Pulsed Laser Deposition (PLD) of Material

Departmental Seminar

Presented by

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Contents

- Objective
- Experimental set-up
- Analysis
- Results and Discussion
- Conclusion
- Applications and Future work

Objective

To deposit and analyze the thin films of Al-doped CdO on Silicon (111) substrate at different growth temperatures using Pulsed Laser Deposition Technique (PLD).

Experimental Set-up

Experimental Set-up

i. Target Fabrication

ii. Substrate

iii. Laser

iv. Vacuum Chamber

v. Vacuum Pump

vi. Schematic Diagram

vii. Experimental Conditions

Experimental Set-up

i. Target Fabrication (Al-doped CdO)

Stoichiometric Weights Measurement

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Grinding and Mixing

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Calcination

↓

Pellet Formation

↓

Sintering

Experimental Set-up

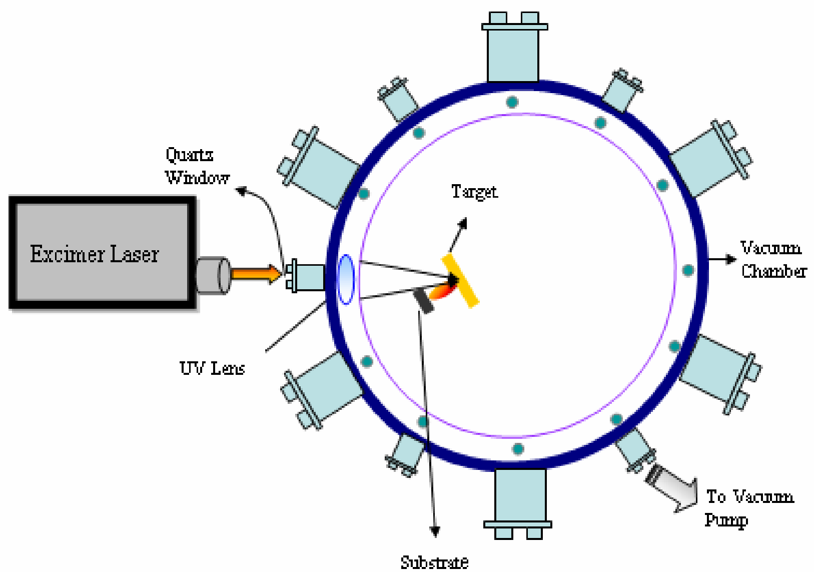
ii. Substrate

Silicon (111)

iii. Laser

Excimer Laser (KrF 248 nm, Ex50 GAM Laser Inc. USA)

Experimental Set-up



Schematic Diagram of Experimental Set-up

Experimental Set-up

Excimer Laser	KrF 248 nm, 20 Hz
Energy	45 mJ
Focal length of UV lens	20 cm
Target	Al-doped CdO
Substrate	Silicon (111)
Target substrate distance	50 mm
Deposition Temperature	25 °C, 100 °C, 200 °C, 300 °C, 400 °C
Base pressure	10^{-6} torr
Number of shoots	6000

Analysis

- Structural (XRD)
- Optical (SE)
- Vibrating sample magnetometer (VSM)
- Surface morphology (SEM)

Results and Discussion

1. Structural Characterization

Structural Characterization

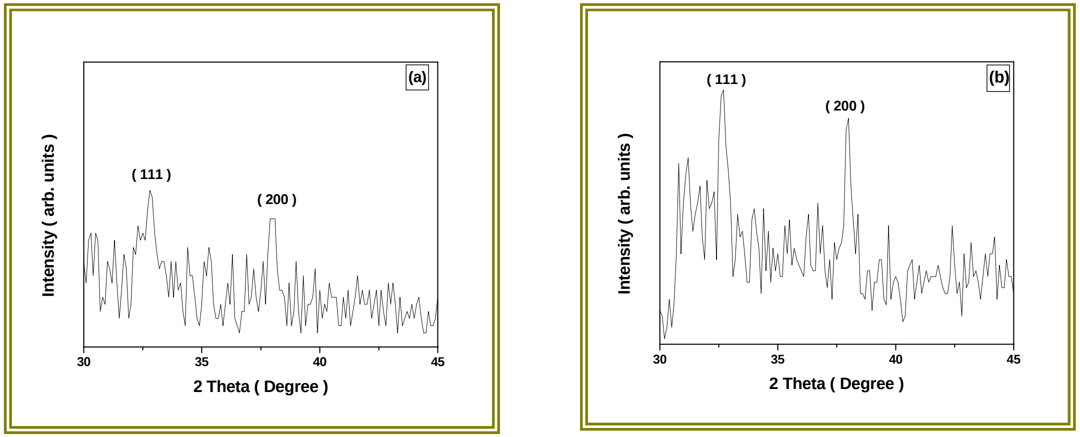


Figure 1: XRD Patterns of Al-doped CdO thin films grown at (a) 25 ° C (b) 100 ° C

