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AN OVERVIEW OF RESEARCHES

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Abstract:

Due to their electrical and optical properties, nanosized semiconductors are widely used to make multifunctional nanoscale optoelectronic and electronic devices. Zinc oxide (ZnO) is a native n-type semiconductor with a broad band gap (3.37 eV) and high exciton binding energy (60 meV) at room temperature. ZnO is used in ultraviolet (UV) light emitters, piezoelectric devices, chemical and gas sensors, transistors, solar cells, catalysts, and spintronics due to this. In the present study, ZnO nanoplates were prepared by hydrothermal method at different hydrothermal temperatures that are 140, 160, 180, 210 and 230°C. Synthesized samples were characterized using X-ray diffraction (XRD), field emission scanning electron microscopy (FE-SEM), UV-vis spectroscopy. X-ray analysis shows that ZnO nanoplates crystallize in a hexagonal structure and good crystallinity. In FESEM study, it was observed that all structures are in the form of nanoplates. Optical measurements show that the band gap energies of the nanoplate are decreased with increasing the hydrothermal temperatures

Introduction

2.1 Introduction

Over the past few decades, much research has been conducted on semi-conducting nanostructures. It is the discovery of surfaces that are the reasons for the study of high light, toxic moon, chemical activities, and chemical stability, among other conductors that have attracted researchers and have received much attention in this case. In this chapter of the research, the investigation and study of the research related to the topic of the present research are discussed.

2.2 An overview of the research

In research in 2006 in the Journal of Nanometals and Biostructure, by studying zinc oxide, they found that it has fewer optical properties than zinc oxide in nano dimensions. In the absorption spectroscopy, it was also seen that in nano dimensions curve (1) has more absorption than bulk zinc oxide in a curve (2). So they concluded that zinc oxide in the nanoscale shows better optical properties than itself.

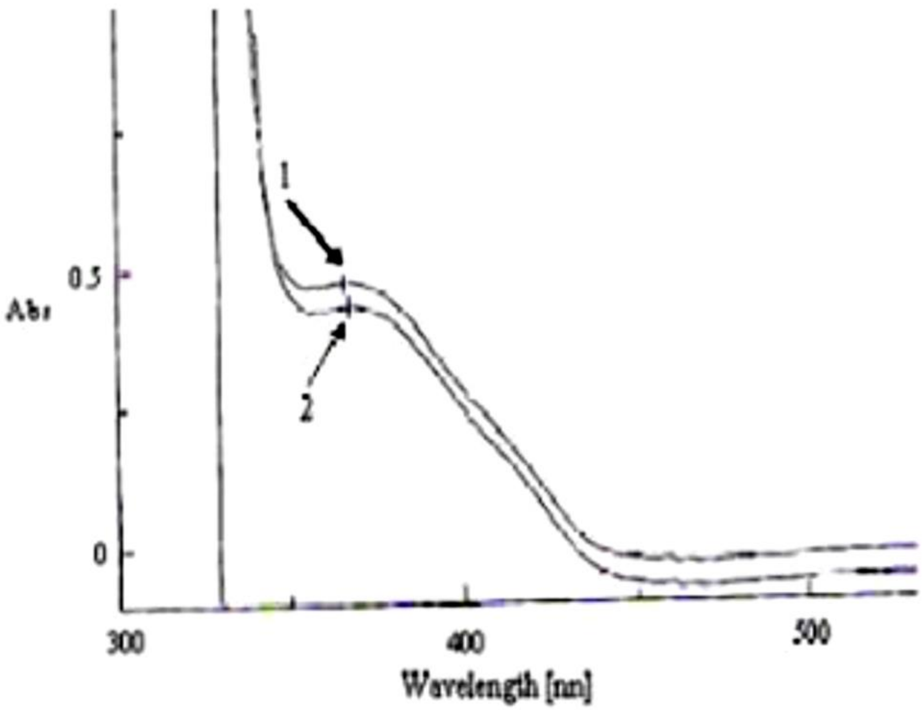

Figure 2-1. The absorption spectrum of 1) zinc oxide nanoparticles and 2) bulk zinc oxide [43]

In 2016, Yang Zhou et al. used hexamethylenetetramine (HMT) as an alkaline source and zinc nitrate precursors to hydrothermally manufacture zinc oxide powder at low temperatures. The impact of HMT concentration on the structural, optical, and photocatalytic characteristics of the generated nanoparticles was next studied.

Liu et al. who created ZnO nanostructures by hydrothermal technique utilizing zinc nitrate and soda as the precursor and alkaline source obtained similar outcomes. They claimed that by increasing the ratio of Zn^{2+}:NAOH from 1:5 to 1:12, the morphology of the particles changes from rods to grains.

The X-ray diffraction pattern showed all the diffraction peaks of the crystal structure of six zinc oxide phones, and no peaks related to $Zn(OH)_2$ or impurities were found (Figure below). A sharp peak in this spectrum means that the ZnO powder has good crystalline quality. The average size of nanoparticles was calculated by the Debye-Scherr formula, and the obtained number was smaller than the actual field.

$$d = \frac{0.98\lambda}{\beta cos\theta}$$

XPS[3] analysis has been used to obtain more detailed information.

