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Analysis of Synthesis Techniques and Properties of II-VI Semiconducting Compounds: A Review

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Abstract: *This paper provides a review focusing on synthesis techniques, various structures and the effect of capping agent on the size of semiconductor nanocrystalline materials. These semiconductor nanoparticles have potential applications in light-emitting diodes, small film transistors, solar cells and photoconductive devices. Compared to most bulk materials, these nano particles have unique properties. If the particle size of these semiconductors becomes smaller than the Bohr excitonic radius, quantum size effects occur and subsequently band gap of the material increases. Capping agents have an important role to play in particle size reduction. Keeping this in view, researchers have explored several new substrates and methods of synthesis using different capping agents for these materials. Some recent contributions of authors about new techniques and properties of nano materials and their use in a variety of fields are also discussed.*

Keywords: *Synthesis, capping agent, nanomaterials*

I. INTRODUCTION

Nano crystalline materials have attracted many material researchers due to their enhanced properties when compared to that of bulk materials. They are becoming increasingly interesting for optoelectronics and photonics. The electronic and electrical properties of such materials show a remarkable change as the particle size approaches that of its excitonic Bohr radius and then electrons and holes are subject to the effects of quantum confinement [1, 2] due to their wide range in volume, which has led to the formation of higher regions. Nanoscale semiconductors show exciting electro-optical structures and stimulating behavior [3]. As the size of the nanocrystal decreases, the strength of the initial solid state decreases, following the quality following the performance of the particle-box. This effect of the dependence on the size and emergence of the electronic structure separates from the continuous levels in the valence and conduction bands of the semiconductor effect in bulk is caused by quantum confinement. [4]

Semiconductor nano materials have a wide band gap with $E_g = 2.4$ to 3.7 eV at 300 K. As Compared to bulk materials and melting point, electronic absorption, gap strength, crystal structure, and other structures properties of these nano particles (CdS, CdSe, ZnS, ZnO, and TiO₂-NP) are also affected by size [5 - 7]. These synthetic nano particles can be used in the fields of electronic and photovoltaic devices [8], [9], catalysis, molecular diagnostics and interfacial electron transfer [10]. This detailed review shows some areas, which have not been adequately addressed so far. Various integration routes have been used over the past few years to accommodate these structures. They can be adjusted to customized sizes and structures such as increased durability, surface area, magnetic properties, optical and catalytic properties. This study includes the various techniques for the synthesis, structure and application of these nanomaterials in various fields and the effect of capping agent in size.

II. DIFFERENT METHODS

There are various methods for synthesis of Nanomaterials like Chemical Precipitation method, Hydrothermal method, Sol-gel method, Chemical Bath Deposition (CBD) method, Biosynthesis method. One method for synthesis of Nano Material is chemical co-precipitation method. Nanoparticles were synthesized with different sizes by chemical precipitation method [14]. Another method is hydrothermal method, in which nanoparticles with good crystallinity were prepared by hydrothermal method [15] in micro emulsion composed of polyoxyethylene lauryl ether/water/cyclohexane/butanol. This method is used to improve the photoluminescent property of the nanoparticles. Nanocomposites have also been synthesised by sol-gel method, and such prepared nanocomposites show much higher and more stable activity for photoluminescence (PL) properties. Nanocrystals are successfully grown in porous silicon (PS) sol-gel method [16]. The most common procedure for the synthesis of Cadmium sulphide is a chemical bath [17] where Nano Material is deposited on the glass substrate and thus a thin film is prepared. The film size is almost full when the deposition time is more than 90 min.

Although nanomaterials can be produced using a variety of traditional physical and chemical processes, it is now also possible by biological processes. Recent studies show the preparation of nano materials by biological method [18] or green synthesis. In this method, plant extract is used as a stabilizing/ reducing agent with less hazards towards environment, They can be easily scaled up, are stable, economically viable and suitable for large scale production.

III. DIFFERENT PROPERTIES OF NANO MATERIAL

Different properties of nanomaterials are presented in table no.1. There are various uses of nano materials such as solar cells, such as pigment, antireflection coating and others of great interest. Different synthesis methods and properties of nanomaterial have been reported by many researchers and this review would help in further investigations on this material [19].

Table 1: Different Properties of Semiconductor Nanomaterials

S. N o.	Name of Materials	Properties				Ref.
		Optical Properties	Structural Properties	Electrical Properties	Band Gap	
1	CdS	$\lambda = 200-700$ nm (wavelength)	hexagonal structures	photo voltage is higher and photocurrent is lower	2.45eV	20
2	ZnS	$\lambda = 570$ nm (wavelength)	hexagonal structures	operating at 40 kV and a current of 30 mA	3.54eV	21
3	CdSe	$\lambda = 500-650$ nm (wavelength)	hexagonal structures	operating at 40 kV and 40 mA	3.7eV	22
4	ZnO	$\lambda = 420-500$ nm (wavelength)	hexagonal structures	operated at 35 kV and 20 mA	3.37eV	23
5	TiO ₂	$\lambda = 360-720$ nm (wavelength)	tetragonal structures	operated at 42 kV and 120 mA	3.05eV	24

IV. EFFECT OF CAPPING AGENT ON SIZE

Capping agents are a basic component in the synthesis of nanoparticles with controlled size and well-defined shape. These results will be given in the construction of a metal-ligand interphase, its distinctive structures that deal with catalytic behavior. Therefore, understanding the structure of this interphase is critical to the use of a suitable nanocatalyst structure. This table provides an overview of the effect of capping agents on the size and structure of these substances [25].

Table 2: Effects of Capping Agents on size of nano materials-

S. N o.	Name of Materials	Capping Agents			Ref.
		Mercaptoethanol	Thioglycerol	PVP	
		Size	Size	Size	
1	CdS	4nm	2.8-5nm	3.8nm	26,27,28
2	ZnS	1.80-2.45 nm	1.85-2.44 nm	1.95-2.28 nm	29,30,31
3	ZnO	18-20nm	2.6-3.3nm	32nm	32,33,34
4	CdSe	3.5nm	1.9nm	74.68 nm	35,36,37
5	TiO ₂	7.4 nm to 20 nm	9.50-26.14 nm	29.20-49nm	38,39,40

V. CONCLUSION

A review on different synthesis methods, properties and effects of capping agent of nanomaterial is presented in this article. The different types of techniques used to synthesis nano materials and the various reported structures are also discussed.

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