Structural Characterization

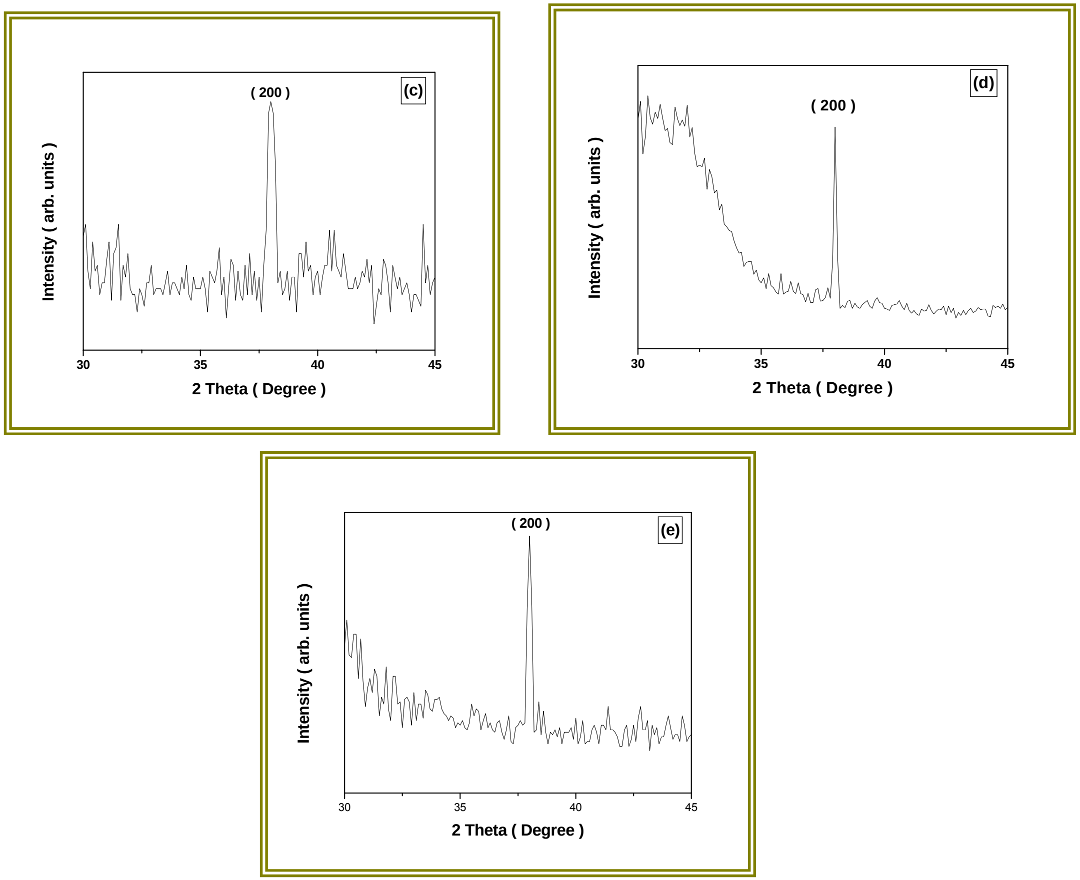


Figure 2: XRD Patterns of Al-doped CdO thin films grown at (c) 200 ° C (d) 300 ° C (e) 400 ° C

Structural Characterization

Table 1: XRD data of Al-doped CdO thin films grown at (1) 25 °C (2) 100 °C (3) 200 °C (4) 300 °C (5) 400 °C

Samples no.	2θ of (200) plane	d spacing (°A)	Δ2θ	FWHM in Degree β of (200) plane	Particle size D (nm)
1	38.02	2.36484	0.44	0.29	27.076
2	38.015	2.36512	0.63	0.22	35.691
3	38.024	2.36505	0.638	0.198	39.656
4	38.0245	2.36499	0.636	0.167	47.017
5	38.025	2.36503	0.832	0.146	53.780

Structural Characterization

Particle size Calculation

Scherrer's formula

$$D = \frac{k\lambda}{\beta \cos\theta} \qquad \textbf{(1)}$$

D = Particle size

k = Scherrer's constant ~ 0.94

λ = Wavelength of X-rays ~ 1.5406 °A for Cu Kα

β = FWHM

θ = Bragg's angle

Structural Characterization

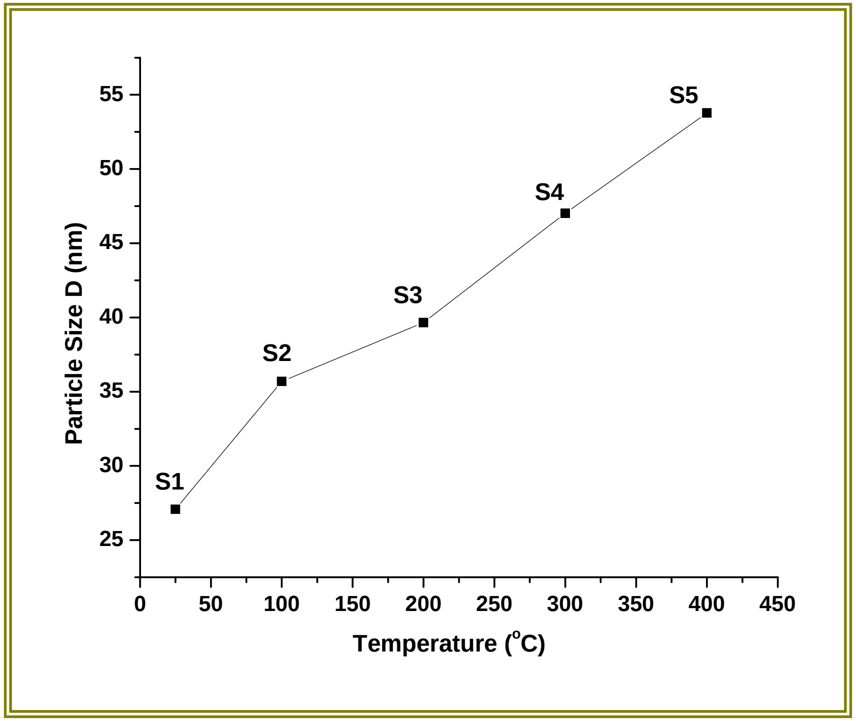
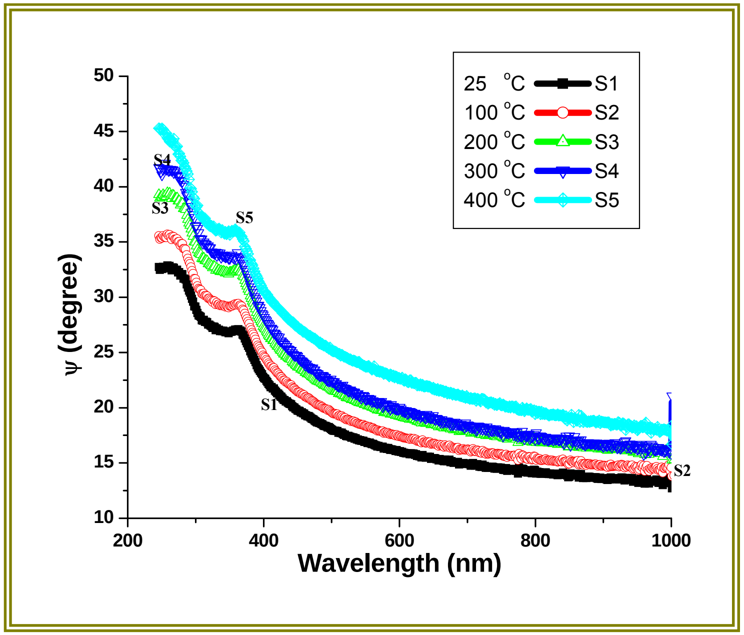


Figure 3: Graph between particle size D (nm) and deposition temperature T (°C)

