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OPTICAL PROPERTIES OF ZINC OXIDE DOPED BY (Al, Cd, Co, Li and Mg)

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ABSTRACT

In this work Zinc Oxide was doped by (Al, Cd, Co, Li and Mg). The samples were prepared using chemical method at 70ºC.The optical characteristics of the prepared samples have been investigated by UV/Vis spectrophotometer in the wavelength range (200 – 800) nm .The samples have a direct allow electronic transition with optical energy (E_g) values decreased from (3.966) eV for Zn Al_2O_3sample to (3.505) eV for the $ZnLi_2O_2$sample. The maximum value of the absorption coefficient (α) for all sample are given about (> 1.68 $x10^4$ cm^{-1}) for the Zn $Al_2O_3$and Zn Cd O_4 sample at (320 nm and 310 nm). Also the extinction coefficient (K) was calculated. The results indicate the samples have good characteristics for optoelectronic applications.

Keywords: *Zinc Oxide, optical properties, absorption coefficient, optoelectronic applications.*

I. INTRODUCTION

ZnO is a direct wide band-gap (3.37 eV at roomtemperature) II-VI binary compound semiconductor and crystallizes inthree forms: hexagonal wurtzite, cubic zincblende, and the rarely observedcubic rocksalt [1]. The hexagonal wurtzite structure of ZnO is the most common phase having a crystal structure C6v or P63mc, which occurs almost exclusively at ambient conditions [2, 3]. The ZnO structure has polar surface (0001) which is either Zn or O terminated and non-polar surfaces (1120) and (1010) possessing an equal number of both atoms. The polar surface of ZnO is highly metastablein nature and is responsible for several unique and astonishing properties including piezoelectric properties, it also play a key role in column growth, favorable for etching due to higher energy. The polar surface is also known to possess different physical and chemical properties[4].Direct band gap materials have intrinsically high luminescence yield compared to indirect band gap materials and increase in the band-gap reduces the leakage current of the devices and their temperature dependence significantly [5,6]. Among the II-VI semiconductors, ZnO has relatively higher and stable exciton binding energy of 60 meV at 300 K, almost three times larger than its competitor GaN which has an exciton binding energy of25 meV. It is also one of the reasons that ZnO is so attractive for optoelectronic devices. Higher exciton binding energy materials give brighter emissions, because exciton is already a bound system, which radiatively recombine with high efficiency without requiring traps to localize the carriers [7,8]. Other favorable aspects of ZnO are that it is non-toxic, cheap, relatively abundant source materials, and chemically stable. It can be synthesized as a large single crystal by various methods and it can be grown invarious morphologies and dimensions. ZnO nanostructures are promising candidates in miniaturized optoelectronics and sensing devices. By alloying, the band-gap can be tuned further into the UV or down into the green spectral ranges i.e. from 2.8 to 4 eV [9]. A tendency of different fast growth directions of ZnO could result in growth of a diverse group of hierarchical and complex nanostructures. This is partly reflected by the various structural morphologies of Zn On a nomaterials such as nanorods, nanotubes, nanocorals, nanoflowers, and nanowalls. These unique nanostructures show that ZnO probably has therichest family of nanostructures among all known materials which demonstrate potential for its diverse practical applications in the near future. In particular,1-D ZnO nanorods are potentially useful for various nanodevices such as lightemitting diodes (LEDs), chemical

sensors, solar cells, and piezo electric devices, because of their high aspect ratio and large surface area to volumeratio ensure high efficiency and sensitivity in these applications. Furthermore, ZnO is bio-safe and biocompatible and may be used for biomedical applications without coating.

