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Preparation Of Cadmium Sulfide Nanoparticles By Laser Ablation In Methanol Solution

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***Abstract*—Cadmium Sulfide anoparticals (NPs) were synthesized by Laser ablation technique, simple system was used consist of Nd:YAG laser, hard pellet of CdS, aglass beaker and absolute methanol. The obtained product was examined by XRD Diffractometer and the structural parameters were calculated, morphology of the surface was studied using SEM and AFM devices. Also the optical properties were studied and shows direct transition with energy gap of 2.6 eV.**

Keywords—XRD, Laser ablation , AFM, CdS

1. Introduction

Laser ablation provide us accurate control of preparation conditions, high stability of the obtained colloidal solutions, so that the nanoparticals can be used for many important technological applications in such fields as medicine, microsensors, microelectronics, optics, catalysis, and bio photonics [1],then the quantum size effects and surface effects, the nanoparticals can display novel electronic, optical, chemical, magnetic, and structural properties.

CdS (Cadmium sulfide) is an important n-type semiconductor with a direct band gap 2.6 eV,(in contrast to most thin films which are p-type), has been utilized as a thin film sensor and as a detectors for laser and infrared. An improved understanding of CdS thin film material properties will aid in achieving improved performance in these applications [2].

Rather than, various techniques had been used in preparing thin films of Cadmium Sulfide, such as physical vapor deposition (PVD), the best device performance has historically been achieved with solar cells incorporating CdS films grown by CBD [1]. In CdTe thin-film PV devices, which are grown on Cadmium Sulfide substrates to form an active heterojunction, the CBD process for CdS has produced high efficiencies (9), although alternatives to the CBD process, such as close-spaced sublimation, are being actively pursued (9,10) and have excelled in some cases[1]. Herein, we propose a numerical study of the major processes involved in laser ablation into liquids that affect NPs formation. The study is aimed at the analysis of the experimental parameters favorable for the formation of small NPs and at the explanation of the experimental results available in the literature as a first case study, we consider gold ablation in water. The roles of such parameters as laser pulse duration and liquid temperature are discussed [3].

2. Experimental work

High purity (99.99 %) provided from Poch Company in methanol (CH_4O) at room temperature with Cadmium Sulfide pressed pellet having diameter of 1 cm^2then Cadmium sulfide nanoparticals were produced by laser ablation. The Cadmium Sulfide target was placed in the bottom of open glas vessel filed with 5 ml of solution above the target. The colloidal solutions were synthesized by irradiating of Cadmium Sulfide pellet with pulsed Nd:YAG laser operated at λ = 1064 nm(type HUAFEI),7 ns pulse width and 10 Hz repetition. The laser beam was focused on the target surface by using converging lens of 12 cm focal length. The spot size of laser beam on pellet was measured and found to be 2.3 mm with laser flounce was (1.76 J/cm^2) at 6 min as ablation time as shown in fig. 1. The structure and lattice parameters of Cadmium sulfide nanoparticles film were analyzed by a LabX XRD 6000 SHIMADZU XR–Diffractometer with Cu Kα radiation (wavelength 1.54059 Å, voltage 30 kV, current 15 mA, scanning speed = 4 °/min).The crystallinity of the produced material was characterized using X-ray diffraction (XRD). This technique was also employed by another group which gives an indication about the grain size and formation material type of the prepared nanoparticals.

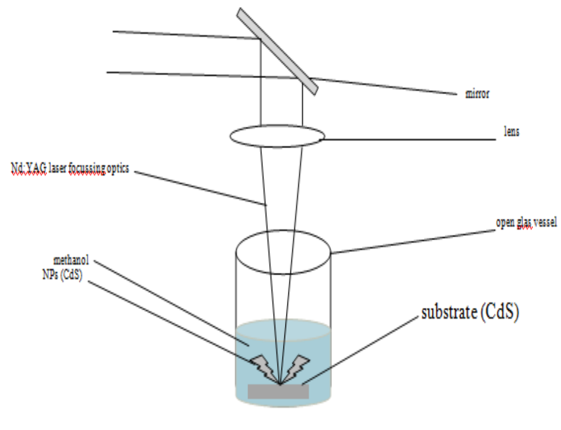


Fig. (1): Experimental set-up of pulsed laser ablation in liquid media.

