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# Optical Analysis of CdO Nano Structure Prepared using Pulsed Laser Deposition Method

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**ABSTRACT**

*This study used pulsed laser deposition (PLD) to create nano-films of cadmium oxide (CdO) that were deposited at various substrate temperatures of 200, 300, and 400 ℃, to reach the optimum substrate temperature for deposited films. The pulsed laser system with a 1064nm wavelength, pulse duration of 10 ns, and pulsed energy of 1800 mJ energy has been applied on the CdO target for ablation of the CdO nano-grains on a substrate of the quartz. The transmittance results of the deposited nano-films provide high transparency reach to 86%, which decreases as the substrate's temperature increases, as well as the absorption results, which decrease as the temperatures of the substrate increase. Finally, the optical energy gap for the deposited films at various substrate temperatures ranged from 2.08 to 2.85eV, as the temperatures of the substrate increased. These results give an indication that the deposited films can be used in optoelectronics devices.*

**Keyword:** CdO; TCO thin film; PLD; Optical analysis; low oxygen atmosphere

## 1. INTRODUCTION

Oxide films such as indium, zinc, and cadmium are transparent conductive oxides that are used in the high technological field of optoelectronics such as detectors and solar cells in addition to the more of the state of solid nano-devices [1-6]. Cadmium oxide is a metal oxide of semiconductors with donor conductivity [7-12]. Considering how crucial it was for the advancement of many solid-state hardware innovations the optoelectronics components, the panel display, the insulating glass, etc. [13-20]. One of the most significant transparent oxides for the second set to the sixth semiconductors with the highest radiation emission and the best absorption in the energy gap. [21-27].

A reddish powder known as cadmium oxide is produced by carefully controlling the interaction of air with purified cadmium metal vapor [28, 29]. Each atom is surrounded by six more atoms with an electrical charge that is the opposite of its own, giving it a cubic crystalline structure [30, 31]. Depending on its temperature history and particle size, it can range in color from greenish-yellow to brown to practically black [32, 33].

The CdO thin film is a transparent conducting film that is both electrically conductive and very transparent in the visible wavelength region [34, 35]. The first CdO film was recorded in the early 20th century, which is when the interest in these transparent conductors originally emerged [36, 37].

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The laser-induced oxidation process is an important issue in literature for many years ago due to its inherent importance for the material processing industry [38, 39]. The main advantage is that laser heating may be extremely localized admitting for the oxide growth in a pre-determined region with an accuracy of some microns [40, 41]. Such a process is occurred without changing the physical properties of the surrounding environment [42, 43]. Also, thermo-chemical modification of the film is widely used for optical recording, deposition of masking layer, and so on [44, 45].

In such a device, the key parameter controlling the efficiency is the thickness of the insulating layer [46, 47]. A higher resistance at the transparency conductive oxides TCO/Si interface is attributed to the presence of an insulating interface (I) layer [48, 49]. This insulating layer ($SiO_2$) has resulted from the reduction of the oxide by the Si, which makes such semiconductors insulators semiconductors SIS device behave much like a metal insulators semiconductors MIS structure [50-52].

It received notice because of its promising properties, such as its direct and narrow gap ranging between (2.2 - 2.8), besides its elevated transmittance in the visible spectrum which is very important for solar applications [53-55]. In addition to the above properties, this material is very easy to dope, plentiful in nature, chemically stable in hydrogen plasma, and non-toxic [55-57].

It has low resistance as a result of oxygen vacancy defects and interstitial cadmium atoms nearby (from 10 to 10 or 2 to 4 cm) [58-60]. It is a cubic crystal with a center facial cubic (fcc) crystal structure, and its lattice constant is 0.4695 nm [61, 62]. Many writers have looked at some of the physical characteristics of this oxide [63, 64]. In the visible and near-infrared spectrums, the semiconducting CdO sheets are transparent [65, 66].

