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Effect of Transition Metal on Luminescence Quenching of Zns Nanoparticles

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Abstract — Quantum confinement effect changes the electronic structure of the nanocrystal. The most striking observation due to this effect is blue shift which is attributed to smaller particle size. ZnS nanoparticles are synthesized by chemical route gives a strong UV-Vis property at 315nm. But when these nanoparticles are doped with different nanoparticles their UV-Vis property changes which is used in opticalfilter design. We synthesized ZnS nanoparticles by chemical route with doping of Ni and characterized by UV-Visible photospectrometer, AFM in concentration range of 0 to 10 wt%. Variation in UV-Vis characteristic is recorded and discussed in this paper for different concentration of dopant ranging from 0 to 5 wt% for optical filter preparation.

Keywords— ZnS nanoparticles, doping, quantum confinement, UV-Vis, quenching

I. INTRODUCTION

Sulfide semiconductor materials in the nano dimensional range have attracted great attention recently, as it posses such important properties which us useful in light converting electrodes [1], optical filters [2] and quantum devices [3]. ZnS is an important semiconductor material with a wide bandgap of 3.54 eV for the cubic phase [4] and 3.68 eV for the hexagonal wurtzite phase [5] at room temperature. ZnS is an inorganic compound. Mainly occuring in the minerals sphalerite and wurtzite which are intrinsic, wide-band gap semiconductors. Applications for the ZnS materials could be given as : white pigment, detector of alpha-rays, luminescent, infrared optics, used as phosphor in several applications, including X-ray screens and cathode ray tubes[6].

Here, we have used transition metal material for confining the particles which can be said as Nickel [7]. Coatings, and high-performance magnetic recording materials, magnetic fluid nanoparticles, Microwave-absorption materials. applications of copper nanoparticles: EMI shielding, highly thermal conductive materials, [8]efficient catalyst for chemical reactions and for the synthesis of methanol and glycol, displays, and transmissive conductive thin film applications[9]. Nickel is electrically conductive and hence used for several applications: magnetic fluid and catalyst, propellant and sintering additive[10,11].

In this paper we have carried out detailed study to identify the effect of doping in the ZnS nanoparticles which results in quenching of the nanoparticles, decreased bandgap, increased particle size.

II. EXPERIMENTAL

ZnS nanoparticles were synthesized using wet chemical route. For the synthesis, EDTA (0.1 M) solution prepared in 20 ml distilled water. Then 10 ml of Zinc acetate (0.5 M) and 10 ml of Sodium sulphide (0.5 M) solution was added in EDTA solution drop by drop with stirring at room temperature and pressure. Stir the solution for 2 hours which leads to formation and precipitation of ZnS nanoparticles[12,13,14]. The solution was washed properly 4-5 times with distill water, dried in incubator and crushed using mortar pestel to obtain ZnS nanoparticles. For the synthesis of Ni doped ZnS nanoparticles Nickel Chloride solution (0.01 M in 100 ml) added drop by drop in EDTA solution along with Zinc acetate and Sodium sulphide solution[15,16]. The color of the solution turns out to be milky white which makes us to conclude that the ZnS nanoparticles formed. UV-Vis spectrum of NPs was taken using UV-Vis spectrophotometer SHIMADZU 1800[17,18,19]. The Nanosurf AFM used for the study of the particle size formation[20,21,22].

