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RESEARCH ARTICLE

STUDY OF THE CHANGE IN THE ENERGY GAP OF SOME SEMICONDUCTING OXIDES AND THEIR MIXTURES PREPARED BY THE CHEMICAL BATH METHOD

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Abstract

Chemical bath deposition technique was used to deposit nickel oxide, Copper oxide and their mixture. The optical gap properties of both compounds and mixture were measured, the transmittance, absorbance, reflectance, extinction and refractive index have been calculated with in the wavelength range (320-900 nm).

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Introduction:-

Semiconductor materials are referred to as small-gap insulators. What distinguishes these materials is their ability to add impurities that change their electronic properties in a controlled manner. Nano-oxides are used in many photovoltaic applications because they are easy to make, have a good chemical balance, and have a high absorption (1). Although it is well known that oxide deposition produces advanced materials with high purity characteristics, we discovered that the behavior of these oxides is as Nano composition NiO: CuO after researching their properties. A number of factors can affect the band gap of prepared semiconductors, including the precursor materials used, the deposition temperature, and the deposition technique used (2). To make semiconductor oxide thin films, researchers used pulsed laser deposition (3), sol-gel (4), evaporation (5), and spray pyrolysis (8). In amorphous materials, the annealing process affects the crystal structure and electronic transition, resulting in a reduction in local level, whereas in crystalline materials, it works to reduce crystal defects by giving atoms kinetic energy to rearrange themselves in the crystal lattice (1).

Nickel oxide is a cube-shaped p-type semiconductor with a 3.7 eV energy gap (7). Because it's easy to make, melts quickly, and is inexpensive, it's one of the most effective oxides. It works well with a variety of technologies. Many researchers have tried to make thin-film photo-catalysts more creative because of their good photo-catalytic stability and low cost (8). It can be made more conductive by filling Ni voids or replacing Ni with Li at Ni sites (3). Electrons transitioning from O 2p to Ni 3d cause the band gap in NiO, according to theory (9) (10).

Copper oxide (CuO) has a number of benefits, including low cost, non-toxicity, ample copper supply, high performance, and selective solar energy absorption. The oxide layer is also relatively easy to form. It's an n-type semiconductor with a narrow band gap (1.3-2.1 eV) (11).

Experimental method:

Chemical bath deposition is a very low-cost technique, the system consists of simple laboratory tools, as shown below, where the solution is mixed with a magnetic stirrer that contains a thermostat to obtain a homogeneous solution (12) for the production of thin film of nickel oxide (NiO), copper oxide CuO and their mixture of NiO-CuO,

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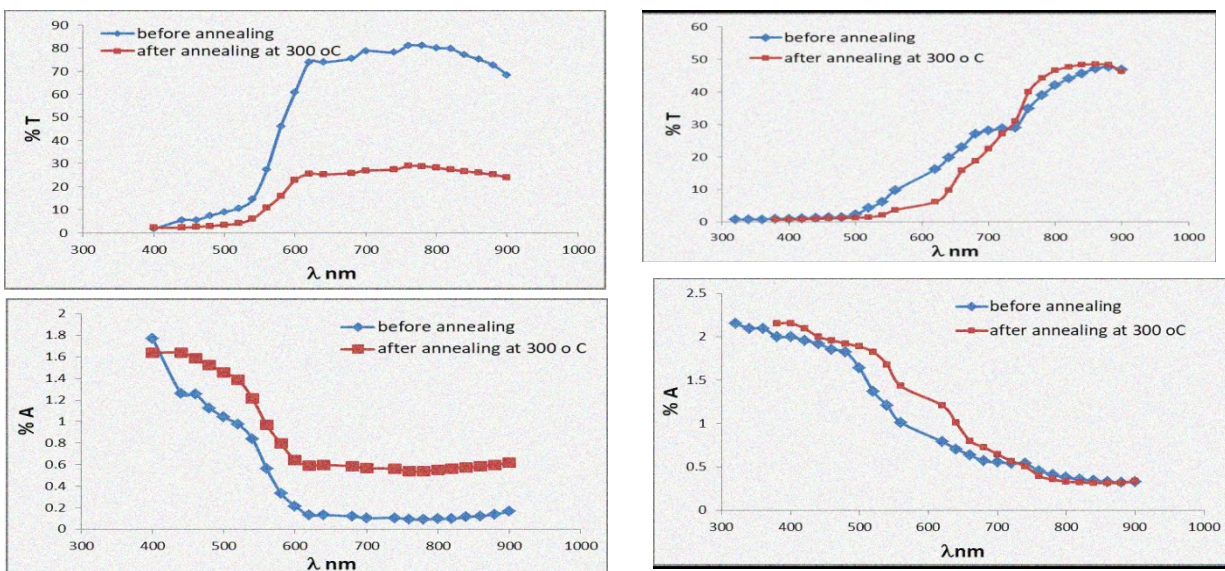
first (0.1gm) of nickel chloride and copper chloride. Finally, (1.2gm) potassium hydroxide dissolved in 20 milliliters of distilled water is added to each solution. Similarly, (0.05 gm) nickel chloride and (0.05 gm) copper chloride are dissolved in 20 ml of distilled water, then the last solution (0.12 gm) of potassium hydroxide dissolved in 20 milliliters of distilled water is added. Glass slides are used as a substrate in the preparation of thin film oxides after cleaning with local cleaning powder, methanol and, finally, distilled water(13). The temperature of deposition was kept at 600c for 48min. Transmittance and absorbance were calculated before and after annealing at 300⁰C using a type device (spectrophotometer 2000.721) within the wavelength range (320-900 nm) we used the weighted method to calculate the thickness, then the energy gap, the optical absorption coefficient constants were calculated for each oxide(12).