2. Optical Characterization

Optical Characterization



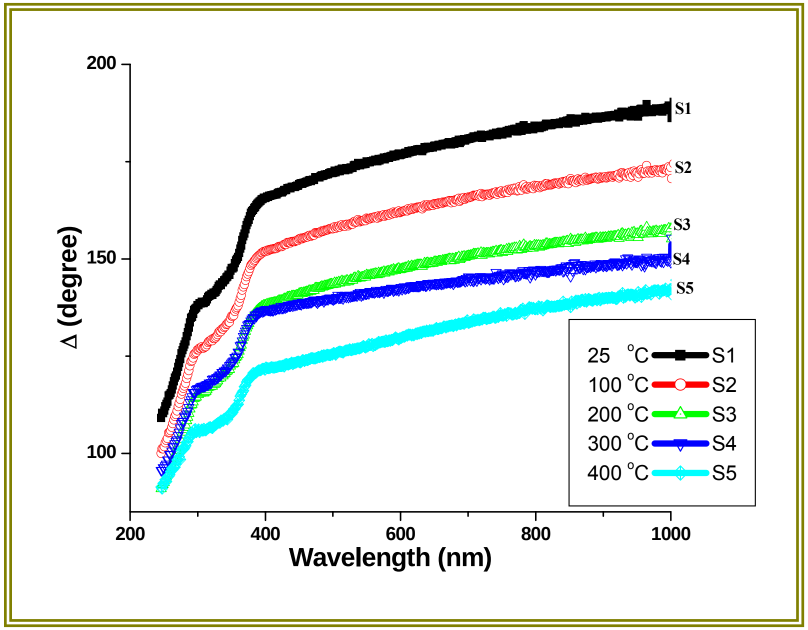
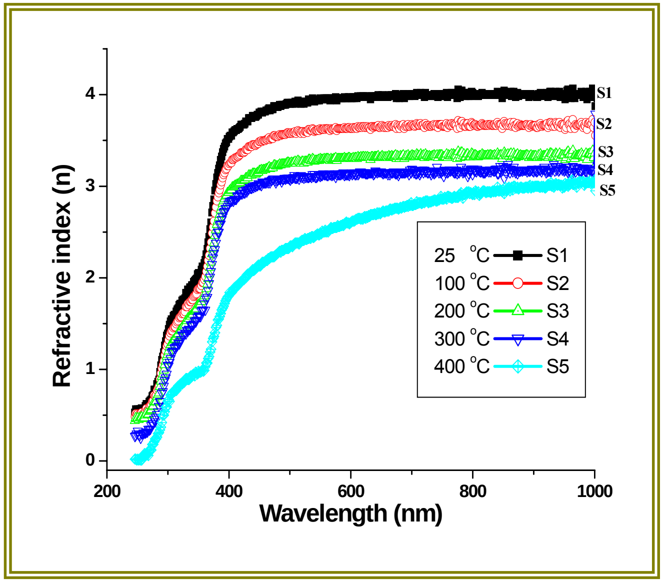


Figure 4: SE parameter ψ, Δ of Al-doped CdO thin film deposited at different temperature.

Optical Characterization



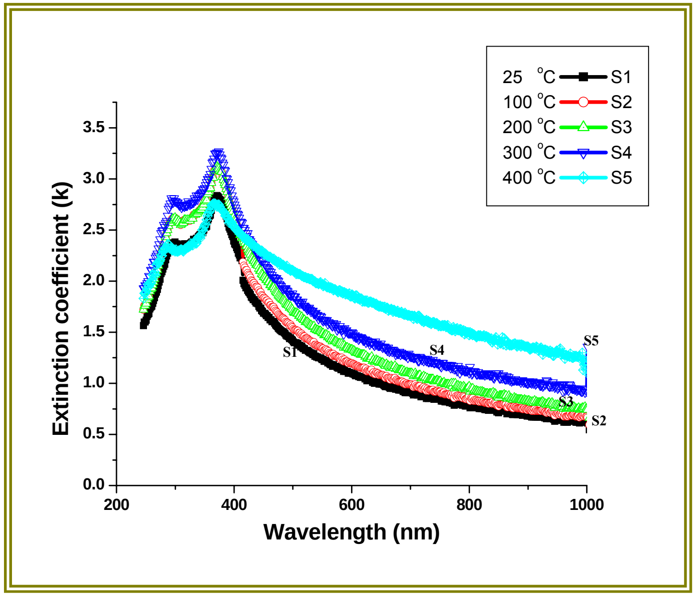


Figure 5: Refractive index and Extinction coefficient of Al-doped CdO thin film deposited at different temperature.

Optical Characterization

$$\alpha = 4\pi k / \lambda \quad \text{——— (2)}$$

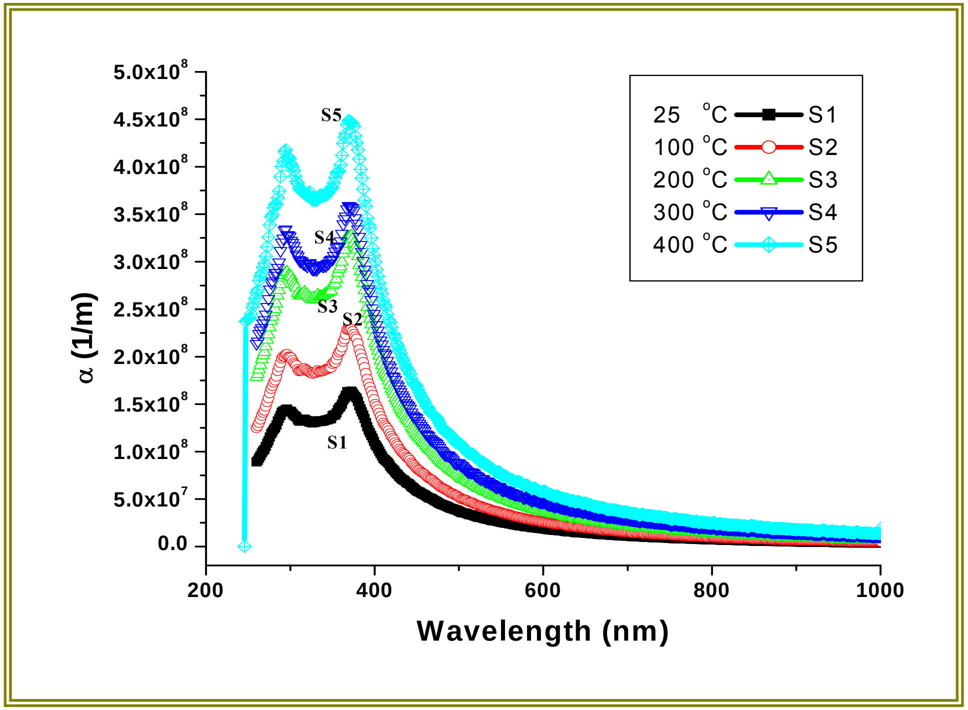
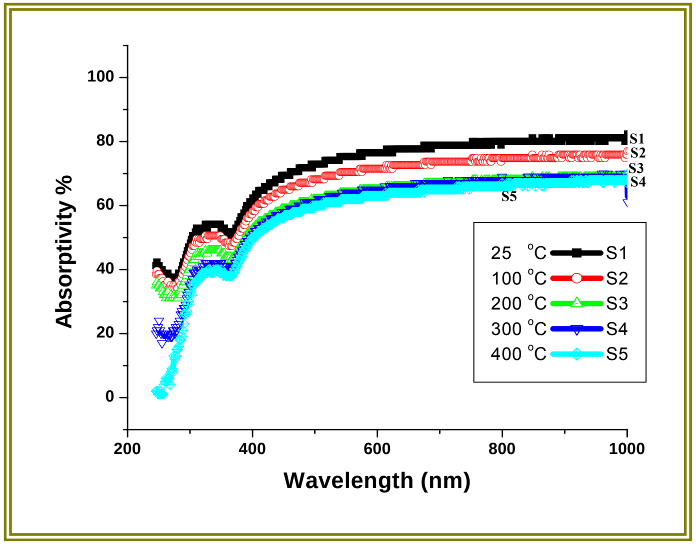


Figure 6: Absorption coefficient of Al-doped CdO thin film deposited at different temperature.

