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Characterization of Manganese Sulphide Thin Film by Spray Pyrolysis

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Abstract

Manganese sulphide (MnS) thin film is deposited on the glass substrate using aqueous solution of manganese chloride (0.1N) and thiourea (0.1N) dissolved in double distilled water by using spray pyrolysis deposition method at 390^0. The prepared MnS thin film is characterized optically by using UV–Visible Spectrophotometer and microstructural by using X-Ray diffraction. Optical absorption measurements of thin films were carried out in the visible region (380–1000 nm) with glass surface as a reference. The electrical properties of MnS thin film is carried out using four probe methods. The strong absorption edge of the spectrum is used to calculate the optical energy band gap of MnS thin film.

Keywords: MnS thin film, Electrical properties, Optical properties, Spray pyrolysis.

Introduction

Wide ranges of metal and non metal semiconductor compound are studied for the deposition of thin film on substrate (1-5) .Now a day's varieties of methods are used for thin films deposition such as chemical bath deposition, electro deposition, spray pyrolysis, screen printing, spin coating, sol gel coating, etc. In this article spray pyrolysis method used for deposition of MnS thin film. Spray pyrolysis method is simple, low cost and convenient for large layers of deposition on the glass substrate (6-9).

Manganese sulphide belongs to VII–VI compound semiconducting material. Optical band gap of MnS film (Eg = 2.2 eV) having a potential application in photodiode, gas sensors, solar cell, transparent electrodes, solar cell, photo transistor. The MnS thin films are having potential use in solar cell application in the form of a window buffer material (11 -12).

Optical characterization of MnS thin films were prepared using spray pyrolysis technique is studied by UV- VIS spectrometer from its absorption spectrum in optical range (380–1000nm). Electrical characterization of MnS thin film is done by four probe methods with correction factor and for thickness measurement gravimetric method is used (11). The structural nature of deposited thin films is determined by XRD analysis.

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Experimental Work

Before deposition the glass substrate was cleaned in conc. Nitrate acid, alcohol and distilled water for several times to remove the impurities on the surface of substrate. The glass substrate is weigh before and after deposition using electron unipan microbalance of accuracy 10^{-4} gm. Manganese chloride (0.1N) and thiourea (0.1N) solution are prepared in 100 ml double distilled water and stirrer for 7-8 hours on electronic stirrer. By mixing manganese chloride and thiourea in balance from an aqueous solution of MnS thin film is prepared. Now the clean glass substrate was arranged on hot metal plate on heating coil with controlled variac with suitable temperature (390°C). The solution sprayed on the glass substrate to form MnS thin film. After deposition the glass substrate was allow to cool at room temperature.

Prepared MnS thin film is used to study optical properties, electrical and energy gap measurement (6-9) . Optical absorption and percentage transmission were measured by UV–VIS Spectrophotometer Elco (SL- 159) in the wavelength range 380–1000 nm. Electrical properties are studied using four probe methods with correction factor for thin layer (4.532) and the thickness of deposited MnS thin film is determined by gravimetric method.

Result and Discussion

1. **Structural characterization:**

   Fig. 1 show XRD pattern of MnS thin film deposited by spray pyrolysis method. The film was characterized by using X-ray diffractometer. The XRD pattern is mixed phases of Cubic and hexagonal symmetry. The peak observe at 2è = 26.358, 32.784, 49.832, 60.431 and 73.176 (JCPDS card no. 06 - 0518). The nature of deposited MnS thin film is crystalline.

2. **Optical characterization:**

   Fig. 2 and Fig. 3 show Optical absorption and % transmission of the deposited MnS thin film in visible region (380–1000 nm) on ELCO –SL159 Spectrophotometer which shows high transmission in the visible wavelength. Band gap (Fig. 4) of MnS thin film is determine by the equation of stern (6-9). Absorption coefficient $(á.hí)^2$ is linear function of frequency which indicates direct transition in MnS material at strong absorption edge.

