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Study of Photoconductivity in ZnO Nanoparticles Synthesized by Co - Precipitation Method

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ABSTRACT

In present work an attempt has been made to study photoconducting properties of ZnO nano particles synthesized by Co- precipitation method. Structural study has been performed using XRD and SEM. Rise and decay curve of photo current exhibits almost anomalous behavior during steady illumination.

1. INTRODUCTION

Nanometer-sized semiconductor materials have attracted scientists and researchers these days. Semiconductor nanomaterials have novel electronic and optical properties originating from quantum confinement. Currently, II–VI compound-semiconductors with dimension in nanometer range such as ZnO, CdS, CdO and ZnS have generated considerable interest due to their widespread applications such as photodetectors, solar cells, laser, sensors and light emitting diodes [1-3]. This provides us opportunity to study physics in small dimensions which in turn provides optical and transport properties including photoconductivity properties under UV and visible excitation exhibited by these materials.

In the last few decades, ZnO has got more attention due to its specific electrical, catalytic, optoelectronic, and photochemical properties. Its band gap energy of 3.37 eV [4] in the ultraviolet (UV) range has generated much interest in various applications [5-7]. ZnO nanostructures are becoming increasingly attractive because their properties are different from those of the bulk counterparts. The high surface- to-volume ratio, surface defects, and surface states of ZnO nanostructures are important in their optical, electrical, semiconducting, piezoelectric, magnetic, sensing, and transport properties. As a result, ZnO nanostructures have been widely used in piezoelectric transducers, gas sensors, photonic crystals, light-emitting devices, photoconductors, photodiodes, optical wave guides, transparent conductive films, varistors, solar cells, and acoustic wave devices [8-12]. Different types of zinc oxide nanostructures such as nanorods, nanotubes, nanonails, nanopencils, nanoribbons, nanowires, nanobelts etc. has been synthesized by use of different synthesis methods [13-15].

Photoconductivity is an important property of materials and has been extensively studied and used in a variety of applications [16-18]. Photoconductivity in a semiconductor usually arises as a result of generation of electron - hole pairs in the material after absorption of a photon of suitable energy. The photoconductivity of a large number of bulk materials, viz. Se, ZnS, ZnO, MgO etc. has been studied by several workers [19-22].

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In the present work, ZnO has been synthesized by Co-precipitation method. In the first stage ZnS has been synthesized and further annealing it at 700 ^{0}C for two hours we get the ZnO NPs.

2. EXPERIMENTAL SECTIONS

2.1. Chemicals

Zinc acetate ($Zn(CH_3COOH)_2 .2H_2O$) and sodium sulfide (Na_2S) were purchased from E. Merk Ltd., Mumbai. These chemical were directly used without any special treatment.

2.2. Sample Preparation

For synthesis of ZnS, 10ml of 1M zinc acetate was mixed in 80 ml of double distilled water. In the above solution 10ml of 1M of Na_2S was added drop wise under vigorous stirring for 24 h. A white precipitate was obtained which was separated by centrifugation and washed several times with double distilled water and ethanol. The precipitate was dried in muffle furnace at 80 ^{0}C overnight to get the sample in powder form and that powder was annealed at 700 ^{0}C for two hours. Finally we get ZnO in powder form.

2.3 Instrumentation

The samples were characterized by XRD, SEM and PC studies. The crystal structure of ZnO NPs was characterized by X-Ray diffraction using rigaku D/MAX-2200H/PC with Cu Kα radiation (λ¼1.54 Å). In Photoconductivity study, photocurrents were measured with help of a cell type device. The cell was mounted in a dark chamber with a slit where from the light is allowed to fall over the cell. An Hg-bulb of 300W was used as a photo-excitation source. A stabilized dc field was applied across the cell to which a digital dc nano-ammeter, NM-121 (Scientific Equipment, Roorkee) for the measurement of current and RISH Multi 15S with adapter RISH Multi SI 232 were connected in series.