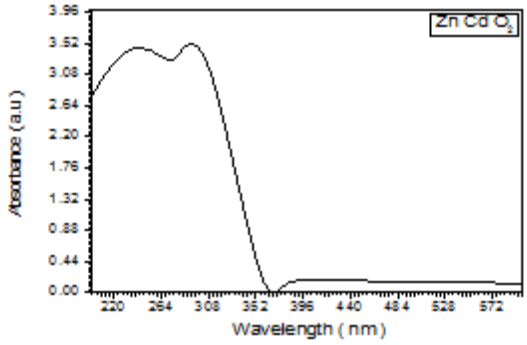
II. MATERIAL AND METHOD

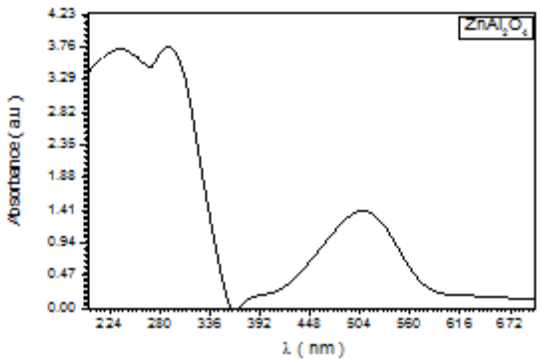
Zinc nitrate hexahdate, 2-metoxyethanol, and ethanolamine, DEA, were used as starting material, solvent and stabilizer respectively. The dopant source of (Al $(NO_3)_3.9H_2O$,$Cd(NO_3)_2.9H_2O$,$Co(NO_3)_2.9H_2O$,$Li(NO_3).9H_2O$and $Mg(NO_3)_2.9H_2O$). The choice of nitrate coming from the fact that hydrolysis of nitrate group give products which are soluble in the solvent medium and get easily decomposed into volatile compounds under heat treatment [10,11]. In a typical synthesis, two different solutions of 0.5 M of zinc nitrate and Aluminumnitratewas slowly dissolved in 2-metoxyethanol followed by addition of DEA. The molar ratio of DEA to zinc nitrate and Aluminum nitrate was. The resulting mixture was stirred for 1 h at 70°C of ZnO Sol-gel, respectively. These samples were stirred for 1 h at 70°C. The synthesized Zn Al_2 O_4, and repeat this steps on other sample.

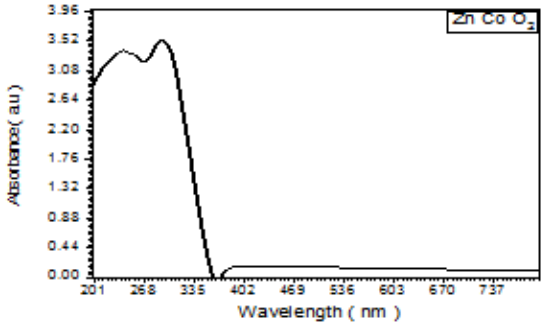
The optical characteristics of the prepared samples have been investigated by UV/Vis spectrophotometer in the wavelength range (200 – 800) nm.

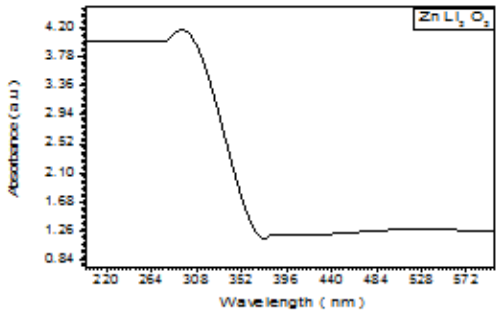
III. RESULTS AND DISCUSSION

The results and curves obtained by the Ultra-Violet device and curve.









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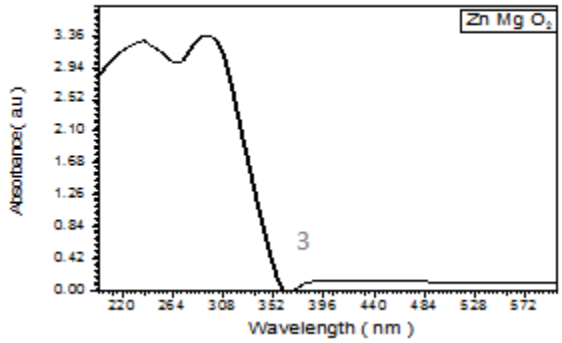