3. Result and discussion

3.1 Optical Studies of Cadmium Sulfide nanoparticals

In order that have information about the optical properties of Cadmium Sulfide nanoparticals, transmission (T) and absorbance (A) spectra for this nanoparticals was taken and some optical parameters such the energy gap (E_g) and absorption coefficient (α) were analyzed by using these spectra. The effectiveness of growth provision on the optical properties of the prepared Cadmium Sulfide was thoughtful extensively. The transmission and absorption of the nanoparticals size of Cadmium Sulfide was measured and registered at the ultraviolet and visible regions for this nanoparticals growth by laser beam in methanol.Fig.2 shows the results exhibit decreasing sharply in the transmission from the range 200 to 300nm at the ultraviolet region that isattributed to the adhesive and kind of Cadmium Sulfide which can be ascribed to the formation of this nanoparticals. It is visibly seen that the transmission was increasing starting the minimal~ 300nm, and the chart showed a marked contrast in transmission spectra in the range from 510 to 530nm due to quantum size effect, to form resonance Plasmon region as shown in fig. 2,resulting, improvement in fabric arrangement, best optical properties [4]. This characteristic coincide with Cadmium Sulfide nanoparticals characteristics which are intended by other process [5],[6]. In fig. 3 the absorption coefficient (α) as a function of the photon energy (hv) for a Cadmium Sulfide nanoparticals, shows a linear dependence on hv, giving 2.6 eV for a direct energy gap[7].

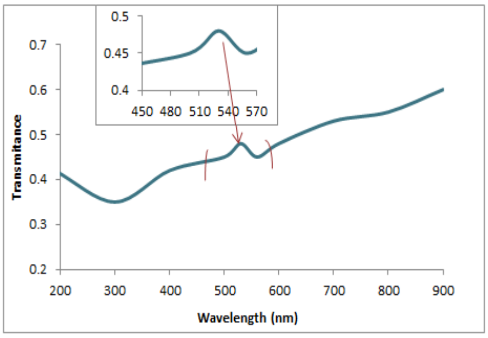


Fig. 2 optical transmission as a function of wave length for Cadmium Sulfide nanoparticals prepared by laser ablation

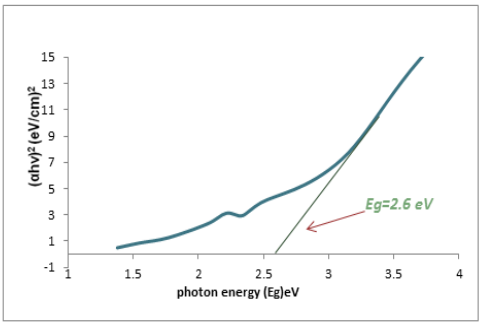


Fig.3 $(\alpha h\nu)^2$ versus photon energy gap of Cadmium Sulfide colloidal dissolved in methanol with 1.76 J/cm^2 laser flounce.