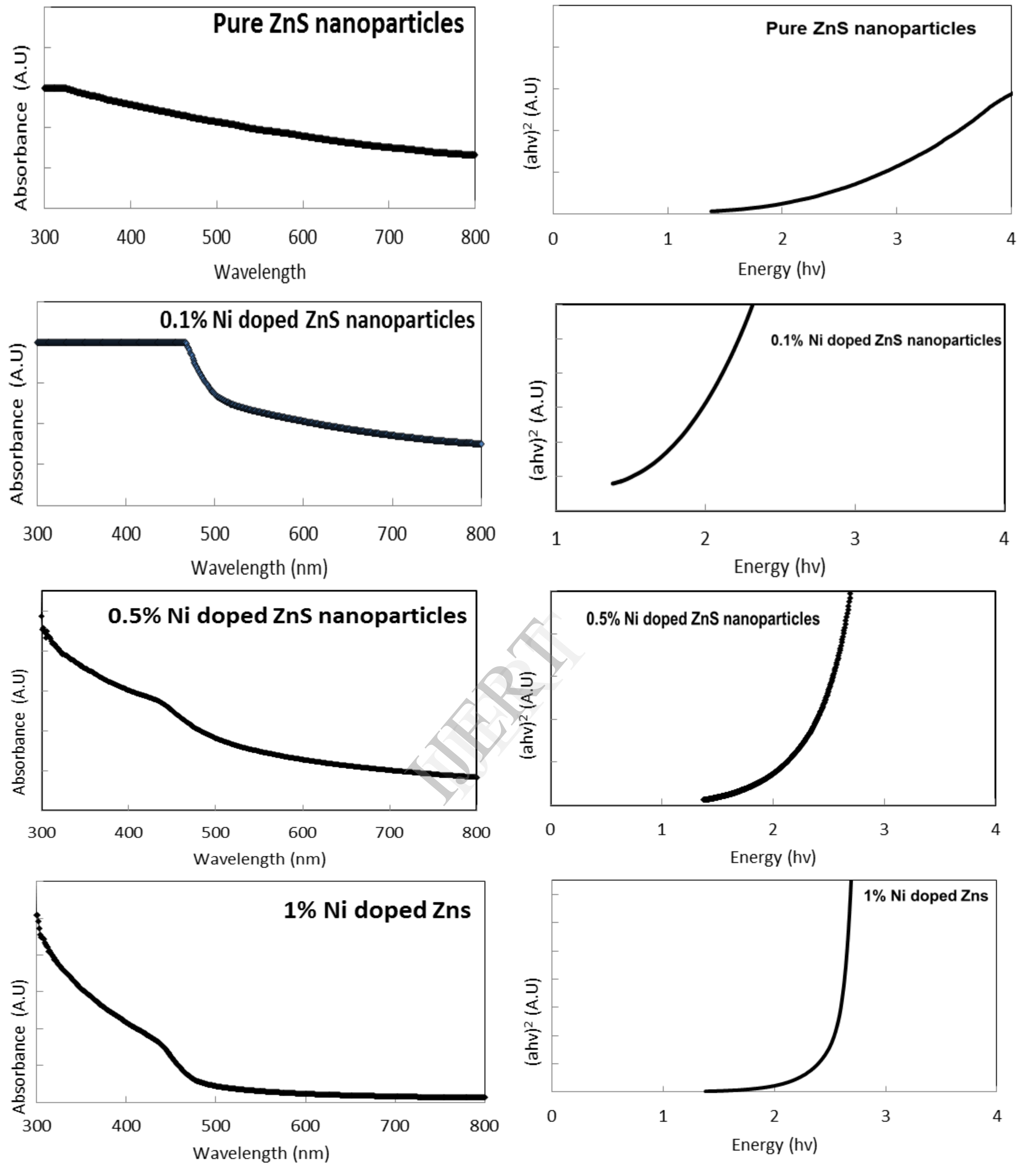

Fig. 1 UV-Vis characterization & Tauc Relation graphs of Ni doped ZnS Nanoparticles
(Pure ZnS, 0.1% Ni doped, 0.5% Ni doped, & 1% Ni doped nanoparticles)