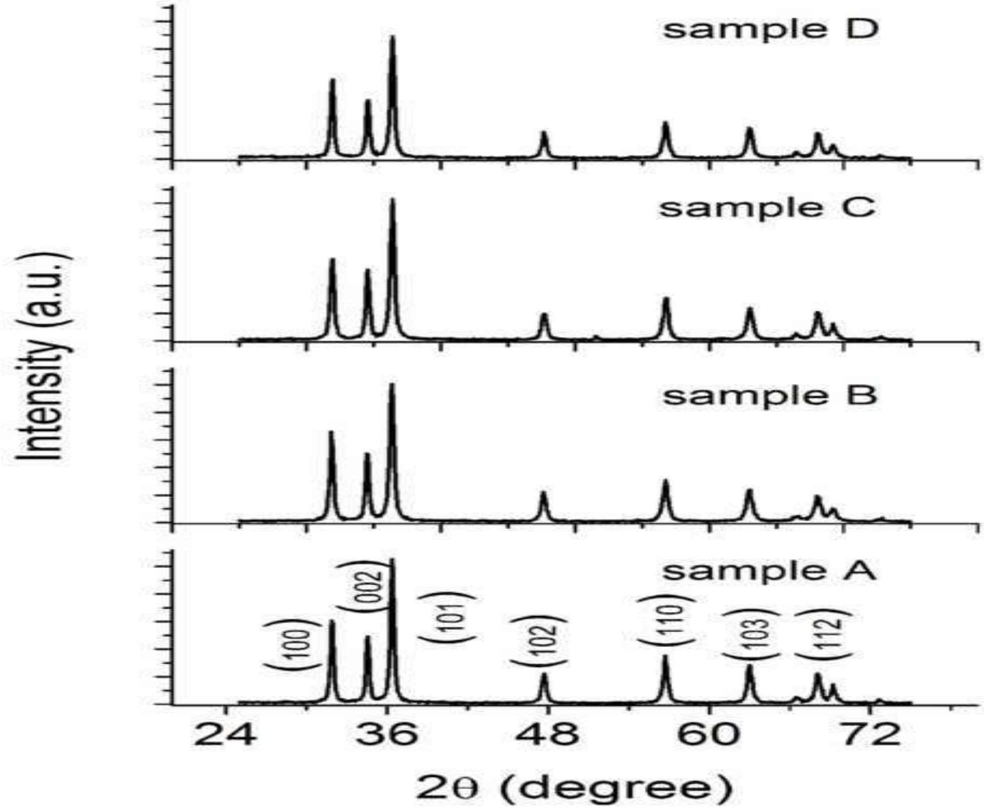

Figure 2-2. XRD spectrum of 4 growth solutions A, B, C, and D with different molar ratios of Zn^{2+}:HMT, 1:1, 1:2, 1:3, and 1:4 respectively[44]

The XPS spectrum of their produced sample D is shown in the figure above. In the figure below, it can be seen that there are only Zn and O elements without impurity elements in the sample. The peak corresponding to the element C is located at the energy of 284 eV, which must be the result of CO_2 and CO adsorbed on the zinc oxide surface

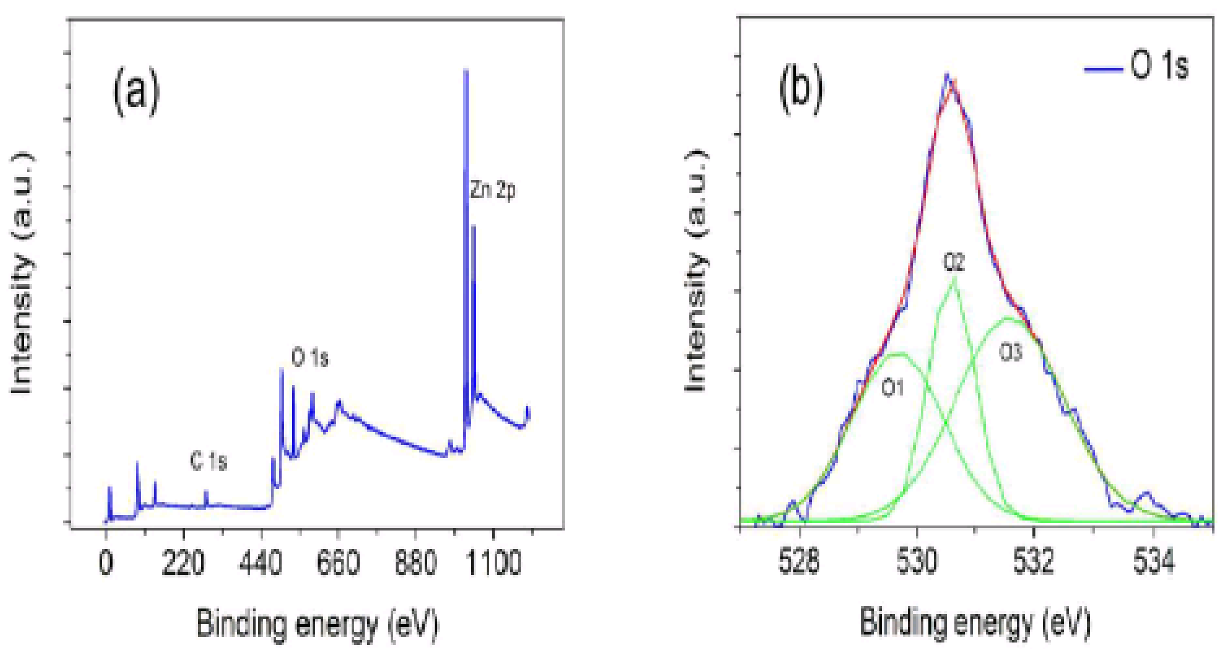

Figure 2-3. XPS spectrum of ZnO nanopowder [35]

O1s is a broad peak indicating the presence of multiple oxygens near the surface, which can be aligned with three Gaussian components O_1, O_2, and O_3, as shown in the above figure.

Mojdi and Hossein Khani (2013) have shown that the X-ray diffraction pattern confirms the formation of the wurtzite phase of nanoparticles. In this research, optical properties of nanoparticles such as attenuation coefficient, Goff energy, Auerbach energy, transition threshold wavelength, penetration depth, refractive index, dielectric constants, and optical conductivity were calculated by visible and ultraviolet spectroscopic data.

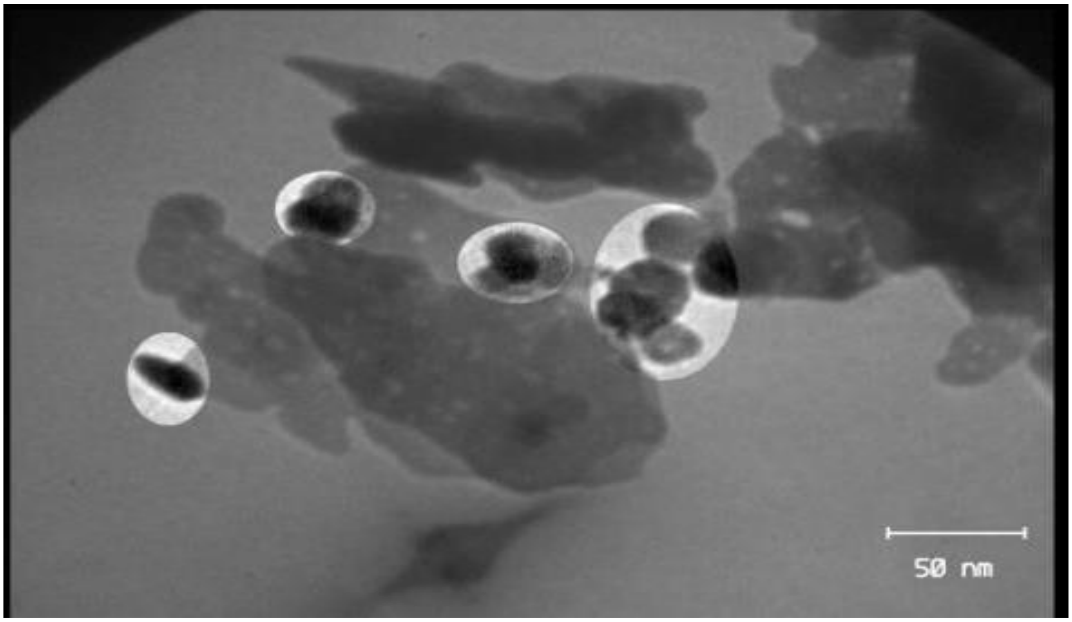

Figure 2-4. Transmission electron microscope image of zinc oxide nanoparticles with 50 nm magnification [43]