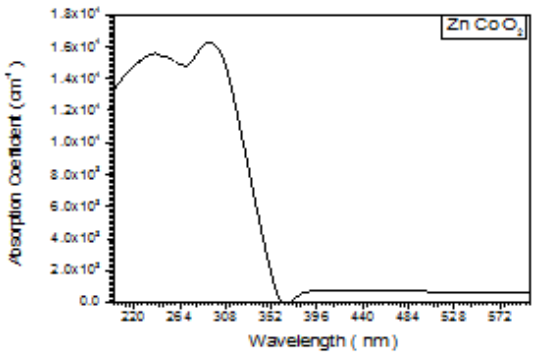

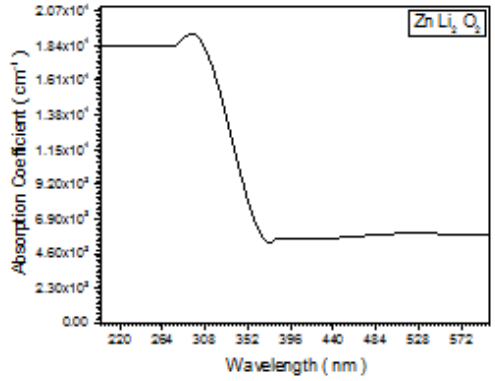

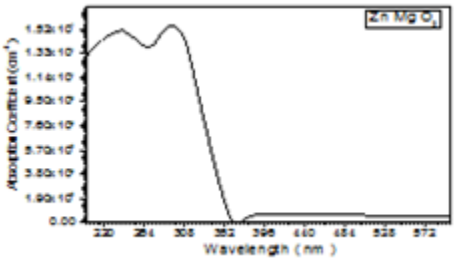

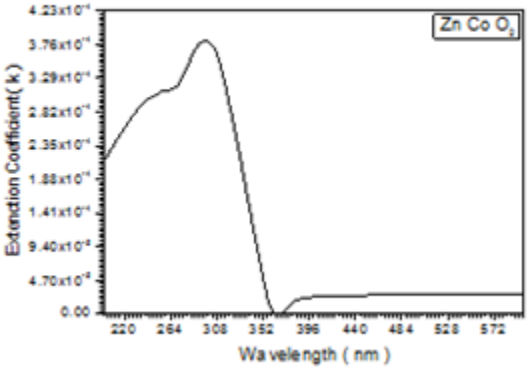

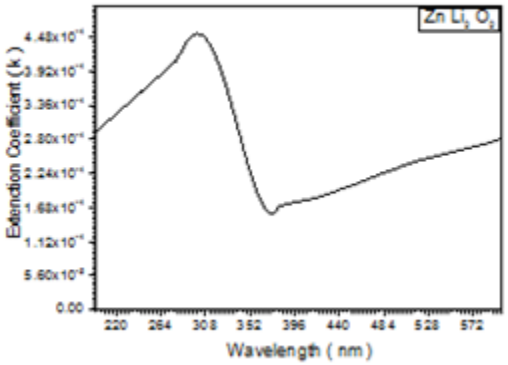

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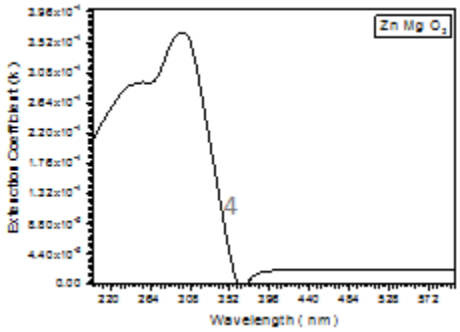