Optical Characterization

$$A = \frac{4n}{(n+1)^2 + k^2} \qquad \text{——— } \mathbf{(3)}$$

$$R = \frac{(n-1)^2 + k^2}{(n+1)^2 + k^2} \qquad \text{——— } \mathbf{(4)}$$



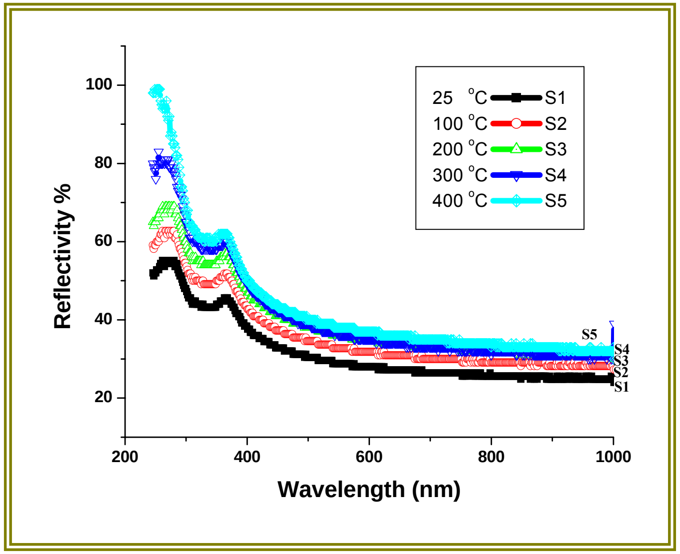
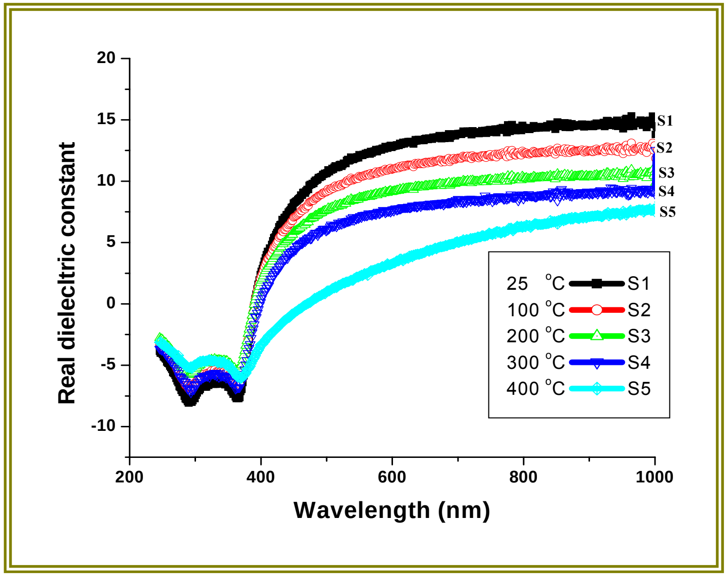


Figure 7: Plot of (a) Absorptivity and (b) Reflectivity as a function of wavelength for Al-doped CdO thin film deposited at different temperature.

Optical Characterization

$$\varepsilon_1 = n^2 - k^2 \quad \text{———} \quad \textbf{(5)}$$

$$\varepsilon_2 = 2nk \quad \text{———} \quad \textbf{(6)}$$



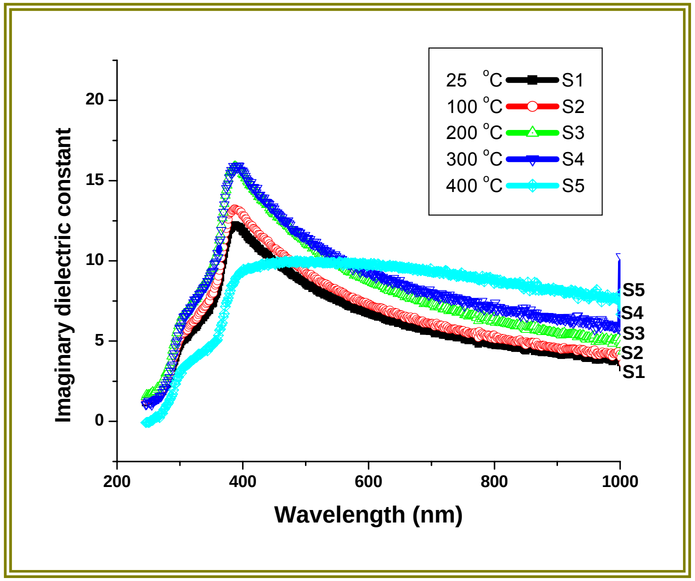


Figure 8: Plot of (a) real and (b) imaginary parts of dielectric constants as a function of wavelength for Al-doped CdO thin film deposited at different temperature.

Optical Characterization

$$(\alpha hf)^2 = A\,(hf - Eg) \qquad (7)$$

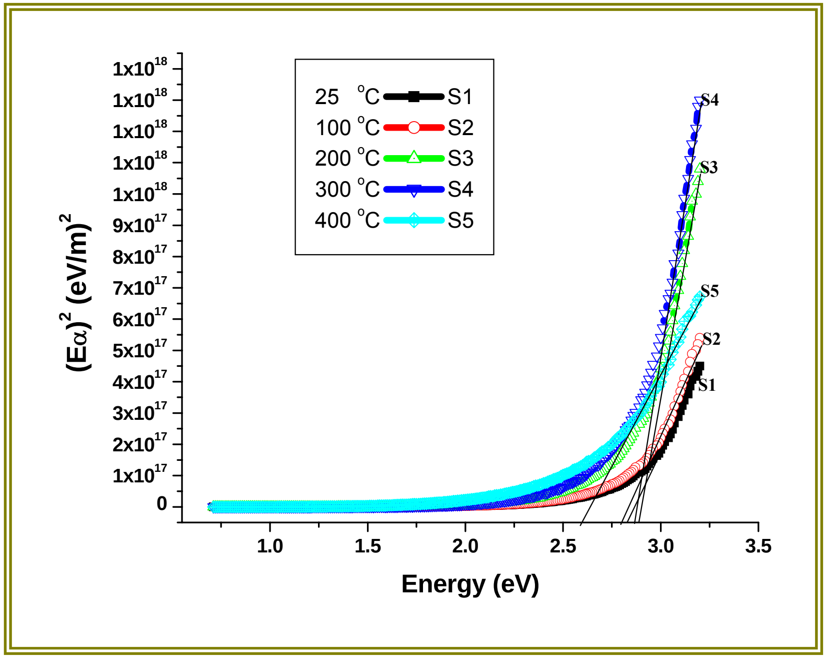


Figure 9: Plot of $(\alpha h\upsilon)^2$ versus $h\upsilon$ of Al-doped CdO thin film deposited at different temperature.

