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The Effect of Thickness on Structural and Optical properties of MgO Thin Film Prepared by Chemical Spray Pyrolysis

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ABSTRACT

This study investigated the structural and optical properties of magnesium oxide films produced by chemical Spray Pyrolysis. They were deposited on glass substrates at 400°C and had thicknesses of 300, 400, and 570 nm. According to X-ray diffraction results, all prepared films have a polycrystalline, cubic structure. The optical characteristics (transmittance, absorption and reflectance) of films were studied for wave lengths between 300 and 900 nm and for thickness (300, 400, 570) nm at room temperature, these results showed that the absorption values increase with increasing thickness of the thin films and decreases rapidly with increasing wavelength, the reflectance values increase with increasing thickness of the thin films but increases with increasing wavelength. The results indicated that these films have an energy gap for direct transitions and that the energy gap decreases with increasing film thickness, with the forbidden direct transition energy being less than that of the allowed direct transition.

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1. INTRODUCTION

The translucent oxide family includes magnesium oxide (MgO), which crystallizes into a face-centered cubic structure with a = b = c = 4.217. A [1]. For pure MgO, it has a wide direct band gap of 7.8 eV and high transmission values in the visible range up to 90% [2], with a gap energy below 7.8 eV. The presence of defects in type FS and FB is thought to be the cause of the low band-gap energies. The primary benefits of a magnesium oxide (MgO) material are its quantity of elements, chemical and physical stability, and non-toxicity [3–4]. MgO's antibacterial [5], antimicrobial [6], and photo-catalytic [2,7] qualities make it a good choice for a variety of applications. Additionally, MgO has potential in gas sensors [8] and solar devices [9,10]. Chemical vapor deposition (CVD) [11-13], pulsed laser deposition [14], reactive sputtering [15], laser ablation [16], metal organic molecular beam epitaxy [17], sol-gel [18], thermolysis of an ultrathin Mg(OH)2 precursor under a dynamic vacuum to obtain ultrathin single-crystalline MgO nanosheets with a preferential orientation stacked by (111) planes [19], and a chemical spray pyrolysis technique [2,20] are just a few of the experimental methods developed to produce MgO materials. In order to eliminate contaminants and safeguard the environment, researchers are currently looking for novel therapies, such as the extractive-pyrolytic approach [20]. For these reasons, organic pollutants that are bad for the environment and risk to human health are broken down by photocatalysis using semiconductor materials. Numerous experimental methods and instruments, including FTIR spectroscopy, confocal microscopy, FTIR spectroscopy, X-ray diffraction (XRD). Examining the structure and optical characteristics of sprayed magnesium oxide thin films is objective of this work.

2. METHOD

In this project, a thin film of magnesium oxide was deposited on to a glass substrate, which was ultrasonically cleaned With distilled water for ten minutes. the Magnesium chloride Mg(Cl2-6H2O) solution prepared with 0.1 M by dissolve 2.1949 g of Magnesium chloride in 100 ml distilled water and added some drops of HCL .The solution was agitated with a magnetic stirrer and permitted to stand for 20 minutes to ensure that no residue remained and that the finished product was uniform.

The resulting solution was sprayed over the heated substrate at 400°C. The distance between the capillary tube and the substrate is one of the most important variables in producing a homogenous film. In this experiment, the optimal nozzle spray height was determined to be (12) cm. As this distance increases, the atomized solution scatters away from the substrate, and as this distance decreases, the solution drops gather at a single spot. This result will affect the homogeneity of the final thin film and as the chemical equation (1):

Mg(Cl2-6H2O) + 6 H2OMgO + Cl2 …………..... *(1)*

Where the average of spray was 10 second and stopped for 1 minute and return to spray to get crystal growth for deposition material and repeated it (10) times to get the film

3. RESULTS AND DISCUSSION

The structure of Magnesium oxide thin film prepared on glass substrate with 400 °C and thickness of 700nm investigated by XRD . After matching with JCPDS card No.(87-0653) XRD diffraction showed that the Magnesium oxide thin film have a cubic system and polycrystalline with a preferred orientation of (2 0 0) and as the figure (1)

