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Effect of silver doping on properties of ZnO nanoparticles by chemical precipitation method

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ABSTRACT
Silver doped ZnO nanoparticles are prepared by chemical precipitation method. XRD, FTIR, UV- visible spectra are used to determine the crystallite size, chemical bonding and optical properties of prepared nanoparticles. XRD analysis shows that the prepared samples are single phase and have hexagonal wurtzite structure. The crystallite size of Ag doped nanoparticles is determined using Scherrer method. From the optical studies, the band gap is found to be increased with doping. The different behaviour of different dopants can be explained on the basis of their different chemical nature and different ionic radii as compared to the host cation. All stretching and vibrational bands are observed at their specific positions through FTIR.
Keywords: XRD, crystallite size, FTIR, optical band gap, nanoparticles.

INTRODUCTION
ZnO materials have received broad attention due to their well-known performance in electronics, optics and photonics [1,2]. ZnO is a direct wide band gap (Eg ~ 3.3 eV) at room temperature and high excitonic binding energy (60 meV). This provides opportunities to develop transparent electronics, optoelectronics and integrated sensors [3]. In the last few years, ZnO has emerged as one of the most suitable materials due to its optical, electrical, mechanical and chemical stability properties. Although ZnO can be used as transparent conductive oxide, mainly for applications such as solar cells, liquid crystal displays [4-7]. Doping in ZnO with selective elements improve properties and accelerate the course of their practical applications [8-11]. Transition metals ion improves properties of ZnO due to exchange interaction between s and p electrons of ZnO and d electron of transition metal ion [12]. The metals of group IB are fast-diffusing impurities in the semiconductor compound. Among group-IB elements, Ag could be a good candidate for enhancing luminescence efficiency and producing p-type ZnO. The diffusion of silver into ZnO can cause variations in its lattice structure and physical properties. Many methods have been by used by researchers for synthesis of ZnO nanostructured materials like sol-gel method [13], electron beam deposition [14], an electro chemical route [15], colloidal chemical synthesis [16],chemical precipitation method [17] etc. Among these methods, chemical precipitation method is the best because it is less expensive and simple.

In the present paper, we report the structural and optical properties of Ag doped ZnO nanostructures synthesized through chemical precipitation process and their structural and optical properties are discussed.

EXPERIMENTAL
Ag doped ZnO nanoparticles were prepared by mixing Zinc acetate dihydrate , nickel nitrate and silver nitrate in a mixture of deionized water and ethanol with further purification. Then ammonia solution and sodium hydroxide solution were added in proper amount. The solution was kept in a water bath at 60^{O}C. Then precipitates were dried at 500^{O} C in furnace. Then dry precipitates were ground.

RESULTS AND DISCUSSION

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XRD ANALYSIS

The XRD patterns Ag ZnO nanoparticles are shown in Figure 1. X-ray diffraction study confirms that all peaks match the hexagonal ZnO structure and the diffraction peaks are in agreement with the standard data The X-ray diffraction data were recorded by using CuKα radiation. The average crystallite size of the nanoparticles is calculated using Scherrer [14]formula $D = 0.94\lambda / \beta Cos\theta$, where λ is X-ray wavelength used (1.5406 Å), β is full width at half maximum(FWHM),θ is Bragg's diffraction angle. There is a negligible shift in peak position as doping concentration increases.The different structural parameters determined through XRD pattern are given in table 1. It is found that with increase in doping, average crystallite size Ag doped ZnO nanoparticles increases.

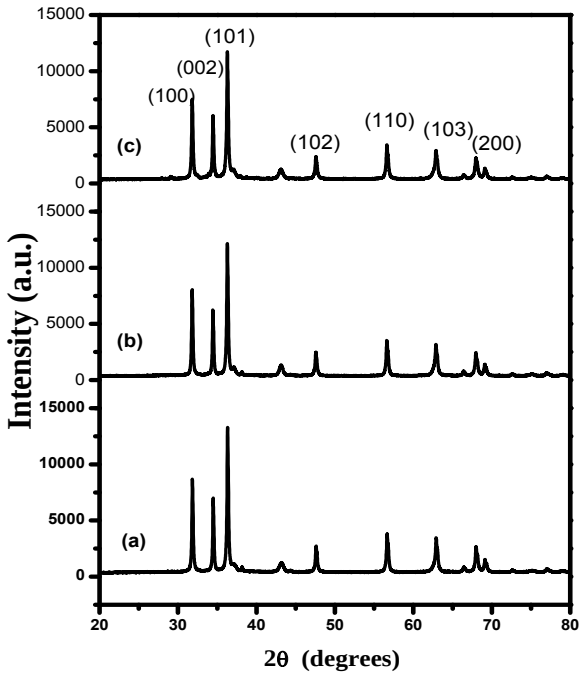

Fig 1. XRD pattern of (a) $Ag_{0.1}$ doped (b) $Ag_{0.2}$ doped (c) $Ag_{0.3}$ doped ZnO nanoparticles

Table 1. The structural parameters of (a) $Ag_{0.1}$ doped (b) $Ag_{0.2}$ doped (c) $Ag_{0.3}$ doped ZnO nanoparticles

Compound	D(nm)	Lattice Parameter (A^0)
$Ag_{0.1}$ doped ZnO	34.22	a =3.24 c/a=1.60
$Ag_{0.2}$ doped ZnO	36.37	a =3.24 c/a=1.60
$Ag_{0.3}$ doped ZnO	37.80	a =3.25 c/a =1.60

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UV-VISIBLE SPECTRA

Diffuse reflectance spectra was recorded to find optical band gap of Ag doped nanoparticles using UV-visible spectrometer. Figure 2 shows the graph between percentage reflection as a function of band gap energy. The band gap is found to be increased with increase in doping concentration. The blue shift is due to increase of carrier density which shifts the Fermi level close to conduction band and band gap increases that is explained through Burstein-Moss effect [18].

