

Structural and Optical Properties of Nanostructured CdSe Thin Films Prepared by Electrochemical Deposition

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ABSTRACT

Cadmium selenide (CdSe) nanostructured thin films have been grown on fluorine doped tin oxide (FTO) coated glass substrates by potentiostatic electrochemical deposition (ECD) technique for use in solar energy conversion devices. The effect of bath temperature on the structural, morphological and optical properties of prepared CdSe films has been explored. X-ray diffraction (XRD) and Raman spectroscopy clearly show that the CdSe films are polycrystalline and exhibit phase transformation from wurtzite to zincblende structure with increase in bath temperature. Optical spectra reveal that the nanostructured CdSe films have high absorbance in visible region and the films show a red shift in direct optical energy band gap from 1.90 to 1.65 eV with increase in bath temperature due to change in phase and bandgap tuning related to quantum confinement effect.

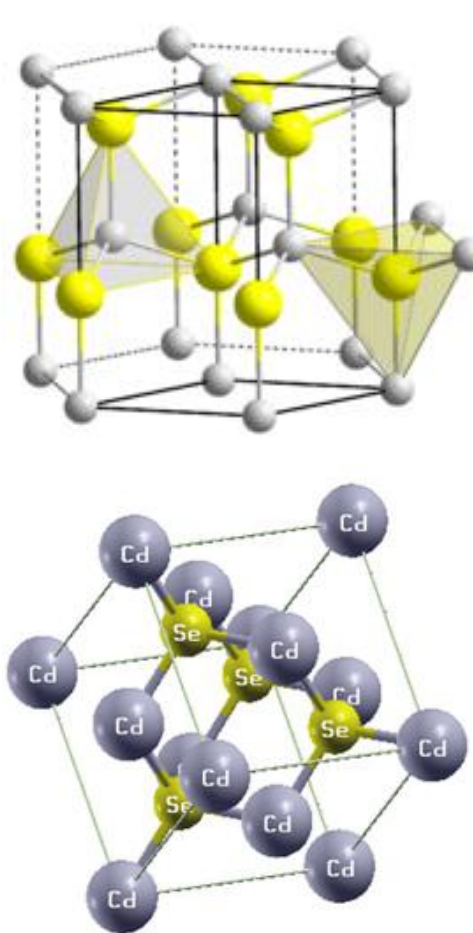
Why CdSe?

n-type II-VI semiconductor

Direct band gap (1.74 eV)

