International Journal for Research in Engineering Application & Management (IJREAM)
ISSN : 2454-9150 Vol-04, Issue-05, Aug 2018

Review on the Synthesized Zinc Sulfide Nanoparticles Using Different Techniques

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Abstract - Quantum dots are semiconductor materials with dimensions of some power nanometers. Because of their size, they are also called nanoparticles or semiconductor nanocrystals. One of the most interesting characteristics of this type of materials is the quantum confinement of electrons in a small space. Quantum confinement confers special properties to these semiconductor nanoparticles which are dissimilar as of the bulk materials. By controlling the bulk and form of quantum confined materials, it is possible to tune their optical and electronic properties making them suitable for numerous applications. During the last few decades a great deal of research has been performed on different types of nanostructure materials. In this review paper I have to discuss the several method for the synthesized zinc sulfide nanoparticles using different techniques such as single source precursor, sonochemical, solid state reaction, solvothermal, microwave irradiation method, chemical vapour deposition method, spray pyrolysis, metal catalyzed thermal evaporation, thermal evaporation and electrophoretic deposition method.

Keyword: zinc sulfide, nanotechnology, confinement

I. INTRODUCTION TO NANOTECHNOLOGY

The term "nanotechnology" was for the first time used in 1974 by Prof. Norio Taniguchi. Nanotechnology was defined as follows: "Nanotechnology mainly consists of the processing of separation, consolidation and deformation of materials by one atom or one molecule" [1]. On 29 December 1959, Richard P. Feynman gave a talk that "There's Plenty of Room at the Bottom" [2]. He offered a scientific idea of great dwarf in 1959, many years ago the word "chip" became fraction of the glossary. He talked about the difficulty of distorting and preventing things on a small level. Extrapolating from known physical laws, Feynman envisioned a technology using the ultimate toolbox of nature, building nanoobjects atom by atom or molecule by molecule. In 1980s, numerous imaginations and discoveries in the making of nanoobjects have been proof to his dream. The K. E. Drexler gave the idea of "molecular nanotechnology" in 1986 using small molecular structures to act in a apparatus like manner. He projected the utilize of many robotic like machines called "assemblers" (or nanobots) that would form the basis of a molecular manufacturing technology capable of building literally anything atom by atom and molecule by molecule. Molecular ensembles present in plants, which include light-harvesting molecules such as chlorophyll arranged within the cells on the nanometer to micrometer scales, capture light energy and convert it into the chemical energy that drives the biochemical machinery of plant cells.

Nanoscale technology is the skill to distort single atoms and molecules to fabricate nanostructure materials and have many uses in universe. Nanotechnology involves the production and application of physical, chemical and biological systems at scales ranging from individual atoms or molecules to about hundred nanometers, as well as the integration of the resulting nanostructures into larger systems. Nanoscale technology is likely to have a deep impact on our market and culture in the 21st century. Science and technology research in nanotechnology promises breakthroughs in areas such as materials and manufacturing, nanoelectronics, medicine and healthcare, energy and the environment, biotechnology, information technology and national security. It is broadly numnah that nanotechnology will be the next trade uprising. When the dimension of a material is reduced from a large size, the properties remain the same at first and then small changes occur, until finally, when the size drops below 100 nm, dramatic changes in properties can occur. The word quantum is associated with these three types of nanostructures because changes in properties arise from the quantum-mechanical nature of physics in the domain of the ultra small.

II. INTRODUCTION OF ZINC SULFIDE

Zinc sulfide has wide band gap semiconductor of 3.6 eV and this is oldest and very good materials in the industry of electronics with a large series of appliances with light-emitting diodes and capable phosphors in flat panel displays [3]. The excitation of ultraviolet, X-ray, cathode ray or electrical currents have been used in the luminescent properties [4]. Zinc sulfide have high refractive index and is used in photonic crystal devices in the visible to near-infrared [5]. At comprehensive situation, zinc sulfide have cubic sphalerite and hexagonal wurtzite [6]. Surprisingly, wurtzite zinc sulfide is much more desirable for its optical

 DOI : 10.18231/2454-9150.2018.0623

properties than the sphalerite phase [7]. ZnS roll under in two structures wurtzite and zinc blend. In these two structures some features are common:

- stoichiometry of Zn:S (1:1)
- coordination 4:4

Zinc blend has 4 asymmetric units in its unit cell and wurtzite has 2. Zinc blend is best thought of as a face-centered cubic array of anions and cations occupying one half of the tetrahedral holes.