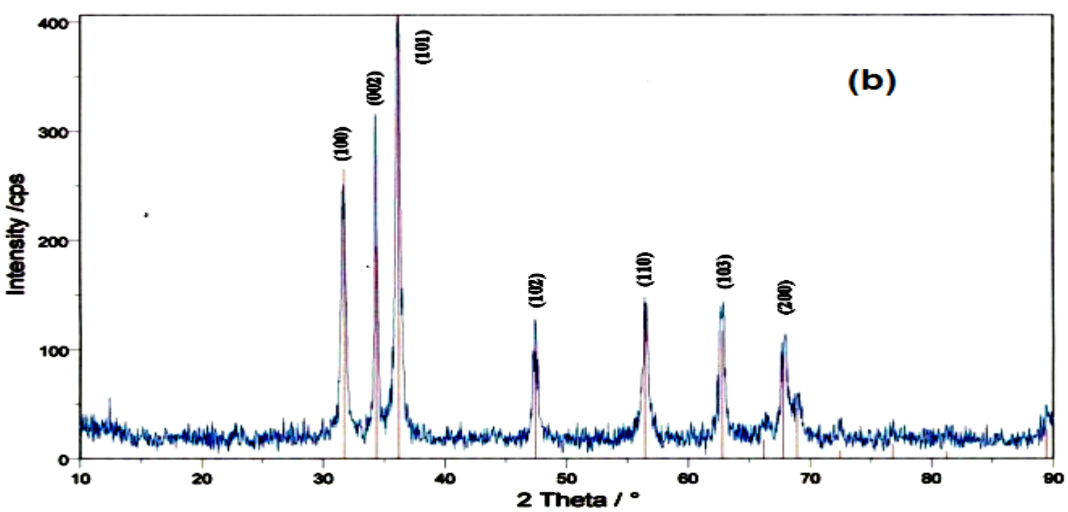

Figure 2-5. XDR size 1- pure zinc oxide nanoparticles 2- zinc oxide contaminated with gallium[43]

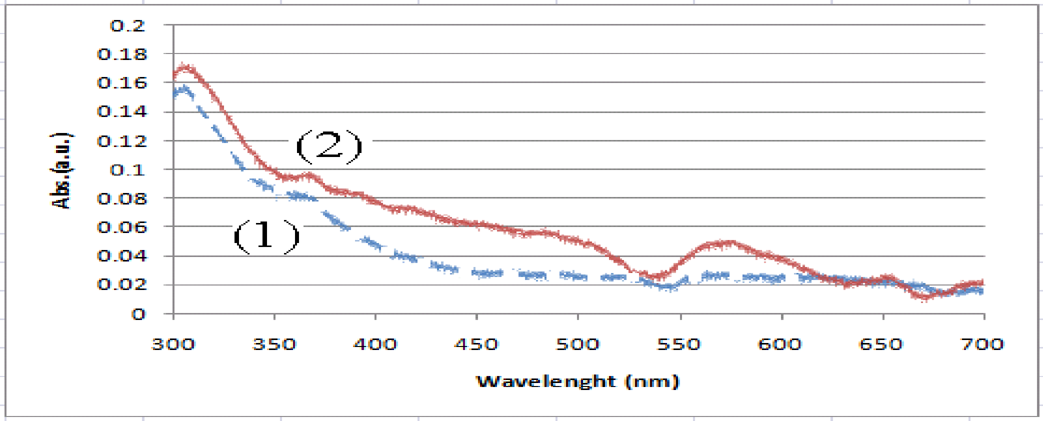

Figure 2-6. the absorption spectrum of nanoparticles 1- pure zinc oxide 2- zinc oxide contaminated with manganese[46]

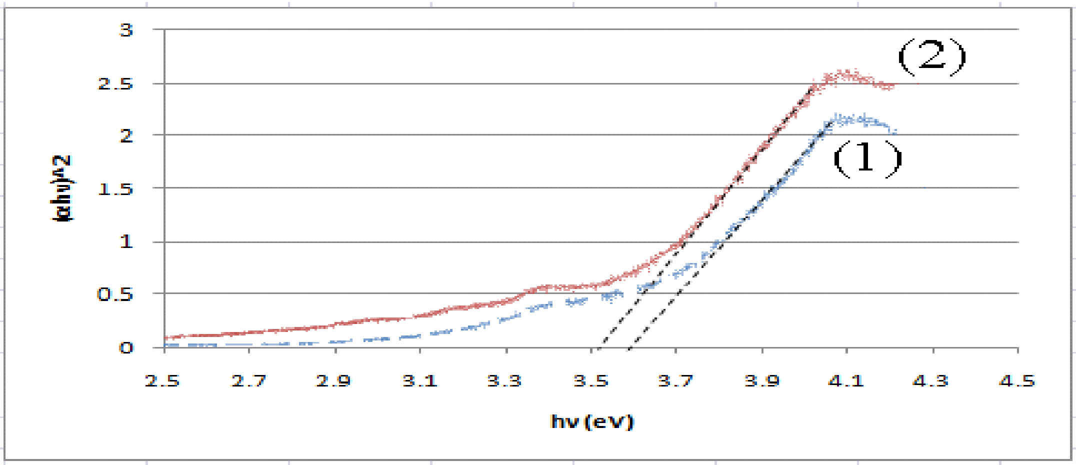

Figure 2-7. Optical energy band of nanoparticles 1- pure zinc oxide 2- zinc oxide doped with manganese[46]

Kozegar and Mousai (2017) have shown that all the samples at 450 degrees Celsius consist of the crystalline phase of zinc oxide. The particle size of the samples is smaller in the presence of metal cation. Examining the photocatalytic properties of the samples indicates the positive presence of metal pollutants to improve the photocatalytic properties of the samples. In such a way that in the sample with the simultaneous pollutant, compared to the pure ZnO sample and the separate pollutant samples (TZ and SZ), it has higher photocatalytic efficiency.