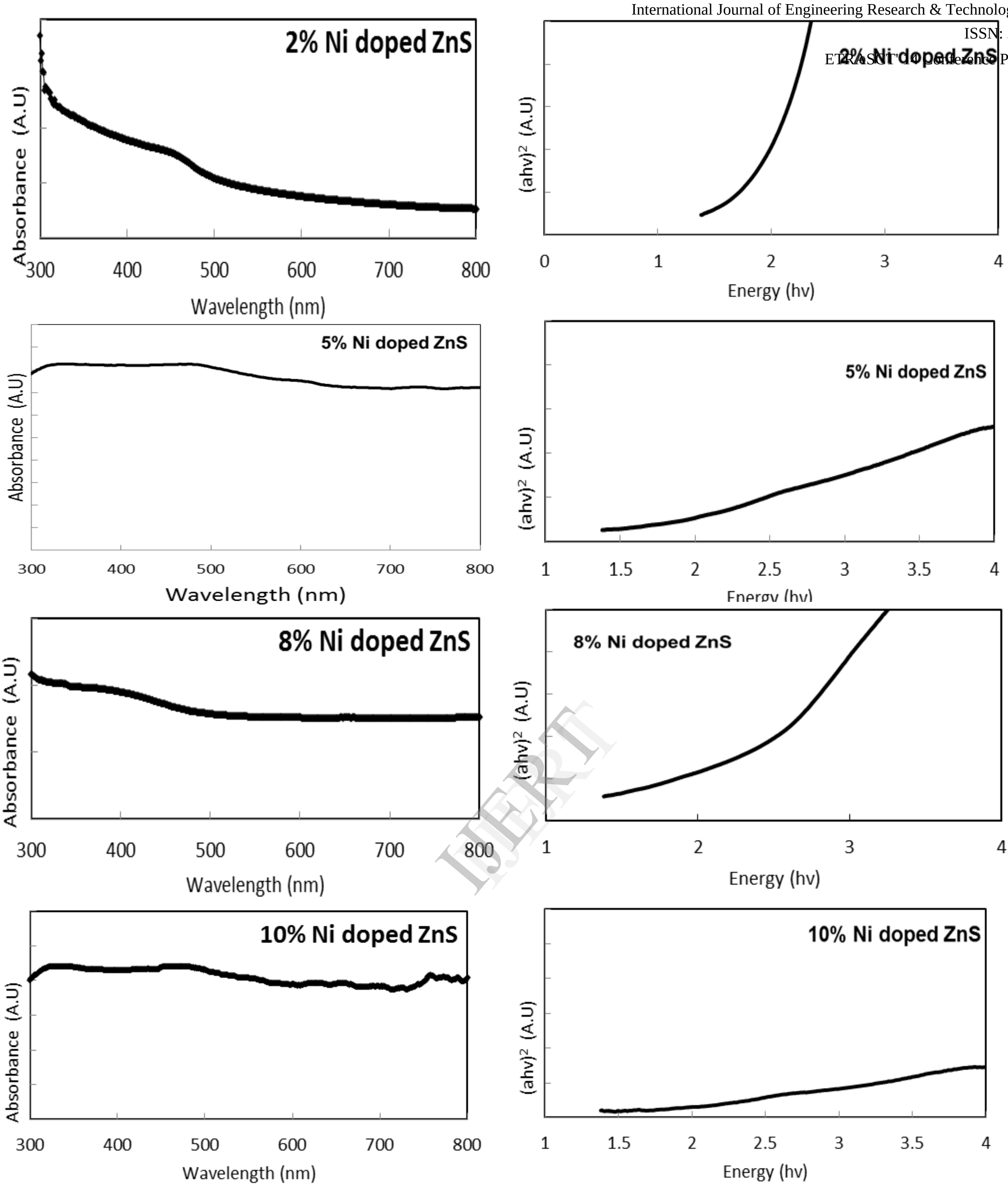

Fig. 2 UV-Vis characterization & Tauc Relation graphs of Ni doped ZnS Nanoparticles
(2% Ni doped, 5% Ni doped, 8% Ni doped & 10% Ni doped ZnS nanoparticles)