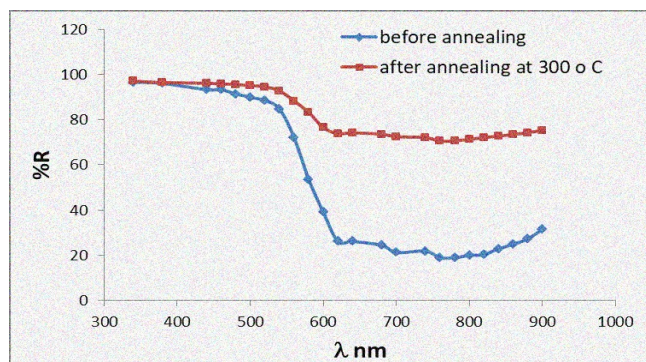


Result and Discussions:-

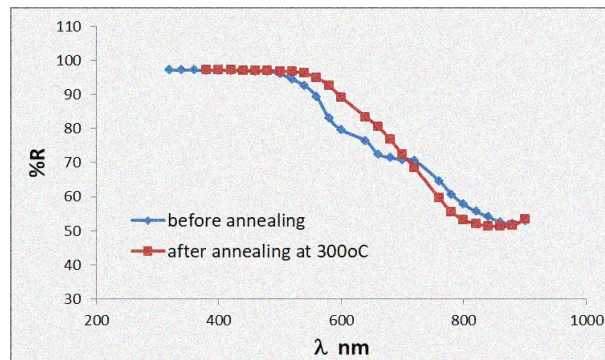
The optical properties of CuO and NiO have been measured for both the semiconductor and its mixture.

Figure (1) shows the measured transmittance, absorbance and reflectance of CuO and NiO thin film before and after annealing at 300⁰C. The effect of annealing at 300⁰C was more clear and affected by the optical properties of nickel oxide than copper oxide, and this can be explained by the nature of the internal structure of these oxides and the degree of recrystallization. The absorption coefficient decreases exponentially with increasing wavelength as in the case of the NiO nanoparticle, this behavior is typical of some semiconductor and occurs for several reasons, including the internal electrical fields in the crystal, the stress that distorts the grid resulting from the deficiency and the inelastic dispersion of the phonon loadcarrier(14). Absorbance increases as the wavelength of both members decreases, explains that the incident electron did not stimulate the electron and transfer it to the valance band because its energy is less than the energy gap of metal oxides, and increases more after annealing, which reduces crystal defects.