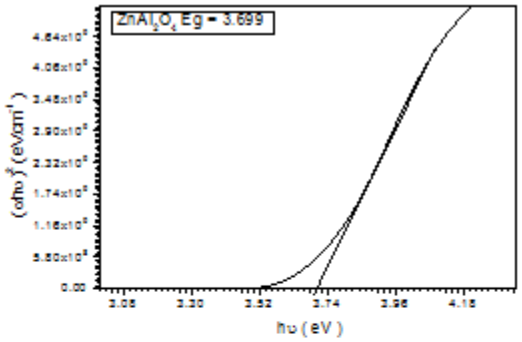

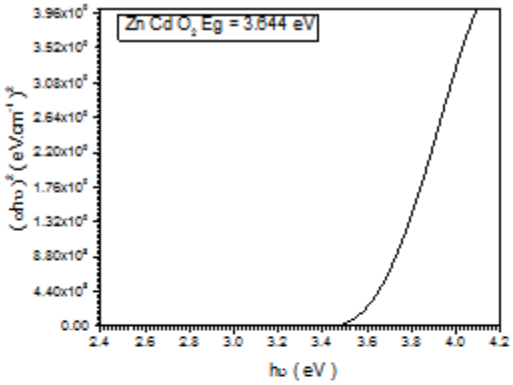

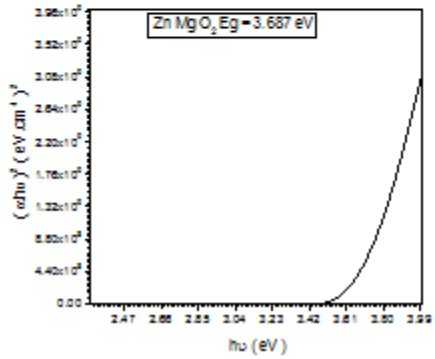

IV. DISCUSSION

Starting from the top from left to right the optical absorption spectra in the (200 - 800) nm wavelength range for the ($Zn\ Al_2O_4$,$Zn\ Cd\ O_2$,$Zn\ Co\ O_2$,$Zn\ Li_2\ O_2$and$ZnMg\ O_2$)was depicted in Fig (1) to fig (5) . The absorption edge of the $Zn\ Al_2\ O_4$occurs at wavelength (320 nm),of the $Zn\ Cd\ O_2$occurs at wavelength (310 nm),absorption edge of the $Zn\ Co\ O_2$ occurs at wavelength (325 nm),absorption edge of the $Zn\ Li_2\ O_2$ occurs at wavelength (308 nm) andabsorption edge of the $Zn\ Mg\ O_2$ occurs at wavelength (310 nm). On fig (6) to fig (10) shows the relation between absorption coefficient and wavelengths, absorption coefficient were calculated by equation $\alpha = \frac{2.303xA}{d}$ where (A) is the absorbance's and (d) is optical axes length on the sample[8] .Also in fig (6) to fig (10) show that the maximal value of absorption coefficient $>1.68x10^4\ cm^{-1}$ at (320 nm) for $Zn\ Al_2\ O_4$sample,$>1.6x10^4\ cm^{-1}$ at (310 nm) for $Zn\ Cd\ O_2$ sample,$>1.6\ x10^4$ at (325 nm) for $Zn\ Co\ O_2$ sample ,$>1.84x10^4\ cm^{-1}$ at (308 nm) for $Zn\ Li_2\ O_2$ sample andthe $>1.4x10^4\ cm^{-1}$ at (310 nm) for $Zn\ Mg\ O_2$ sample.

The extinction coefficient of Zn Al_2 O_4 was calculated by equation $k = \frac{\alpha\lambda}{4\pi}$[9] as show in fig (11) to fig(15) shows the relation between extinction coefficient and wavelengths, the extinction coefficient crave as liked the absorption coefficient crave. Also in fig (11) to (15) show that the maximal value of extinction coefficient > $4x10^{-4}$ at (320 nm) for Zn Al_2 O_4 sample,> 3.736 $x10^{-4}$ at (310 nm) for Zn Cd O_2 sample,> 3.76 $x10^{-4}$ at (325 nm) for Zn Co O_2 sample, > $3.92x10^{-4}$ at (308 nm) for Zn Li_2 O_2 sample and> $3.52x10^{-4}$ at (310 nm) for Zn Mg O_2 sample.

The energy band gap of Zn Al_2 O_4 is determined using the absorption spectra. According to the absorption coefficient (α) for direct band gap material is given by the relation $\alpha h\nu = B(h\nu - E_g)^n$ where E_g the energy gap [10], constant *B* is different for different transitions, (*hν*) is energy of photon and (n) is an index which assumes the values 1/2, 3/2, 2 and 3 depending on the nature of the electronic transition responsible for the reflection.
And by extrapolating the straight thin portion of the curve to intercept the energy axis, the value of the energy gap has been to found be (3.699 eV)for Zn Al_2 O_4 sample,(3.644 eV) for Zn Cd O_2 sample, (3.685 eV) forZn Co O_2 sample,(3.505 eV) for Zn Li_2 O_2sample and(3.687 eV) for Zn Mg O_2 sample as show in fig (16) to fig (20).

V. CONCLUSION

The samples have a direct allow electronic transition with optical energy (E_g) values decreased from (3.966) eV for Zn Al_2O_3 sample to (3.505) eV for the $ZnLi_2O_2$ sample.The maximal value of absorption coefficient between >$1.68x10^4$ $cm^{-1}$and >$1.4x10^4$ $cm^{-1}$for all samples. The results indicate the samples have good characteristics for optoelectronic applications.

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