### Introduction:
In last few decades efforts have been devoted to synthesis of high quality semiconductor thin films such as CdS, CdZnS [1-3], MoSe2 [4], CdSeS, CdSeS [5], ZnS [6], CuS [7], and CdFeSe [8] by using several deposition methods. Materials containing manganese are interesting because of their applications in many areas of modern technology. MnS is a wide gap (band gap energy, Eg ~ 3.1 eV) VIIB – VIA magnetic semiconductor. MnS is a DMS (Dilute Magnetic Semiconductors) material having potential use in short wavelength optoelectronics devices, and in many areas of modern technology. MnS is a wide gap semiconductor. MnS is a DMS (Dilute Magnetic Semiconductors) material having potential use in solar cell applications as a window buffer material. MnS thin films were deposited by chemical bath deposition (CBD) technique. The glass substrates used were previously cleaned. The synthesis of MnS thin films was carried out using CBD technique. The glass substrates used were previously cleaned. The prepared MnS films were annealed at 100 °C for one hour in air. The temperature, duration of deposition and molar concentration of ammonium hydroxide on electrical properties was investigated.

### Material and Methods:
The synthesis of MnS thin films was carried out using CBD technique. The glass substrates used were previously cleaned. The prepared MnS films were annealed at 100 °C for one hour in air. The temperature, duration of deposition and molar concentration of ammonium hydroxide on electrical properties was investigated.

In present study, MnS thin films were deposited onto glass substrates by using Chemical Bath Deposition Technique (CBD). Film deposition was carried out by controlling the PH of the precursors by addition of different molar concentration of ammonium hydroxide (NH3OH). The prepared MnS films were characterized by X-ray diffractometer and UV-visible spectrophotometer. The optical band gap was evaluated and reported. The MnS film deposited for 14 ml of 7M ammonia exhibit maximum 4.023 eV band gap. The high temperature electrical conductivity was studied by using two probe technique. The film deposition technique. The glass substrates used were previously cleaned.

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### KEYWORDS
Chemical bath deposition, MnS thin films, Optical Properties, electrical properties.
the substrate immersed in the solution. But presence of ammonia/ammonia water as the complexing agent slows down the precipitation process enhances the formation of MnS thin films.

Result and discussion:

I. Thickness: Film thickness is an important parameter in the study of the film properties. The film thickness calculated by using weight difference method equation and tabulated in table 1.

\[ t = \frac{m}{\rho} \]  

(1)

Where m is the mass of the film deposited on area A, \( \rho \) is the density of the material.

The variation of the film thickness vs. concentration of ammonium hydroxide was plotted in fig. 1. Initially the thickness was very low for low \( P^0 \) and was observed linearly increased from 1000 nm to 1270nm on increasing \( P^0 \) (concentration of ammonium hydroxide). No significant change was observed in the film thickness by increasing the ammonia concentration above 12 ml; however uniform MnS thin film (sample S4) was obtained for 14 ml of 7M ammonia. This concluded that the \( P^0 \) of precursor is very important bath parameter for slowed down the precipitation process and enhances the formation of MnS thin films.

II. Structural Study: The film sample S4 was characterized by using X-ray diffractometer Miniflex II (CuK\( \alpha_1 \) 1.54 nm radiation). The crystallographic properties have been investigated by using XRD pattern as shown in Fig. 2. XRD pattern exhibits polycrystalline structure of MnS with mixed phases of Cubic and hexagonal symmetry. The intense peak at 2\( \theta \) = 31.231 attributed to (200) plane of \( \beta \)-MnS cubic structure (JCPDF card No:40-1288) and peak at 2\( \theta \) =25.810 attributed to (100) plane of hexagonal structure (JCPDF card No:40-1289). Other peaks at 2\( \theta \) = 32.583, 34.763, 51.123, 60.236 exhibits (210), (211), (222) and (400) planes of cubic structure MnS2 (JCPDF card No:76-2051).

III. Study of Optical Parameters: The deposited films were characterized by using systronics double beam 2201 spectrophotometer, the percentage absorption was plotted against wavelengths (nm) as shown in fig. 3. All the films show that absorption decreased with increase in wavelengths. Film samples S1 and S2 show no significant decrease in absorption, however significant blue shift was observed. The film samples S3 and S5 show decrease in absorption with negligible blue shift. The film sample S5 deposited for 14ml of 7M NH4OH exhibit significant blue shift. It was reported that blue shifting of absorption edge indicates that the prepared film exhibit low absorption in the blue region which is the advantage for solar cell application [23]. The optical band gap was obtained by using the relation [24].

\[ A(h\nu-E_g)^n = h\nu \]  

(2)

Where A is constant depending upon the transition probability, for direct allowed transition n=1/2, \( E_g \) is band gap energy and \( h\nu \) is the photon energy.

The values of direct band gap (Eg) were determined by plotting (\( \alpha\hbar\nu \))^2 vs. photon energy as shown in Fig. 4 and extrapolating the straight line curve to zero absorption. The intercept on energy axis gives the optical band gap (Eg). The variation of band gap with \( P^0 \) of the precursor was tabulated in table 1. The band gap was observed increase for increasing \( P^0 \) values up to certain limit. The film sample S5 prepared by using 14ml concentration of 7M NH4OH exhibit maximum 4.023 eV band gap. The similar band gap was reported for MnS thin films [25].
The percentage transmittance vs. wavelengths was plotted in Fig. 5. It was observed that transmittance increased in general for all samples. The film sample S4 show high transmittance (50 to 65%) in the ultraviolet, visible and infrared regions of the electromagnetic spectrum as compared to other samples. It was concluded that the 14ml of 7M ammonia was the optimum value to slow down the reaction and better formation of the MnS thin film. The variation of band gap vs. concentration was plotted in Fig. 6.

Electrical Study:
The resistivity of all samples lies in the range $10^6$ to $10^7$ KΩ -cm. the variation of conductivity $1/\tau$ per °K was shown in fig 7.

Electrical studies are done to determine the thermal activation energy and the effect of PH on activation energy. The studies are carried out in the temperature range 293 to 473 K by using two probe method. The electrical resistivity measured at regular intervals of 5 K.

$$\rho = \frac{A}{I} \times \frac{V}{d}$$

Where $A$ is area of the film, $I$ is current $V$ is voltage between two probes and $d$ is the distance between probes. The electrical conductivity ($\sigma$) was obtained from resistivity ($\rho$) by using equation (3) The thermal activation energies $\Delta E_a$ are calculated by using equation (4) (25).

$$\sigma = \sigma_0 \exp \left(-\frac{\Delta E_a}{K T}\right)$$

Where $\sigma$ is the carrier conductivity, $\Delta E_a$ is the activation energy, $K$ is the Boltzmann constant, $\sigma_0$ is the constant depending upon the material and $T$ is the temperature in absolute scale. The electrical conductivity as a function of inverse of temperature of MnS films are given in Fig.7. It was observed that the resistivity of the MnS thin films decreased and electrical conductivity was observed increased with increasing temperature. The increasing electrical conductivity with temperature concludes that MnS material deposited on the substrates is semiconducting. The linear increase in electrical conductivity with temperature show the conductivity is due to only one type of charge carriers. The similar results were reopored for Mns thin films [26]. From the slopes of these graphs activation energies was estimated. The activation energy of the samples varies with $P^n$ of the samples. The activation energy for film sample S4 is maximum (0.273eV). The variation of activation energy with $P^n$ was tabulated in table 1.
REFERENCES