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# Study the effect of Mn-doped CuO thin film on its optical properties

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## ABSTRACT

The sprayed pyrolysis technique was carried out to prepare CuO thin films with different Mn-doping. Optical properties were calculated by recording the absorption spectra by UV-Visible spectrophotometer. The absorbance and absorption coefficient are increased with increasing Mn-doping in the CuO thin films. While the energy gap decreased from 2 eV before doping to 1.91 eV after 4% Mn-doping. In addition, extinction coefficient, and skin depth are decreased with increasing Mn-dopingin the CuO thin films. 

## INTRODUCTION

The CuO with narrow band gap of 1.2 eV is extensively used in various applications such as catalysis[1], solar energy conversion[2], gas sensor[3] and field emission[4]. Most of the techniques produce p-type conducting thin films. Many the theoretical and experimental studies have been revealed that the Cu vacancies originate the p-type conductivity[5-8]. Polycrystalline thin and thick films of copper oxide have been prepared by various techniques such as thermal oxidation, electro deposition, chemical conversion, chemical brightening, spraying, chemical vapor deposition, plasma evaporation, reactive sputtering and molecular beam epitaxy[9-11]. CuO is subjected to a chemical spray, it is deviated and thereby causes from stoichiometry due to defects and impurities.

The aim of this work is to study the effect of Mn-doped on some of optical properties of CuO thin films prepared by chemical pyrolysis method.

### Experimental procedures

Thin films of CuO were deposited onto a glass substrate by chemical spray pyrolysis technique.

The glass substrate was cleaned by chromic acid for 5 hours, rinse with running water for 15 minutes and subsequently putting in an ultrasonic bath filled with absolute ethanol for 10 minutes. After these operations, the glass was ready to use. 0.1M of $CuCl_2.2H_2O$ supplied from Sigma-Aldrich Chemicals with 0.1M of $MnCl_2.4H_2O$ supplied from Merck Chemicals. Various contain of Mn that used (0, 2, 4, 6%). Dissolved in double distilled water as a starting solution. Many trails have been accomplished in order to meet the requirements of optimization which arrived at the following parameters: Substrate temperature was kept at 400°C during the spray. The carrier gas was compressed air and was found to be around $10^5$ N/m$^2$.

Deposition rate was 5 ml/min, the spray period was 7 sec lasted by 2.5 minutes to avoid cracks during the cool substrate exposure by spray time and distance between nozzle and substrates was about 29 cm. The film thickness was recorded using weighing method and was found to be 300±30 nm. Utilizing double beam spectrophotometer (Schimadzu 1650Japan) was used to measure the transmittance

and absorbance of the films in the wavelength range (460-900) nm.

## RESULT AND DISCUSSIONS

UV-Visible spectrophotometer that used to determine the absorbance spectra in the range (460-900) nm for Mn-doped CuO thin films. These spectra are shown in Figure1 that inversely depended with wavelength. The absorbance increases with increasing Mn-doping in CuO thin films.

The optical absorption coefficient (α) in the fundamental absorption region was evaluated using the following equation[12]:

$$\alpha = \frac{\ln T^{-1}}{t} \quad (1)$$

Where t is the film thickness and T is the transmittance. The absorption coefficient increased with increases Mn-doping in the CuO thin films as represented in Figure2. The optical band gap of the samples was determined based on the equations reported by Pankove[13]. For CuO which has a direct band gap, αis given by the following relation:

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

Where A is a constant, hυ is a photon energy, and $E_g$ is the optical band gap. Figs (3-6) shown the decreases of energy gap with increasing Mn-doping in the CuO thin film from 2 eV for pure CuO to 1.91 eV for 4% Mn-doping. This behavior is a result of make sub-levels in the band gap that decrease the optical band gap.

The extinction coefficient related inversely with wavelength for all deposited Mn-doped CuO thin films as in Figure 7. In addition, the extinction coef-