WZ and ZB Crystal Structure

High absorption coefficient



Broad Absorption spectra

Strong quantum confinement

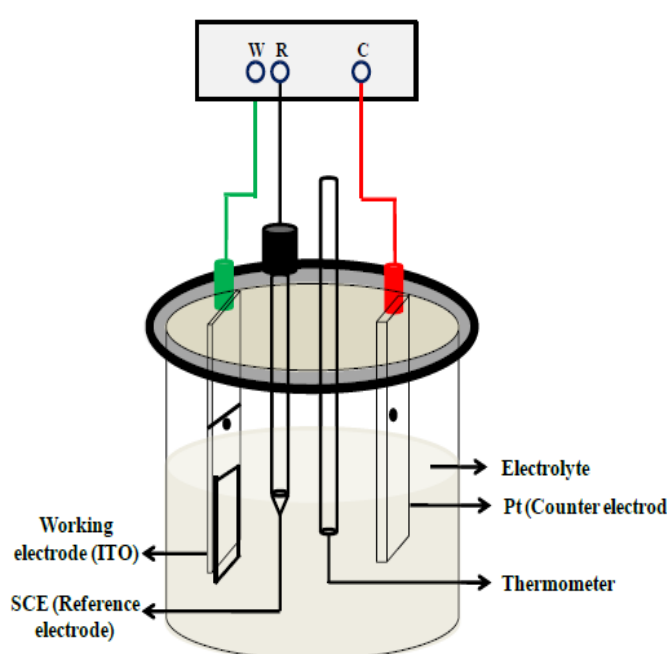
High Visible photosensitivity

Good Photo-stability

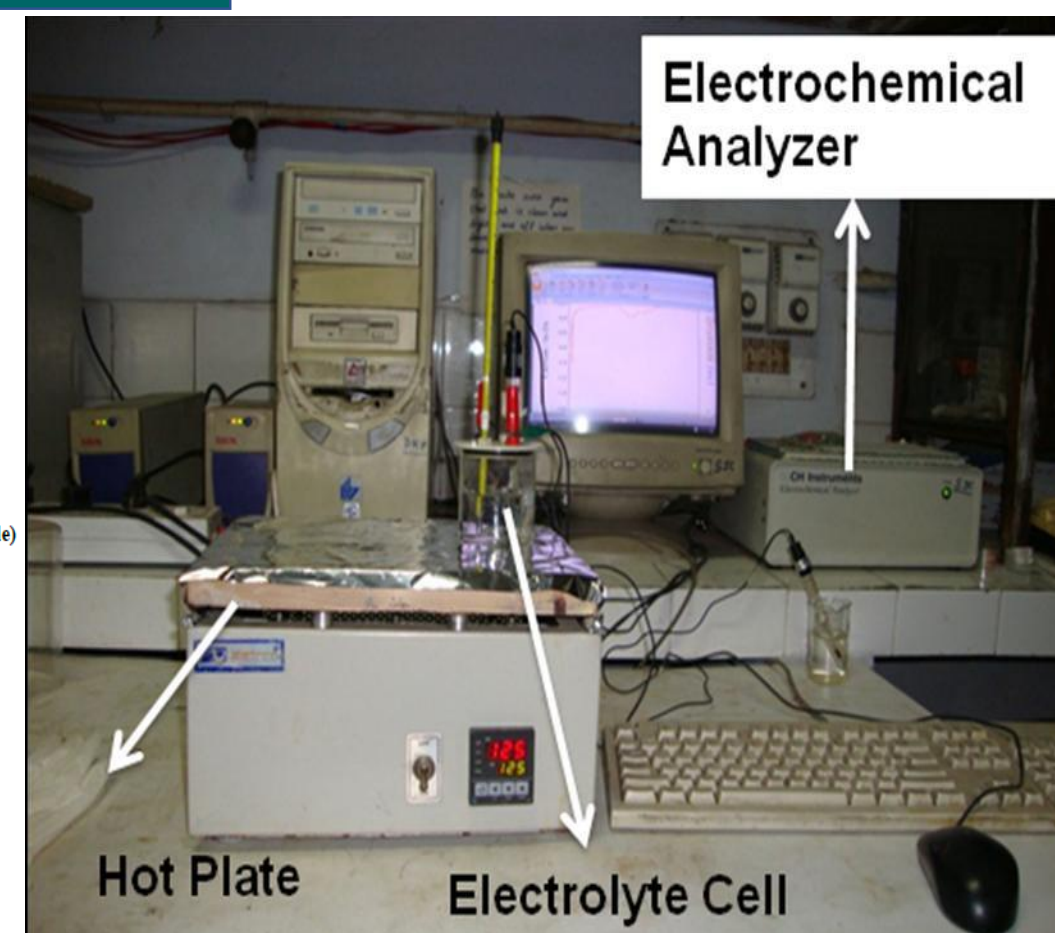
Experimental Details

Deposition Parameters for CdSe Thin Films by Electrochemical Deposition (ECD)

Cadmium Precursor	CdCl ₂ ·H ₂ O
Selenium Precursor	H ₂ SeO ₃
Bath concentration	5-25 mM
Cd:Se Concentration	5:1
Bath Temperature	40–60°C
Deposition Potential	-0.5V-0.7V(vs. SCE)
Bath pH	1.8-2.6

