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INVESTIGATION OF OPTICAL AND STRUCTURAL PROPERTIES OF CDO AND CDO: CU PREPARED BY LASER-INDUCED PLASMA

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Abstract

In this research, thin films of cadmium oxide (CdO) and cadmium oxide doped with pure copper (CdO: Cu) attracted a lot of attention due to their applications in electronic and optical devices. Thin films were adopted in this work that were deposited on substrates made of glass using laser-induced plasma technology at (1064nm, 6x10-2mbr, and 6 Hz) in vacuum conditions, where the plasma formed as a result of the pulsed laser is used to transfer and deposition the film on the glass substrates, then the prepared films are annealed at a temperature of 500 degrees Celsius. The purity of the material was confirmed by taking the crystal structure of X-ray diffraction. The optical properties of the thin films of cadmium oxide (CdO) and cadmium oxide doped with copper (CdO: Cu) were analyzed by drawing the relationship between (αhυ)1/2 against the two-photon energy curves and found that the energy gap is 2.5. eV for the cadmium oxide CdO film, and you noticed that the energy gap decreases when the pulse increases, but in the case of tarnishing with copper, the energy gap decreased from 2.5 eV to 2.4 eV, and it suffers from a greater decrease when the pulse increases.

Keywords: *Laser-Induced Plasma, Plasma, Pulse Energy, Cadmium Oxide, Optical Properties.*

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Introduction

Cadmium (Cd) is an element that is part of set 12 of the table of elements, along with mercury and zinc. It has a minimal melting point “320.9 °C”, low boiling point “765 °C”, and high vapor pressure. [1,2] Cadmium oxide, which quickly oxidizes in the air to generate cadmium, is used in batteries, electroplating baths, pigments, polymers, and other products. and synthetic goods[3].Due to its unique electrical and optical characteristics, cadmium oxide (CdO) draws a lot of attention. The direct band gap of the n-type semiconductor CdO is about 2.5 eV [4,5].

CdO films have been used with success in numerous applications. solar cells gas sensors, electroplating baths, pigments, plastics, and solar cells [6,7,8]. smart windows, optical communications, flat panel displays, photo-transistors, as well as other types of applications like IR heat mirrors.Cdo: Cu films are syntheses by two types: physical and chemical methods such as spray pyrolysis, vacuum evaporation solution growth, and laser-induced plasma [9,10,11,12]. In this work, the pulsed laser deposition technique is used to create CdO and (CdO: Cu) thin films and their optical and structural properties are examined using a PU-8800 UV/VIS Spectrophotometer.

Experimental Work

(0.5 wt %) Cu-doped CdO target for PLD was prepared by solid-state reaction method. Cadmium oxide High purity (99.999) powder and Cu of these materials were mixed in gate mortar used to form the target as a disk of 1.5cm diameter and 0.3cm thickness using hydraulic piston type (SPECAC), under the pressure of 6 tons for 10 minutes. In this paper, the plasma was produced using a pulsed laser on a solid target (CdO: Cu). The deposition of (CdO, Cu, and CdO: Cu) at (200,300,400) pulses and 500 mJ energy respectively.

The film was achieved immediately after the laser beam hit the target resulting in the evaporation of the target material, which itself mounted on the holder at 45°. All the samples were annealed in a furnace at a temperature of (500) K for 2 hours. To determine the structural and optical properties of Cadmium Oxide with copper thin films, X-ray diffraction measurement, AFM, and UV were employed.

Figure. 1 LASER INDUCE PLASMA SYSTWM.

Results and discussion

Figures (2) and (3) show the X-ray diffraction pattern (XRD) of the CdO and Cu films synthesized by laser-induced plasma. X-ray was used to confirm the material and its crystal structure for both cadmium since cadmium oxide has a cubic crystal structure.

The abundance of specific atomic configurations within the crystal lattice is correlated with the peak intensities in the X-ray diffraction pattern. The greater the peak's intensity, the more common that specific arrangement is in the sample.

The copper (Cu) X-ray diffraction pattern is displayed in Figure 3. The face-centered cubic (FCC) crystal structure, which is the usual crystal structure for bulk copper, is consistent with this pattern.