Table 1: Zinc blend have statistics

Formula	Zinc Sulfide
Crystal System	Cubic
Lattice-type	Face-centred
Cell Parameters	Z=4, a = 5.41 A^{o}
Atomic Positions	Zn: 0.25, 0.25, 0.25 S: 0, 0, 0
Density	4.103 gm cm^{-3}
Melting Point	Phase transition at 1020^{o}C
Alternate Names	Zinc blend, Sphalerite

Zinc Sulfide nanocrystals is a quantum dots i.e. the particle in a three dimensional box and hence three dimensions are confined so there is zero degree of freedom. Quantum-dots have discrete energy levels. As expected, quantum dots of ZnS have electronic structures between those bulk and molecular materials, and quantum confinement effects should be evident by a blue of the absorption edge with decreasing particle size.

III. SYNTHESIS OVERVIEW

Yi Yong et. al. [8] have synthesized ZnS nanocrystals in polymer matrices. Absorption spectrum and small-angle x-ray scattering (SAXS) studies showed that the particle size of the ZnS was 3.0 nm. Electron diffraction results showed that the ZnS nanocrystals have hexagonal structure.

Navendu Goswami and P. Sen [9] have synthesized ZnS nanoparticles lacking dopants or fascinating impurities. In this case ZnS nanoparticles were synthesized by electro-explosion of wire (EEW) method. The nanoparticles were prepared by electro-explosion of pure zinc wires in a cell filled with sulfide ions to produce a free-standing compound ZnS semiconductor. To investigate the structural and optical properties, these nanoparticles were characterized by x-ray powder diffraction (XRD), atomic force microscopy (AFM), UV–Vis and photoluminescence (PL) spectroscopy. Consistent with the enhancement of the PL intensity of the 443 nm peak due to deep blue emission of ZnS nanoparticles.

She Yuan-yuan et. al. [10] prepared Zinc Sulfide nanoparticles by solid-liquid chemical reaction route. In the method, at low temperature, ZnS nanoparticles were synthesized by reaction of ZnO and Na_2S in water with ultrasonic radiation. The effects of process parameters on the properties of ZnS particles were investigated. The products were characterized by x-ray diffraction (XRD), scanning electron microscopy (SEM), transmission electron microscopy (TEM) and infrared spectroscopy (IR).

Mahsa Mobarraz et. al. [11] have synthesized L-cysteine capped-ZnS nanoparticles in aqueous solution, and then fluorescence spectra shows the interaction of some of the amino acids. Electron transfer process between the capping ligands and histidine was mainly responsible for the remarkable quenching effect of histidine, because according to the structure of histidine, it is the strongest acceptor among essential amino acids.

V. L. Gayou et. al. [12] have synthesized, uncapped ZnS nanoparticles by a wet chemical method at room temperature. Qualitative differences in UV-Vis absorption spectra are discussed in the context of Z-contrast scanning transmission electron microscopy (Z-contrast), low and high resolution transmission electron microscopy (TEM) results. For the intermediate mixture, it has been found that about 78% of ZnS nanoparticles have a diameter smaller than the excitonic bohr radius of 2.5 nm. HRTEM studies have revealed that nanoparticles grow preferentially with hexagonal structure.

Rita John et. al. [13] have synthesized ZnS semiconducting nanoparticles by simple chemical reaction of $ZnCl_2$ and Na_2S in aqueous solution. The use of this method is non toxic precursors and water is used as solvent. The synthesized zinc sulfide nanoparticles have average size of 12 nm. The structural, morphological, chemical composition and optical properties of the nanoparticles have been investigated by x-ray diffraction (XRD), scanning electron microscopy (SEM), fourier transform infra red spectroscopy (FTIR), ultra violet spectroscopy (UV) and photo luminescence (PL).

S. Radhu and C. Vijayan [14] have synthesized wurtzite ZnS nanoparticles are synthesized by a low temperature chemical method using ethylene glycol. Photoluminescence studies reveal a new red emission along with strong UV and blue emission known to occur from nanocrystalline ZnS. An energy level diagram involving oxygen trap levels and interstitial sulphur ions is proposed to explain the origin of the observed emission peaks. Micro-Raman spectroscopic studies indicate that the optic modes get softened whereas the second order longitudinal acoustic (LA) phonon mode get hardened in the nanocrystals. The analysis is done by taking into account the effect of the small particle size of nanoparticles as well as the existence of defects resulting in strain in the lattice.

J. Mu et. al [15] prepared silica-coated ZnS nanocomposites by a seeded-growth method in iso-propanol. The results of XRD, HRTEM and UV absorption show that the ZnS nanoparticles can be incorporated in the silica nanospheres without changing the particle size, and the composites are

 DOI : 10.18231/2454-9150.2018.0623

of multi-core structure. UV absorption and emission spectra have been performed to check the character of the composites, which show that the silica shell not only increases the PL intensity, but also greatly improves the anti-oxidation ability and thermal stability.

