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# Morphological Changes In Cdse Layers Deposited On Porous P+-Gaas;Correlation With Optical And Structural Proprieties

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**Abstract.** Synthesized-CdSe nanoparticles were deposited by using spin coating method onto porous GaAs substrate elaborated by an electrochemical process. The surface morphology of deposited CdSe layer was investigated by scanning electron microscopy (SEM), the surfaces' roughness and morphology after the Growth the CdSe nanoparticles modification was exhibited by atomic force microscopy (AFM), X- ray diffraction (XRD techniques proved the incorporated of CdSe nanoparticles on the surface states. SEM imaging shows that the CdSe was penetrated deeply in the porous structure down to the bottom and reaching the interface GaAs/porous GaAs. It was also observed that the reflectivity decreased after the deposition process of CdSe nanoparticles due to the size of CdSe nanoparticles. In addition, the photoluminescence (PL) spectroscopy exhibits a new intense peak at 2.08 eV due to CdSe nanoparticles deposition. It was attributed to CdSe nanoparticles with narrow particle-size distribution uniformly coated on the surface.

**Keywords.** Porous GaAs, Cadmium selenium (CdSe), SEM, UV-Visible. AFM,Pl,XRD.

## INTRODUCTION

Porous semi-conductors III-V such as porous GaAs have gained considerable interest because of their attractive optoelectronic properties due to the quantum confinement effect. In the recent years, many work have been directed towards deposing semi-conductors layers on porous substrates because the demand for more powerful and sophisticated device application such the solar cells. the reasons for using a porous semiconductor as a substrate for depositing semiconductor layers is that the nano-patterned porous structure would lead to a reduced extended defect density (Lade et al., 2001; Kainthala et al., 1980; Kale et al.,2000) also, to protect surface from chemical and/or electronic degradation, due to oxidation. Cadmium selenium (CdSe) (Eg=1.7 eV) is one of the promising semiconducting material that has been studied for application in solar cells (Lade et al., 2001),

A number of workers have: - Chemically synthesized CdSe thin films by using the electrodepositing (Kainthala et al., 1980; Kale et al., 2000; Rajeshwar, 1981). - Physical vapor deposition method of electron beam evaporation (PVD: EBE) (Suthan Kissinger, 2007).
- Vacuum evaporation (Baban, 2003). - Hot wall deposition (Velumani, 2003). -Pyrolysis (Elango et al., 2000). - Chemical bath deposition (CBD) (Deshpande, 2013), etc.
Several complexing or stabilizing agent was used for the CdSe QDs preparation such as the L-Cysteine (Cys), triethanolamine (TEA) and nitrilotriacetic acid (NTA) (Mehta et al., 2007; Mondal, 1983; Hodes et al., 2003).
In this study, we used L-Cysteine as stabilizing agent for preparation of CdSe nanoparticles at room temperatures by sol-gel spin coated method on porous GaAs substrates. In order to improve the growth of CdSe nanoparticles on porous GaAs layers. The structural and optical properties of deposited CdSe QDs have been investigated and discussed in this article.

## CHARACTERIZATION

The reflectance spectra were realised using UV-Visible (lambda 950) spectrophotometer. The optical properties of chemically vapour etched sample were investigated by photoluminescence (PL) using a configuration consisting of a double monochromator, a photomultiplier with a photocathode GaAs. The samples were excited with 488 nm laser light of an arc line. Surface morphology study was performed using atomic force microscopy (AFM) in tapping mode configuration by a Topometrix TMX 2000 Explorer AFM and scanning electron microscopy (SEM) JEOLJSM-5400. The X-ray diffraction analysis of the samples were realized a Philips PW1710 diffractomter using CuKa radiation ($\lambda$=1.5405A°) .The $2\theta$ range was from 10° to 80°.