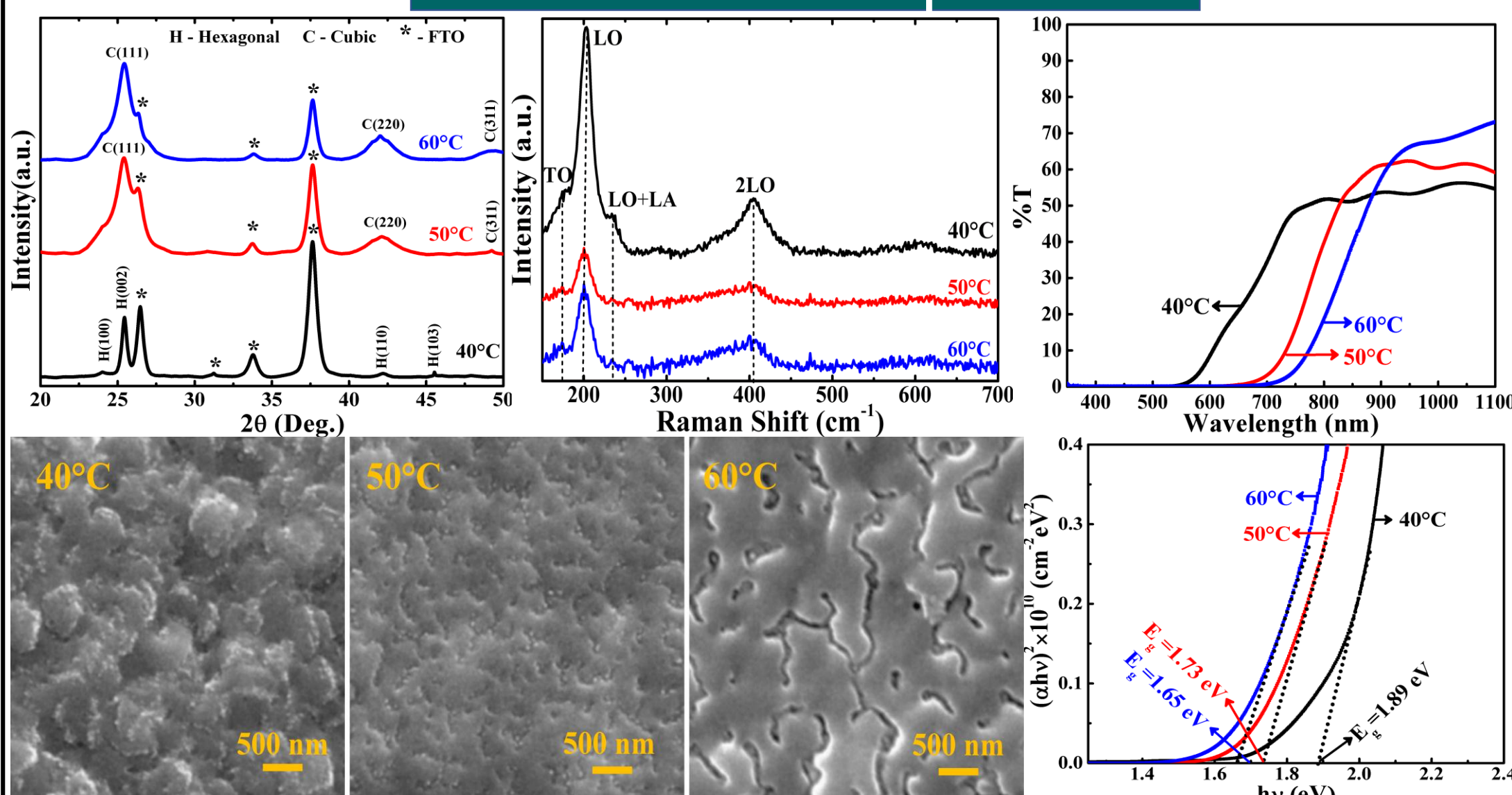


Schematic of 3-electrode electrochemical cell set-up



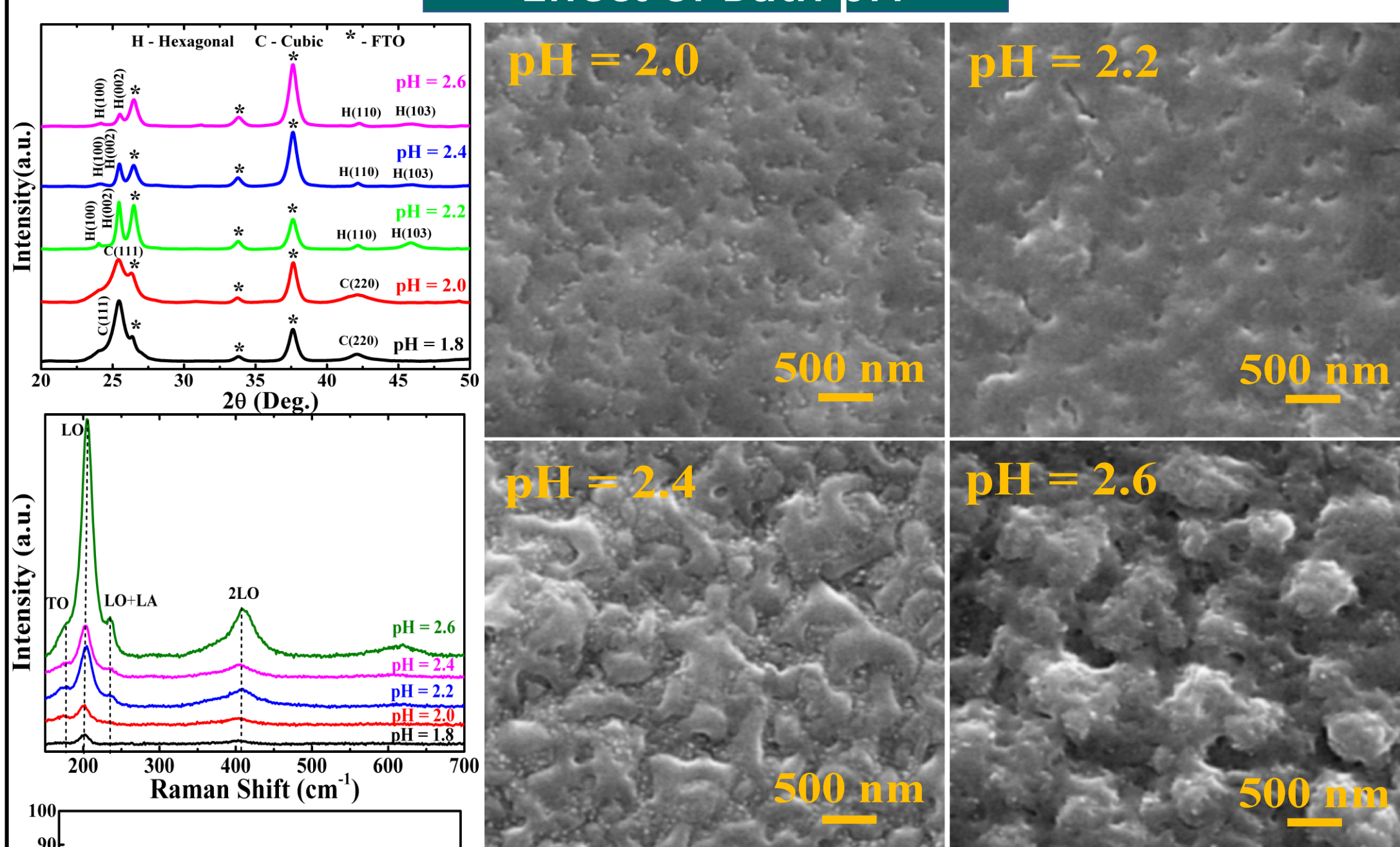
Electrochemical deposition set-up

Effect of Bath Temperature



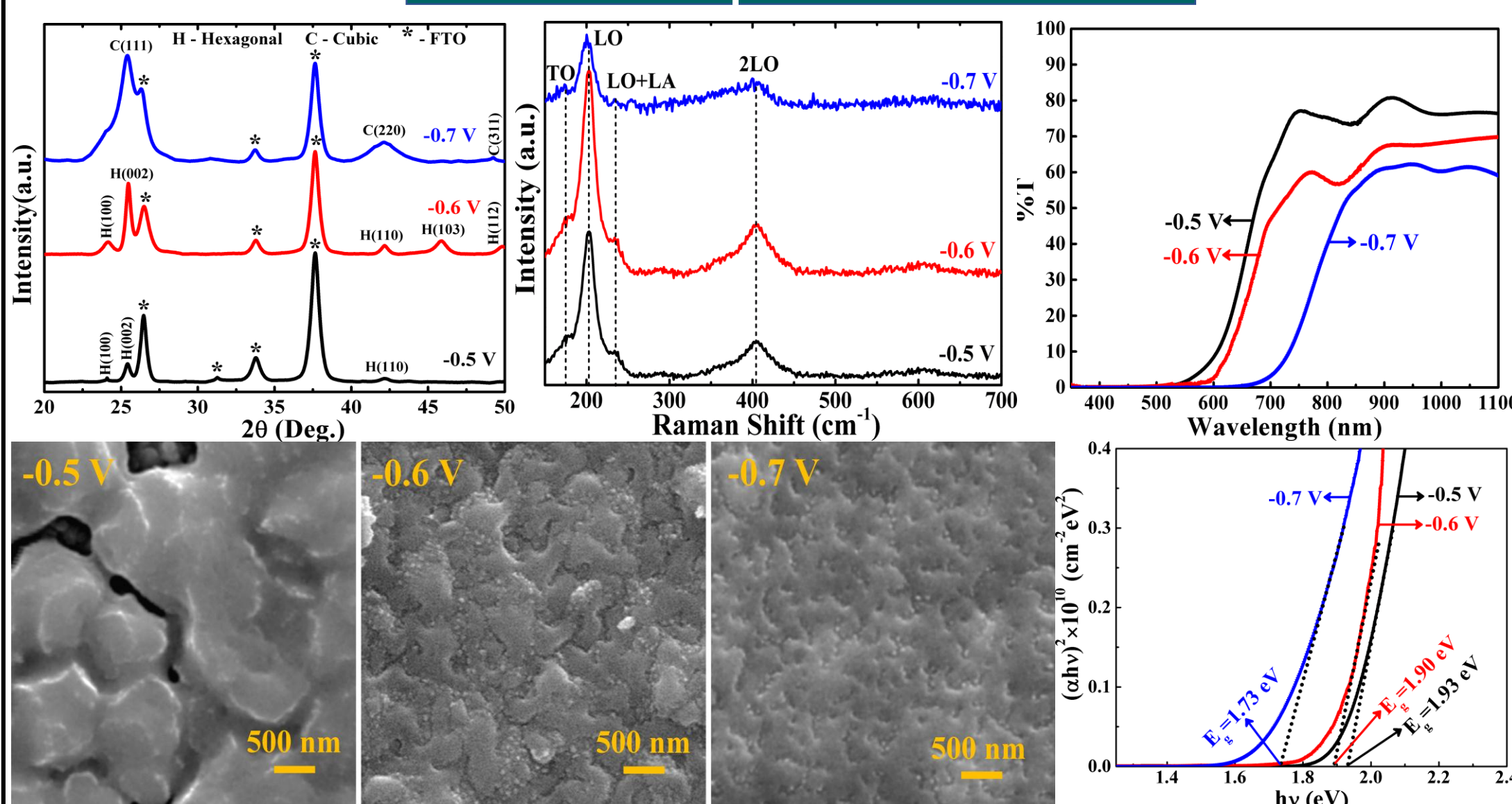
- CdSe nanostructures grown with deposition potential of -0.7V(vs. SCE) for 30 min with varying the bath temperature from 40°C to 60°C
- With increase of the bath temperature from 40°C to 60°C, the crystal structure of CdSe changes from wurtzite to zincblende
- The crystallite size of as-deposited CdSe films is 8-20 nm
- Surface morphology of the deposited films show uniform distribution over total coverage area of the substrate with compact and fine grained morphology
- Thickness of as deposited films increases from 0.85–2.36 μm with increasing the bath temperature
- With increase in bath temperature, the optical band gap decreases from 1.90 to 1.65 eV