In their study, Tseng et al. (2012) investigated the effect of Ti cation percentage (5, 10, and 15%) on the optical and structural properties of ZnO nanoparticles. In this research, nanoparticles were synthesized by the sol-gel method. The results of the specific surface area of the particles indicate an increase in the presence of Ti pollutants in the ZnO network. Increasing the percentage of Ti in the zinc oxide network has led to an increase in the forbidden band of zinc oxide in the contaminated sample. The results of the X-ray analysis in this research show that the intensity of the peaks decreases and the width of the peaks increases, which indicates that the size of the crystal becomes smaller in the presence of Ti cation.

Naeem et al. (2010) investigated the effect of Ti metal cation on the optical properties of the samples. The results of the research indicate an increase in the forbidden band of zinc oxide from 3.4 to 3.6 electron volts.

Khosravi et al. (2012) have conducted research entitled "Growth and investigation of optical properties of pure zinc oxide nanostructures contaminated with silver by sol-gel method". The XRD results showed the hexagonal structure (wuertzite) of the products and the inclusion of silver ions in the middle of the ZnO network. Also, the PL and UV-Visible results showed that the optical properties of pure zinc oxide nanoparticles are better than the samples affected by silver contamination. In addition, the results of optical studies showed that the energy gap of zinc oxide nanoparticles has increased due to the presence of silver.

Engoyan et al. (2012) prepared and characterized zinc oxide nanostructures doped with silver. In this research, silver nanoparticles were deposited on the surface of zinc oxide nanorods (made by hydrothermal method) using a photochemical simplification under UV irradiation.

Gholami and Ebadzadeh (2013) investigated various methods of ZnO production. They also investigated the specificity of VLS, VS, sol-gel, hydrothermal, and nanocrystal production methods using microwaves and investigating their properties.

Jiao Yang Yiling et al. (2016) investigated the optical, electrical, and surface structure features of ZnO thin films by doping GZO thin films with various percentages of gallium using the sol-gel method. The findings revealed all the contaminated films had a wurtzite structure and the grain size and surface roughness decreased with the increase in impurity concentration. Simultaneously, improved optical layer transmission and absorption edge of GZO film were obtained because of the addition of impurity. Optical constants were determined in broad UV-VIS-IR spectral regions where the refractive index and extinction coefficient decrease with increasing carrier concentration. The optical transmission spectra of the GZO thin films showed a transmission of more than 80% in the visible region, and a blue shift of the optical gap was observed with increasing Ga concentration, which was explained based on the Borstein-Moss effect.

The SEM images also showed that the particle size decreased with the increase in impurity concentration, which justifies the XRD diagram. Transmittance in the visible region increased with increasing concentration. By reducing the size of the optical gap particles, the presence of gallium in the crystal structure was confirmed by the XPS spectrum (X-ray photoelectron spectroscopy) for the zinc oxide sample doped with 5% gallium. All these results may be useful for development

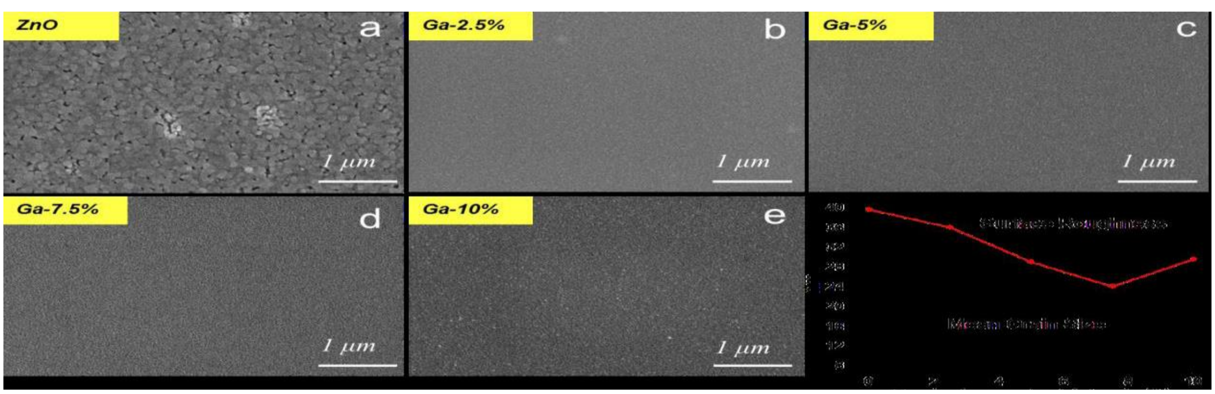

Figure 2-8. Transmission electron microscope images Ga10%-e , Ga 7.5% - d, Ga 5%, -c, Ga 2.5% -b, ZnO-a [35]

From the above figure, which shows the dimensions of $1\mu m$ the FESEM images, it was observed that the size of the nanoparticles decreased with the increase in the impurity percentage and the boundaries disappeared.