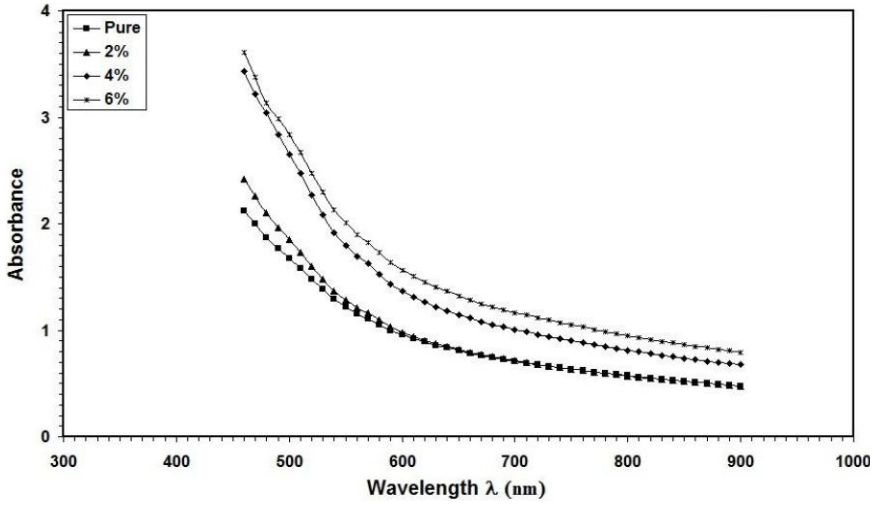


**Figure 1 : Variation of absorbance spectra with wavelength for Mn-doped CuO thin films**

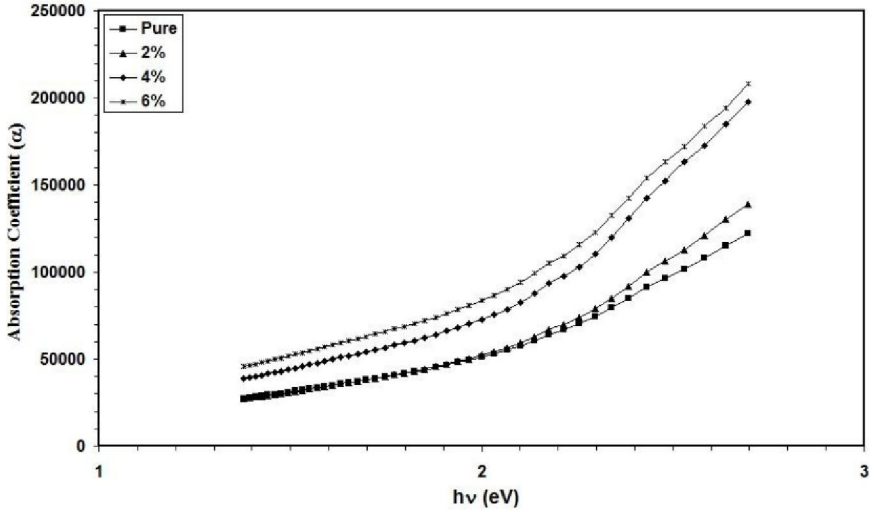


**Figure 2 : Variation of absorption coefficient with wavelength for Mn-doped CuO thin films**

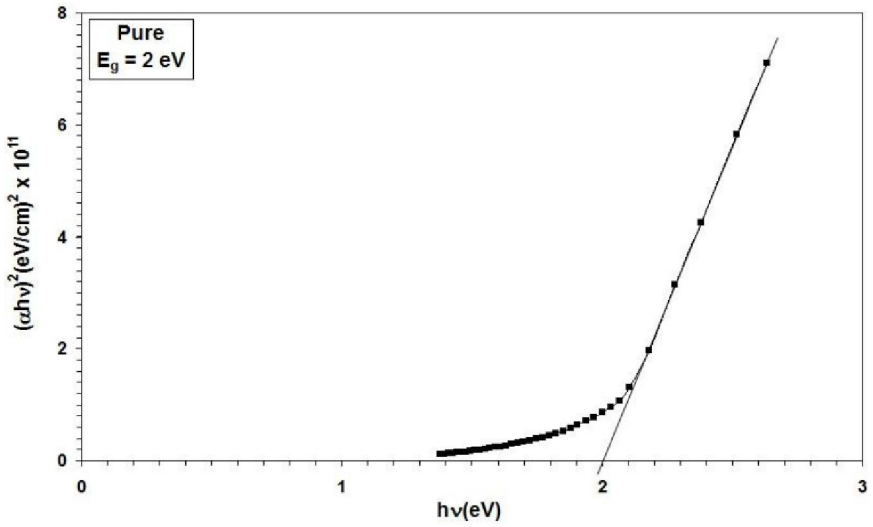


**Figure 3 : Variation of $(\alpha h\upsilon)^2$ with hυ for pure CuO thin films**

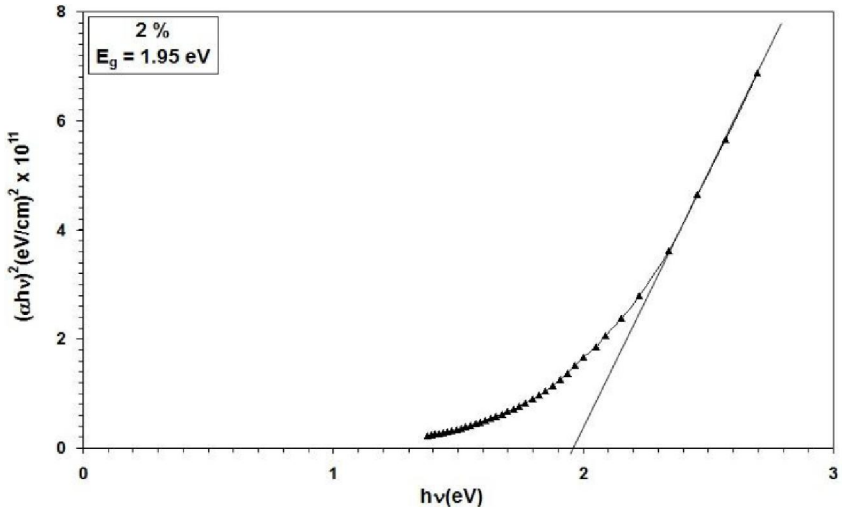


**Figure 4 : Variation of $(\alpha h\upsilon)^2$ with hυ for 2% Mn-doped CuO thin films**

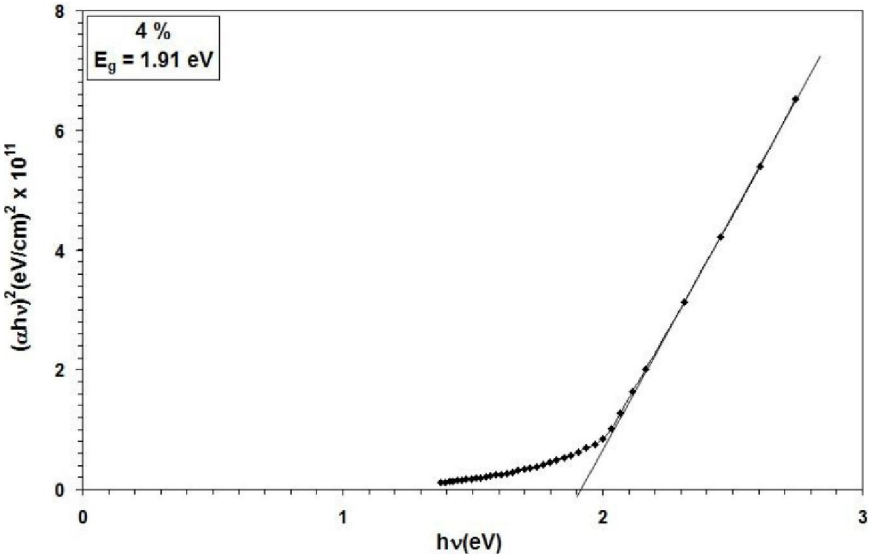


