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VARIATION OF PHOTOCURRENT OF ZnO/$(CdS)_{1-x}$ $(ZnS)_x$ CORE SHELL BUFFER LAYER NANOSTRUCUTURES WITH MICROWAVE POWER

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ABSTRACT

Band gap-graded ZnO/$(CdS)_{1-x}$ $(ZnS)_x$($0 \leqslant x \leqslant 1$) coaxial nanowire arrays on fluorine doped tin oxide(FTO) substrates have been successfully fabricated by afacile two-step-approach, combining sol-gel and microwave (MW) assisted method.We prepared the ZnO/$(CdS)_{1-x}(ZnS)_x$ core shell buffer layer nanostrucuturesby using zinc oxide (ZnO) nanowires (NWs) as the core / Zinc sulphide(ZnS) as the shell and buffer layer of cadmium sulphide(CdS). Three samples of ZnO/ $(CdS)_{1-x}$ $(ZnS)_x$ core shell buffer layer nanostructureswere prepared for different deposition time in MW at static power.We observe the peak intensity of deposited film prepared for less deposition time is high from XRD pattern. SEM indicates that the film density increases when deposition time increases and the same film shows high photoconductivity (PC) in rise and decay curve.

Keywords: Nanowire, Core-shell, Buffer layer, Photoconductivity.

I. INTRODUCTION

Band gap grading has attracted considerable attention for several decades for tuning electric and optoelectronic properties of semiconductors in optoelectronic devices [1-3].Core/shell buffer layer nanostructuresalter the charge, functionality, and reactivity of the surface, and enhance their thermal, chemical and mechanical stability[4,5]. Much effort has recently been invested to create new class of nanomaterial through different kinds of core/shell nanostructures have been fabricated by various synthetic methods, including the CdSe/ZnS nano crystals obtained by a biomimetic method [6], FePt/ZnO core/shell nanoparticles synthesized by a seed-mediated growth[7],ZnO@$Cd(OH)_2$ core-shell nanoparticles by a sol–gel method[8],CdTe/CdS/ZnS core/shell/shell quantum dots synthesized in the aqueous phase assisted by microwave irradiation[9], and so on. ZnO is a transparent oxide semiconductor that possesses piezoelectric properties, which has been widely used for Nano lasers [10], optoelectronic devices [11], solarcells [12], and electromechanical coupled sensors etc. [13]. CdS nanocrystals are one of the most studied systems among all the semiconducting nanocrystals [14].It has a direct band gap of 2.4 eV at 300 K, and the typical Bohr exciton diameter of CdS is around 5.8 nm. ZnS is a non-toxic semiconductor with a wide and direct band gap. The function of CdSbuffer layer in a hetero-junction is to form a junction with the absorber layer while admitting a maximum amount of light to the junction region and absorber layer [15]. Buffer layerremoves the contact which has high minority carrier recombination losses from the absorber or base layer and when these layers are used near the top of a cell, optical enhancement is achieveddue to reduced absorption and reflection losses[16].We report the synthesis ofZnO nanowire/$(CdS)_{1-x}(ZnS)_x$ nanoparticle heterostructure arrays fabricated by microwave assisted deposition

method through a facile hydrothermal approach[17].MW radiation played an important role in the synthesis and enhancement of the optical properties of the$ZnO/(CdS)_{1-x}(ZnS)_x$ core/shell nanostructures. Wesynthesized the $ZnO/(CdS)_{1-x}(ZnS)_x$ core/shell nanostructures at different deposition time in MW at static power. The morphological, structural, and optical properties of as prepared structure are studied by SEM (Scanning Electron Microscope), XRD (X-Ray Diffraction) and PC respectively.

II. MATERIALS AND METHODS

2.1 Synthesis of ZnO Nanowire Arrays

ZnO nanowire arrays were directly assembled on fluorine-doped tin oxide (FTO)substrates by a seed-assisted sol-gel method. FTO were initially dipped with (1:3 ratio of HCl and H_2O_2) solution for 24 hours and ultra sonicated in ethanol and deionized water for 30 min respectively, then dried it in air.After drying cleaned FTO substrates were deposited with thesolution containing ethanol, zinc acetate&MEA inan appropriate amount for the seed layer preparations by sol-gel method. Then, the coated substrateswere annealed in a muffle furnace under air ambient condition at 350 °C for one hour to form a seed layer ofZnO nanoparticles. Afterwards, the seeded-FTO substrates were immersed into a beaker containing 80 ml reaction solution containing 25mM zinc nitrate hexahydrate ($Zn(NO3)_3 \cdot 6H_2O$) 25mM hexamethylenetetramine (HMTA) (1:1) at microwave power 400watt at different time variation30m/ 50m/70m in pulse of 1min on/30 secoff. The as prepared NWs were washed with deionized water for several times and annealed at 350°C for 30min in a muffle furnace and rinsed with deionized water several times to remove the residuals and dried in air.

2.2 Synthesis of ZnO/ZnS Coaxial Nanowire Arrays

Anion exchange was adopted to fabricate ZnO/ZnS coaxial nanowire arrays based onas-synthesized ZnO nanowire arrays. ZnO nanowire arrays on FTO substrates were immersedinto 50mM thiourea (⩾99%) aqueous solution kept in MW at 500watt power. The final substrates were washed with deionized water for several times to eliminate the impurities anddried at 350°C.

2.3 Synthesis of ZnO/ $(CdS)_{1-x}$ $(ZnS)_x$ Coaxial Nanowire Arrays

Cation exchange reaction was adopted to fabricate ZnO/ $(CdS)_{1-x}$ $(ZnS)_x$ coaxial nanowire arraysbased on as-synthesized ZnO/ZnS coaxial nanowire arrays. The substrates with ZnO/ZnScoaxial nanowire arrays were immersed into 50mM cadmium chloride (CdCl2) aqueoussolutionkept in MWatpower 400watt at different time (30min,50min,70min) in pulse form as before.The final substrates werewashed with deionized water several times and dried at 350°C before being studied. The final structure is called ZnO/ $(CdS)_{1-x}$ $(ZnS)_x$ core/shell buffer layer nanostrucutures arrays.