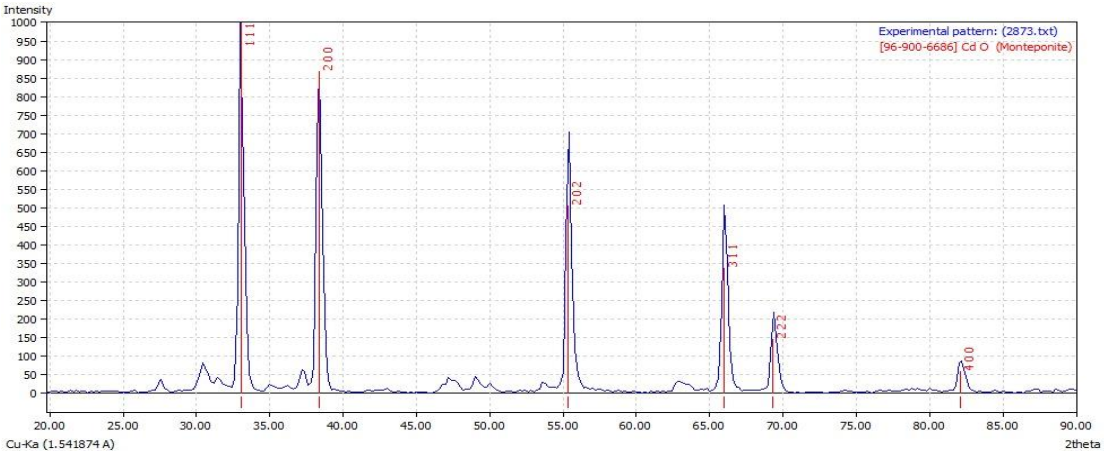


Figure. 2: XRD patterns for pure CdO

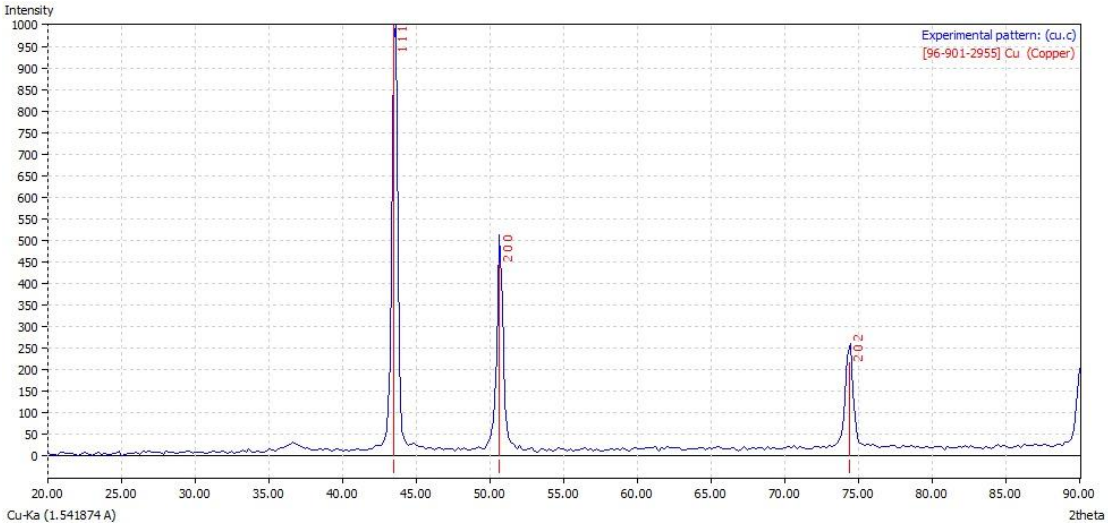


Figure. 3: XRD patterns for pure Cu

The CdO and CdO: Cu were prepared as AFM images (2D and 3D) thin films displayed on glass substrates in Figure. 1a and b. In Figure. 1a, the average roughness is 46.1 nm, and the root mean square is 69.3 nm, while in Figure. 1b, the average roughness is 25.9 nm, and the root mean square is 32.9 nm.

