

Fig.5. a) XRD spectra of CdS samples deposited by CBD in reciprocal lattice, b) (002) plane of orientations in direct lattice plane of HCP, c) stacking of (002) planes in HCP, d) unit cell of primitive lattice vectors made by 120°

2.4 Surface Morphological Study

The surface micrograph of CdS thin films deposited by using UCBD and CBD is shown in Fig. 6. Effect of sonications at 300 K temperature for 15min, surface looks more uniform with relatively smaller grains $\sim 60\text{nm}$ (Fig. 6(a)). In case of magnetic agitating at constant 333 K temperature for 15 min and 20 min causes the formation of larger grains $\sim 100\text{ nm}$ along with some coalescence and clusters of overgrowth (Fig. 6(b)). Such overgrowth can be explained on the basis of nucleation and coalescence process. At high 60°C temperature, well-covered irregular shaped grains interconnected with each other are seen from Fig. 6 (b) & (c).

Much bigger grain size morphology of CdS thin film instead of irregular shaped grains has been reported. It is well known that the efficiency of crystalline thin film solar cell increases with increasing grain size of the window layer [32-34].

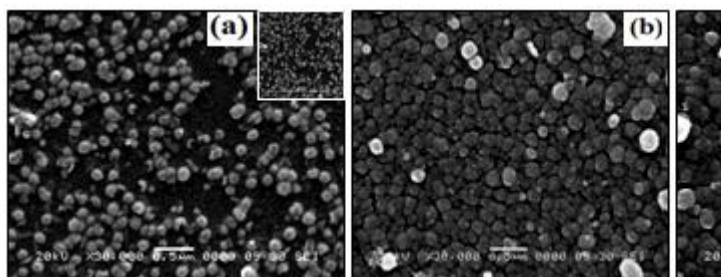


Fig. 6. The surface micrograph of as deposited CdS thin films at (a) 300 K for 15min by UCBD (b) 333 K for 15 min by CBD and (d) 333 K for 20min by CBD temperatures. Reference XRD patterns of bulk CdS, ZnS and SnS₂ materials are also shown for the comparison.

3.4. Growth mechanisms of CdS thin film

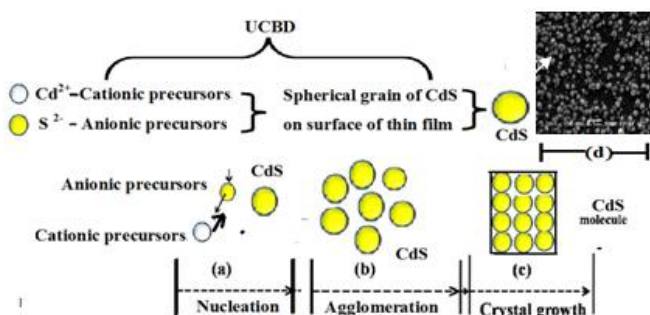


Fig. 7. The schematic representation of growth process of CdS thin film (a) Nucleation, (b) agglomeration and (c) crystal growth deposited by UCBD. [Inset (d) shows enlarge SEM image of as-deposited CdS for UCBD].

As-deposited CdS thin films surface is found to be as a smooth and compact. Also the film surface is covered with irregular shaped grains of random size without pinhole for UCBD and CBD respectively. This can be explained on the basis of nucleation growth mechanism in both chemical systems. Initially formation of very small tiny particles is known as nucleation, Cd^{2+} metal ions come

closer to each other resulting into cationic nuclei on the substrate surface. Further from the anionic precursor bath, S^{2-} ions are adsorbed over the cationic nuclei to form CdS molecule. This process is called as aggregation, which is shown in Fig.7. and Fig.8. for UCBD and CBD respectively. In the magnetic agitations, many such CdS molecules are grow with different size by means of coalescence. In Fig. 8(f). shows that, coalescence is appear on the surface substrate for CBD. $\text{Cd}(\text{OH})_2$ forms a cluster with overgrowth without sonication. Finally crystal growth take place by coalescence and Cluster of CdS molecule. The continuity in geometric orientation to give rise a smooth and compact morphology of deposited CdS thin film as shown in Fig. 8.(e). Inset Shows an enlarge fig 8. (f) and fig.8.(g) of SEM image of as-deposited CdS thin film by CBD. Similar type of growth mechanism of CdS thin film formation for UCBD except coalescence and Cluster avoid due to the ultrasonication, which leads to formation of nanosonic particles explained by suslick et al. [4].

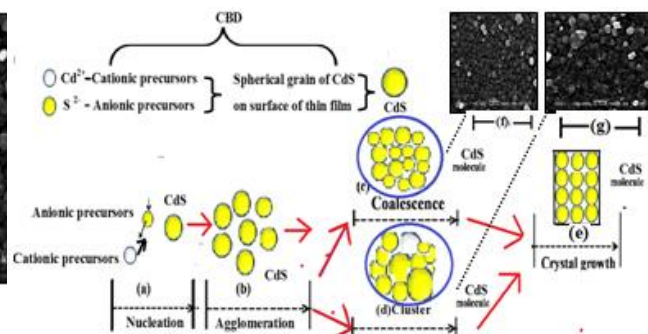


Fig. 8. The schematic representation of growth process of CdS thin film (a) Nucleation, (b) agglomeration, (c) coalescence, (d) cluster and (e) crystal growth deposited by CBD. [Inset (f) and (g) shows enlarge SEM image of as-deposited CdS for CBD].