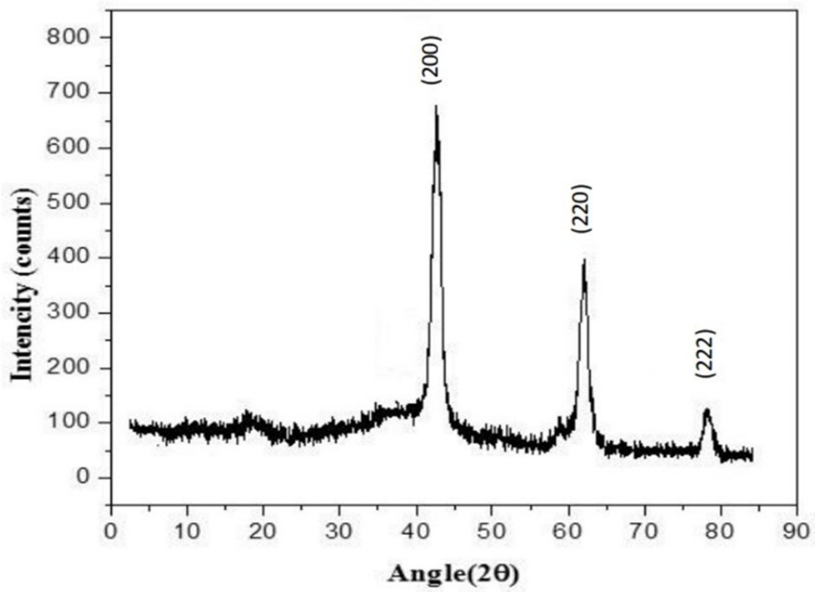

Figure (1): X-ray diffraction pattern of Magnesium oxide thin film

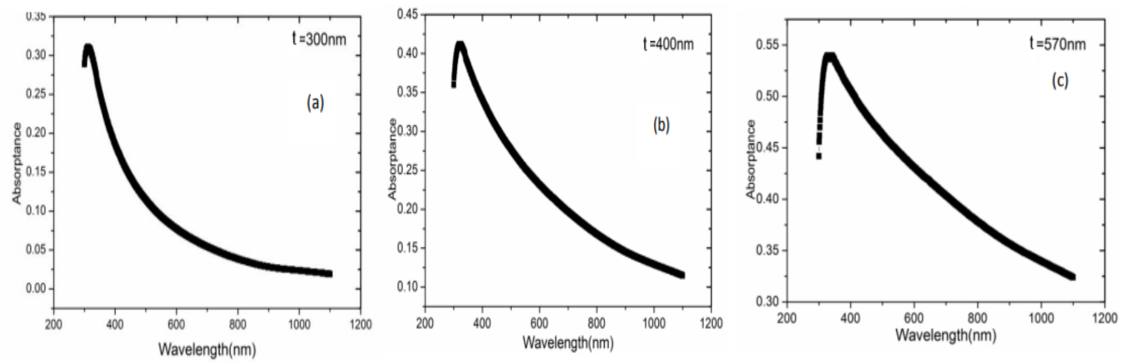

Figure (2): The absorbance of MgO thin film for different thicknesses

Absorbance and transmittance measured for wavelength range (300-900 nm) for all prepared films and for thickness (300, 400, 570) nm at room temperature, these results showed that the absorption values increases with increasing thickness of the thin films and decreases rapidly with increasing wavelength, as shown in the figure (2), which confirms that absorption in semiconductors depends on the energy of the photons falling on it, [21].

The absorption coefficient for all films was calculated through the relationship (2):