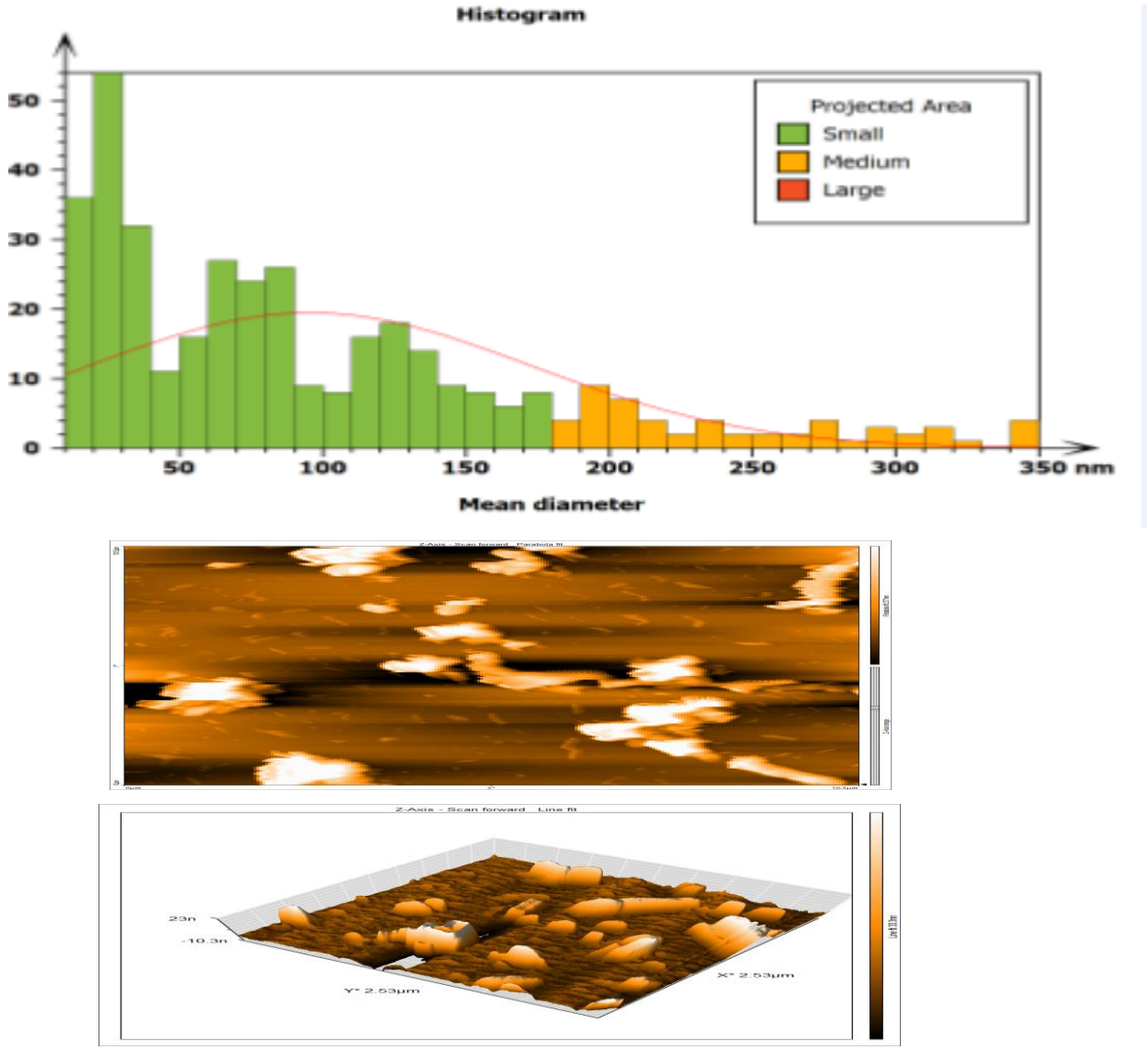


Figure 4: AFM of CdO thin film

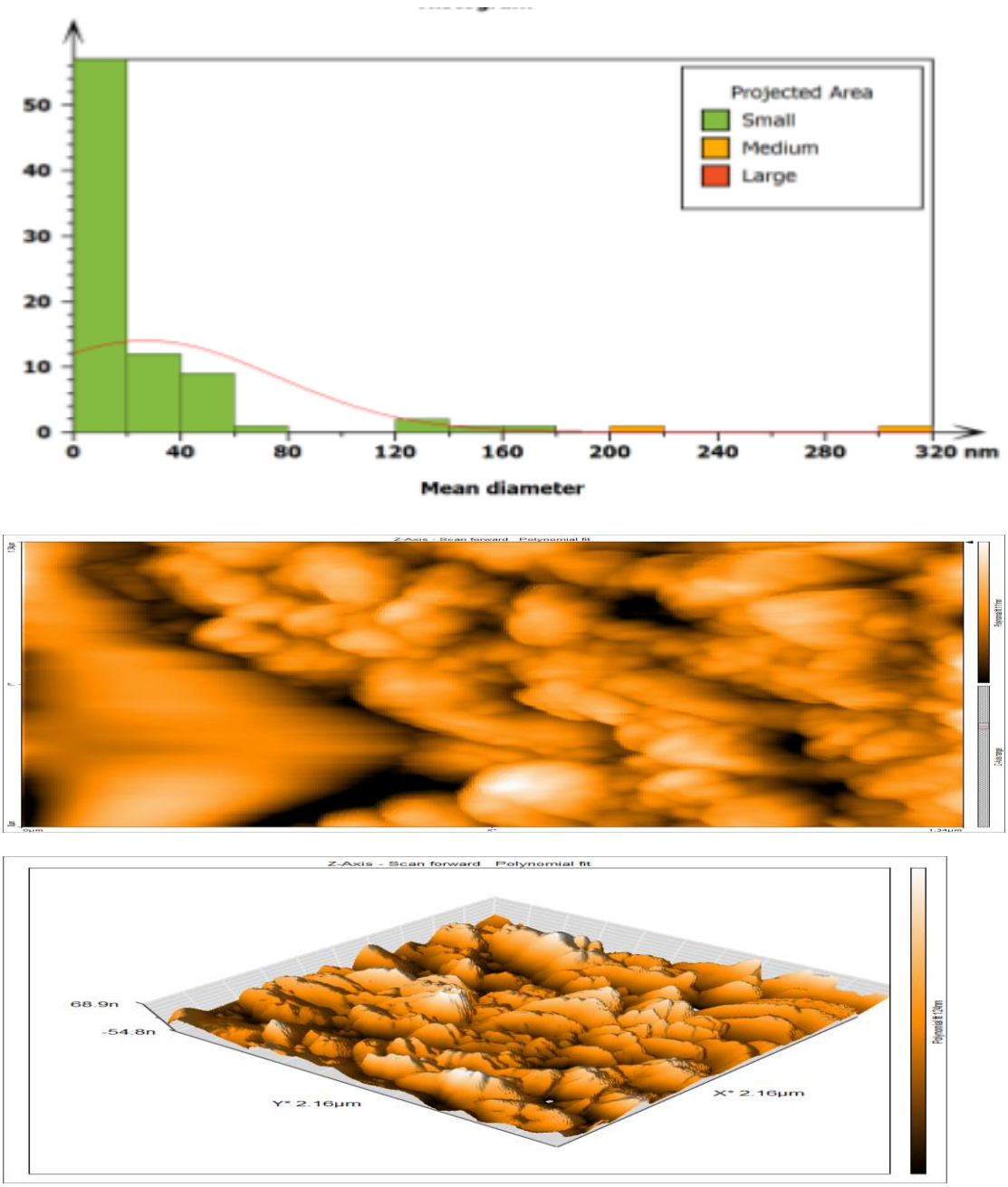
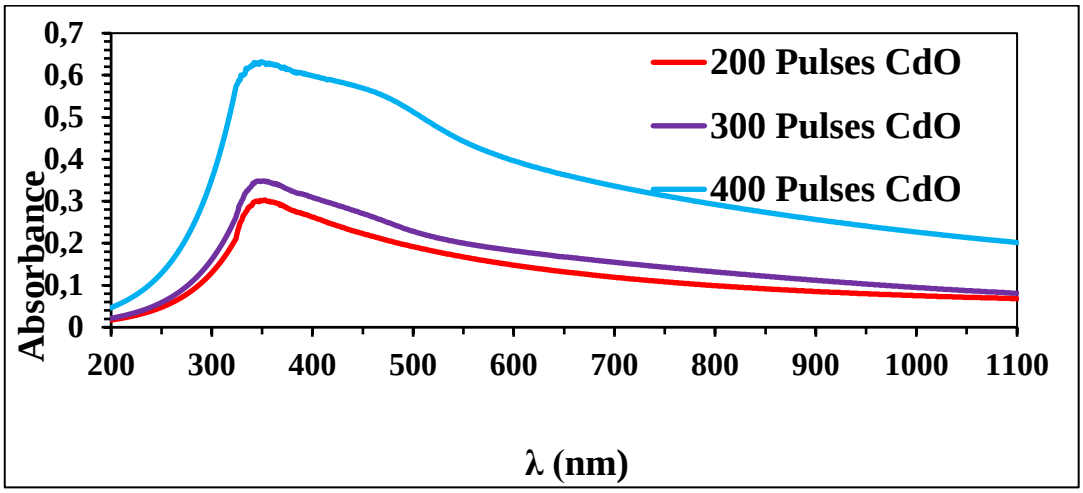


Figure 5. AFM of CdO: Cu thin film

The optical characteristics of CdO and CdO: Cu thin films that have been produced using the pulse laser deposition (PLD) method and annealed at 500 K. The transmittance spectra have been studied. The optical energy gap (Eg) and the optical constants which include the refractive index (n), imaginary (εi), and real (εr) extinction coefficient (k) dielectric constant have been determined with different preparation conditions. The absorption spectrum of CdO and: Cu thin films are shown in Figure 5. The figure and Table 1 depict a high absorption in the ultra violate area, a transparent CdO layer in the visible region, and a shifting and increasing absorption coefficient for CdO: Cu film in the visible range.

Table (1): UV parameter thin Cadmium and Cadmium with Copper.

CdO thin film	A	α (cm^{-1})	K	n	ε_r	ε_i	Eg (eV)
200	0.30	34660	0.097	2.611	6.808	0.504	2.50
300	0.35	40072	0.112	2.642	6.970	0.590	2.40
400	0.63	72625	0.202	2.164	4.641	0.876	2.10
CdO:Cu thin film	**A**	**α (cm^{-1})**	**K**	**n**	**ε_r**	**ε_i**	**Eg (eV)**
200	0.34	39612	0.110	2.641	6.964	0.583	2.40
300	0.59	68399	0.191	2.274	5.134	0.867	2.30
400	0.71	81181	0.226	1.910	3.598	0.864	2.20