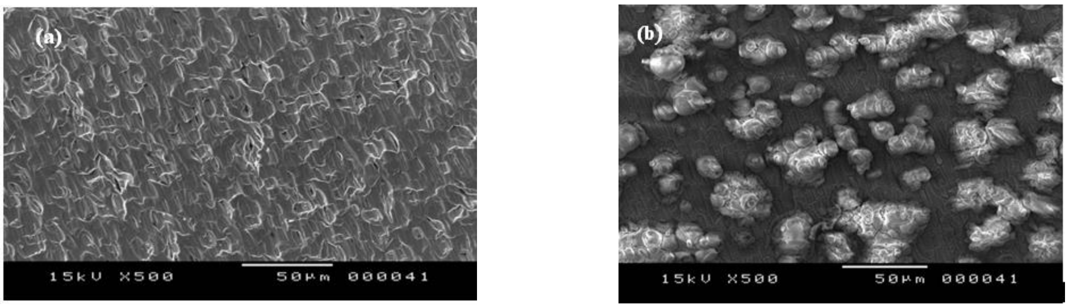
## EXPERIMENTAL DETAILS

The substrate used in this study is p+-GaAs (1 0 0) doped with Zn, having a hole concentration of about 1019 cm-3. The sample is electrochemically etched in HF based solution under Galvano static condition. The electrochemical etching conditions are: HF-EtOH (1:2), j=24mA cm_2 and etching time of 12 s. The L-Cysteine capped CdSe nanoparticles layers was synthesized and grown over p-GaAs by spin coating method. The prepared solution at a fixed duration for stirring bath was spin coated onto porous GaAs substrates at the speed of 500 rpm for 60 s. The as-deposited films were dried in air at 100 °C for 10 min using a hot plate to evaporate organic residuals. The porous GaAs substrate was prepared before overgrowth by cleaning it in propanol, methanol and rinsed with deionised water and then blown dry in N2.

## RESULTS AND DISCUSSIONS

### SEM and AFM image

Evidence for the formation of pores during anodization was found in the image obtained with SEM. Figure 1.b shows a SEM micrograph of top surface of the anodized sample. As we can see clearly a sponge structure of a nano-porous structure with size pores of about 10-50nm.Compared to the SEM image of starting substrates (Fig.1.a). This Structure appeared to be typical compared to that found in other studies (Beji et al., 2003; Sabataityte, 2002).
After the deposition of CdSe Cap layers on porous GaAs substrates. SEM micrograph of the Top surface of the CdSe layers deposited on porous GaAs substrates (Fig2.a) reveal that the CdSe particles are well dispersed and close the dark areas which corresponding to the macro pores and Nano pores present in the porous GaAs layers. CdSe layers were connected with the pores wall of the porous GaAs layers. The Size crystallites diameter of the CdSe nanoparticles was of about 1-3nm (Fig 2.b)



(a) the untreated GaAs (b) the anodized

Fig. 1. SEM micrograph of Top surface of sample.

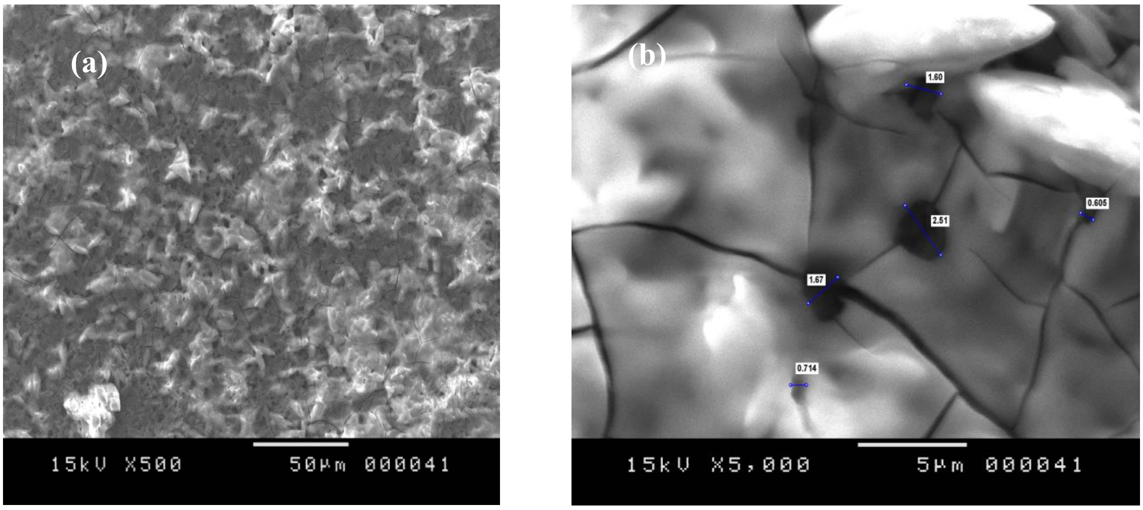


Fig.2. SEM micrograph of the Top surface of the CdSe layers deposited on porous GaAs substrates.