Optical Characterization

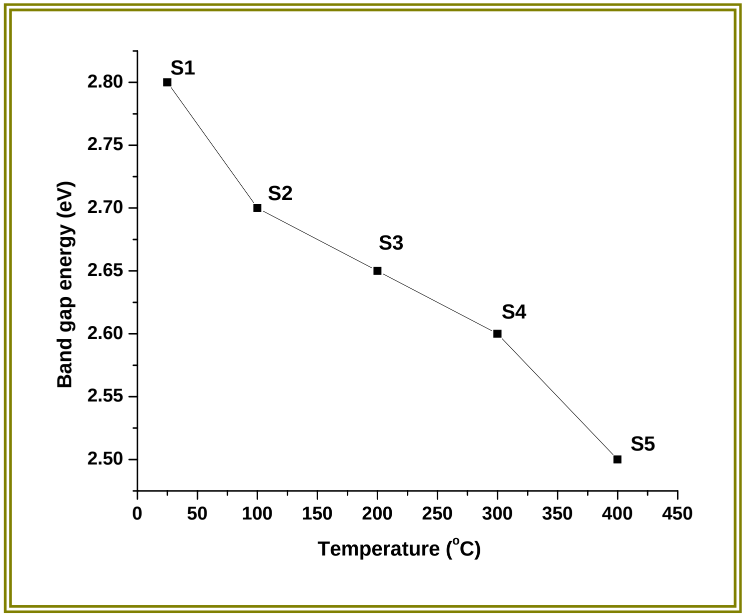


Figure 10: Graph between band gap energy versus temperature

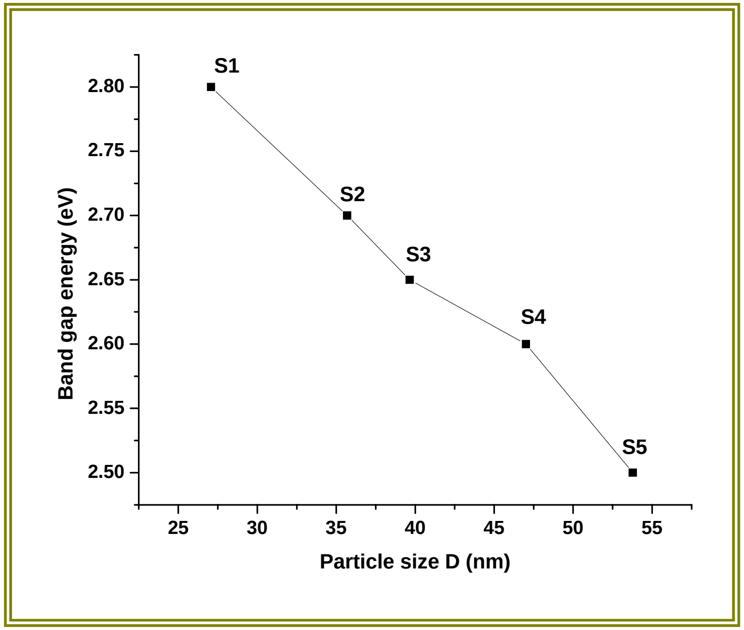


Figure 11: Graph between band gap energy versus particle size

3. Magnetometry

Magnetometry

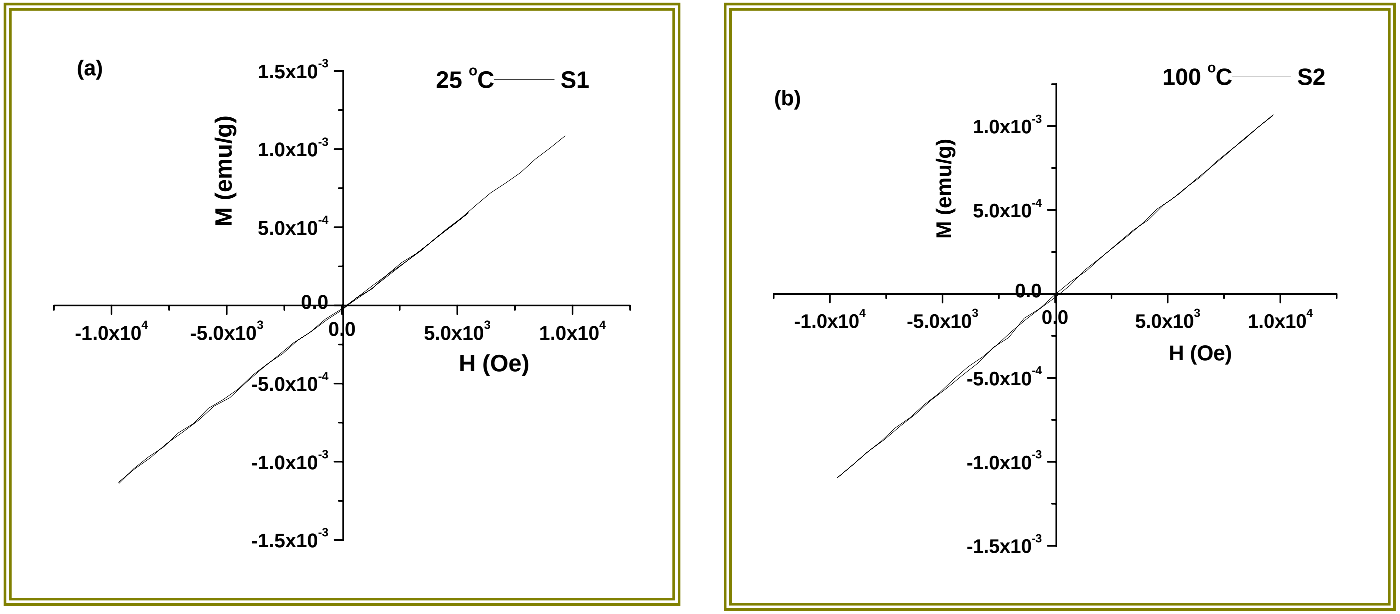
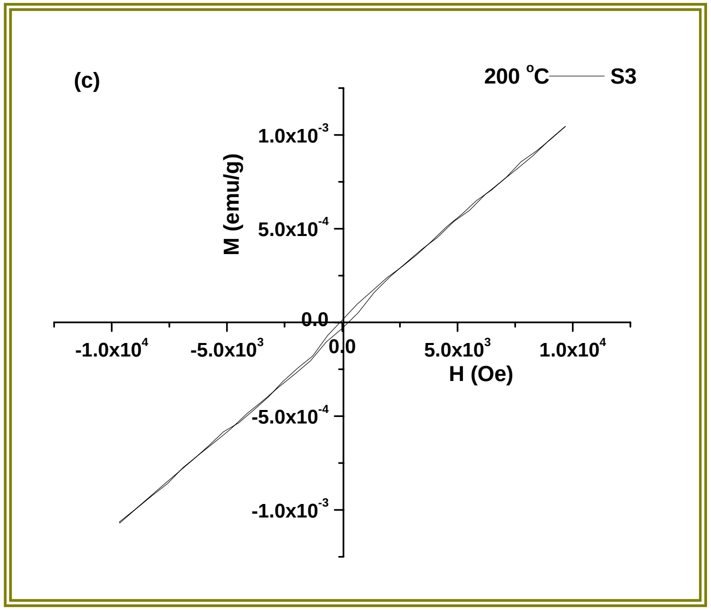