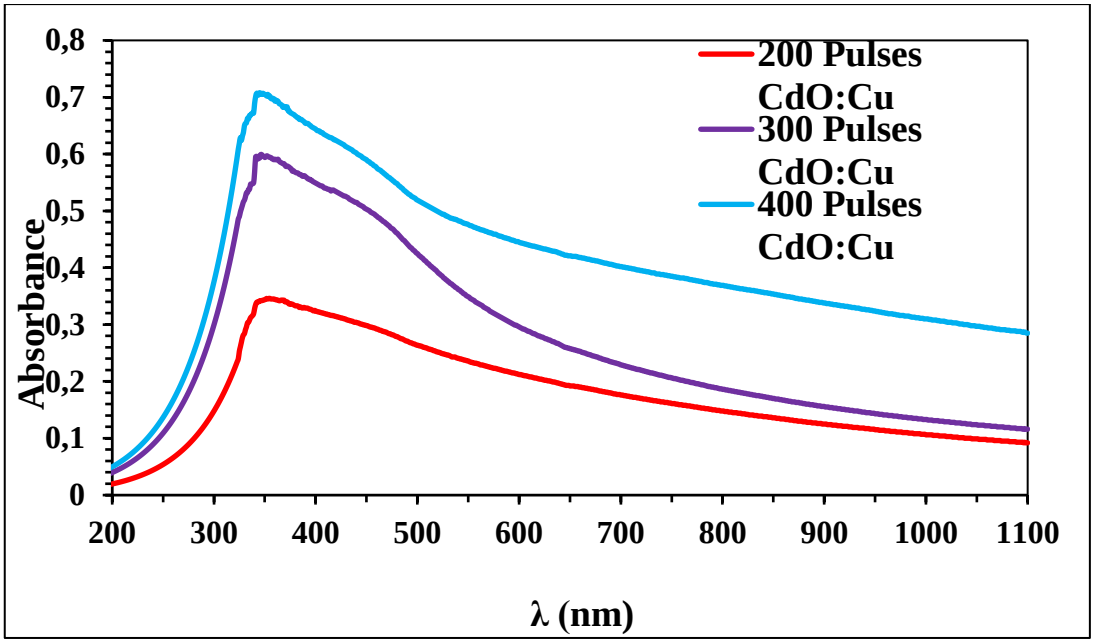
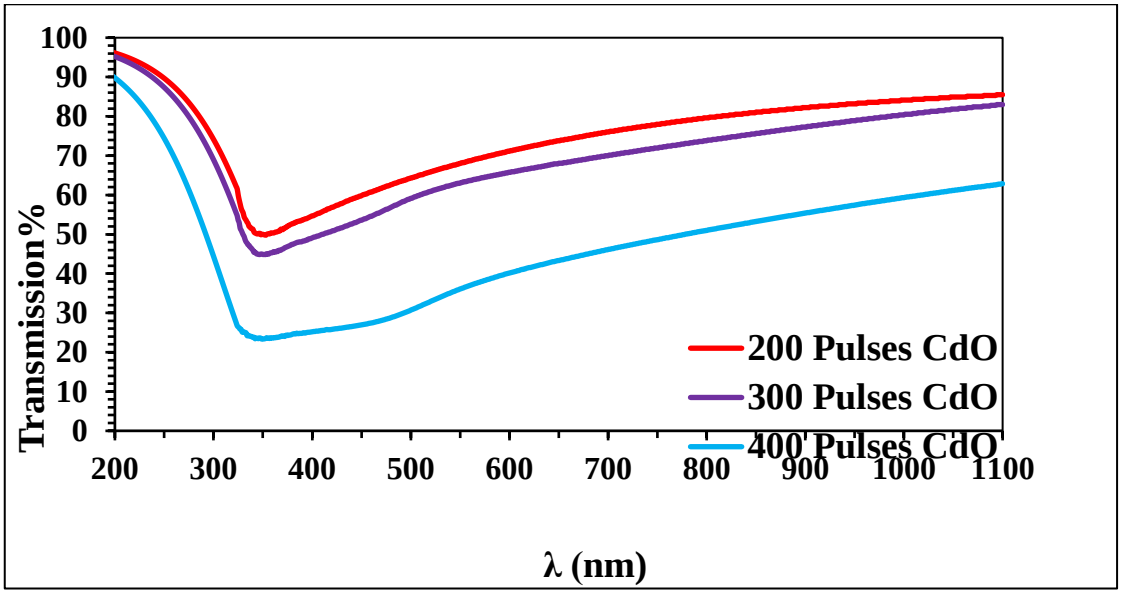


Fig. 5: Absorbance for Cadmium and Cadmium with Copper at different pules (200,300,400).

Figure 6 The Transmittance of Cadmium and Cadmium with Copper with wavelengths ranging from 200 to 1100 nm. This shape demonstrates: the films exhibit high visible-band transmission and poor UV-band transmission. The optical transmittance decreases with increased energy as shown in Table 1.