Now a day, this material is very interesting due to its applications, which are used in the electrical and optical analysis of specific, especially in the field of photo diodes, solar cells, photo transistors, transparent electrodes [67, 68] different sensors [69], IR detectors [70, 71] anti-reflection coatings, wear-resistant applications, low-emissivity windows [72, 73], and flat panel displays [74, 75].

Different methods are tested to prepare these nano-films for example solution growth methods [76, 77], spray pyrolysis [78, 79], radio-frequency sputtering [80], chemical vapor deposition [81], pulsed laser deposition [82, 83], and dip coating [84, 85], sol-gel method [86, 87], chemical laser deposition, ion beam sputtering, and DC sputtering [88] radio-frequency sputtering [89], electro-deposition by ultrasonic [90].

## 2. EXPERIMENT

On the cleaning of the quartz substrates, the pulsed laser deposition technology by Nd: YAG laser was used to create undoped CdO thin films. The cadmium target (high purity of 99.999% donated by Fluka company.) was focused by Nd: YAG Q switched laser pulses with 30 ns (FWHM) and 1.064 nm through a 12 cm focal length of a converging lens, at 45 angle of incidence. A 1 Hz rotational frequency was used by the target. The laser's pulse energy density was kept at 1.8 J at the target surface. At a substrate temperature of 523K, 100 laser pulses were used to create all films. The PLD setup utilized in this research is shown schematically in Fig. 1 [51–56].

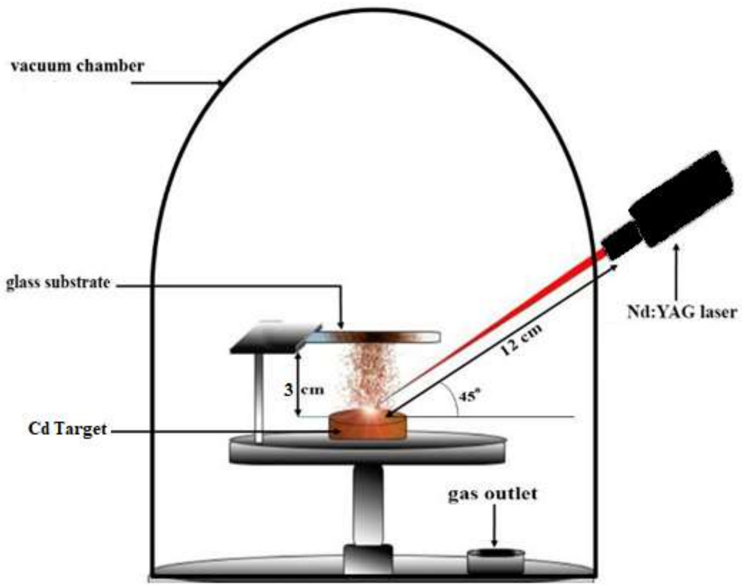


**Figure 1.** System diagram for pulsed laser deposition system.

## 3. RESULTS AND DISCUSSION

Two spectrophotometers operating in the UV-VIS to FAR-IR regions were used to measure the optical results like the absorptions, transmission, and optical band gap.

Figure (2) shows the impact of substrate temperature spectra on the transmittance value of the CdO Nano-films constructed as the constant pulses number and chosen laser energy of 1800 mJ. Due to the low value of the efficiency for deposition rate and the thick CdO Nano-films, it was discovered that the transmission value are increasing at the temperature of the substrate.