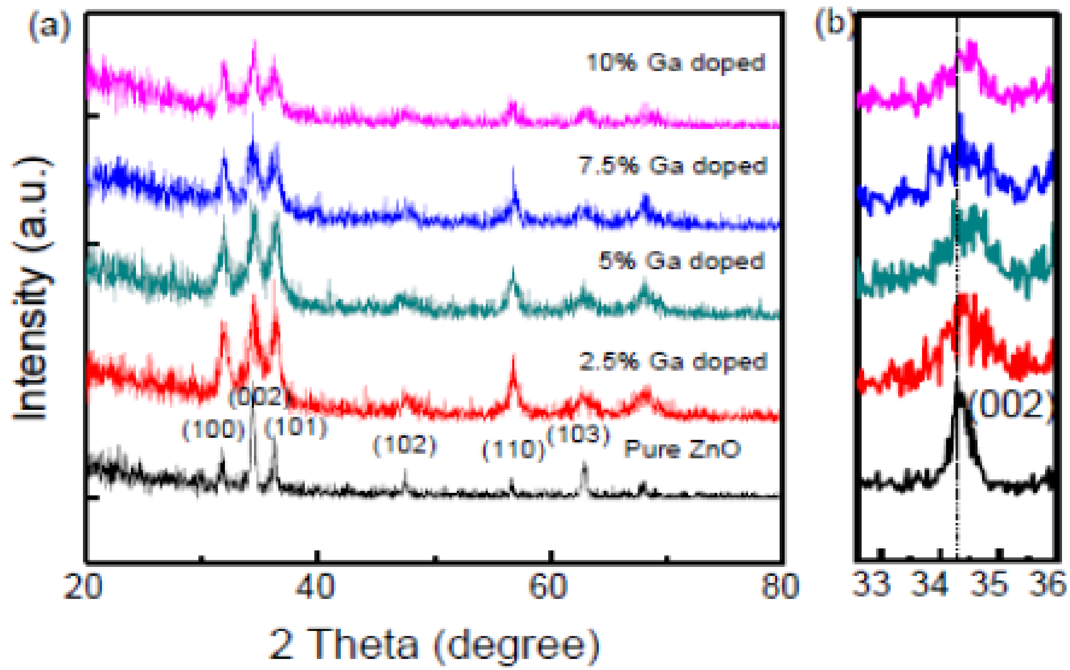

Figure 2-9. XRD diagram of pure zinc oxide nanoparticles [46]

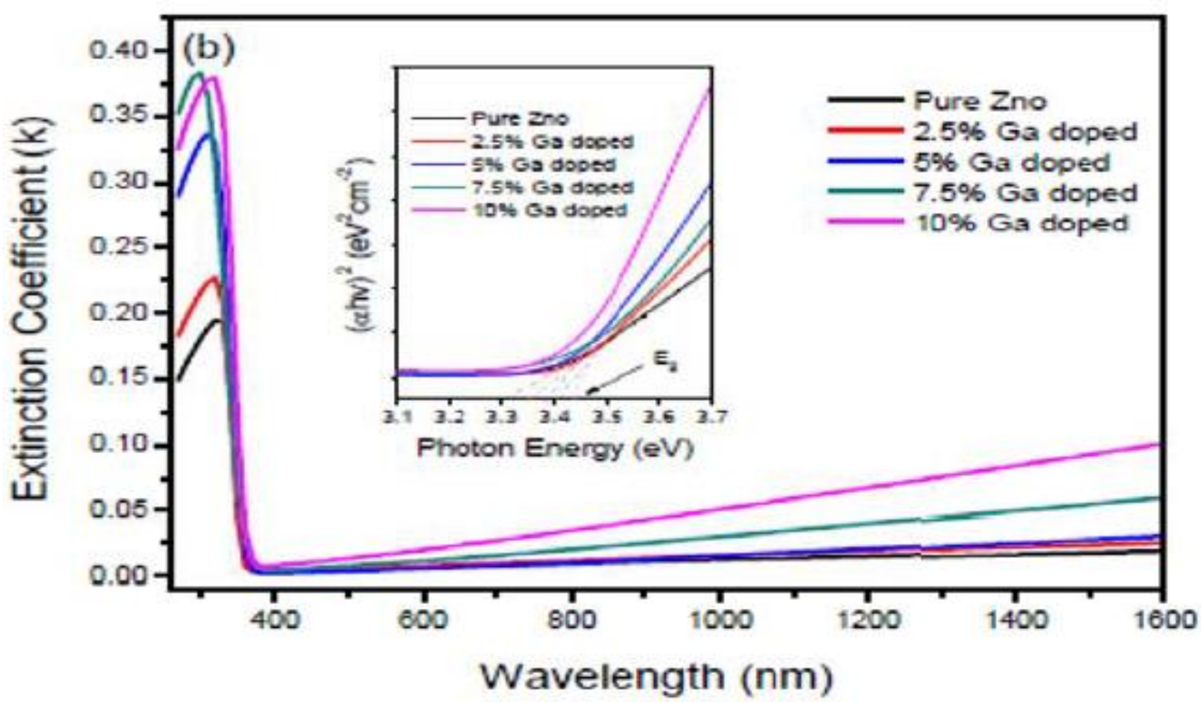

Figure 2-10. Extinction diagram of pure and contaminated zinc oxide with different percentages of gallium[53]

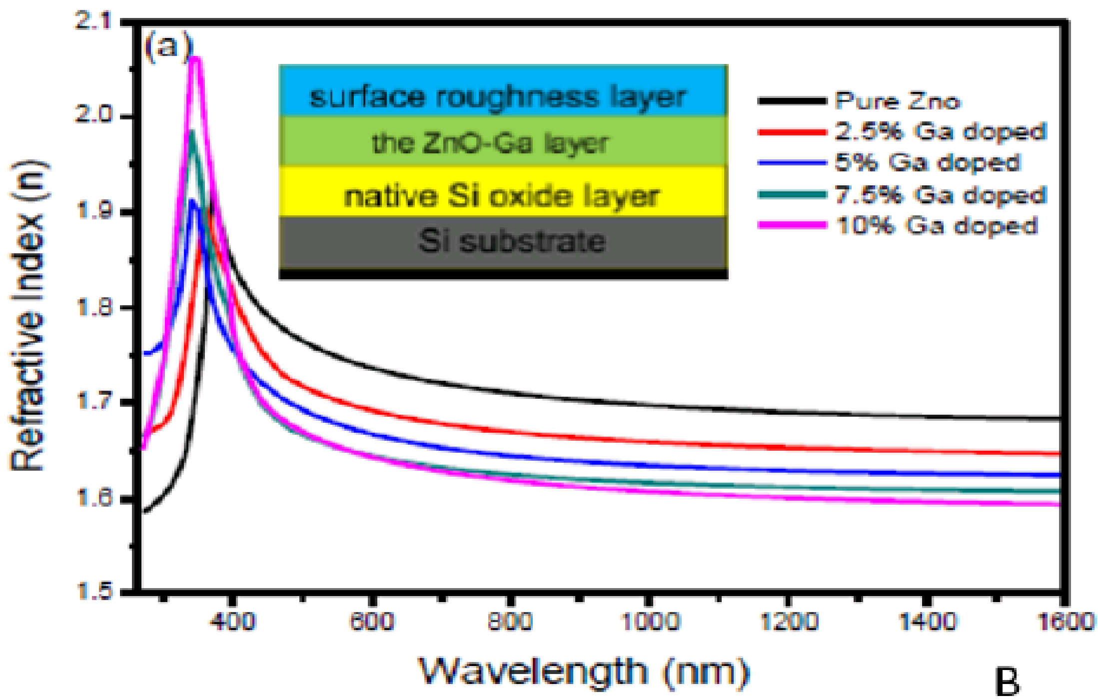

Figure 2-11. Refractive index diagram of pure and contaminated zinc oxide with different percentages of gallium [53]