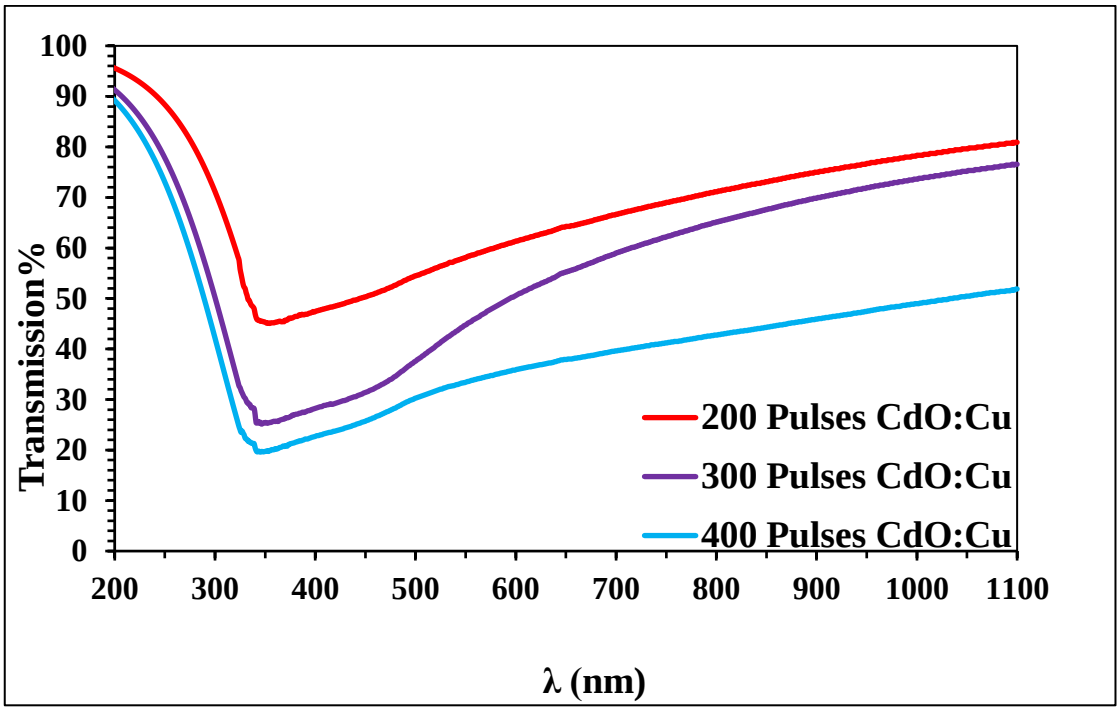
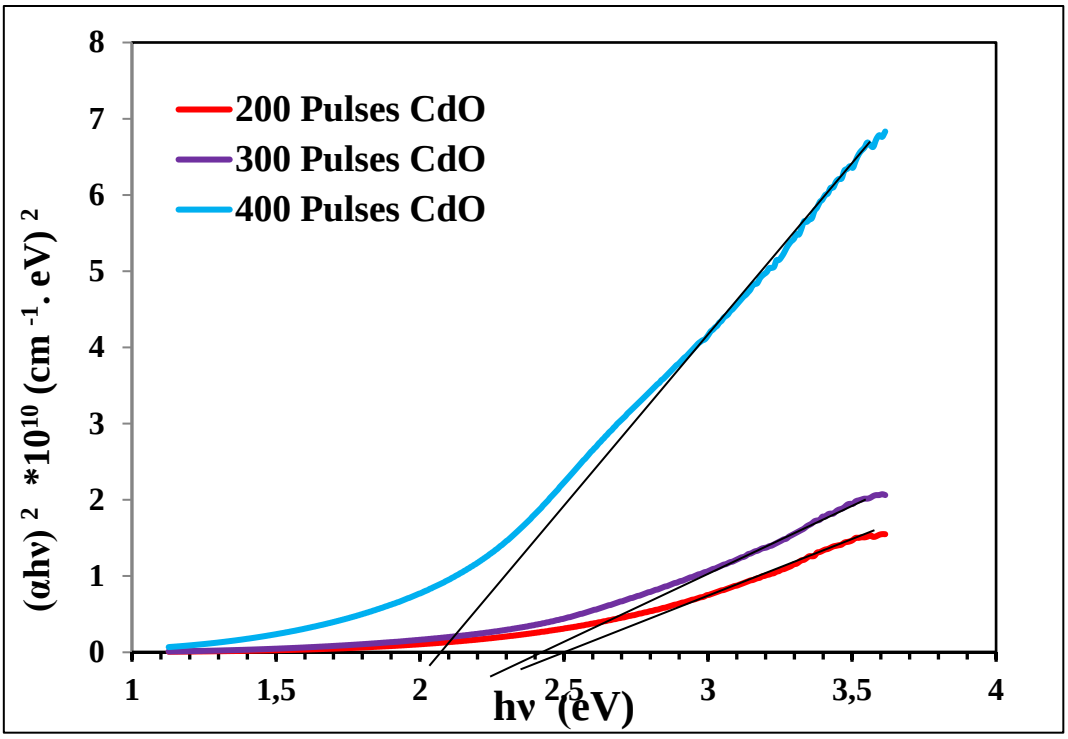


Figure 6: Transmittance for Cadium and Cadium with Copper at different pules (200,300,400).

The energy gap values of the CdO: Cu film were discovered to be around 2.4 eV, 2.3 eV, and 2.2 eV respectively with different shote(200,300,400). These values were obtained by extrapolating the linear component of the Figure 7 display $(\alpha h\upsilon)^2=0$. This graph shows how the energy gap value for the CdO: Cu film is decreasing as shown in tabl1. These ideals are fairly consistent with those expressed by other employees[13].



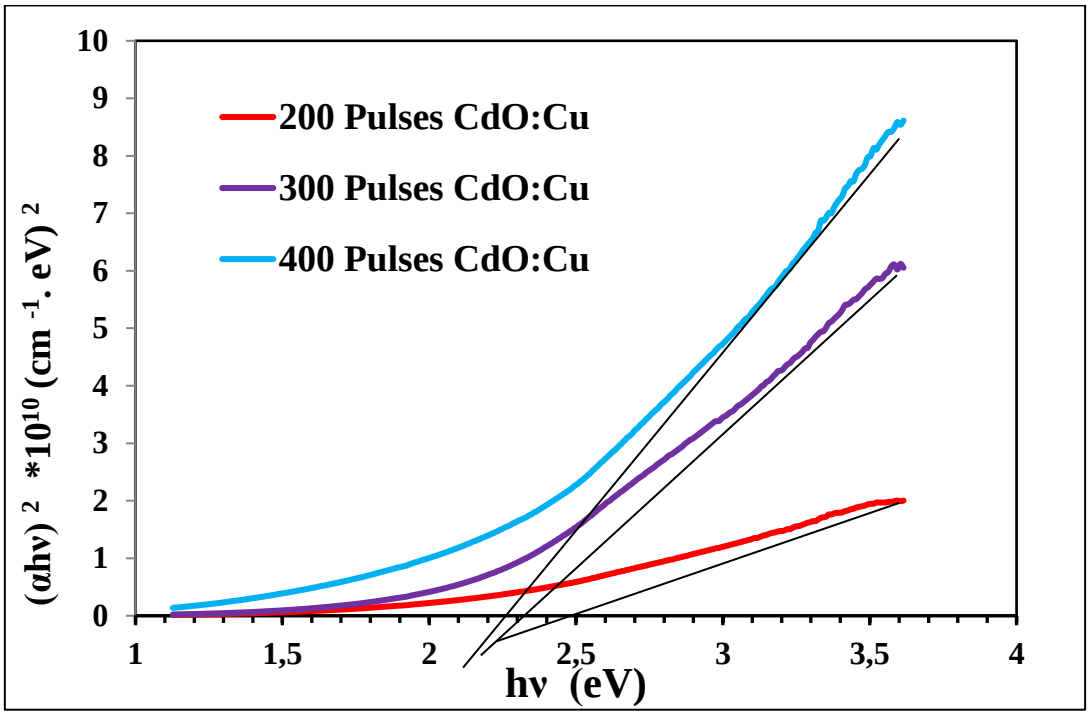
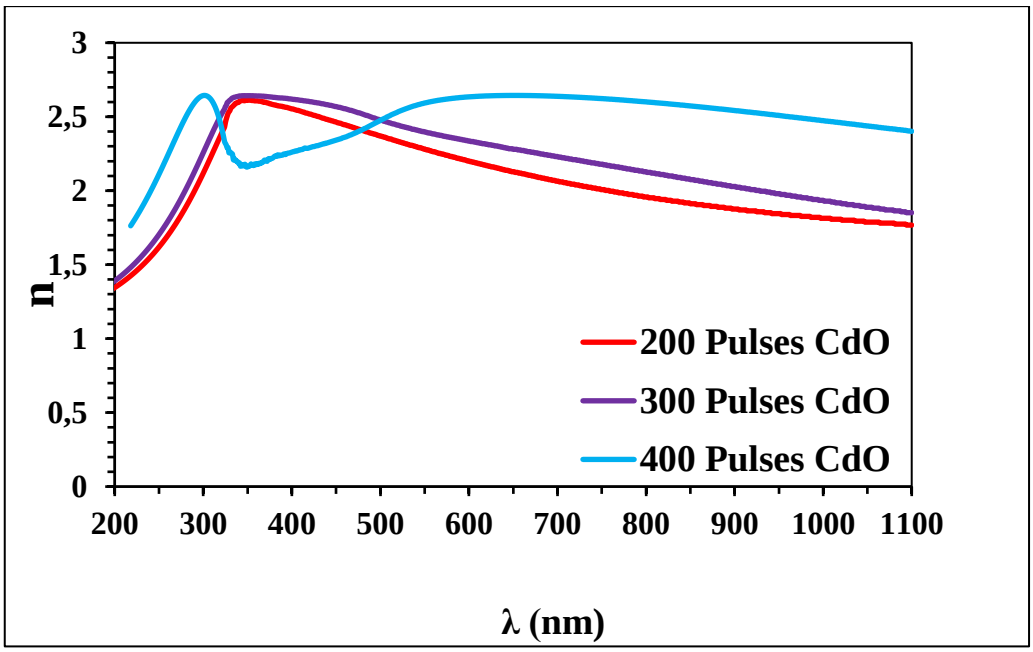