M. S. Shinde et. al. [16] have synthesized nanocrystalline zinc sulfide (ZnS) thin films on glass substrate by modified chemical bath deposition method. The optimized preparative parameters including temperature, pH of solution, immersion time, immersion cycles, have been optimized for fine nanocrystalline film growth. As deposited nanocrystalline zinc sulphide (ZnS) thin films have been characterized for the structural, optical and electrical properties using x-ray diffraction (XRD), UV-Vis spectra and dc electrical conductivity method.

Satyajt Saha et. al. [17] have synthesized ZnS nanocrystals at room temperature by a cost effective chemical reduction method. The dispersed as grown samples in ethanol are characterized using electron diffraction techniques. Simultaneously optical absorption, photoluminescence of these samples is studied at room temperature. The increase of particle sizes and decrease of band gap of the as prepared ZnS nanoparticles are observed with increase in growth time.

Rajesh Kumar et. al. [18] have synthesized Monodispersed ZnS nanoparticles by the chemical precipitation method using polyvinyl pyrrolidone (PVP) as a surfactant at 80°C The products were characterized by x-ray Diffraction (XRD), transmission electron microscopy (TEM), UV-Vis and photoluminescent (PL) techniques. The sizes of the particles were found to be 4 and 6 nm for uncoated and PVP coated ZnS nanoparticles, respectively. The PVP coated ZnS nanoparticles exhibited high PL intensity than that of the uncoated ones besides an obvious blue shift.

Ashish Tiwari et. al. [19] prepared polyphosphate capped ZnS nanoparticles by simple aqueous method using thiourea as S^{2-} source. x-ray diffraction (XRD) shows the zinc blend structure. Surface characterization of the nanocrystals has been done by FTIR spectroscopy and it was found that the nanoparticles were sterically stabilized by sodium hexametaphosphate. Absorption spectra shows to find the optical band gap. Particle size was calculated by deriving an equation using effective mass approximation (EMA).

J. Taghavian et. al. [20] have synthesized ZnS nanoparticle via precipitation method. Two samples were synthesized and then characterized by XRD techniques, and the size were 11 nm and 23 nm.

Xue Chen et. al. [21] have synthesized zinc sulfide powders as a nanorings via thermal evaporation at 1050°C. This mechanism of ZnS nanoring formation is totally different from those proposed for the formation of ZnO, ZnSe, AlN and GaN nanorings via coiling of their polar surface and long-rang electrostatic interaction.

Rinki Bhadra et. al. [22] fabricated ZnS nanocrystals by chemical route. Characterization is done by UV-Vis spectroscopy, x-ray diffraction, photoluminescence, energy dispersive x-ray diffraction and high resolution transmission electron microscopy techniques. Sizes obtained for most of the samples are below exciton Bohr radius for ZnS, Zinc sulfide is used as a switching element.

Swaroop Kumar Maji et. al. [23] prepared ZnS nanocrystals in the form of powder and thin films by single-source procure (SSP) $[Zn(SOCPh)_2Lut_2.H_20]$. The powder was characterized by x-ray diffraction (XRD), field emission scanning electron microscopy (FESEM). Structural analyses of the prepared ZnS revealed the formation of cubic crystallites with diameters around 5 and l0 nm for the thin films and powder materials, respectively.

Yidong Zhang et. al. [24] have synthesized zinc sulphide (ZnS) microspheres using thiourea as sulphur source. The formation of these hollow spheres was mainly attributed to the oriented aggregation of ZnS nanocystals around the gas-liquid interface between gas (H_2S, NH_3, or CO_2) and water followed by an Ostwald ripening process. The products were characterized by x-ray diffraction (XRD), scanning electron microscopy (SEM), energy dispersive spectroscopy (EDS), transmission electron microscopy (TEM), high resolution transmission electron microscopy (HRTEM), selected area electron diffraction (SAED), electron diffraction (ED), and photoluminescence (PL).

Tran Thi Quynh Hoa et. al. [25] fabricated ZnS nanoparticles by hydrothermal method at temperature 220^0 C. The product was received in powder form. The structure, composition and optical property of the resultant product were characterized by means of x-ray diffraction (XRD), transmission electron microscopy (TEM), UV-Vis optical spectroscopy and photoluminescence (PL). The XRD pattern showed that ZnS nanoparticles have a zinc blend structure.

IV. CONCLUSION

In this review article the fabrication of zinc sulfide nanoparticles by various methods such as chemical precipitation, sol-gel, hydrothermal, thermal evaporation etc. have been studied. The synthesized nanoparticles were being characterized by using XRD, HRTEM, HRSEM, EDX, UV-Visible spectroscopy, TEM, PL, IR spectroscopy, FESEM, SAXS. Zinc sulfide in the form of nanoparticles or nanocrystals has many applications such as light emitting diode, flat panel display, infra red windows etc.

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