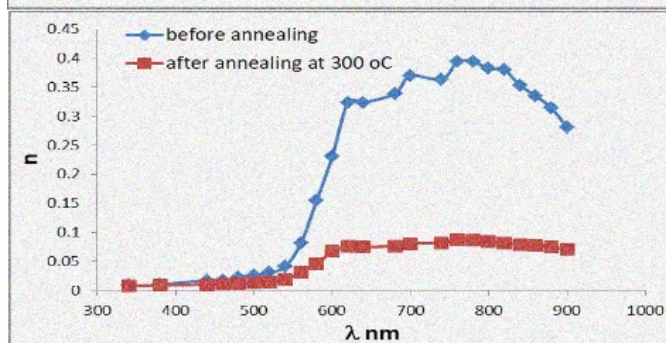
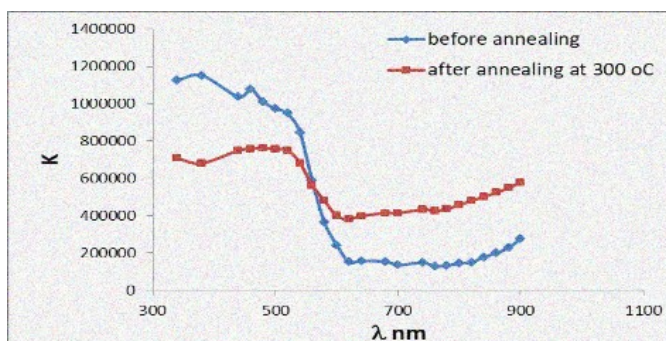
(a)



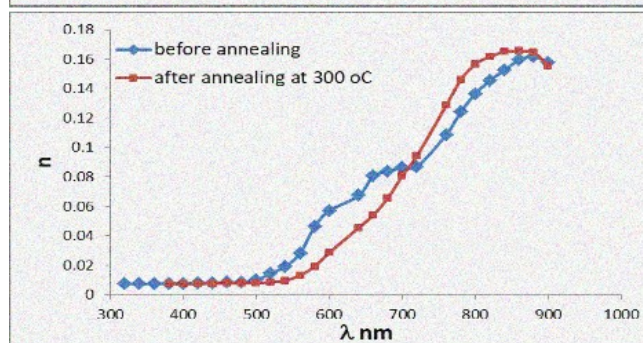
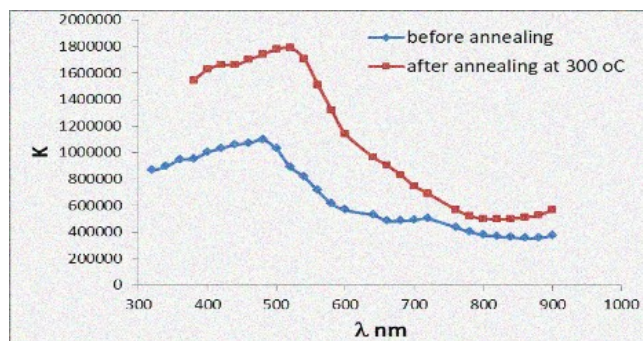
(b)

Figure(1):- Show transmittance , absorbance and reflectance for (a- NiO thin films) (b- CuO thin films).

Both layers' extinction coefficient and refractive index were calculated, and the results are shown in Figure (2). After annealing, the extinction coefficient and refractive index of NiO films are almost constant throughout the wavelength range, whereas copper oxide exhibits constant extinction and refractive index changes almost throughout the wavelength range.



(a)

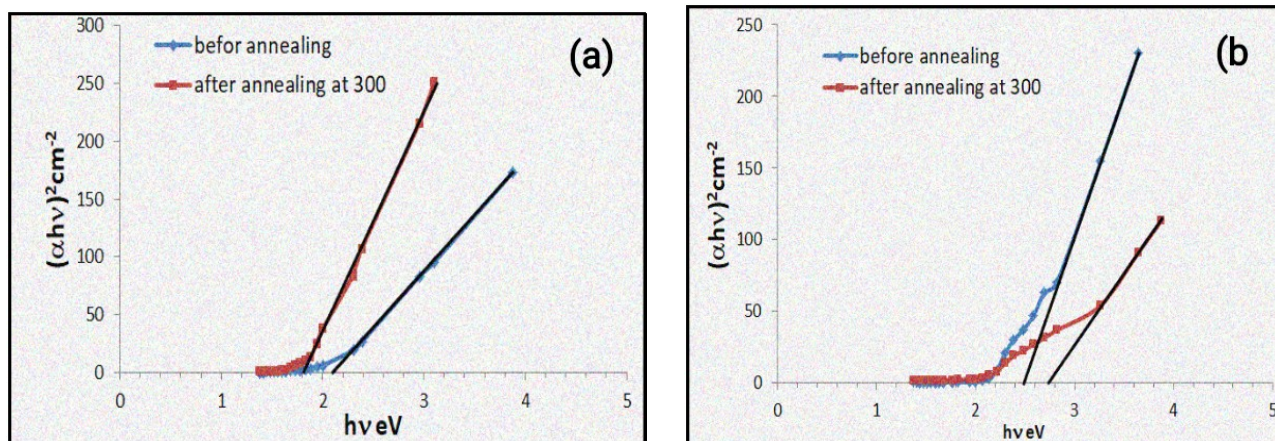


(b)

Figure(2) show extinction coefficient and refractive index for (a - NiO thin films) (b- CuO thin films)

After annealing, the energy gap between oxides and their mixtures decreases. Thermal treatment has a wide range of effects on two compounds, which could be due to the degree of crystallization of each compound at 300°C, as shown in figure (3).