Figure.7: The Energy gab of Cadium and Cadium with Copper at different pules (200,300,400).

An essential characteristic of optical materials and applications is the refractive index (n). Hence, it is crucial to ascertain the films' optical constants. The following relation[14] was used to calculate the film refractive index.

$$n = \left(\frac{1+R}{1-R}\right) + \sqrt{\frac{4R}{(1-R)^2} - k^2} \text{----------} 1$$

where the extinction coefficient, k, equal αλ/4π. Results show that for CdO: Cu thin films, the refractive index increases as the wavelength increases as shown in Table 1 because it depends on wavelength, but for CdO thin films, the refractive index decreases at wavelengths between 580 and 750 nm. Figure 8 illustrates the variation of the refractive index as a function of wavelength for CdO: Cu thin films.



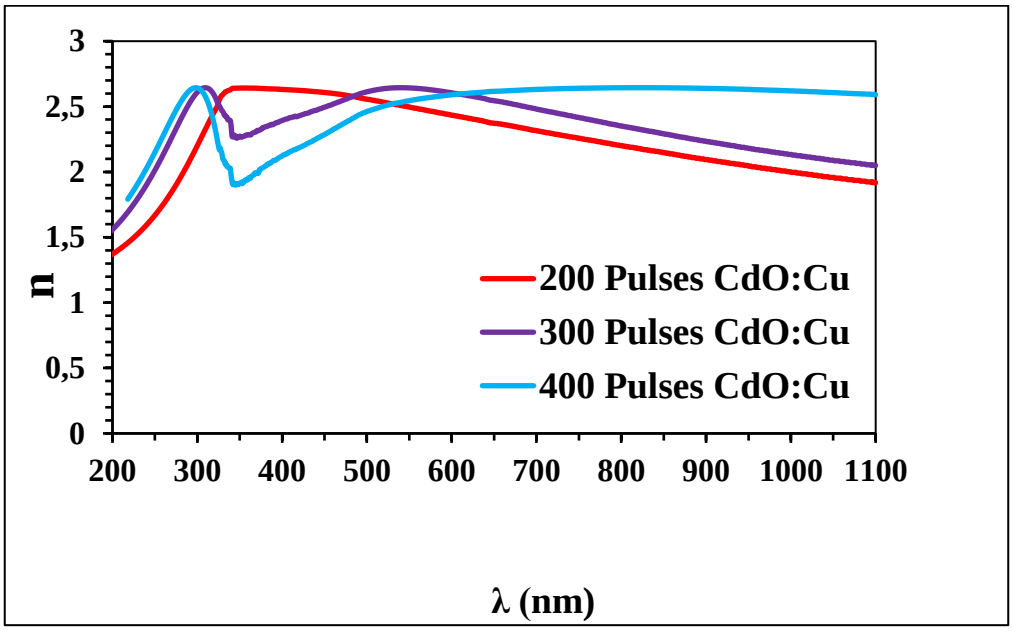


Figure.8: The Refractive index of Cadium and Cadium with Copper at different pules (200,300,400).

The relationship between the wavelength and extinction coefficient (k) of CdO: Cu films and deposited CdO is shown in Figure 9. The figure demonstrates that the k values of the CdO: Cu film are larger than those of the CdO film where win high values in the ultraviolet area, although it is decreasing for Cadium and Cadium with Copper thin films in the visible region, as shown in Table 1.