3.2 X-ray diffraction of Cadmium Sulfide nanoparticals

The structure and lattice parameters of methanol solution and a patterns of synthesized CdS nanoparticals ablated by laser were analyzed by aLabXRD 6000 SHIMADZU XR – Diffractometer with Cu Kα radiation (wavelength 1.54059 Å, voltage 30 kV, current 15 mA, scanning speed = 4 °/min) as illustrated in table (1).This technique was gives an indication about formation material type of this solutionand CdS nanoparticals colloidal, one narrow and sharp first peak with high intensity could be recognized in Fig. 4 , methanol is monocrystalline according to the ASTM standards could be recognized, such result indicated that no formation of another material occurred in this solution. The XRD pattern of CdS nanoparticals prepared in methanol at laser flounce 1.76 (J/cm^2) showed presence of additional three peaks at diffraction angle (25.2268, 26.8753and28.5488), the grown film has a good degree of crystallinity at highly (100), (200) and(101) oriented crystallites of CdS corresponds to Miller indices respectively, Fig. 4 ,these additional peaks can be ascribed to formation of other phases. All the diffractions peaks are indexed to the hexagonal structure and there is no trace of cubic face which were well matched with standard peaks (JCPDS No. 77-2307) [8].The evaluated grain size (G.S)estimated using schreer equation [4].

After substation experimental data from this eq., G.S was found for CdS is (16.83nm) [6]. The strain value ‘η’ and the dislocation density ‘δ’ can be evaluated [9,10] see Table (1):

Hence this agrees with the previous studies [6]. The results revealed that the strain and dislocation density are decreased with the increasing of the grain size [11].

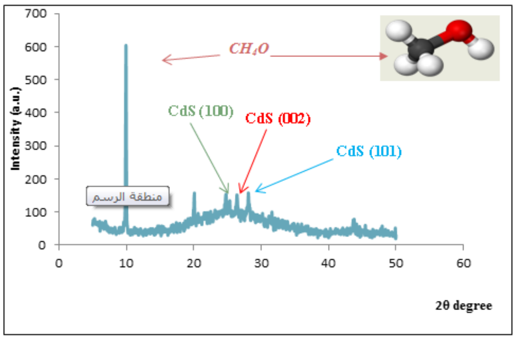


Fig. 4 XRD pattern for methanol solution and Cadmium Sulfide nanoparticals films ablated in methanol

As shown, in fig. 4 XRD pattern of the Cadmium Sulfide nanoparticals. The crystalline structure spacing between the crystal lattice planes of the nanoparticals as they were measured from the images were in agreement with the theoretically predicted ones for the crystal structures of the corresponding bulk materials, the lattice spacing of CdS nanoparticals produced in methanol is measured to be equal to 3.28 Å which corresponds to the distances between the (100), (002) or (101)planes of the hexagonal close-packed (HCP) lattice of CdS structure [12],[13],[14]. The Cadmium Sulfide nanoparticals is a major concern of researchers in the field. However, understanding how to control

Table (1): comparison of observed and standard "d"values for Cadmium Sulfide nanoparticals

Prepared condition	Crystal Structure	$\delta x10^{14}$ lines m^{-2}	$\eta x10^{-4}$ lines^{+2} m^{-4}	2θ (degree)	d (A°) XRD	(hkl) plane
laser flounce at 1.76 (J/cm)	Hexagonal (HCP)	6.61	20.85	25.22	3.508	(100)
		6.59	18.55	26.78	3.296	(002)
		6.62	25.79	28.54	3.107	(101)

crystallinity morphology is extremely difficult owing to the large number of controlling factors [15],[16].

3.3 Scan of electron microscopy Studies

As evident from the plan-view SEM micrograph fig.5, two shapes are recognized; the first one represents the change in the Cadmium Sulfide nanoparticals was agglomeration as apodes and with different grain size also. The second, recognized changes in the topography of these nanoparticles to become like- a cluster with grain size (122nm) in relation to transmissio of scanning light through the prepared colloidal.