The energy gap of nickel oxide increased from 2.5 eV before annealing to 2.75 eV after , with the increase from ideal values explained by Nano structures formed in the deposited layers (15) . After annealing, the band gap of CuO decreases from 2.1eV to 1.8eV due to layer recrystallization (16).



Figure(3):- show the variation of energy gap before and after annealing at 300°C for (a) CuO thin film (b) NiO thin films.

As shown in figure (4), combining equal amounts of CuO and NiO solutions produces a layer with different optical properties. The mixture's transmittance decreases, as evidenced by the energy gap value and transition type.

This Nano structure has a high level of absorbency relative to other Nano structures of the same composition but different proportions, suggesting a decrease in the energy difference, and This doping essentially lowered the distance between the conduction and valance bands while still lowering the energy gap, creating this mixture an excellent material for gas sensing. When this Nano-mixture is added to some basic lubricant oils, it reduces friction and corrosion between contact metals (17)

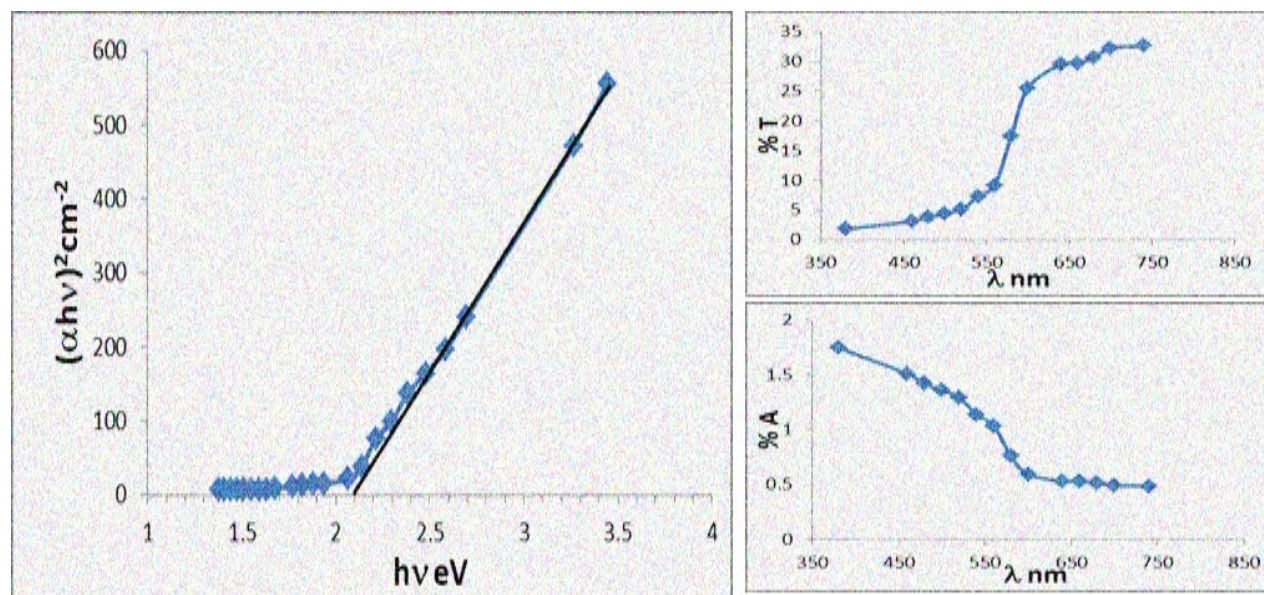


Figure (4):- Show the band gap , transmittance and absorbance for the mixture.

Conclusions:-

After annealing, the energy gap for CuO thin films decreases and increases for NiO thin films.

The crystal structure formed within the layers influences the energy gap values of the prepared layers.

The calculated energy gap supports the formation of Nano structures by a shared of evidence. A good gas sensor is one of its applications.