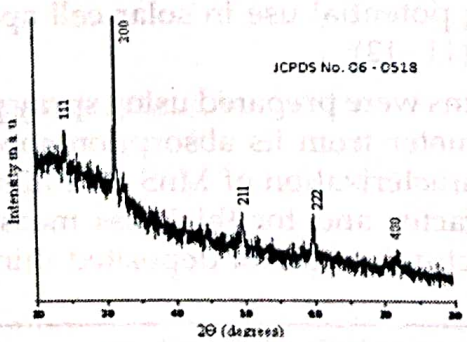

Fig. 1 XRD Pattern for MnS Thin film

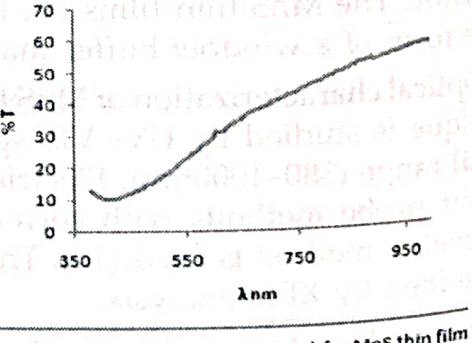

Fig. 3 plot of %T vs wavelength (nm) for MnS thin film

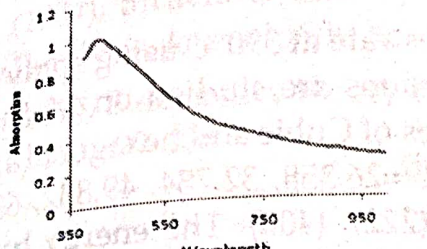

Fig. 2 absorbance of MnS thin film

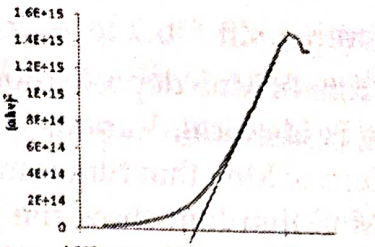

Fig. 4 Band gap of MnS thin film (Eg = 2.1 eV - 2.2 ev)

3. Electrical characterization:

MnS thin Film is studied for thickness parameter by using weight difference density method (gravimetric method). MnS thin film thickness is calculated by weight difference equation.

Electrical characterization of MnS thin film is studied by using four probe techniques which is most commonly method used to determine bulk resistivity and conductivity of the material (11) .

Due to the combination of current and voltage probe correction factor is applied to determine resistivity of the thin film. Fig. 5 and Fig. 6 show the resistivity and conductivity as a function of temperature. Electrical conductivity as a function of inverse of temperature for MnS thin films are show in Fig. 7.

Figure shows Resistivity of the MnS thin films decreased with the increases in temperature and conductivity is increased with increase in temperature.

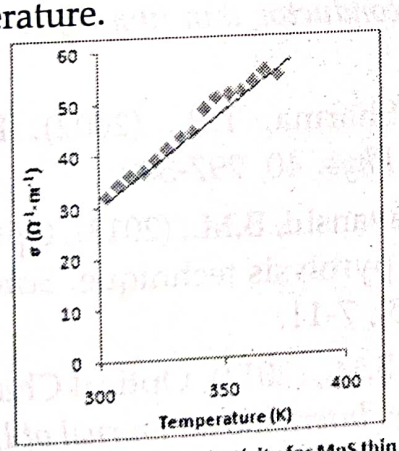

Fig. 6 Electrical Conductivity for MnS thin film

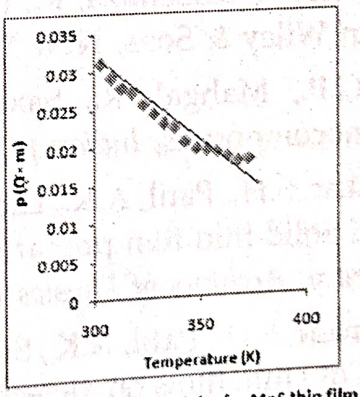

Fig. 5 electrical resistivity for MnS thin film

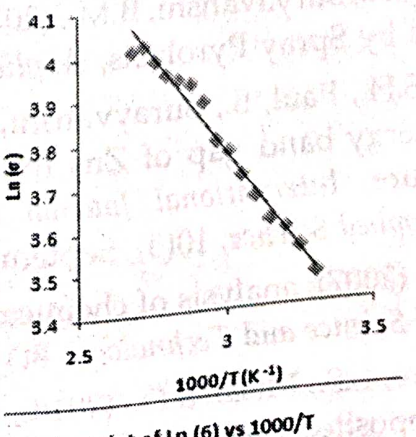

Fig. 7 plot of Ln (6) vs 1000/T

Conclusion:

Thin film of MnS deposited on glass substrate at 390°C using spray pyrolysis technique is identical. Various characterizations are studied on MnS thin film. XRD pattern of MnS thin film is mixed phases of Cubic and hexagonal symmetry. XRD of MnS thin film show the peaks at 2θ=26.358, 32.784, 49.832, 60.431 and 73.176 with orientation (111), (200), (211), (222), (400). The energy band gapof MnS thin films is obtained at Eg = (2.1 –2.2 eV).

Increase in conductivity with temperature concludes that MnS material is semiconducting material with single charge carriers. Various characterizations analysis show that the spray pyrolysis technique can be used to prepared MnS thin film on glass substrate and the deposited thin film can be used in various applications.

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