cells. In the wurtzite (hexagonal) crystal structure, it has lattice parameters a= 0.427 and c=0.699 nm.

There does not exist any systematic study on the electrical and optical properties, in particular for ZnTe/Mn films, at varying deposition conditions. We have therefore under taken a systematic study how varying deposition conditions affect the optical, electrical and magnetic properties of ZnTe.

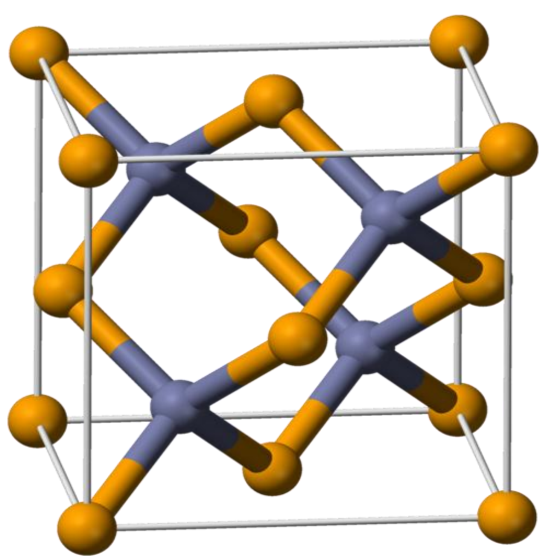

Fig. 1 Structure of ZnTe

II. EXPERIMENTAL PROCEDURE

The ZnTe:Mn 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 ZnTe:Mn 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. CHARACTERIZATION TECHNIQUES

The Ultraviolet-visible spectroscopy is a useful technique to identify some functional group and optical band gap of material. The absorption spectra were recorded using a Hitachi-330.

A hydrogen or deuterium lamp is used for the ultraviolet region and a tungsten / halogen lamp for visible region, so as to scan the entire range of the spectrometer. Light is passed simultaneously through the sample as well as through the reference cell. The transmitted radiation is detected and the spectrometer records the absorption spectrum by scanning the wavelengths of the light passing through the cells. The schematic diagram of UV-VIS spectroscopy is shown in Figure 2.

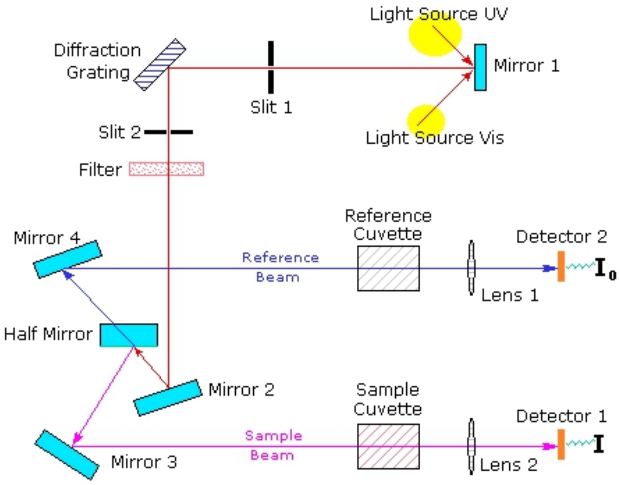

Fig. 2 UV- VIS Spectroscopy

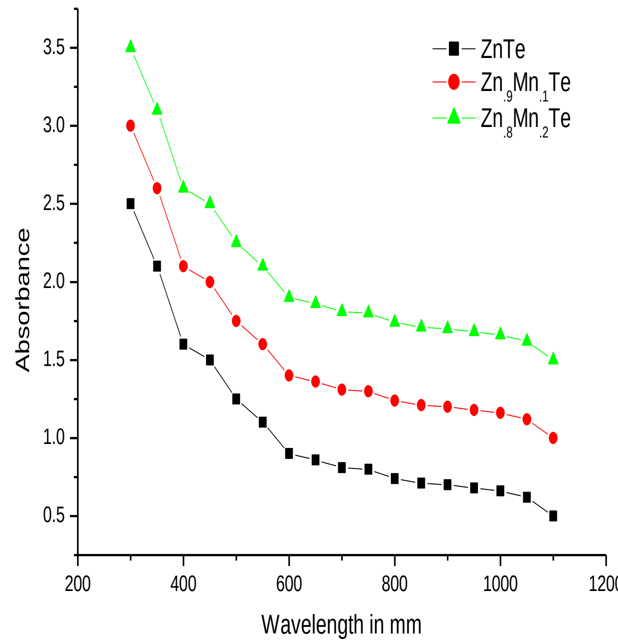

Fig.3 Optical Absorbance Spectra of $Zn_{1-x}Mn_xTe$ Thin Films

A. Optical Analysis

The absorbance spectra of the ZnTe and $Zn_{1-x}Mn_xTe$ for x= 0.1 & 0.2 in figure 3. The spectra reveal that all the films show more absorbance in ultraviolet region corresponding to 200-500 nm spectral region. There is a slight decrease in the absorbance for the doped films due to incorporation of Mn atoms into the ZnTe films $Zn_{1-x}Mn_xTe$ for x= 0.1 & 0.2 thin films are shown. It may be concluded from above studies that optical absorbance decrease below 300 nm but for higher spectral region it is increased in Mn doped ZnTe compared to Zn Te.

The energy band gap of the film can be found by help of the following equation for the direct allowed transition

$$\alpha h\nu = A\,(h\nu - E_g)^{1/2}$$

B. Thickness Measurement

Thickness and refractive index (*n*) of as-grown $Zn_{0.9}Mn_{0.1}Te$, $Zn_{0.8}Mn_{0.2}Te$ and $Zn_{0.7}Mn_{0.3}Te$ films have been estimated using ellipsometery. The thicknesses and refractive index (*n*) of these three films have been observed ≈240 nm (*n*= 2.73), 247 nm (*n*= 2.68) and 249 nm (*n*= 2.54) respectively. This shows that for Mn doped thin films the refractive index has found to be decreased as the concentration of Mn increased in ZnTe.

IV. CONCLUSION

ZnTe and $Zn_{1-x}Mn_xTe$ for x=0.1 & 0.2 thin films could be prepared using thermal evaporation method. It may be concluded from above studies that optical absorbance and refractive index decrease with the increasing concentration of Mn due to incorporation of Mn atoms into ZnTe films.

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