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References:-

1. Mahima, Ra. Das, Eayan, Mukherjee, Partha, Mitra "Influence of Cu incorporation on ionic conductivity and dielectric relaxation mechanism in NiO thin films synthesized by CBD" Journal of Materials Science: Materials in Electronics • January 2018 DOI: 10.1007/s10854-017-8024-x.
2. Iman Ahmed Younus, Anwar M. Ezzat&Mohammad M. Uonis "Preparation of ZnTe thin films using chemical bath deposition technique", Nano composites 2020, VOL. 6, NO. 4, 165–172.
3. Wajeha A. Zoba," Structural, Optical and Electrical Properties for NiO Thin Films Prepared by Pulsed Laser Deposition", International Journal of ChemTech Research, 2016,9(12): 791-798.
4. Ghougali,M.Belahssen,o.Chala , a. "structural, optical and electrical properties of nio nanostructure thin film" journal of nano- and electronic physics, vol. 8 no 4(2), 04059(4pp) (2016).
5. Jiang, D.Y.; Qin, J.M.; Wang, X.; Gao, S.; Liang, Q.C.; Zhao, J.X. Optical properties of NiO thin films fabricated by electron beam evaporation. Vacuum 2012, 86, 1083–1086.
6. Awais, M.; Dowling, D.D.; Rahman, M.; Vos, J.G.; Decker, F.; Dini, D. Spray-deposited NiOx films on ITO substrates as photoactive electrodes for p-type dye-sensitized solar cells. J. Appl. Electrochem. 2013, 43, 191–197.
7. Hoa L T, Tien H N and Hur S H 2014 "A highly sensitive UV sensor composed of 2D NiO Nano sheets and 1D ZnO Nano rodsfabricated by a hydrothermal process Sensors and Actuators" A: Physical 207 20-24.
8. Blizak,D. Remli, S.Blizak,S.Bouchenak, O. YahiaouiK, "NiO thin films for environmental photo catalytic applications :a review" Algerian Journal of Environmental Science and Technology, June edition. Vol.7. No2. (2021).
9. Jun-Woo Park, Kwang Nam Choi, Seoung Ho Baek, Kwan Soo Chung and Hosun Lee, " Optical Properties of NiO Thin Films Grown by Using Sputtering Deposition and Studied with Spectroscopic Ellipsometry", Journal of the Korean Physical Society, Vol. 52, No. 6, June 2008, pp. 1868-1876.
10. Abd El-Aziz A.Said*, Mohamed M.Abd El-Wahab, Soliman A. Soliman, Mohamed N. Goda "Synthesis and Characterization of Nano CuO-NiO Mixed Oxides" Nanoscience and Nanoengineering 2(1): 17-28, 2014.
11. Riyam A. Hammoodi1, Assist. Prof. Dr. Ahmed K. Abbas1 and Prof. Dr. Abdulhussein K. Elttayef.
12. Rafea .A.Monef , Riad .A.Asmiel , Sabre .G.Mohammed"study structural and optical properties of Nanostructure ZnO Thin Film Prepared by Chemical Bath Deposited method" Tikrit journal of pure sciences ISSN:1813 – 1662.
13. Maysam Sh. Ahmed" The Effect of Thickness and Annealing on Structural and Optical Properties of ZnO: Al Thin Films" .Al-Rafidain science journal,Volum27,issue 2,p. 108-124.
14. Mallick,P.Sahoo,C. S. "Effect of CuO Addition on the Structural and Optical Properties of NiO Nanoparticles" Nano science and Nanotechnology, p-ISSN: 2163-257X e-ISSN: 2163-2588 2013; 3(3): 52-55doi:10.5923/j.nn.20130303.04.
15. Nasser Mohammed Hosny," Synthesis, characterization and optical band gap of NiO nanoparticles derived from anthranilic acid precursors via a thermal decomposition route", Polyhedron Volume 30, Issue 3, 21 February 2011, Pages 470-476.
16. Afnan k. Yousif, Ban A. Bader, Rana O. Mahdi "Morphological and Optical Properties of CuO/Sapphire Thin Films Prepared by Pulsed Laser Deposition" Eng. & Tech. Journal, 2014,Vol. 32,Part (B), N.
17. Elmi, Elias^{1,3}, Krishnasamy^{*1K}.Rajendiran A2, Gajanan Malusare², Ganguli²,D. Manikandan¹,Revathi¹V. P. "Enhancement of Tribological Properties of Lubricating Oilsusing CUO and NIO Nanomaterial's "Krishnasamy et al., J AdvSci Res, 2020; 11 (3): 288-295.