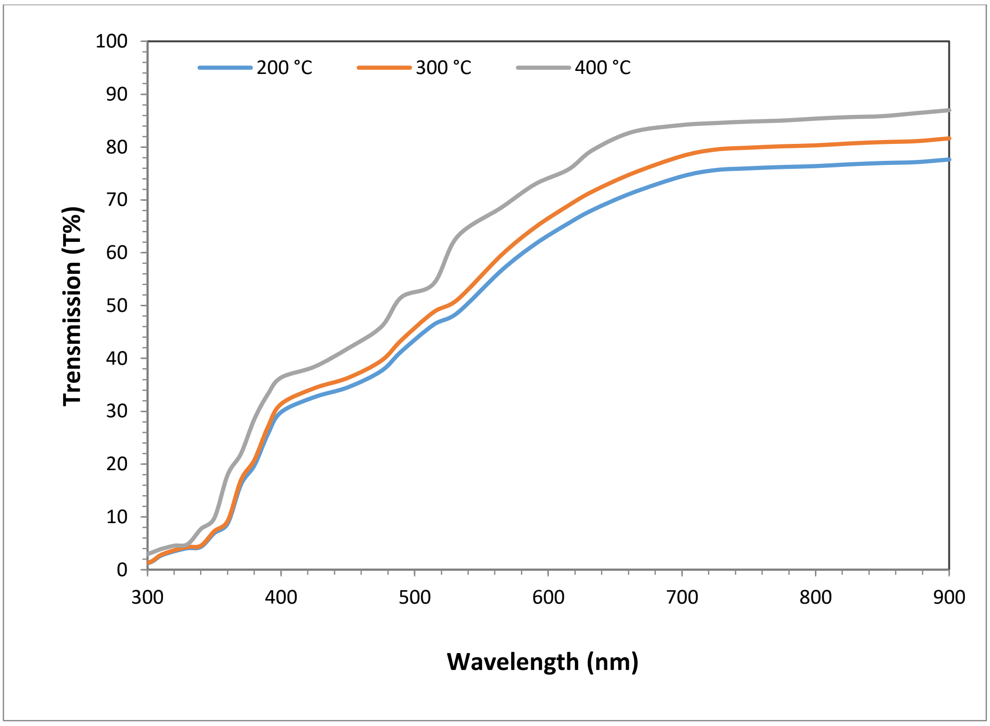


**Figure 2.** Transparency of CdO at various substrate temperatures.

As the substrate temperature decreased, these values shifted to a red shift change (increase in particle size). As the plasma column thickens and turns into a cloud of CdO granules smoothly, the heating media really increases the availability of additional energies that includes a large number of components that cannot be eliminated. This likely indicates the presence of large particles due to the long period of growth rapid and the possibility of particle precipitation. On the other hand, during and after the laser pulses, the molecules and atoms at the micro and nano-deposit potentially move by heating the radiation. Due to the fact that the density of CdO particles increases with increasing heating, larger and more distinguishable particles are produced.

The presented peaks of absorbance are depicted in Figure 3; these peaks are distinguished by a bright red spell with rising laser intensity (increasing particle size). In fact, it implies lowering the quantity greater than the material, which entails saving more energy, as the plasma column grows denser and turns into a cloud of CdO particles. This most likely indicates the presence of big particles due to the lengthy period of rapid development and the likelihood of molecule deposition.