Figure 3 shows the SEM Cross section micrograph of the CdSe layers deposited on porous GaAs substrates, It consist of a porous GaAs intermediate layers between the CdSe layers and the starting GaAs substrate and CdSe layers. This image show clearly that the CdSe layers were composed of a Nano grains and nanocrystals of two connected materials.

The AFM images provided a direct observation of the morphological changes of the deposited CdSe layers on the nanometer range.

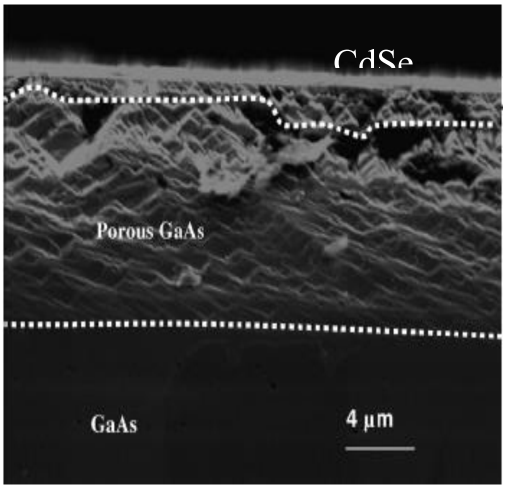


Fig.3. SEM Cross section micrograph of the CdSe layers deposited on porous GaAs substrates.

Figure 4 shows a 3D AFM image of the CdSe layer deposited on porous GaAs substrate. The clusters formed on the porous surface start to coalesce and new small cluster start to grow also, between the bigger ones. It is noticed that the CdSe layer deposited on porous GaAs substrate has more roughness. This result is in agreement with the SEM analysis.

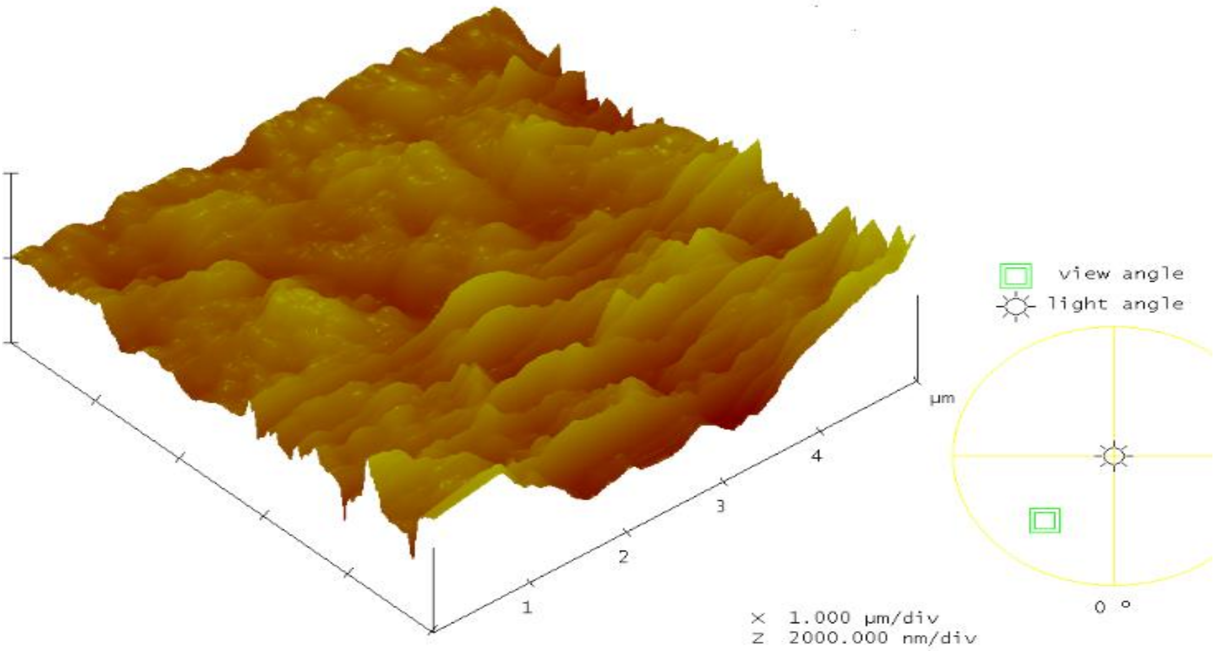
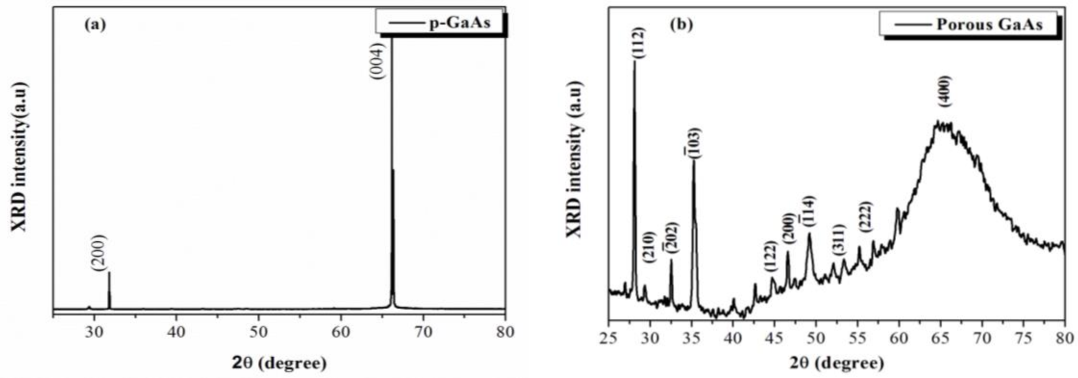


