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Optical Properties of PbS Nanoparticles Grown by Chemical Reduction Route

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ABSTRACT

A simple chemical Reduction Route method has been successfully used to fabricate lead sulphide (PbS) nanoparticles (NPs). In this process Sodium Borohydride was used as reducing agent in the medium THF. The speed of rotation was varied from 5000 rpm to 9000 rpm. UV-visible spectrum was used to calculate the band gap of the nanoparticles. The value of the band gap also suggests the quantum confinement effect. It is observed that optical band gap is increased as the speed of rotation is increased. For a particular RPM the growth mechanism is optimum with respect to other speed. Photoluminescence spectrum of PbS NPs shows emission in NIR region.

***Keywords*:** PbS nanoparticles; Absorption; Band-gap; Photoluminescence

1. Introduction

Nanocrystalline PbS particles has attracted an increasing interest in recent because of their favorable electronic and optical properties for optoelectronic applications [1-4, 15-16]. PbS is a commercially important II–VI direct band gap semiconductor having a narrow band gap (0.41 eV at 300K) rendering it a very attractive material for optical application in the IR region especially in nanocrystalline form [7-8]. PbS has a large excitonic Bohr radius (around 18 nm), high dielectric constant (18) and very high carrier mobility (0.44 $Cm^2\ V^{-1}.S^{-1}$) [7-8]. Hence, PbS NPs exhibit strong quantum size effects for relatively large sizes.

In this work, nanocrystalline PbS structures are formed via a chemical reduction method in room temperature [5, 9]. The chemical method is cost effective and free from experimental hazards [18-20]. Effect of rotational speed (in RPM) of the solution during growth for the formation of PbS nanoparticles are studied by optical spectroscopy.

2. Experimental section

For the preparation of PbS nanoparticles stoichiometric amount of anhydrous $PbCl_2$ and Sulphur powders were used according to the molar ratios in the target compounds. THF and $NaBH_4$ used as Solvent and reducing agent respectively. The ratio of anhydrous $PbCl_2$, sulphur power(S), sodium borohydride ($NaBH_4$) is 1:1:1 and the RPMS are 5000

(PbS-1), 7000 (PbS-2), 9000 (PbS-3). The, optical and photoluminescence properties of as grown samples are characterized by optical absorption and photoluminescence techniques. . Optical absorption measurements were carried out by using Shimadzu-Pharmaspec-1700 UV-VIS in the range 200–900 nm. Room temperature photoluminescence (PL) data were recorded in a PERKIN ELMER LS-55 spectrometer using Xenon lamp as a source of excitation.

3. Results and discussions

3.1. Optical band gap

Optical absorption coefficient has been calculated in the wavelength region 200–900 nm [6]. Optical absorption coefficient (α) is calculated at each wave length. The band gaps of the as-prepared nanoparticles are determined from the relation [10-11]

$$(\alpha h\nu)^2 = c\,(h\nu - E_g)$$

where C is a constant. E_g is the band gap of the material and α is the absorption coefficient. The estimated band gap of the samples PbS-A, PbS-B, PbS-C are 1.1 eV,1.3eVand 1.2eV respectively(shown in fig.1) [12,17] .This shows that at 7000 RPM the particle size is probably reduced and hence this speed of rotation is utilized for the growth of nanoparticles under different condition.