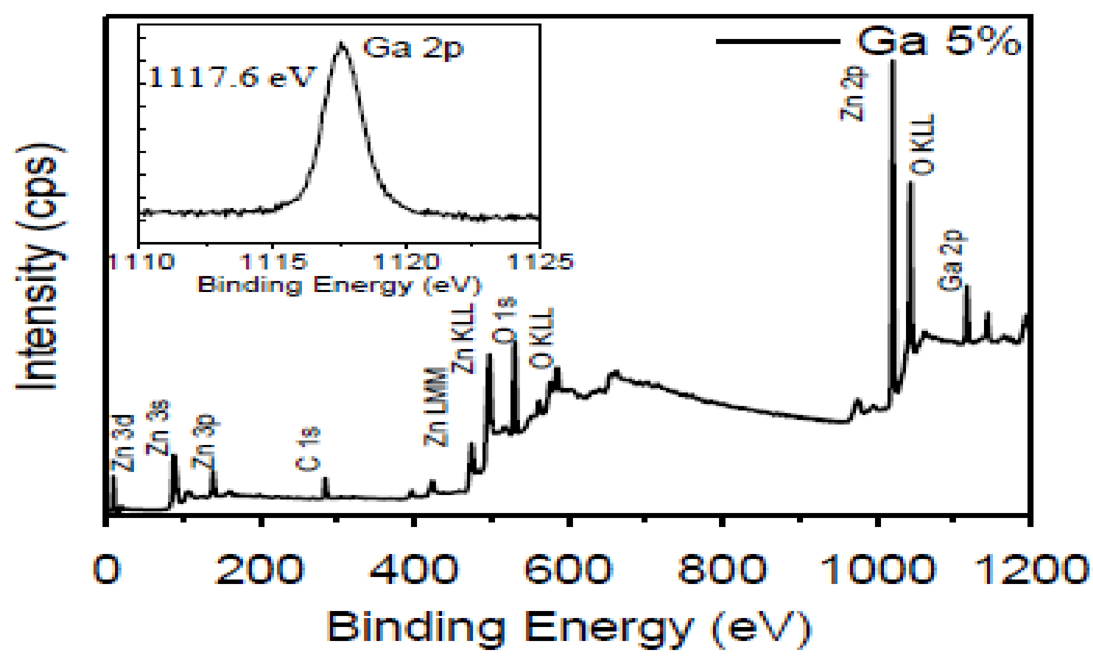

Figure 2-12. XPS diagram of zinc oxide doped with 5% gallium in terms of bond energy[54]

In 2013, Alamdari et al. prepared sol with a high concentration of zinc oxide, along with indium impurity with concentrations between 1 and 3 atomic percent. Then the energy gap changes and their optical properties were investigated. All samples have optical transparency of more than 90% in wavelengths between 400 and 800 nm. IZO thin film was prepared by an immersion coating method and its thermoelectric properties were characterized by the Hall effect and Seebeck test. The results showed that this layer has unique thermoelectric properties. And it can be a suitable option for optoelectric applications, as a current generator. The scanning electron microscope (TEM) image of the IZO thin film sample showed an average grain size of about 40 nm. The value of the band gap for the two percent sample has its lowest value. The intensity of the bond peak between IN-O had the lowest value compared to other concentrations, which easily interacted with the adjacent carriers and suffered electron redistribution and normalization to reduce the clone repulsion, which is consistent with the narrowing effect of the gap.

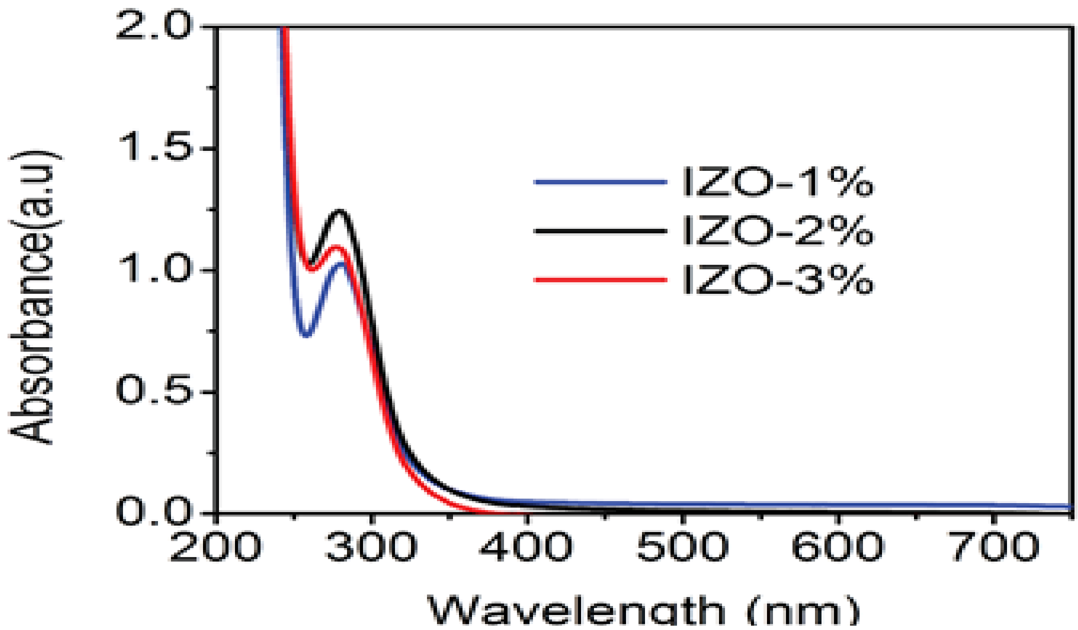

Figure 2-13. The absorption spectrum of zinc oxide solution contaminated with indium[16]