III. RESULTS AND DISCUSSION

3.1 XRD Characterization

XRD characterization can establish the crystal structure of the obtained nanostrucutures by using CuKα radiation (1.5418A^o). Figure 1, gives peaks of ZnO nanowires which can be related to hexagonal structure with cell constant. a = 3.34A◦ and c = 5.29A◦ characterizing the wurtzite structure (JCPDS number 36-1451). The films prepared with MW irradiation for 30m show low intensity peak while the film prepared for long duration like 50m,70m show higher peak intensity.

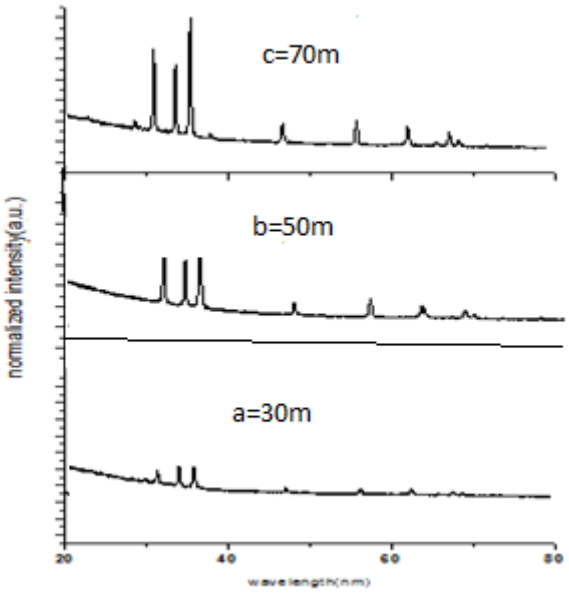

Fig 1. XRD images of ZnO/(CdS)1−x(ZnS)x coaxial nanowires prepared by microwave assisted method at different time (a)30min (b)50min(c)70min respectively.

3.2 Scanning Electron Microscopy

The surface morphology of the ZnO/ $(CdS)_{1-x}$ $(ZnS)_x$ core shell buffer layer was examined by using Scanning electron microscope(SEM). The SEM micrographs of the film at different deposition time for 30min, 50minand 70 min are shownin Figure 2.SEM images show that the growth density of the composite layer increases as the deposition time increases.

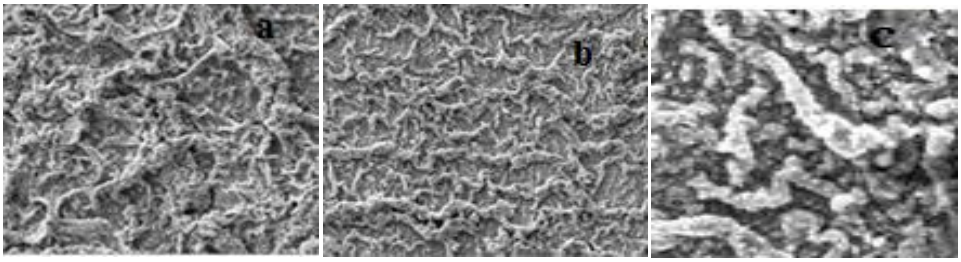

Fig2. SEM images of ZnO/$(CdS)_{1-x}(ZnS)_x$ core shell buffer layer prepared by microwave assisted method at different power variation at (a) 30min (b)50min (c)70min.

3.3 PC Rise and Decay Studies

Because of the high surface-to-volume ratio, trapping atsurface states drastically affects the transport and photoconductionproperties of NWs [18].Fig.3 showsthe photoconduction mechanism in the presence of a highdensity of hole-trap states at the ZnO/ $(CdS)_{1-x}$ $(ZnS)_x$ core shell buffer layer upon illuminationwith photon energy larger than the semiconductor bandgap (Eg), electron-hole pairs are photo generated and holesare readily trapped at the surface, leaving behind unpairedelectrons, which increase the conductivity under an applied voltage for more deposition time. Fig-shows higher saturation current for films grown at higher MW exposure time. This can be related to the fact that the grain density increases with higher exposure time leading to better PC.Further, the also increased with greater exposure time leading to better conductivity of electrons.

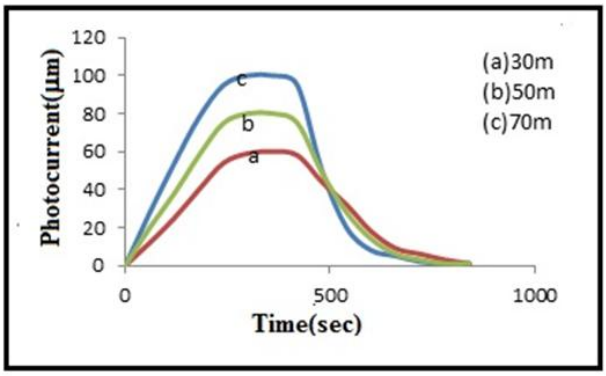

Fig 3:Rise and decay curve of ZnO/ $(CdS)_{1-x}$ $(ZnS)_x$ core shell buffer layer for different deposition time.

IV. CONCLUSION

We have prepared nanostructure ZnO/ $(CdS)_{1-x}$ $(ZnS)_x$ core shell buffer layer on SnO2: F glass by microwave assisted method. Opticalmeasurements indicate that the layer of long deposition time shows high PC which is very favorable for the use in photonic devices and solar cell application.

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