Figure 12: Magnetization loop of Al-doped CdO thin films at (a) 25 °C (b) 100 °C

Magnetometry



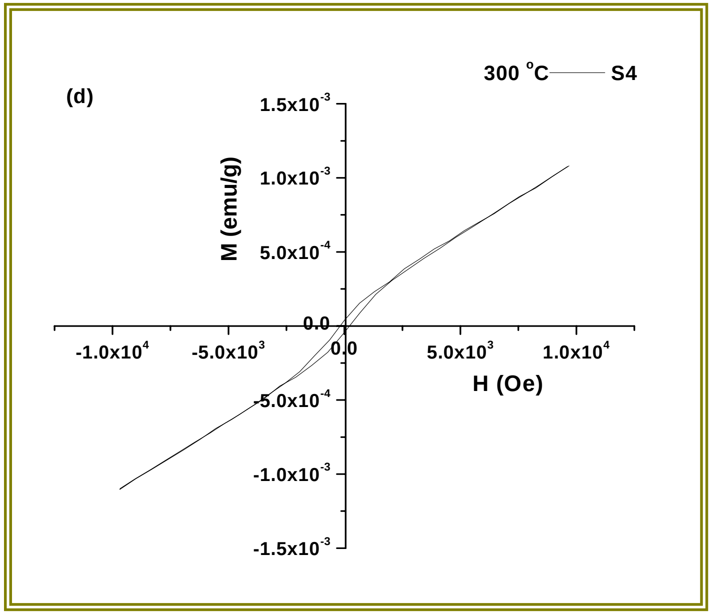


Figure 13: Magnetization loop of Al-doped CdO thin films at (c) 200 °C (d) 300 °C

Magnetometry

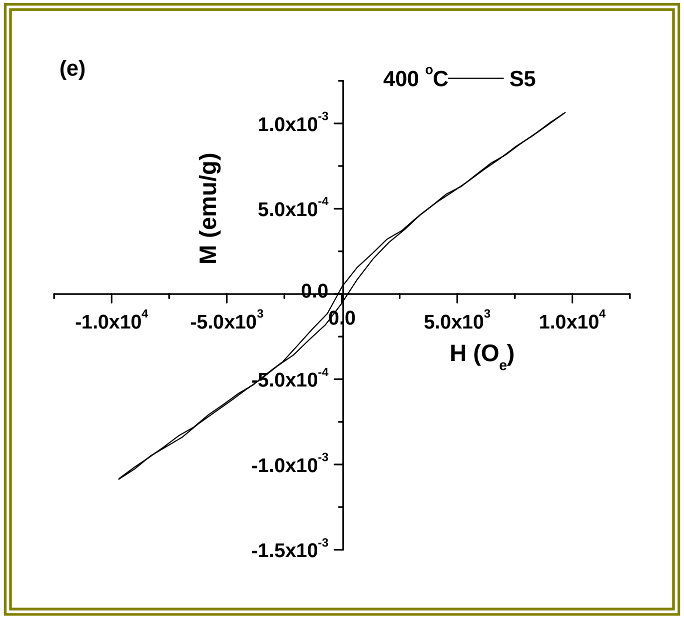


Figure 14: Magnetization loop of Al-doped CdO thin films at (e) 400 °C

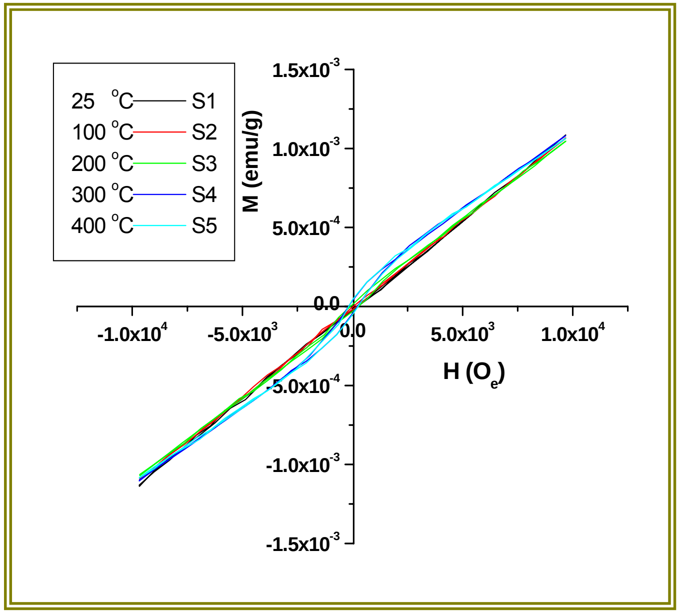


Figure 15: Combined Plot of M-H loops of Al-doped CdO thin film deposited at different temperature.

Magnetometry

Table 2: Saturation magnetization M_s, Remanence M_r, Coercivity H_c and Squareness ratio SQR of Al-doped CdO thin film deposited at different temperature.

Sample name	Deposition Temperature °C	Saturation magnetization M_s (emu/g) x 10^{-3}	Remanence M_r (emu/g)	Coercivity H_c (Oe) x 10^2	SQR = (M_r/ M_s) x 10^3
S1	25	1.07	1.966	2.40	1.837
S2	100	1.07	5.290	3.12	4.943
S3	200	1.07	6.345	3.54	5.929
S4	300	1.07	7.137	3.84	6.670
S5	400	1.07	8.534	4.54	7.975

Magnetometry

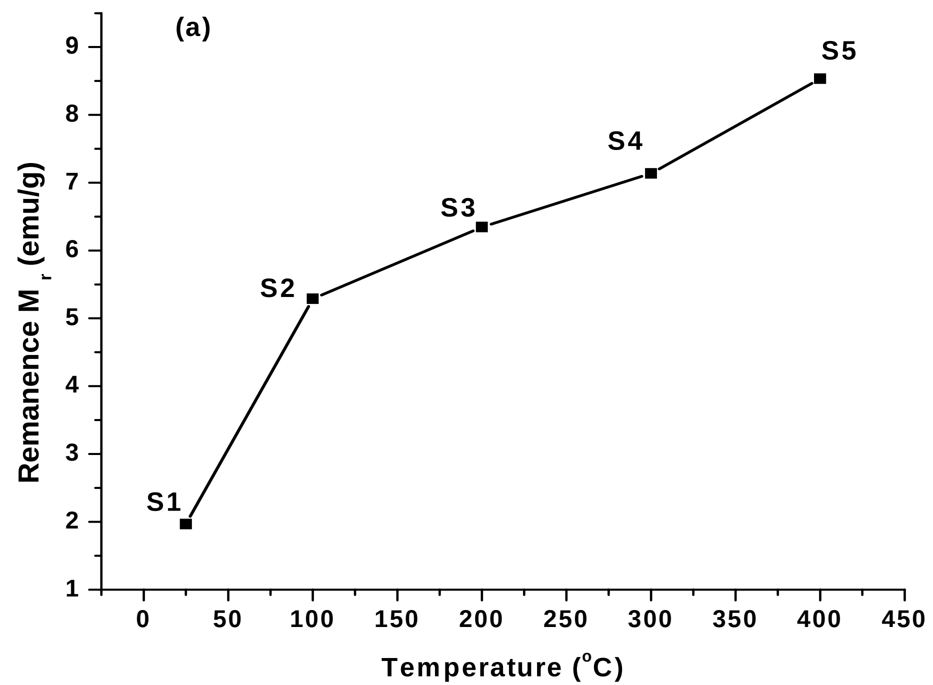


Figure 16: Plot of (a) Remanence M_r, of Al-doped CdO thin film deposited at different temperature.