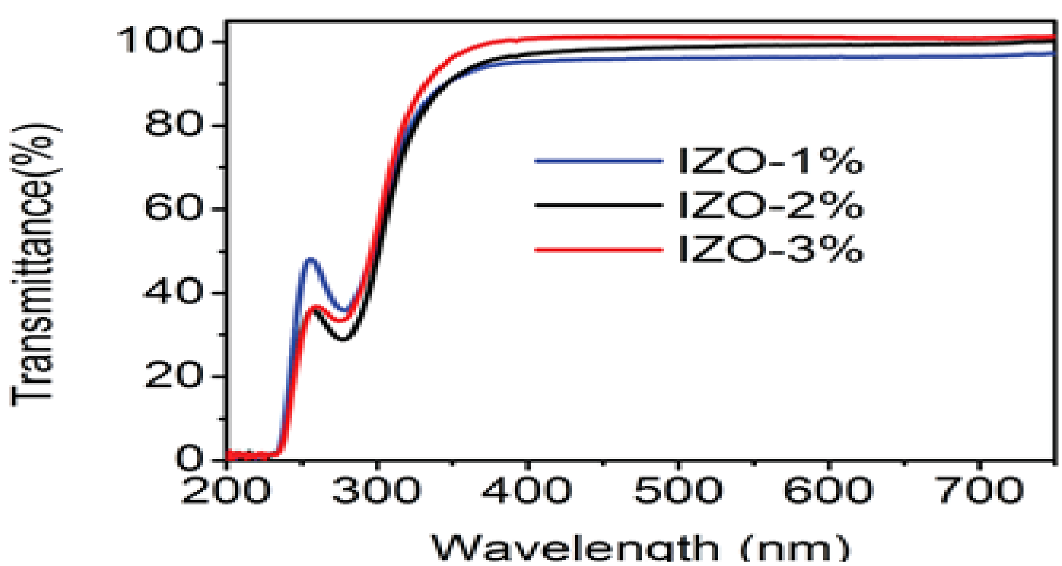

Figure 2-14. Transmission spectrum of zinc oxide solution contaminated with indium[16]

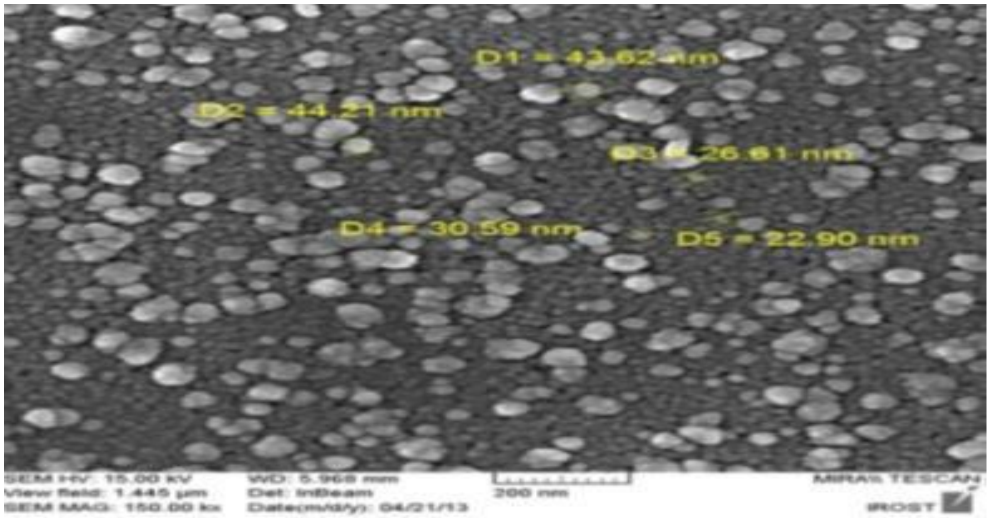

Figure 2-15. TEM image of IZO thin film [46]

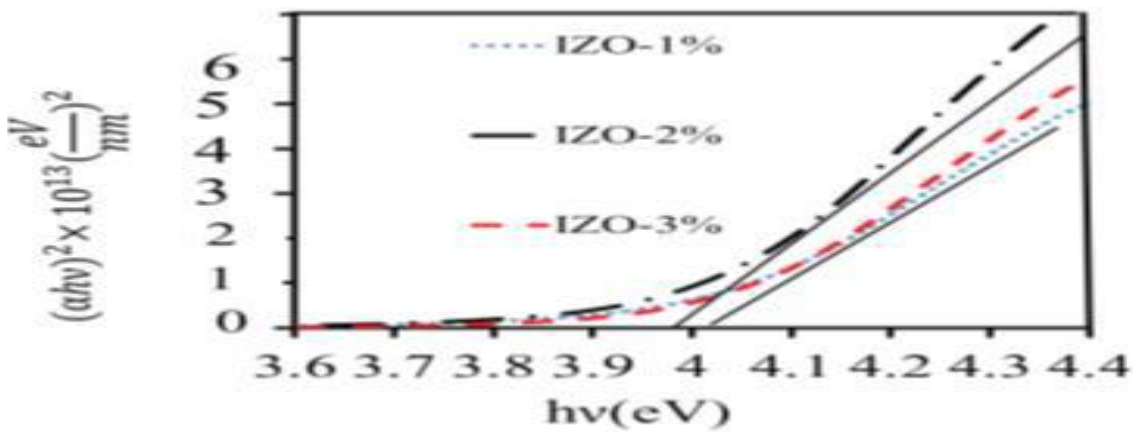

Figure 2-16. Energy band diagram of zinc oxide doped with indium impurities [49]

In 2015, Tsung-Shine Ko et al. investigated the optical properties of zinc oxide nanowires with indium impurity. ZnO nanowires with different concentrations of indium impurity were synthesized by the thermal evaporation method. They used gold nanoparticles as a catalyst. High-resolution electron microscopy showed that the growth of zinc oxide nanowires based on liquid and solid vapor mechanisms and energy dispersion spectrum determined the atomic percentage of indium. Scanning electron microscope showed that the diameters of pure nanowires were between 20 and 30 nanometers. The diameter of zinc oxide doped with indium increased from 50 nm to 80 nm. X-ray diffraction results showed that the crystal quality of nanowires became more irregular with contamination. The photoluminescence study showed that the main emission occurred at 380 nm, leading to exciton regeneration at the near edge of the NBE band. The results showed that the change in blue slope and decrease in pL intensity of NBE emission from zinc oxide nanowires with a high concentration of indium was due to more donors to center generations.