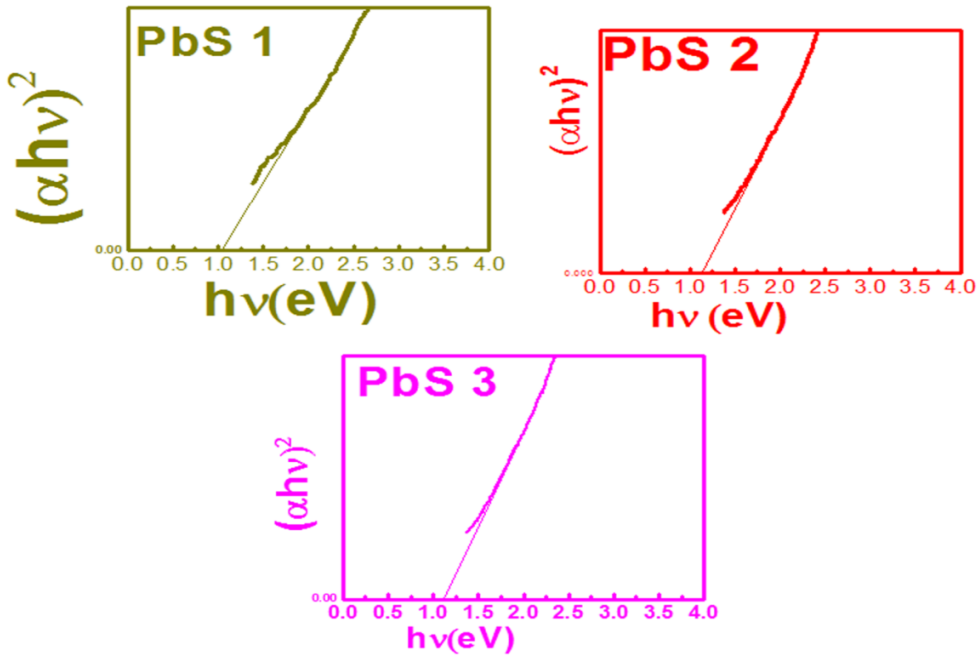

Figure 1: Band gap determination plot of the samples PbS-A, PbS-B, PbS-C

3.2. Photoluminescence spectra

Fig .2 displays the PL spectra of the samples dispersed in ethanol. The excitation wave length is 640 nm in each case. PL peaks are found to be broad around 832 nm (PbS-A), 782 nm (PbS-B), 790 nm (PbS-C). PL study indicates that observed broad peaks centered

on 832 nm, 782nm, 790 nm are commonly attributed to the recombination of charge carriers within surface states. The photoluminescence spectrum of PbS NPs (Fig.3) shows emission in NIR region [13-14].

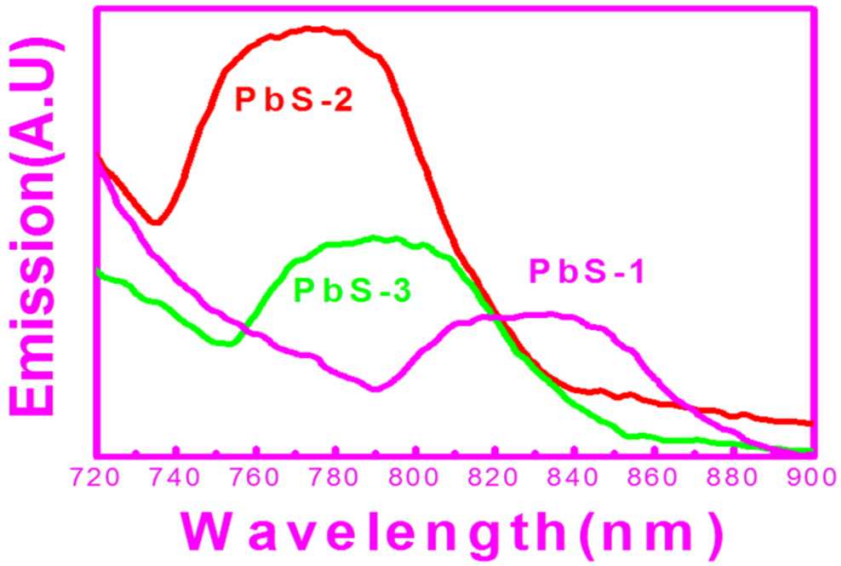

Figure 2: Emission spectra of PbS-1, PbS-2, PbS-3 nanoparticles

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