$$\alpha = 2.303\frac{A}{t} \quad \ldots\ldots\ldots\ldots(2)$$

Where: α - absorption coefficient,

A - absorbance, t - film thickness

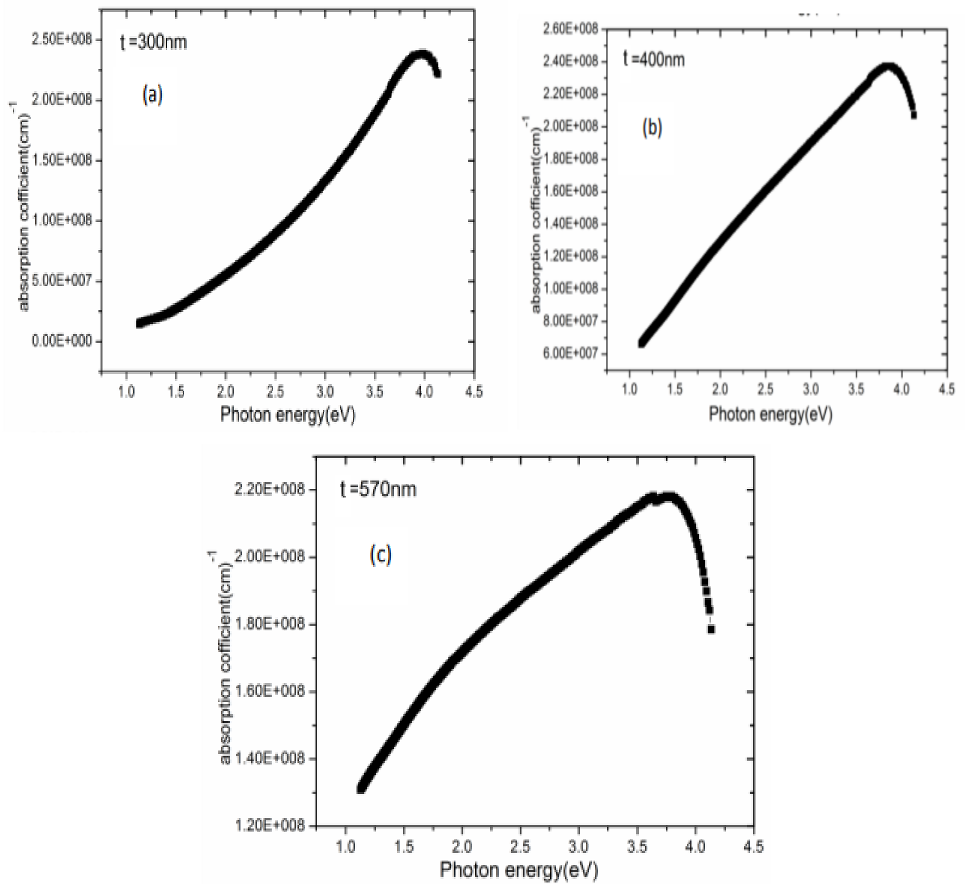

Figure (3): the absorbance coefficient of MgO thin film for different thickness

In figure (4) the energy of the photon, and the straight part extends from the curve to x- axis) the photon energy at point=0 $(\alpha h\upsilon)^2$. We observed the energy gap value was (3) eV with thickness (300nm) and decreases to (2.5 and 2.1) eV with increasing the thickness to (400 and 570) nm this is due to the decrease in the average particle size consequently, the concentration of carriers decreases [21].

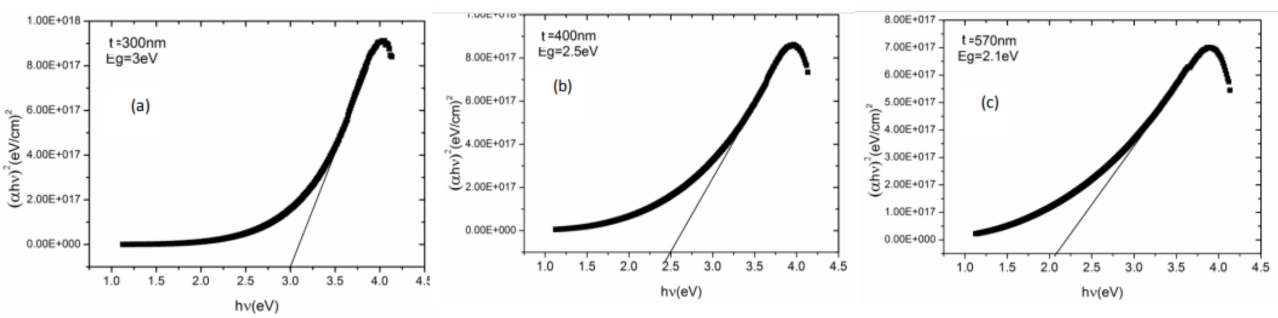

Figure (4): The energy gap for permissible direct transmission as a function of photon energy for different thicknesses