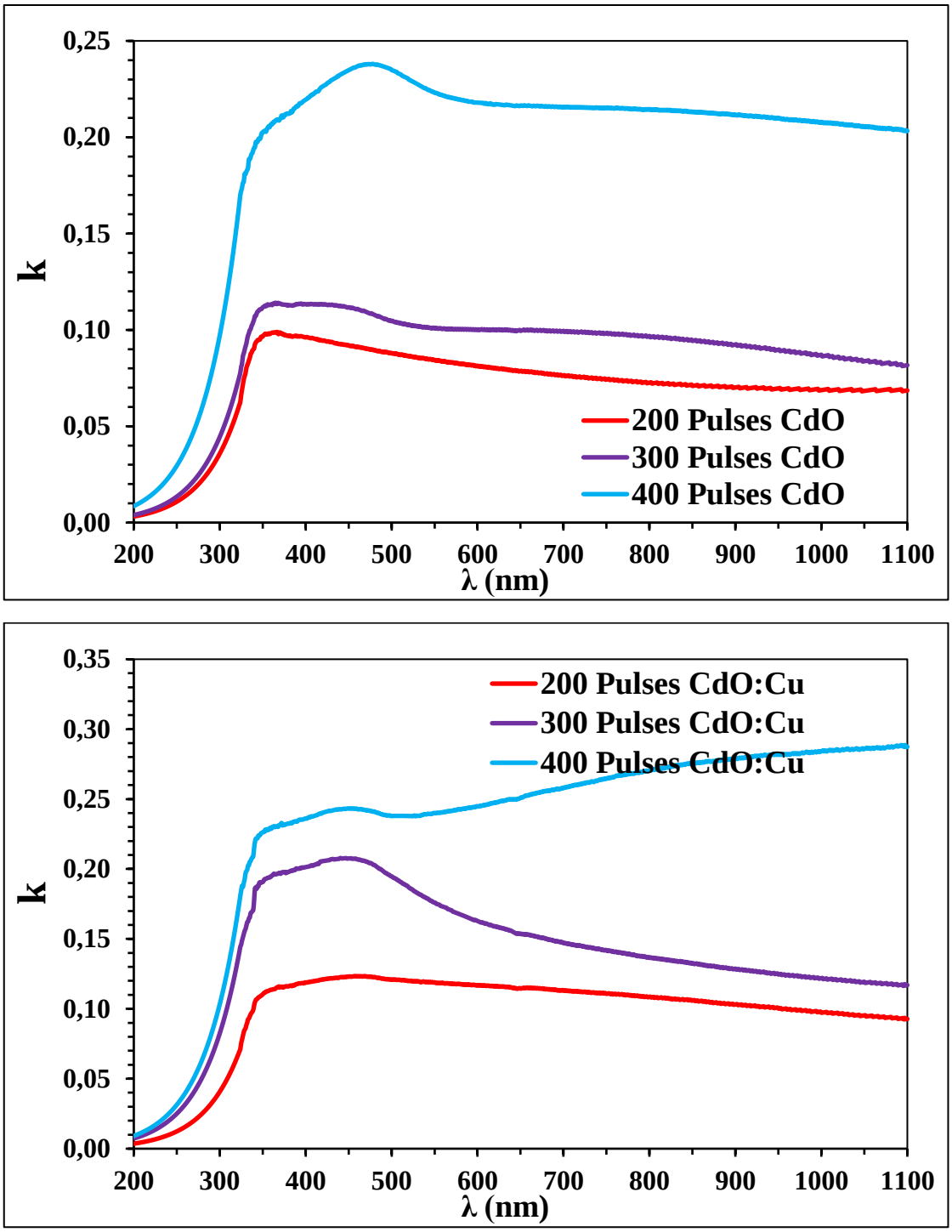
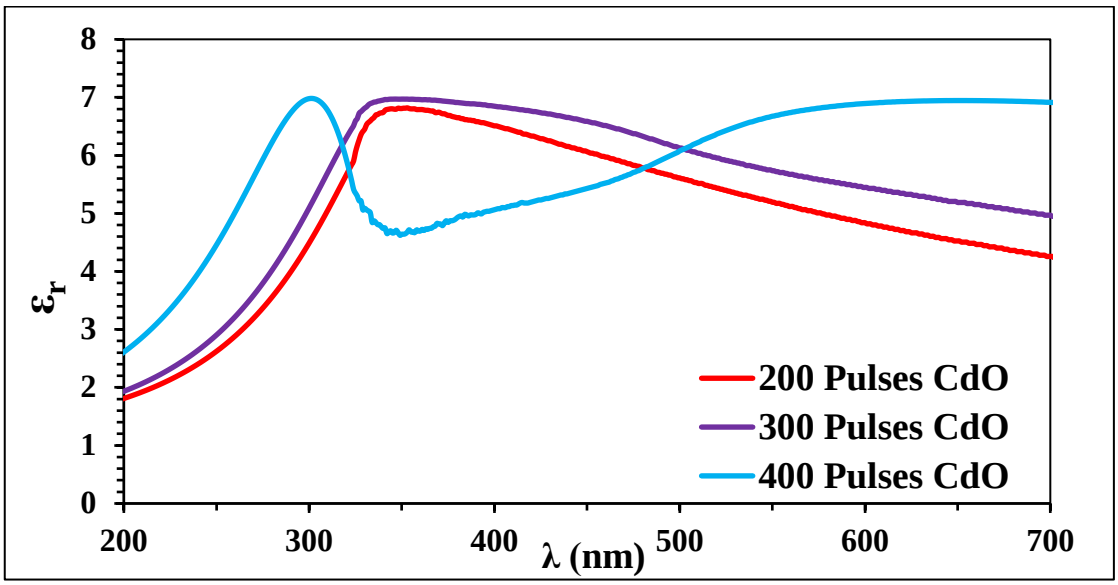


Figure.9: The Extinction coefficient (k) of Cadium and Cadium with Copper at different pules (200,300,400).

The real and imaginary components of the dielectric constant are related to the n and k values, and the dielectric constant K is illustrated as"ε(ω)= εr(ω) + iεi(ω)". The formulas [15] were used to determine the values of εr andεi:

$$\varepsilon_r = n^2 - k^2 \quad , \varepsilon i = 2nk$$

Figure. 10, and 11 display the different values of the real and imaginary components of the dielectric.