3. RESULTS AND DISCUSSION

Figure 1 shows XRD patterns of ZnO nanoparticles (NPs) at room temperature by Co-precipitation method. Peaks from the (100), (002), (101), (102), and (110) planes were observed for ZnO NPs. Peak positions and relative peak intensities were indicative of the wurtzite structure corresponding to JCPDS card no. 75-0576 [23]. The peak corresponding to lattice plane (101) was most prominent. No impurity peaks were observed, indicating the prepared ZnO was of high purity. Average crystallite size was calculated by use of the Scherer formula. Crystallite size of the NPs is in the range 78 nm.

$$D = \frac{0.9\lambda}{\beta \cos\theta} \text{.....} \qquad (1)$$

where D is crystallite size, k is the x-ray wavelength used in XRD, h is the Bragg angle, and b is the full width at half-maximum of the peak, measured in radians.

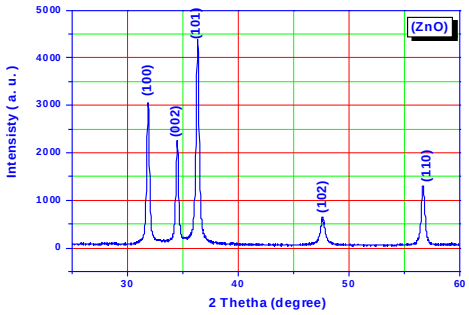

Fig.1: XRD patterns of ZnO nanoparticles synthesized at 700 ^{0} C temperatures by Co-precipitation method.

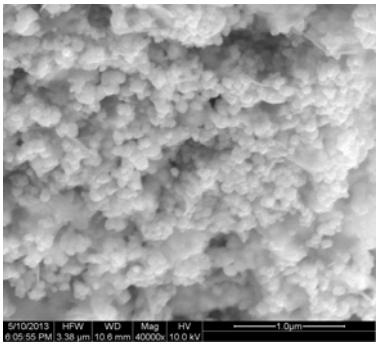

Fig. 2: SEM images of ZnO NPs synthesized by Co-precipitation method.

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Figure 2 shows SEM images of ZnO NPs synthesized at 700 ^{0}C. It is apparent from the figure that the particles are pseudo-spherical. Grain size calculated from SEM imaged is slightly greater size calculated from XRD which is due to agglomeration.

Figure 3 shows the time-resolved rise and decay of photocurrent for ZnO NPs synthesized by co-precipitation method at 700 ^{0} C at room temperature. The cell was first kept in dark until the dark current became stable. As the light was switched on the photocurrent initially increased very rapidly and reached a maximum value. This initial fast increase in the photocurrent is because of rapid generation of carriers as a result of absorption of photons. After attaining the peak value photocurrent then starts to decrease, and eventually stabilizes. When the light was switched off, the photocurrent initially decreased, because of recombination of photo-generated carriers, and later stabilized at a value lower than that of the dark current. Similar anomalous photoconductivity behavior has been reported for ZnO nanowire, Co-doped nanobelts, and Cu-doped ZnS, among other materials, by several authors [23–26].

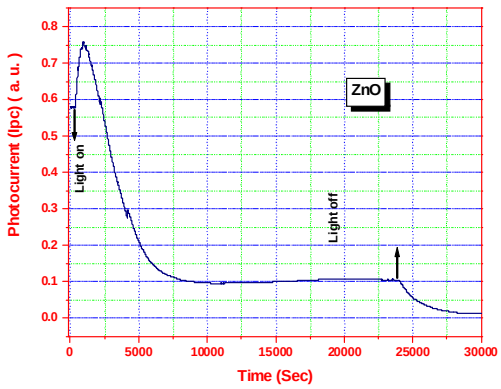

Fig.3: Rise and decay curves of photocurrent for ZnO NPs synthesized by Co- precipitation method

4. CONCLUSION

In this work, ZnO NPs were synthesized by a Co-precipitation method at 700 ^{0}C temperature. From the XRD peak positions and relative peak intensities it is indicated of formation wurtzite structure. SEM image shows agglomeration of particles. Anomalous photocurrent behavior, i.e. a decrease even during steady illumination, is observed for ZnO NPs.

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