**Figure 5 : Variation of $(\alpha h\upsilon)^2$ with hυ for 4% Mn-doped CuO thin films**

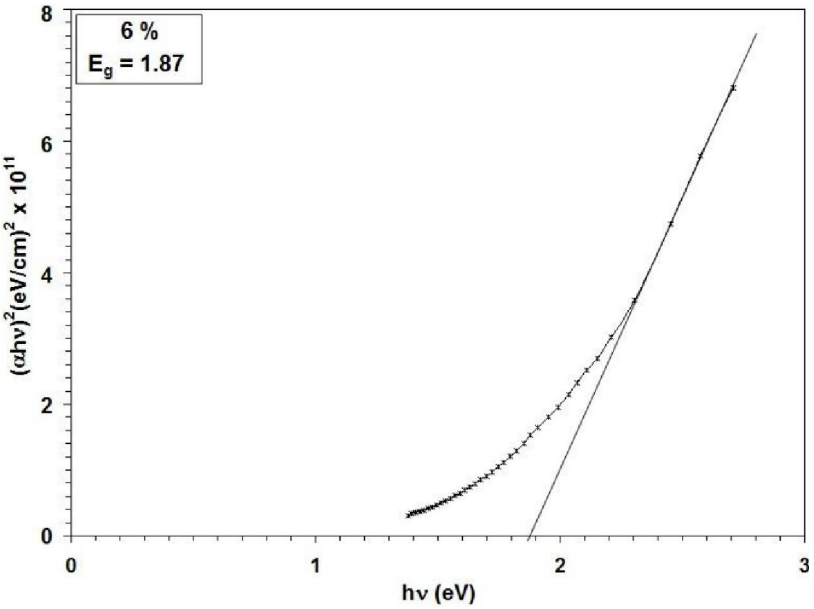


**Figure 6 : Variation of $(\alpha h\upsilon)^2$ with hυ for 6% Mn-doped CuO thin films**

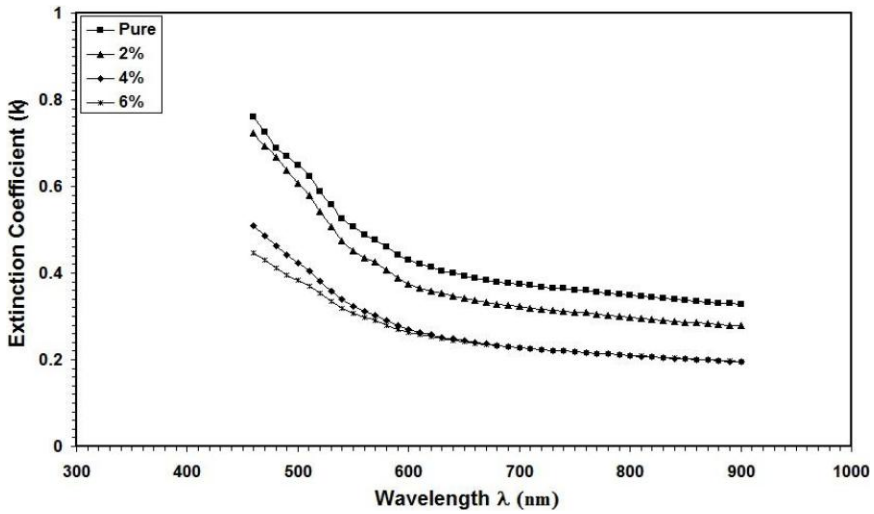


**Figure 7 : Variation of extinction coefficient for Mn-doped CuO thin films**

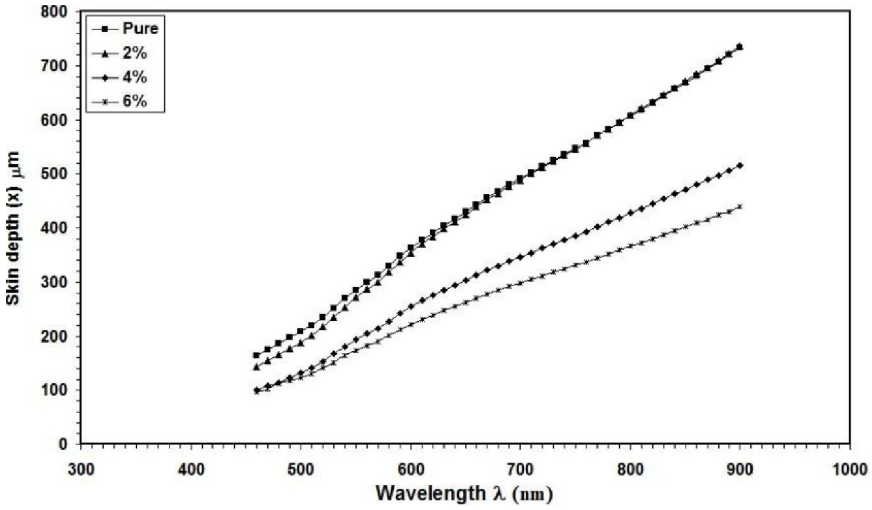


**Figure 8 : Variation of skin depth for Mn-doped CuO thin films**

ficient decreased with increasing Mn-doping in the CuO thin films.

Skin depth decreased with increasing Mn-doping in the CuO thin film as shown in the Figure 7 and directly increases with increasing wavelength.

## CONCLUSION

In this work, we study the effect of Mn-doping on optical properties of CuO thin films. Spray pyrolysis technique were used to preparation Mn-doped CuO thin films. The absorbance and absorption coefficient are increased with increasing Mn-doping in the CuO thin films. While the energy gap, extinction coefficient, and skin depth are decreased with increasing Mn-doping in the CuO thin films.

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