Fig.4. 3D AFM image of the CdSe layer deposited on porous GaAs substrate.

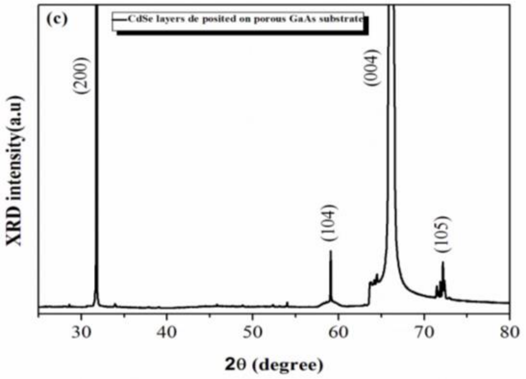
**XRD results**

To more confirm the deposited CdSe layers on porous GaAs substrates. X-Ray Diffraction was carried out to study the degree of crystallinity of the deposited CdSe layers and to elucidate the growth CdSe layers on porous GaAs. The XRD spectra (Fig.5) of starting GaAs shows two intense peaks located at 31.72° and 66.44related respectively to (200) and (400) orientations of p+ GaAs substrate.

The XRD pattern of por-GaAs-L shows four diffraction peaks at: 29.58°, 35.2° ,44.57°, and 48.73° corresponding to directions (210), (103) , (122) and (114) planes relating to As2O3 [JCPDS file N. 71-0563], and four diffraction peaks with low X-Ray diffraction intensity at: 28.16°, 31.80°, 44.83°, 53.06° and 56.39° corresponding respectively to directions : (111), $(\bar{2}02)$, (200), (311), and (222) planes relating to Ga2O3 [JCPDS file N. 32-0389]. From the XRD patters of por-GaAs-L, we can also clearly seen a diffraction peak located at 66.03° corresponding to direction (400) plane with low intensity compared to the starting substrate. The 2θ value of (400) peak which is a characteristic of the Nano crystallites Ga and As present in the patterns of the porous GaAs is 0.31° offset (to the left) compared to the starting sample. This offset is probably due to the formation of porous layer, which has composed of Nano crystallites. That is which means that the porous layers formation is accompanied by the appearance of mechanical and chemical strains.



(a) starting GaAs substrate (b) porous GaAs substrate



(c) CdSe layer deposited on porous GaAs

Fig. 5. XRD patterns.