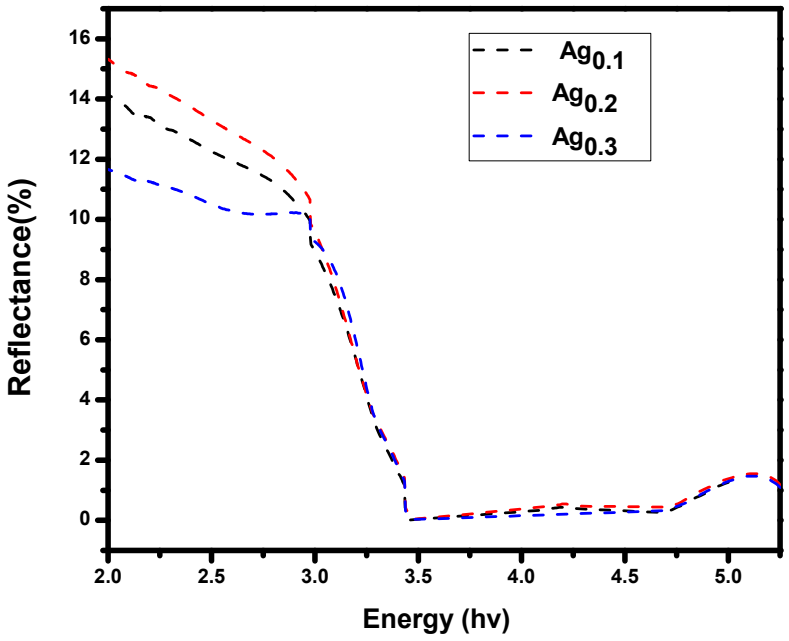

Fig 2. Diffuse reflectance spectraof (a) $Ag_{0.1}$ doped (b) $Ag_{0.2}$ doped (c) $Ag_{0.3}$ doped ZnO nanoparticles

Table 1. Optical band gap variation of(a) $Ag_{0.1}$ doped (b) $Ag_{0.2}$ doped (c) $Ag_{0.3}$ doped ZnO nanoparticles

Compound	Band gap (eV)
$Ag_{0.1}$ doped ZnO	3.55
$Ag_{0.2}$ doped ZnO	3.67
$Ag_{0.3}$ doped ZnO	3.79

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FTIR Analysis

FTIR is a technique used to get information about the chemical bonding in a material. It is used to identify the elemental constituents of a material. The band positions and numbers of absorption peaks depend on crystalline structure, chemical composition and morphology.

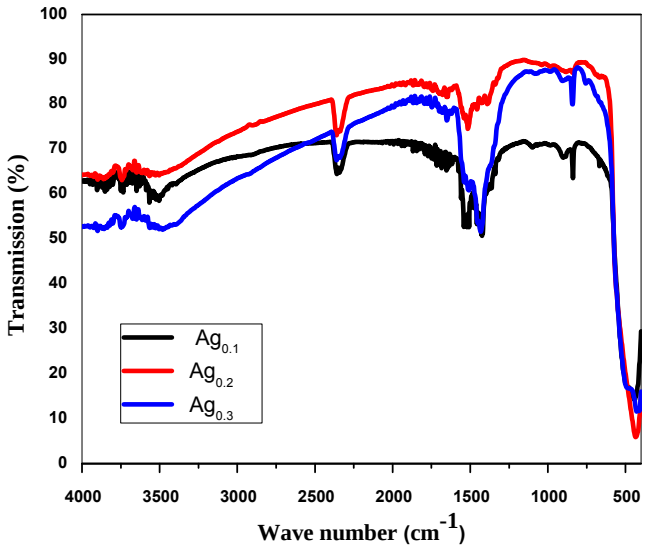

Fig 3. FTIR Analysis of(a) $Ag_{0.1}$ doped (b) $Ag_{0.2}$ doped (c) $Ag_{0.3}$ doped ZnO nanoparticles

The FTIR spectrum of Ag doped ZnO at room temperature is shown in Figure 3.All bands associated with silver are present. All stretching and vibrational bands are observed at their specific positions.

CONCLUSION

Ag doped ZnO nanoparticles have been synthesized successfully by chemical precipitation method. XRD studies confirm the hexagonal structure of the prepared samples. The average crystallite size of Ag doped ZnO nanoparticles is found to be increased with doping. The blue shift in band gap is due to increase of carrier density which shifts the Fermi level close to conduction band. All stretching and vibrational bands are observed at their specific positions and are confirmed through FTIR.

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