**PbS NANO THIN FILM PHOTOCONDUCTIVE DETECTOR**

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**ABSTRACT**

The IR photoconductive detector was fabricated using PbS film prepared by thermal spray pyrolysis technique. The PbS was grown on glass substrate heated 300°C. The films structure was determined by X-ray diffraction studies. The photoluminescence spectrum were studied which show the optical band gap of around 1.6eV. The aluminum electrodes were evaporated on the film to fabricate the IR photoconductive detector. The photoresponsivity, the rise time and the fail time were measured under illumination of PbS film by 23mwatt IR radiation from Gun IR-led. The dimension of the prepared film was estimated by using AFM technique.

**KEYWORDS:** PbS Thin Film, Photoconductive Detectors, Nano Thin Film

**INTRODUCTION**

Lead sulfide (PbS) is a material of interest in a variety of applications including IR detectors and solar cells, due to its small band gap (0.4 eV) [1], and a relatively large excitation Bohr radius of 18 nm [2]. Also there are many other applications for PbS as photo resistance, diode lasers, humidity and temperature sensors, decorative and solar control coatings [3,4]. There are a number of physical and chemical methods for preparing thin films, like pulsed laser deposition, ion beam sputtering, thermal evaporation, vacuum deposition, chemical vapor deposition, co-precipitation, sol-gel, chemical bath deposition etc. (PbS) thin films have been deposited on glass slide substrates via a simple and easily controlled method, proceeding large area films, using the chemical bath deposition technique[5].

Owing into simplicity and inexpensiveness, the Chemical Spray pyrolysis (CSP) technique is a better chemical method at a lower cost for the preparation of thin films with a larger area[5]. Also, it provides an easy way to dope any element in a ratio of required proportion through the solution medium. This method is convenient for preparing pinhole free, homogenous, smoother thin films with the required thickness.

**THE EXPERIMENTAL WORK**

In this work PbS nano film has been implemented by chemical spray pyrolysis technique. The PbS nano films were deposited on glass substrates heated to 300°C by using hot plate heater. The spray solution is prepared by mixing lead acetate (0.1M) and thiourea (0.1M).

The pH of the bath was 9.06 by adding drop wise of aqueous ammonia. The mixture solution was placed in the flask of the atomizer and spread by controlled the spraying time was 4 sec. which controlled by adjustable solenoid valve. The heated substrate was left for 12 sec after each spraying run to give time for the deposited (PbS) layer to be dry.

The experimental parameters which control the homogeneity and thickness of the film are the spraying time, the height of the atomizer and the pressure of the nitrogen gas. The experimental set up of thermal chemical spray pyrolysis technique is shown in figure (1). [6]
Figure 1: The Experimental Set up of Thermal Chemical Spray Pyrolysis Technique

The crystalline structure of the film is studied by using X-ray diffraction (XRD). The photoluminescence spectrum was found using spectro fluorometer recorder. The optical band gap of the PbS film is founded from the photoluminescence spectrum which is around of 1.6eV. Interdigitated aluminum ohmic metal contacts were deposited on the PbS thin film substrate by vacuum evaporation to fabricate the PbS IR detector. The micro mask of (400μm) electrode spacing was used to deposit the electrical electrode on the PbS layer surface. The photo responsivity, the rise time and fail time of the IR photoconductive detector is measured by illuminating the PbS film by 804 nm, 23 mwatt Gun IR-led. The electrical circuit applied in the measurements of the detector parameters is shown in Figure 2

Figure 2: The Experimental Set up of Measuring the Detector Parameters

RESULTS AND DISCUSSIONS

An X-ray diffraction was employed for studying the structure of PbS films, using XRD-6000-Shmadzu system. The sharp structural peaks in the XRD pattern confirmed the crystalline nature having cubic phase structure of the films. [7]. We can see from figure (3) that (200) is the intense peak as compared to others. The same results was obtained by R.S.Patil et.al.[8].The other peaks was in (111),(220),(311)and (222). The diameter of the PbS nano particles is calculated by using Scherer’s equation

\[ D = \frac{\alpha \lambda}{\beta \cos \theta} \] (1)
Where $D$ is the is particle diameter of nano crystallite, $\alpha$ constant (0.9), $\lambda$ the X-ray wavelength (1.5418Å), $\beta$ the half-width of the diffraction peak. The crystallite size was 82nm indicates the film is nanocrystalline.

![Figure 3: The XRD Pattern](image)

The optical properties of the prepared nano PbS film is studied during this work by using the photoluminescence spectrum. The photoluminescence spectrum (PL) of PbS film excited by 320nm line is shown in figure (4). The energy band gap from photoluminescence spectrum of the PbS film is calculated by using the following equation:

$$E_g = \frac{1240}{\lambda (nm)}$$

The calculated energy gap for the nano crystallite PbS was 2.58333eV, this results agreed with the results obtained by other authors [8].

**Scanning Probe Microscope**

The morphology of the PBS thin film through the micrograph of the scanning probe microscope with its linear scan measurements is shown in figure (5). The figure shows that the film is uniform.
The current-voltage (I-V) characteristics of the fabricated device were illustrated in figure (6). The linear I-V curves referring to the ohmic nature of the detector. The dark current 10μA, while the photocurrent is highly increased under the illumination by 804 nm IR light of 23 mW power.

The most important parameter of photoconductive detector is the responsivity. Responsivity of the prepared PbS IR detector is determined using the following equation:

$$R_\lambda = \frac{I_{ph}}{P_{in}}$$  \hspace{1cm} (2)

By using equation (2) the responsivity is 0.3565mA/mW under illumination by light source of 23mW and photocurrent is 15.5μA. The on/off state corresponding to the exposure of the IR light is illustrated in figure (7). The rise time of the PbS detector is in order of 7 sec, whereas the fall time is in order of 76 sec.
REFERENCES