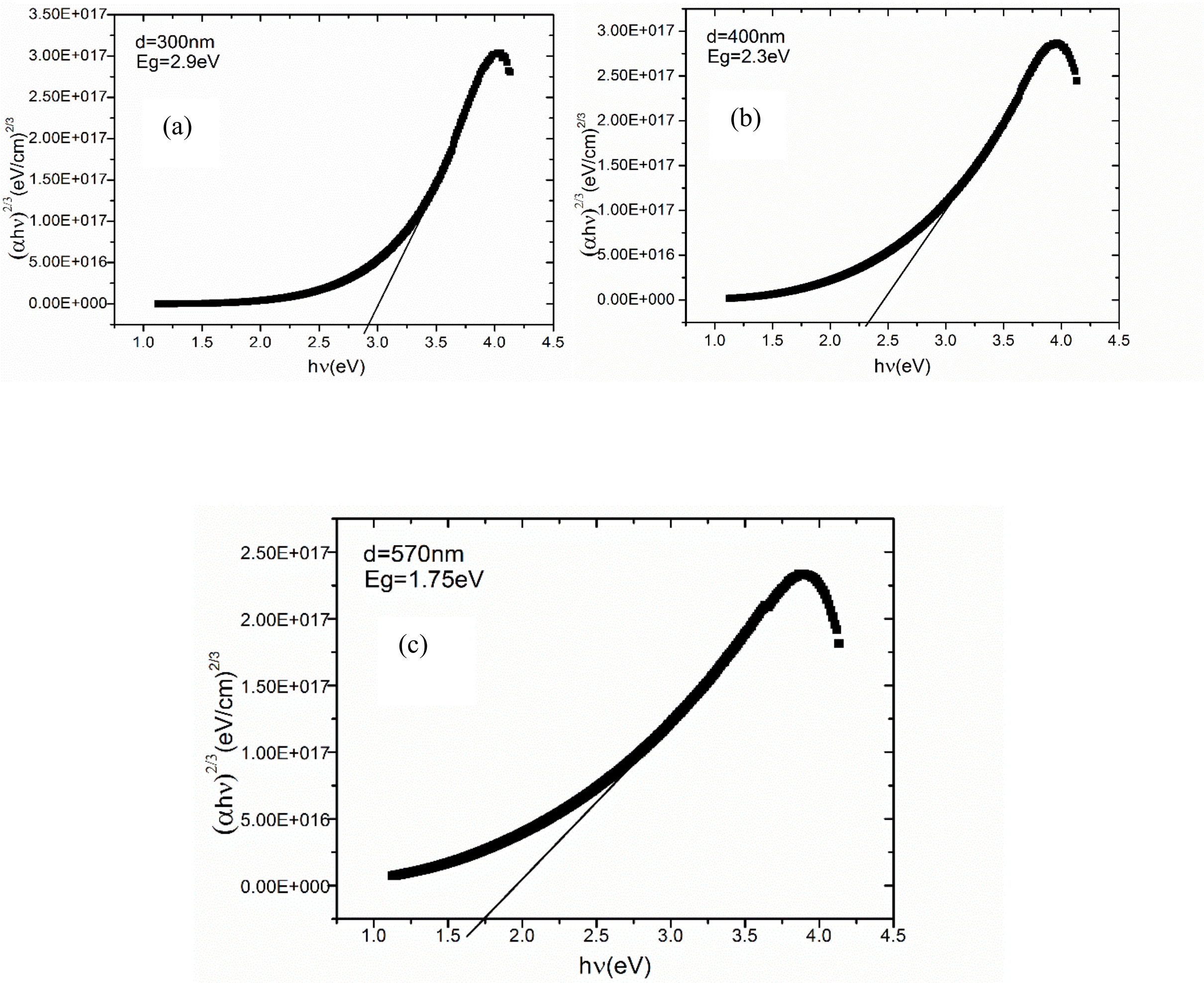

Figure (5): The Energy gap for prohibited direct transmission as a function of photon energy for different thicknesses

Figure (5) shows that the energy gap that is prohibited for the prohibited direct transition is less than the value of the shot gap for the allowed direct transition, which confirms that the value of the energy gap that we obtained is the energy gap for the prohibited direct transition. This is attributed to the fact that the prohibited direct transition occurred between the points of the valence band adjacent to the peak when the points of the conduction band had a lower energy than in the allowed direct transition. Figure (6) shows the change in transmittance as a function of wavelength. The results proved that transmittance gradually increases with increasing wavelength and decreases with increasing thickness of thin films as in Figure (7), Table (1).