Effect of Bath pH



- CdSe nanostructures grown at 50°C with deposition potential of -0.7V (vs. SCE) for 30 min with varying bath pH = 1.8–2.6
- XRD shows that up to bath pH = 2.0, the crystal structure is cubic; and for higher pH, the structure changes to hexagonal wurtzite (crystallite size 10–20 nm)
- With increase in bath pH, the intensity of H(002)/C(111) peak decreases and the film uniformity also decreases with pH
- The thickness of as-deposited CdSe films first increases from 1.52 to 1.56 μm with increase in bath pH from pH=1.8 to pH=2.0, and then decreases continuously to ~0.57 μm with increase in bath pH to 2.6
- The optical bandgap of as-deposited CdSe films increases from 1.68 to 1.97 eV with increase in bath pH

Effect of Deposition Potential



- CdSe nanostructures grown at 50°C with varying deposition potential of -0.5 to -0.7V (vs. SCE) for 30 min having bath pH = 2.0
- As the deposition potential changes from -0.5V to -0.7V, the crystal structure of CdSe changes from hexagonal wurtzite to cubic phase
- At higher potential, the film is uniform and exhibits good surface coverage of the substrate
- The thickness of as-deposited CdSe thin films increases from 0.35–1.56 μm with increase in negative deposition potential
- With increase in deposition potential, the optical band gap decreases from 1.93 eV to 1.73 eV

Conclusions

- ❑ As deposited CdSe thin films are polycrystalline in nature
- ❑ Both types of crystal structure of CdSe(i.e.stable wurtzite & metastable cubic) films are observed
- ❑ Cadmium free cubic phase of CdSe occurs at 50°C for a bath having pH less than 2.0 at higher negative deposition potential and changes to a more stable wurtzite phase at lower negative deposition potential and higher bath pH
- ❑ Crystallite size of CdSe thin films varies from 8–20 nm
- ❑ Raman analysis confirms the phase purity of all the films
- ❑ Morphology of CdSe nanostructures depends significantly on the bath temperature, deposition potential and bath pH
- ❑ SEM study shows that all the films are uniform, homogeneous and have good substrate coverage
- ❑ Optical direct band gap of CdSe thin films varies from 1.65–1.97 eV
- ❑ Bandgap tuning on account of grain size change related quantum confinement effect is observed

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