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Factors that Affect Optical Properties of SemiconductorMaterials

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Abstract:- Semiconductors has many characteristics and properties, such as optical properties that relates to the changes in the reflective index (n), extinction coefficient (k), single oscillator parameters, intensity, and the band gap energy. Factors that affect optical properties of semiconductor materials were investigated, ten papers that related to this topic were reviewed, in order to study these factors. It's found that with the increase of the gamma dose, using surfactant, and using a passive agent such as CeO_2 cause a reduction in the band gap energy, while using elements from group I increase the band gap energy, annealing temperature gas no effect on the optical parameters, while preparation method of the semiconductor can effect these parameters, and using rare earth elementenhance the energy band gab.

Keywords : *Optical Properties ; Semiconductor.*

I. INTRODUCTION

Solid-state materials can be classified into three classes - insulators, semiconductors, andconductors. Semiconductor materials a material whose properties are such that it is not quite a conductor, not quite an insulator. It is generally small band gap insulators. Semiconductors can be composed of a single element such as silicon or consist of two or more elements for compound semiconductors. These devices form the basis of nearly all applications in electronics and optoelectronics.

After reading 10 research articles from 7 deferent journals related to Factors that affect optical properties of semiconductor materials, the following topics will be discussed, the effect of the Gamma irradiation on optical properties of CdS diluted magnetic semiconductors, effect of the surfactant and dopant addition on optical properties of ZnSe (Te) nanostructured semiconductors, the effect of annealing temperature on optical properties of DPEA-MR-Zn organic crystalline semiconductors, effect of preparation method on optical properties on $PbBi_2Nb_2O_9$, effect of Ge-vacancy on optical properties of $GeAs_2$ semiconductor, effect of Dy 3+ doped CdS diluted magnetic semiconductors, Effects of annealing atmosphere on optical properties of $Zn_{0.95}Cu_{0.02}Cr_{0.03}O$ diluted magnetic semiconductors, role of Ag^{1+} substitutional defects on optical properties of n-type CdS thin films semiconductor, optical properties of LiO_2-Al_2O_3-SiO_2-TiO_2 Glassy semiconductor containing passive agent CeO_2, and optical properties of perylene- monoimide (PMI) and perylene-diimide (PDI) organic semiconductor thin films.

This review is aimed to get the appropriate condition that combines some of the factors that affect the optical properties of the semiconductors, and will allow us to a better comprehension on the optical properties of semiconductors. In the past years, a lot of researchers work in this field of semiconductor science and they studied its properties and in particular the optical properties, thiswork combine some of these properties to reach the best results that relates to visual ones.

In the reviewed articles researchers used different investigation methods and different specializeddevices to **(1)** produce the specimens that were used in the experiments such as electron beam evaporation technique, mechanical milling, conventional solid state reaction method, drop casting method, and conventional melting method. **(2)** Structural characterization using X-ray powder diffraction (XRD). **(3)** Determine the Pattern of Nanopowder and particle size distribution by high resolution transmission electron microscopy (HR-TEM), and dispersion light scattering measurements (DLS) respectively. **(4)** Determination of the film thickness using different devices such as FTM6 thickness monitor, and discrete Wave Length Ellipsometer TT-30. **(5)** Determination of optical transmittance and reflectance using double beam spectrometer, Determination of optical absorption using a spectrometer, T70 UV-VIS PG instruments, and otheroptical properties was studded using different instruments such as Field Emission Scanning Microscopy (FE-SEM), and UV-Visible Diffuse Reflectance Spectrometer (UV-DRS).

II. RESEARCH METHODOLOGY

Initially, the scope of the topic was defined and have a conceptualization of it, where it is the investigation of the effects that affect optical properties of semiconductor materials, the following question was asked: What factors influence the optical properties of semiconductor.

Science Direct was chosen as a database to search for related topics in this field. The query used on the database was (Factors affect optical properties of semiconductors), to retrieve papers associated with optical properties of semiconductors, and 21 Papers were chosen based on the title, 16 of them were chosen after reading abstract for each of them, the last 10 papers remain after thefull text review.

Descriptive and data analysis will be reviewed, the effect of factors that studied and the result ofinvestigations will be presented in the next sections.

➢ *Descriptive Analysis:*
The distribution of the papers by publication year were in the period 2011-2020, half of the paper is published recently during the past three years from 2018 to 2020. The countries from which these reports were published: China, India, Turkey, Argentina, Pakistan, Egypt, Iran, and Saudi Arabia. Papers were published in 6 deferent articles: Material Science in Semiconductor Processing, Journal of Alloys and Compounds, Optical Materials, Ceramic International, Spectrochimica Acta Part A: Molecular and Biomoleculae spectroscopy, Synthetic Metals.