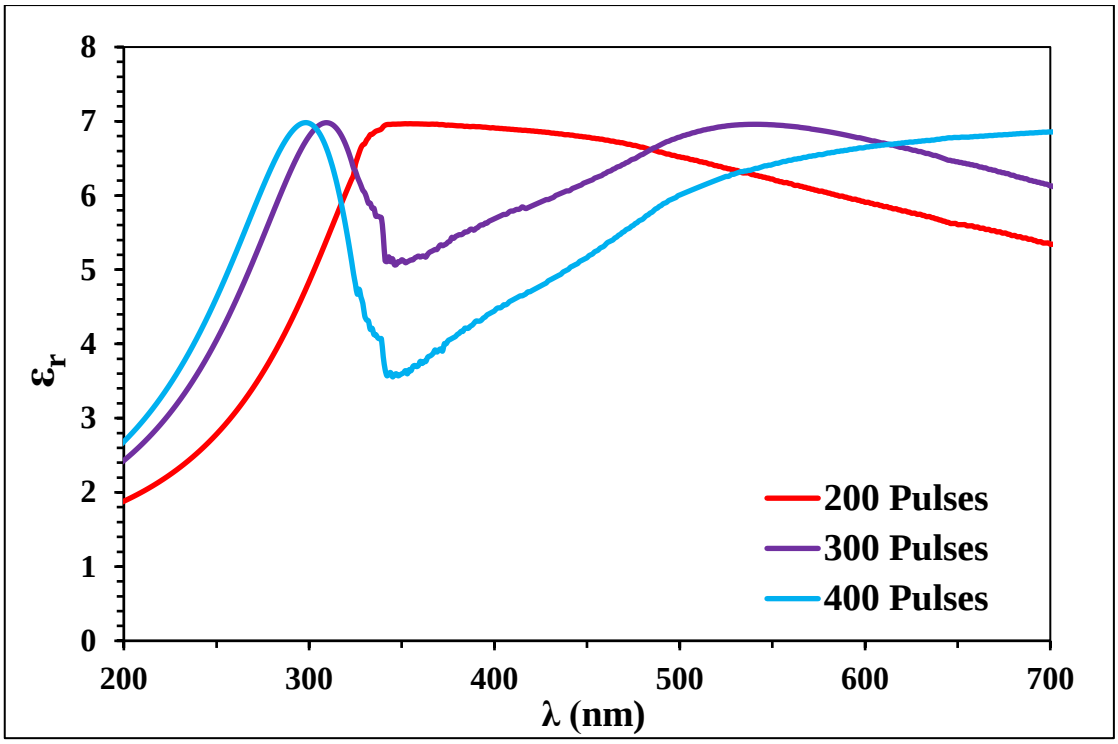
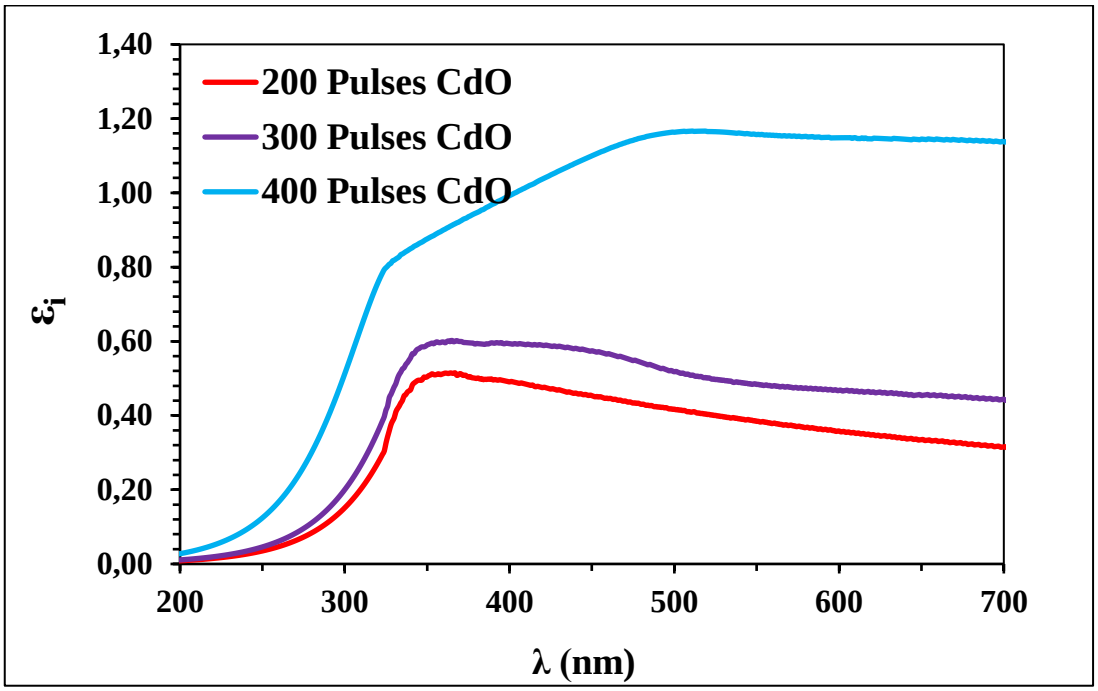


Figure 10: The Dielectric constant parts Real part of Cadium and Cadium with Copper at different pules (200,300,400).



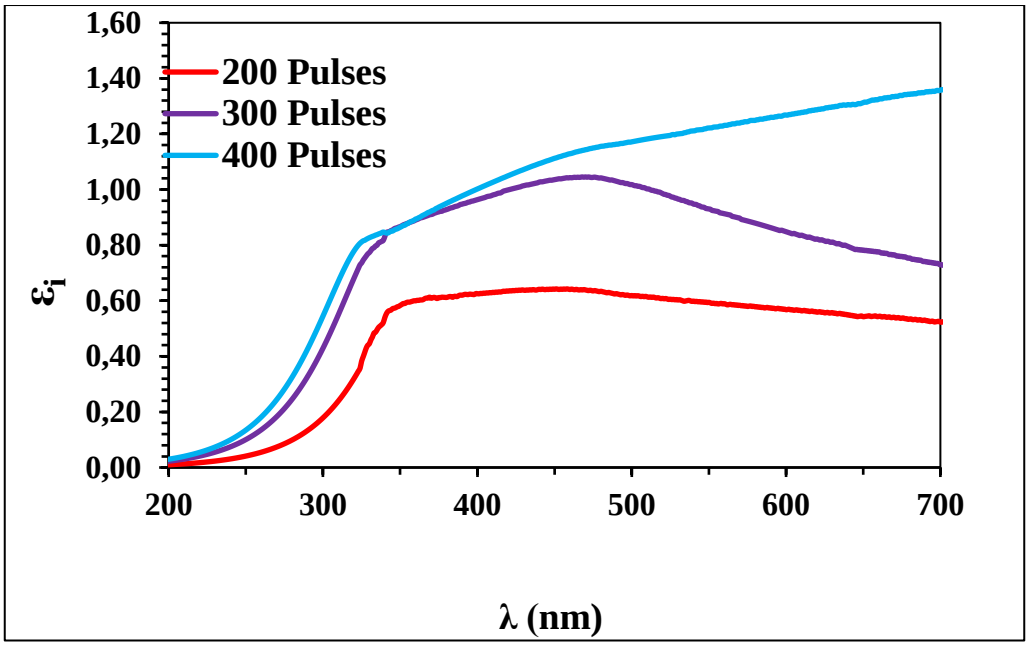


Figure 11: The Dielectric constant parts Real Imaginaryof Cadium and Cadium with Copper at different pules (200,300,400).

Conclusion

On glass substrates, pulse laser deposition was used to create thin films of CdO and CdO: Cu. The films have a 500nm thickness. The results of the structure study demonstrate the polycrystalline nature of the films. The optical transition in the CdO and CdO: Cu films was shown to be a straight transition based on visible transmittance and absorbance spectra. CdO and CdO: Cu has an energy band gap. shot 200, 2.5eV, and 2.4eV, 2.4 to 2.3 with shot 300, and 2.2 to 2.1 with shot 400.

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