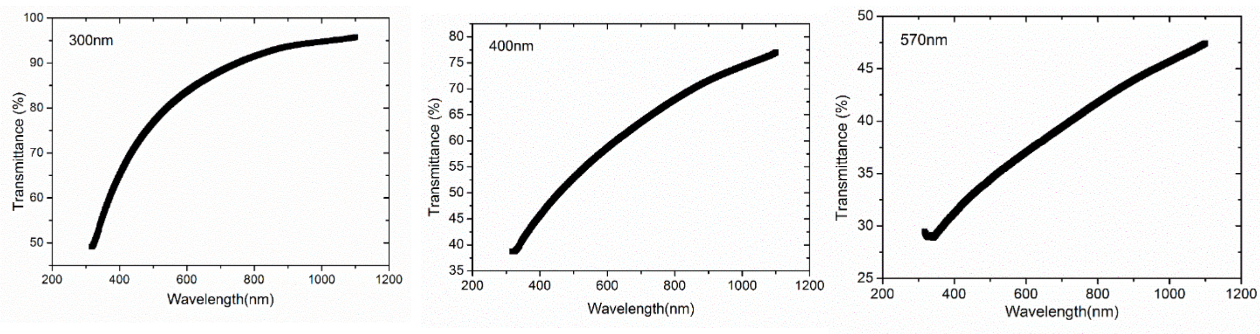

Figure (6): The transmittance of MgO thin film for different thicknesses

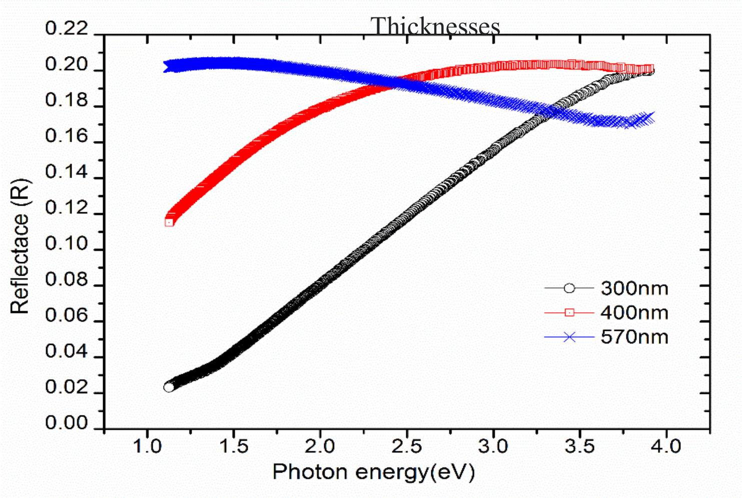

Figure (7): The reflectance of MgO thin film for different thickness

Table (1) Energy gap values for the allowed and prohibited direct transition for Mgo thin for different thickness

Thickness	Energy gap for permitted direct transfer	Energy gap for prohibited direct transfer
300nm	3eV	2.9eV
400nm	2.5eV	2.3eV
570nm	2.1eV	1.75eV

4. CONCLUSION

Preparing MgO thin film at different thickness by chemical spray pyrolysis method. Crystallite structure of films is cubic with Polycrystalline. The best absorbance in UV measurement was at thickness of 750nm and absorbance coefficient having a great value get 104 cm^{-1} and the absorption values increases with increasing thickness of the thin films and decreases rapidly with increasing wavelength , reflectance values increases with increasing thickness of the thin films but increases with increasing wavelength. The results indicated that these films have energy gap for direct transitions, and that the energy gap value reduces as the film thickness increases and the prohibited direct transition is less than the value of the shot gap for the allowed direct transition.

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