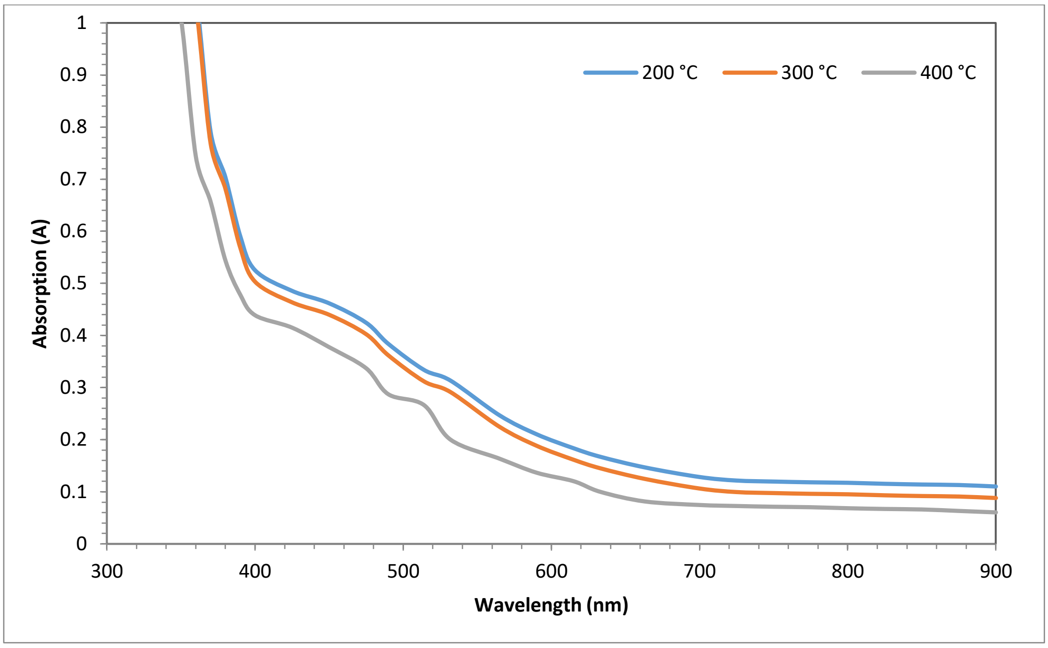


**Figure 3.** Optical absorption of CdO at various substrate temperatures.

It is well known that fundamental light absorption and free-carrier absorption, respectively, are to blame for the dramatic loss in the transparency of zinc oxide films in the UV and somewhat decreased IR areas. This is consistent with the findings of related research [2]. We previously mentioned using Tauc relation to get the optical band-gap of the ready CdO Nano-films. The variation in the band-gap energy bands between the two substrate temperatures is rather slight. The charts imply the nature of the direct band-to-band transfer. The band gap energy is estimated by extrapolating the straight-line section to zero absorption co-efficient =0, and this band gap is determined to be around 2.31–3.82 eV as shown in Figure 4.

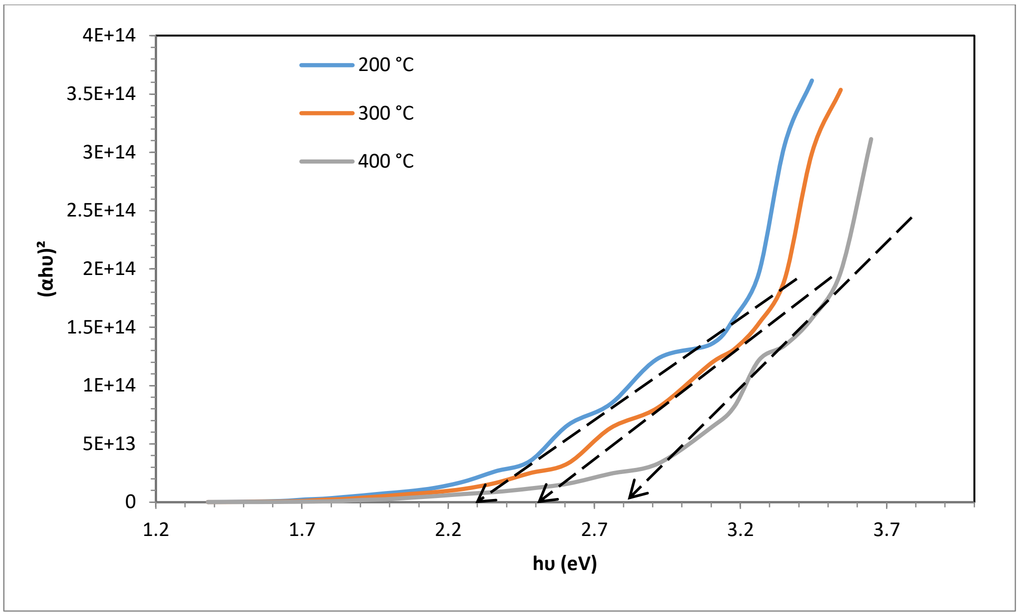


**Figure 4.** Optical ban gaps of CdO at various substrate temperatures.

## 4. CONCLUSION

A high-quality cadmium oxide thin film was successfully deposited by ablation of a cadmium target with an added Nd-YAG laser in an environment with low oxygen pressure. Average transmittance is observable up to 85% based on the optical transmission values of the produced samples at various substrate temperatures, and the optimum energy band gap of 2.82 eV.

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