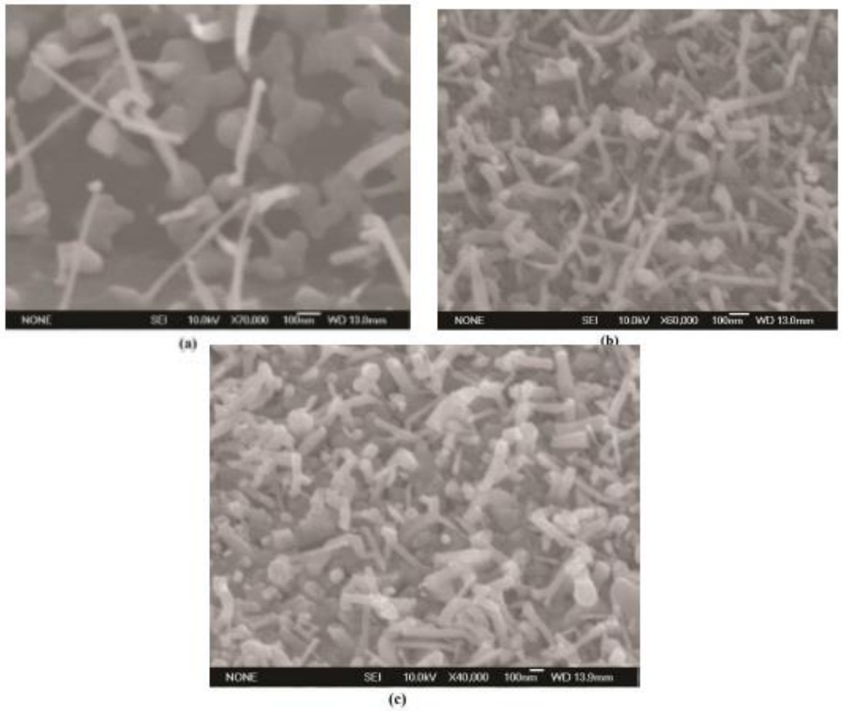

Figure 2-17. Scanning Electron Microscope (SEM) images a- pure zinc oxide nanowires in dimensions of 500 nm b- zinc oxide nanowires doped with indium 0.86% c- nanowires doped with indium 0.95% [55]

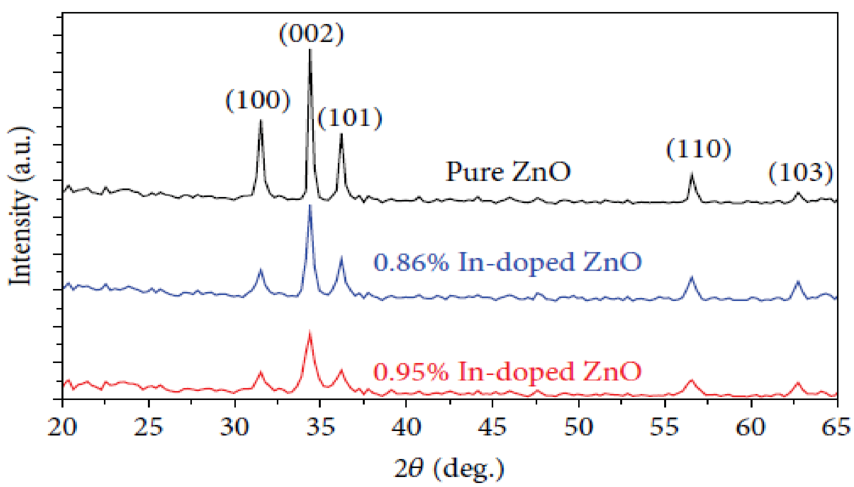

Figure 2-18. XRD spectrum of pure and indium-doped zinc oxide nanowires (0.86 percent and 0.95 percent)[55]

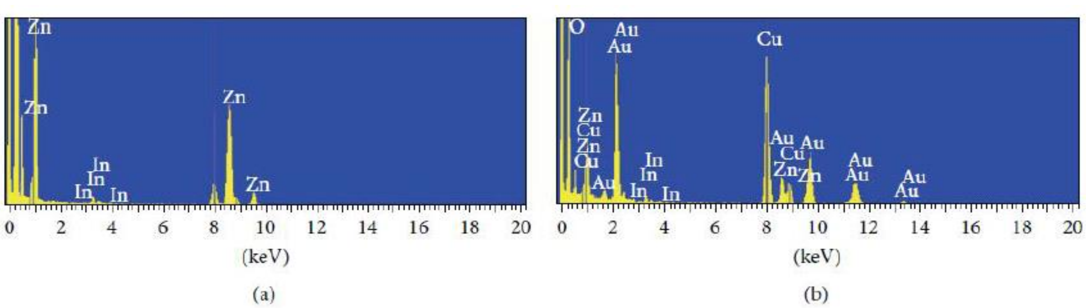

Figure 2-19. X-ray Energy Diffraction Spectroscopy (EDS) of zinc oxide nanowires doped with indium a- stem part b- tip part[55]

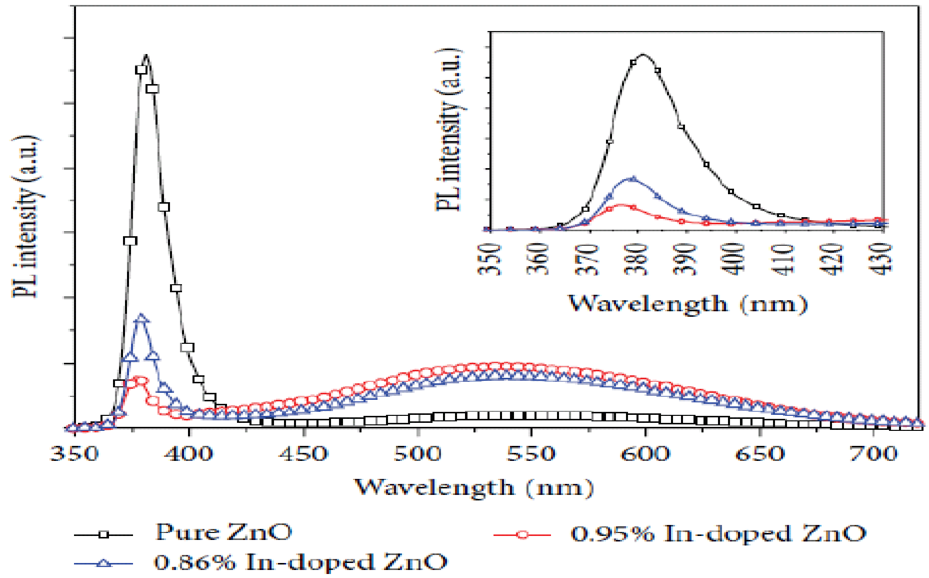

Figure 2-20. PL photoluminescence spectrum of pure and indium-doped zinc oxide nanowires (0.86 percent and 0.95 percent)[55]

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