Magnetometry

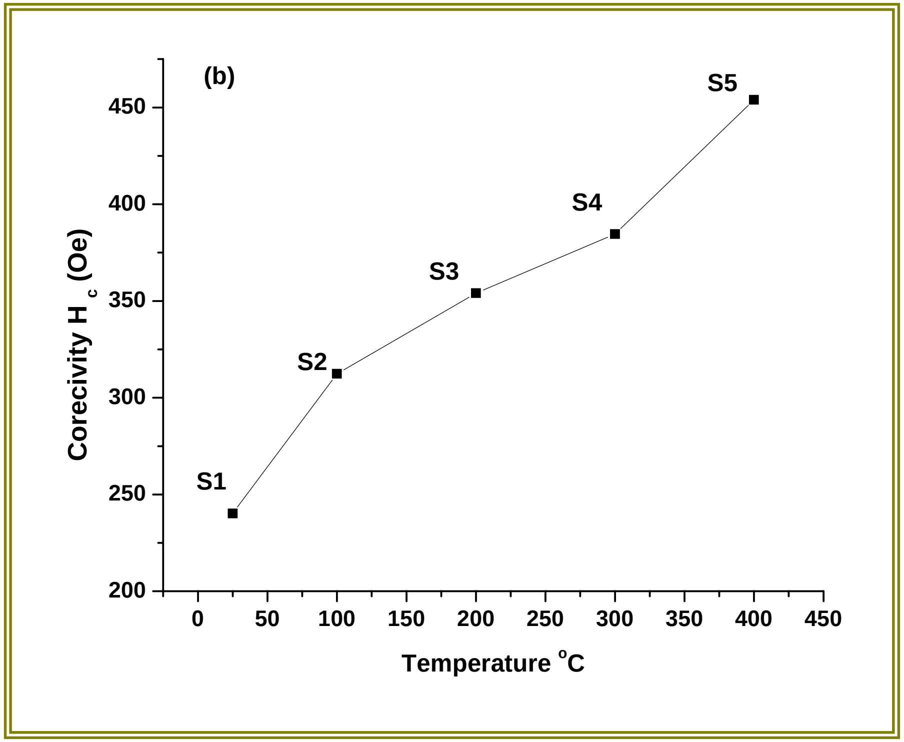


Figure 17: Plot of (b) Coercivity H_c of Al-doped CdO thin film deposited at different temperature.

Magnetometry

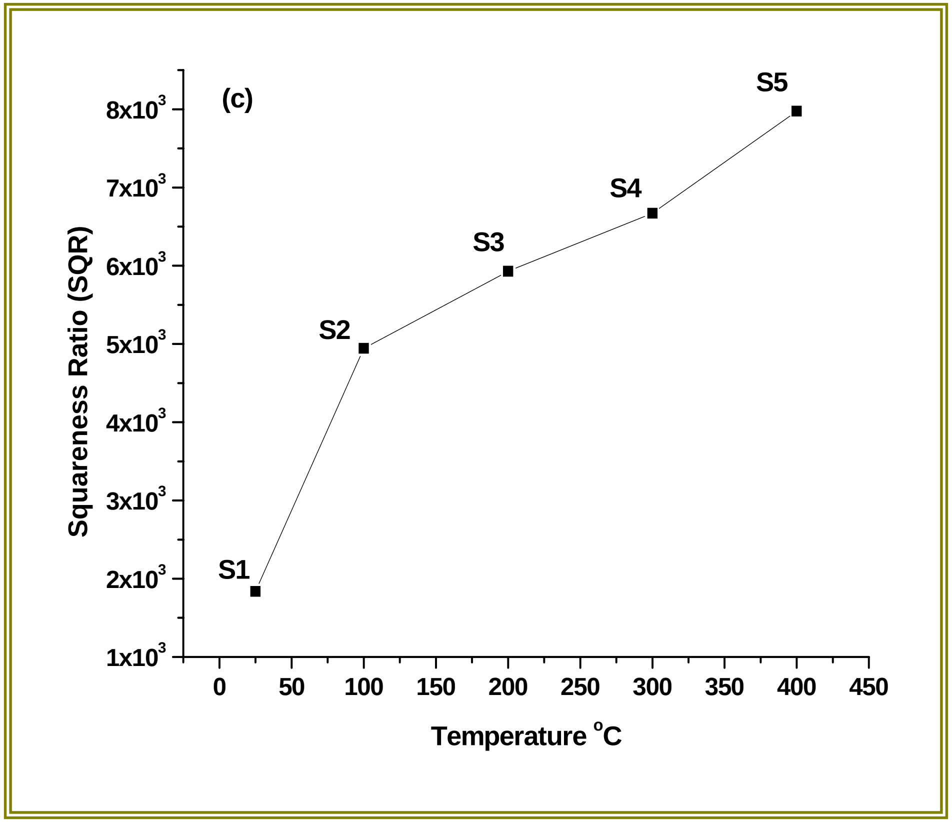


Figure 18: Plot of (c) Squareness ratio SQR of Al-doped CdO thin film deposited at different temperature.

4. Surface morphology (SEM)

Surface morphology (SEM)