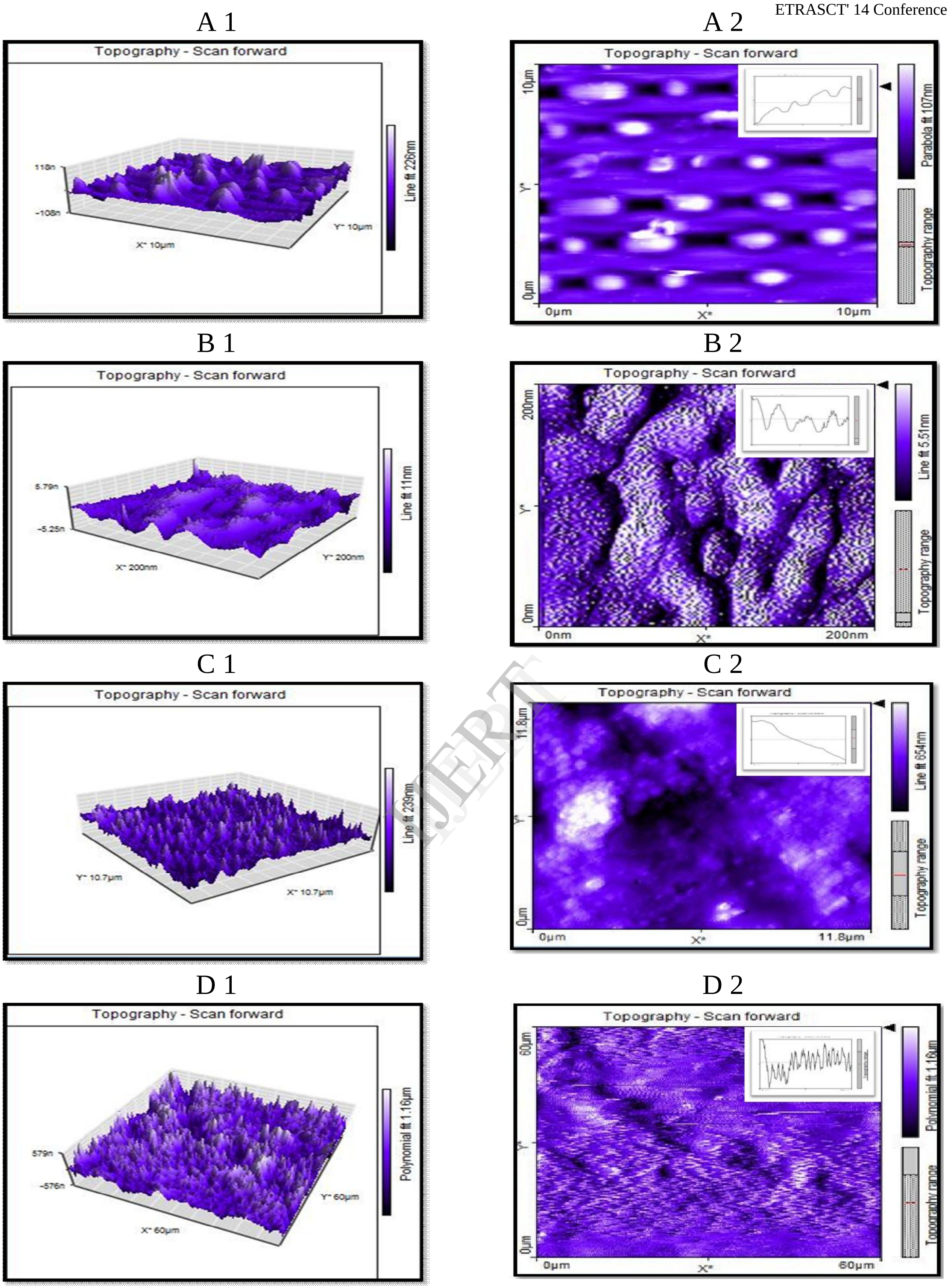

Fig. 3 AFM 3D graphs, standard graphs & line graphs(inset) graphs of Ni doped ZnS Nanoparticles **(A)** Pure ZnS Nanoparticles**, (B)** 1% Ni doped ZnS Nanoparticles**, (C)** 5% Ni doped ZnS Nanoparticles & **(D)** 8% Ni doped ZnS Nanoparticles

Sample	Bandgap (eV)	
Pure ZnS	2.4eV	
0.1% Ni	1.44eV	
0.5% Ni	1.41eV	
1% Ni	1.4eV	
2% Ni	1.41eV	
5% Ni	1.21eV	
8% Ni	1.21eV	
10% Ni	1.74eV	

Table 1. Variation in bandgap with increasing dopant amount

This table represents the variation observed in the bandgap based on the calculations done using Tauc Plot. The observed values can be depicted as the pure ZnS nanoparticle bandgap found to 2.4eV with decreasing bandgap while the amount of the doping increased. Upto to a certain amount of doping material, the bandgap shows lowering value but as the maximum amount of dopant material used i.e 10%, we found that the bandgap increased suddenly. Hence, we conclude based on these results that after certain amount of doping, bandgap start to increase.

The peak value for the ZnS nanoparticles found to be around 315nm using UV-Vis spectrophotometer & average particles size were also found using the same technique while the average band gap for the nanoparticles so synthesized found using the Tauc relation (fig 1,2). The doping of the transition metal found to decrease the band gap, increase the particle size & the absorbance peak shifts to the longer wavelength i.e Red shifting occurs. The average particle size found to be in 20nm for the pure ZnS nanoparticles while 65 nm for the maximum amount of the dopant used i.e 10% doping of nickel from the optical spectroscopy, while as the concentration of the dopant material is increased, it is observed that the particle size tend to increase while the band gap tend to show lower values ranging from pure ZnS nanoparticle which is having the bandgap around 2.4eV to maximum doping done as 10% Ni dopant in ZnS nanoparticles is 1.7eV (refer Table 1, fig. 1,2).

The AFM tool was used for the characterization of the pure nanoparticles & also the doped ones which when analyzed the particle size found to be in increasing order by using the depth profiling in the standard graphs with the line graphs indicating the average particles size (refer fig 3).

SUMMARY & CONCLUSION

The color change of the solution from colorless to milky white is a indication of the formation of the ZnS nanoparticles after which Nickel added as in various amounts, the visual observation was the color change of the so obtained milky white solution turns into bluish by which, we concluded that doping is successful. The further characterization was done using UV-Vis photospectrometer which gives us the absorbance peak value, using this data, change in bandgap & average particle size was found. The AFM was also used for supporting the results obtained using UV-Vis about the average particles size.

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