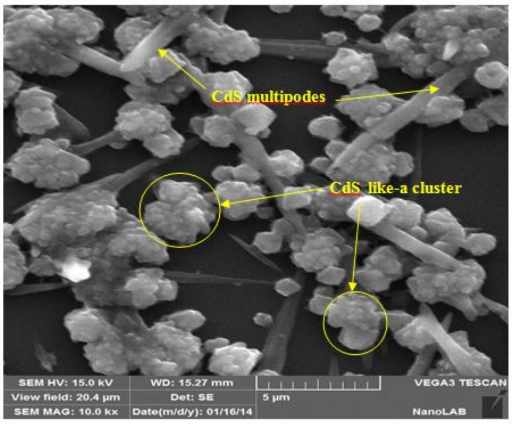
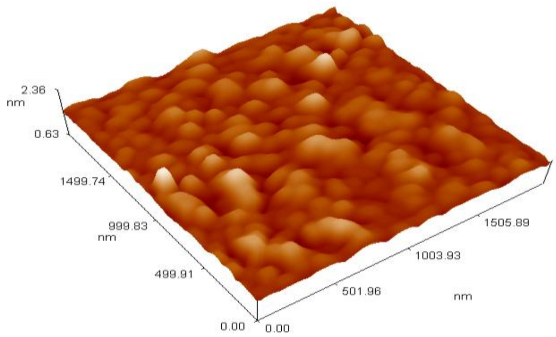


Fig. 5 SEM image of Cadmium Sulfide nanoparticals deposited at room temperature by laser ablation produced in methanol

3.4 Atomic force microscopy

Information about the shape of the NPs in the produced colloidal solutions was obtained by AFM imaging [15].The spherical particle will be viewed as a bumps matrices corresponding to granularity normal distribution according to the laser flounce by the Atomic Force Microscope in Fig. 6. The surface morphology of CdS nanoparticals prepared with laser flounce(1.76J/cm^2) as observed from the (AFM-AA3000, Angstrom Advanced Inc. USA) micrographs proves that the grains are uniformly distributed within the scanning area (1000×1000 nm) with individual columnar grains extending upwards as shown in Fig. (6-a). The grain size and the roughness increases with various laser flounce (1.76J/cm^2), while this nanoparticals presented agglomerate to form larger particles (83 nm) it suggests that the charge transport is occurring predominantly intra-grain in this cases, or equivalent to greater grains, in this kind of microstructure it is usually not dominated by bulk properties but by grain walls, which either act as low conductivity blockades or as high conductivity carrier accumulation regions. This surface characteristic is important for applications such as, gas sensors and catalysts [17],[18],[19]. The root mean square (r.m.s) of this surface roughness was (0.9 nm). The fig. (6-b) corresponding to Granularity normal distribution chart according to the diameters of the grains [5].

a



b

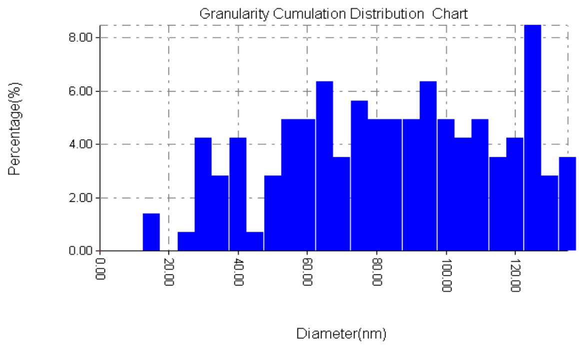


Fig. (6): a-b 3D AFM image and Granularity accumulation distribution chart of Cadmium Sulfide nanoparticals ablation in methanol with 1.76 J/cm ^{2}laser flounce.

Conclusions

Cadmium sulfide nanoparticals were prepared by laser ablation, structural and optical properties of Cadmium Sulfide nanoparticals were investigated. However, in optical properties the particle Plasmon resonance wave-length was appeared from 510 to 530nm with increased Cadmium Sulfide particle size and this NPs obtained show a direct band gap of 2.6eV measured by optical absorption experiments. The reversible nature of the decomposition reaction at room temperature of Cadmium Sulfide nanoparticals was confirmed by SEM and Cadmium Sulfide nanocrystals were synthesized. Our approach is believed to be applicable to many other semiconductor materials for the creation of (n(nanostructure) with novel optical properties.

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