3.5. Optical Study

Fig. 9 represents that, typical curves of the optical absorbance versus the wavelength (nm) for UCBD and CBD techniques. The band edge absorption of CdS thin films have corresponds to the λ (nm) is estimated by a linear interpolation of each curve to wavelength (nm) axis. An optical spectrum has accuracy up to 0.02 nm. The band edge absorption of CdS thin films has found to be in visible regions, Bulk materials of CdS thin films has been reported a longer wavelength ($520\text{ nm} \pm 534\text{ nm}$) for CBD [37,- 39]. The band gap of CdS films prepared by CBD, both with magnetic agitation and ultrasonic vibration, are shown in the first two curves of Fig. 9. Note the differences, the optical spectra obtained for CdS thin films prepared by CBD and UCBD techniques are shown in figure 9. The values of band edge absorption observed for CdS films grown by CBD and UCBD are 534 nm and 476 nm respectively. The smaller wavelength of band edge absorption is obtained from the films with ultrasonication imply that CdS grown under ultrasonication cause a stable nucleation, which can stop further growth mechanism. The band edge absorption shifted towards the lower

wavelength region caused by acoustic cavitations process, which leads to the formation of nanosonic particle and other hand higher wavelength regions, which could be due to the formation of bulk materials, band edge absorption of spectrum in the longer wavelength region (≥ 520 nm) is usually caused by coalesces and cluster (cadmium hydroxide) crystalline defects such as grain boundaries and dislocations as early reported. The change in band gap occurs due to the change particle size or improvement in crystallinity for UCBD as compared to the CBD.

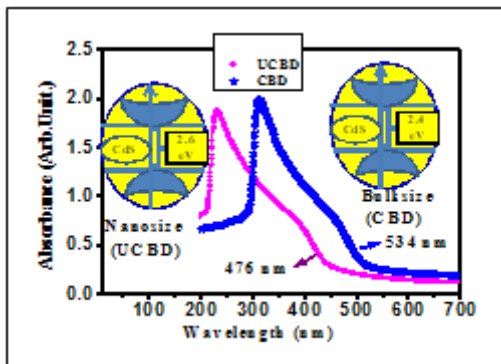


Fig 9. UV visible absorption spectra of CdS thin film deposited by CBD and UCBD technique

3.6 PL Studies:

The study of photoluminescence (PL) spectra of CdS thin films for UCBD and CBD method, which reveals various peaks as shown in fig.10. The PL spectra of CdS thin films excited at 460 nm to determine the band edge emissions of semiconductors in the visible region. since the most common radiative transition is occurred in the semiconductor, the forbidden difference from the states of bottom of the conduction band and the top of the valence band both lie on the same energy axis versus wavelength (nm) also with some non radiative transitions from trapping states of vacancies and defects[41].

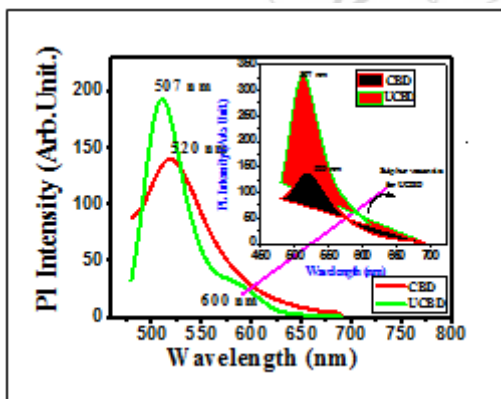


Fig: 10. The photoluminescence (PL) spectra of CdS thin film deposited by CBD and UCBD techniques.

Different agitations on CBD method, ultrasonically thin films show a very high intense peak at 507 nm (2.44 eV), which is leads to the formation nanocrystalline thin films and also with sulphur vacancies of small hump at 590 nm [35-36]. The magnetically agitated thin films shows small intense peaks of band edge emissions at 520 nm reveals a bulk materials. PL spectra of CdS thin films were appeared in the range of 2.3 – 2.54 eV [42-44].

4. Conclusions

The Nanocrystalline transparent CdS thin films are successfully prepared by UCBD and CBD techniques. The sonication and magnetic agitations impact is observed as follows, both films are compact and well adhesive to the substrate. Uniform and adhesive films were observed with improved crystallinity by using UCBD technique. Hexagonally closed packed structure of CdS thin films have a single crystalline phase obtained by both techniques. Coalescence and cluster can be avoided by using sonication method. The band edge absorption found to be at smaller wavelength 476 nm for UCBD and higher wavelength band edge absorption was observed for bulk materials in case of CBD process. The blue shift observed in PL spectra of CdS thin film for UCBD method, which is due to formation of nanosonic particles of CdS.

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