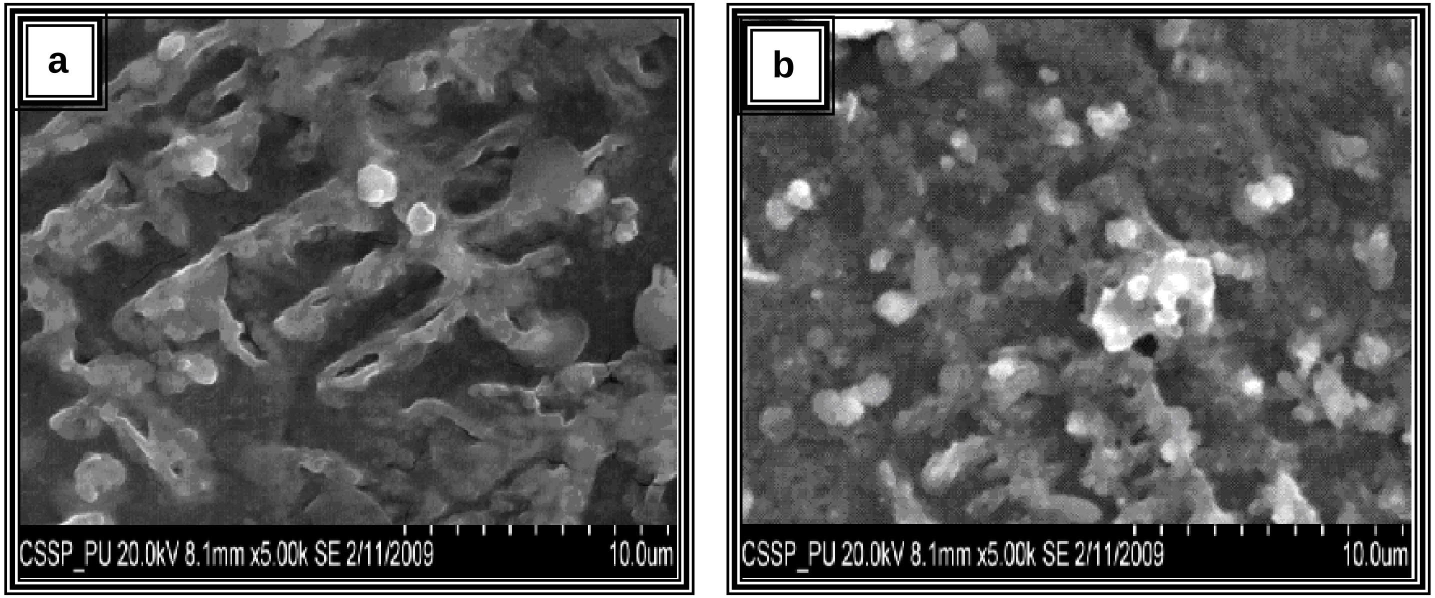


Figure 19: SEM images of Al-doped CdO thin films on Silicon substrate at (a) 25 °C (b) 100°C

Surface morphology (SEM)

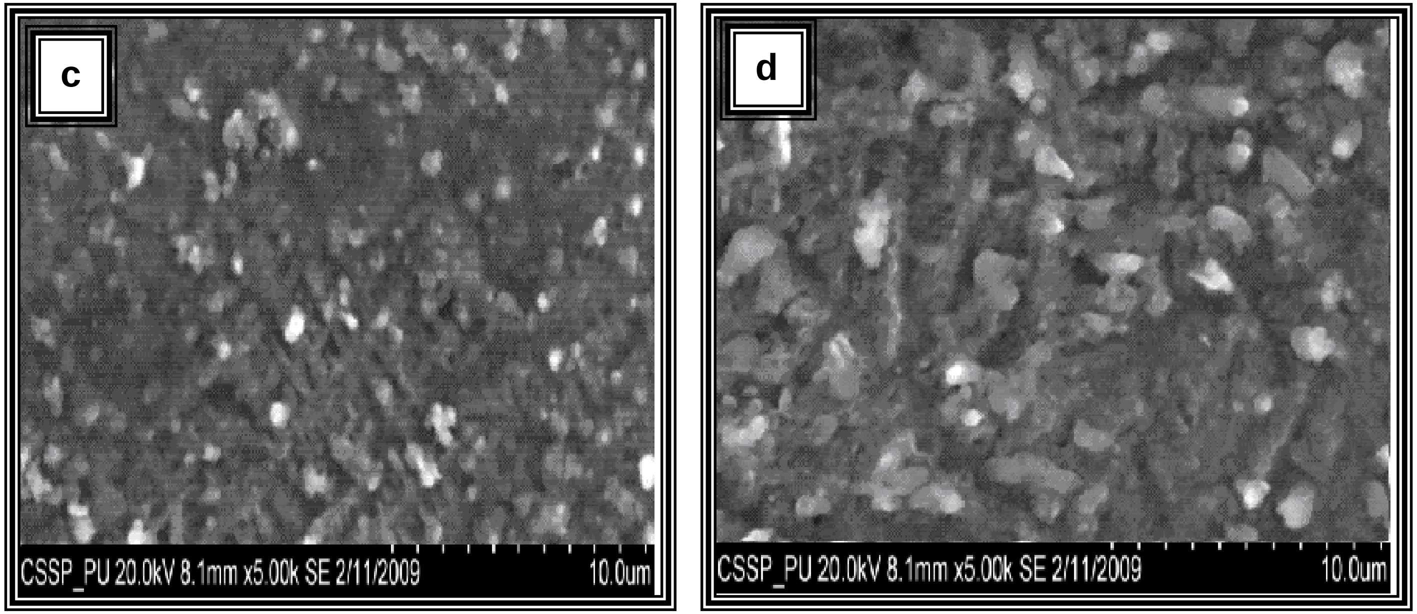


Figure 20: SEM images of Al-doped CdO thin films on Silicon substrate at (c) 200°C (d) 300°C

Surface morphology (SEM)

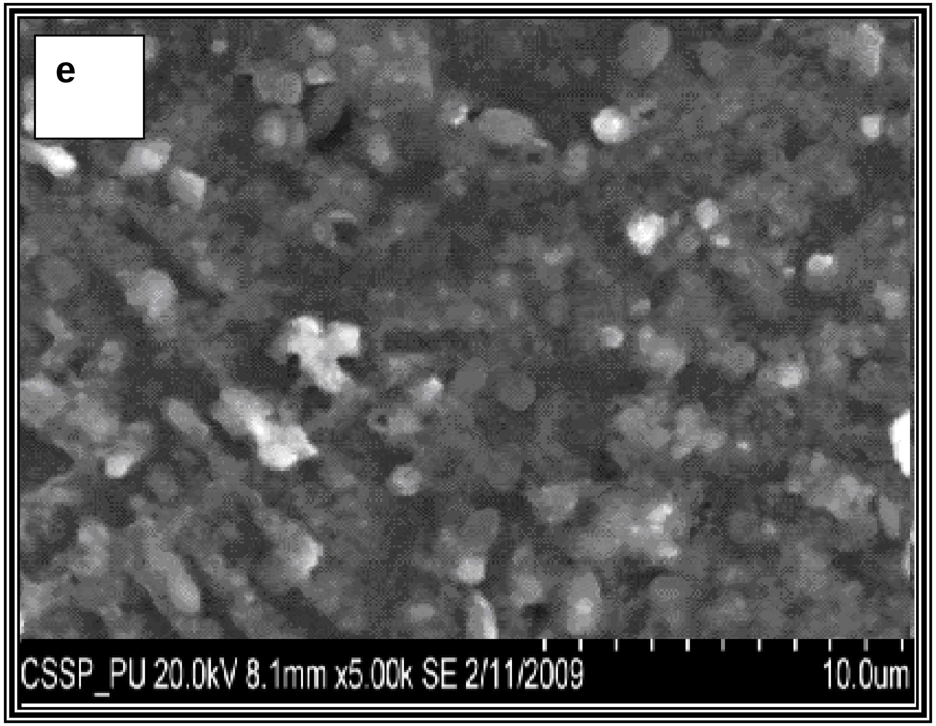


Figure 21: SEM images of Al-doped CdO thin films on Silicon substrate at (e) 400°C

Conclusion