The XRD patterns of CdSe layers deposited on por-GaAs- substrates exhibits that the CdSe layers have oriented crystallite with hexagonal structures. The most intense peaks of CdSe appeared at: 58.90° and 71.90°. It Can be indexed respectively as: (104) and (105) reflection of hexagonal phase at 58.13° and71.90° [JCPDS file N. 77-2207]. It was also observed that the (200) peak diffraction appears again and the FMWH of the GaAs (400) decreased compared to that of porous GaAs. This result confirms well the deposit of a compact CdSe layers on the porous structure with a good crystallinity. Furthermore, this result confirms the SEM image and reflected the Pl investigations.

## PL results

Figure 6 depicts respectively the room temperature spectra of starting GaAs substrate, porous GaAs layers and CdSe deposited on porous GaAs layers.

Pl spectrum of porous sample exhibits an infrared Pl peak at 1.32eV which shifted to the lower energies (red shift) compared to that of starting sample. This red shifted is attributed in many works to the fluctuation of band gap energy caused by the layers porosity and to the difference in lattice parameters between the starting GaAs and the porous sample (Sabataityte, 2002).

For the Pl spectrum of CdSe deposited on porous GaAs layers as we can see the appearance of pl emission peak with higher pl intensity centered on 2.08eV which attributed to the emission of CdSe nanoparticles. The comparison between the position of the emission result (2.08eV) and that of CdSe bulk to 1.7eV (Wang et al., 1999) showed a shift towards blue what could be due to the quantum effect of nanocrystals sizes.

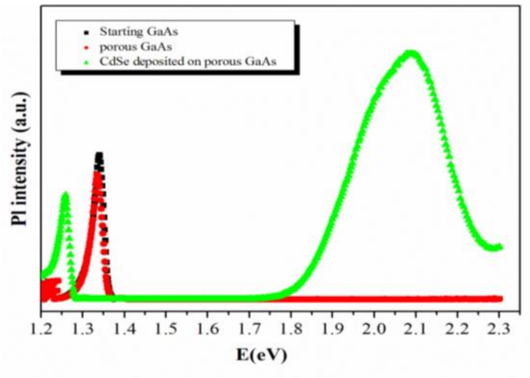


Fig.6 Room temperature spectra of starting GaAs substrate, porous GaAs layers and CdSe deposited on porous GaAs layers.

**UV.Visible:**

Figure 7 depicts the reflectance factor of starting GaAs substrate, porous GaAs layers and CdSe deposited on porous GaAs layers respectively, it can be seen that the reflectance factor of porous GaAs layers decrease after the deposing of CdSe nanoparticles indicate antireflection structure. For the range of wavelengths of visible light (300-800) nm, these spectra show that there is mark able decrease in the reflectivity of the samples that have undergone a deposition of CdSe nanoparticles compared to porous GaAs one. This decrease from almost 50 to 25 is mainly due to the increase in the surface roughness of porous GaAs after deposition, which is in agreement with the AFM topography. Optical improvements that occur during deposition of CdSe nanoparticles on Porous GaAs are related to the morphology and distribution of CdSe nanoparticles.

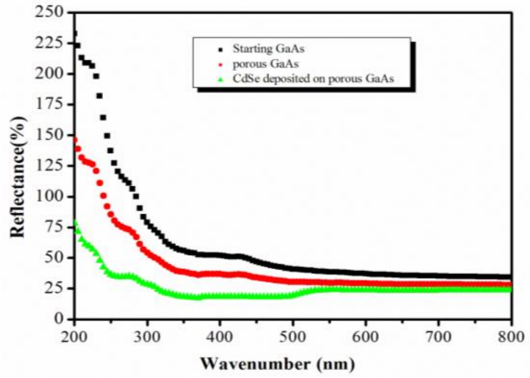


Fig.7 The reflectance factor of starting GaAs substrate, porous GaAs layers and CdSe deposited on porous GaAs layers respectively.

## CONCLUSIONS

In our work, we proved that the deposition of CdSe nanoparticles produce considerable variation in the morphological and structural properties of porous GaAs, confirmed by PL SEM and AFM investigations. This treatment allows to the decrease in the reflectivity and enhancement photoluminescence of the samples. To crop it all, we demonstrate that these improvements are due to the increase of roughness following the incorporation of nanoparticles in the pores. The XRD studies showed that a hexagonal structure was present in the as-grown CdSe layer on porous GaAs and was well crystallized. The main intense reflection peaks are the hexagonal (104) and (105).

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