III. LITERATURE REVIEW

➢ *Introduction:*
Optical properties of semiconductors affected by several factors, the following will be discussed, Gamma irradiation induced effects on optical properties, Surfactant and dopant addition effect on optical properties, the effects of annealing temperature on the optical properties, Effect of preparation method on optical properties, effect of Ge-vacancy on the optical of GeAs2 semiconductor, the effect of rare earth (RE) doping in particular Dy3+ doping in Cds nanoparticle on optical properties, Effects of annealing atmosphere on optical properties, effect of using Elements that belong to Group I such as gold (Au), Copper (Cu) and silver (Ag) as a dopants in II-VI semiconductors, Effect of the presence of CeO2 as a passive agent on optical properties, and optical properties of organic semiconductor was investigated as a new promising semiconductors.

Different methods, instruments, and technique ware used to produce samples and investigate the changes in optical parameters, electron beam evaporation technique, mechanical milling, conventional solid state reaction (SSR), modified sol-gel process (SG) are some examples for methods and techniques that used in the preparation stage, double beam spectrometer, Atomic Absorption spectrometer (AAS), are some examples for methods and techniques that used in investigate the changes in optical parameters.

IV. RESULT AND DISCUSSION

➢ *Effect of Gamma Irradiation:*
Electron beam evaporation using high vacuum coating unit was used for the deposition of semiconductor, and gamma chamber was used for irradiates the film with gamma rays, many changes on the optical parameters were observed, as the radiation dose increase from 0 to 500 kGythe direct optical energy gap Egopt decrease due to the increasing degree of disorder in film and upon gamma irradiation some of the Cd-S bonds are broken, and also when increasing the radiation dose, an increase in reflective index (n) and extinction coefficient (k) were observed, this increase in (n) is due to density increase in the films, as for single oscillator parameters, an decrease in it was observed with the increasing in the dose of gamma irradiation. [1]

➢ *Surfactant and Dopant Addition Effect:*
The changes in optical properties were evaluated measuring the diffuse reflectance by UV-vis spectroscopy, mechanical milling have been applied to obtained nanoparticles, quantum dots, anddoped semiconductors, this method has a disadvantage of particle agglomeration and cold weldingthat increase the particle sizes, to solve this problem surfactant such as methanol, ethanol and zinc chloride are used during milling, undoped ZnSe and ZnTe nanocrystaline powders prepared in similar way for comparison.

Optical data reveal all samples as direct band gap semiconductors with a slight shift to lower energy band gap due to the presence of open volume defect, it is known that optical band gap depends on preparation method, morphology and defects presence it was observed that optical band gap for samples with Surfactant lower than band gap energy for bulk samples. For ZnSe thereis a reduced in absorption value when methanol is used as surfactant, ZnTe characterized by an abrupt absorption edge with similar absorption values for pure, doped, and surfactant milled samples. [2]

➢ *Effects of Annealing Temperature:*
The effect of the annealing on (diphenylphosphino) ethyl) amino) acetic acid-methyl red- monochloro zinc dihydride (DPEA-MR-Zn) optical properties at different annealing temperature was studied. (DPEA-MR-Zn) thin films was deposited on a silicon substrate using the spin coatingtechnique, the compound under investigation belongs to the class of diphenylphosphine ligands. It was observed that increasing the annealing temperature does not affect the optical band gap due to the thermal stability of the lattice parameter, and also the reflective index found to be constant with increasing annealing temperatures. As a result the annealing temperature does not modify the optical parameters of the (DPEA-MR-Zn) semiconductor. [3]

➢ *Effect of Preparation Method:*
There are too many ways to prepare a semiconductor material which effect the optical properties of the semiconductor. PbBi2Nb2O9 (PBN) samples were prepared by two different methods, Solid-state Reaction method

(SSR), and modified Sol-Gel process (SG), UV- Visible spectrophotometer to obtain the optical absorption spectrum.

The estimated band gap values for PBN-SSR samples were 2.46 eV and 2.88 eV in indirect and direct band gap respectively, and for PBN-SG samples were 2.94 eV and 3.45 eV indirect and direct respectively the differences in band gab for PBN-SSR and PBN-SG due to the increase in surface area with the associated decrease in particle size of PBN-SG compared with PBN-SSR, for the photoluminescence spectra of PBN-SG and PBN-SSR samples shows a sharp emission peatat 430 nm and there was decreased in the PL intensity due to the higher surface area of PBN-SG. [4]

➢ *Effect of Ge-Vacancy on the Optical of GeAs2 Semiconductor:*

GeAs2 is frequently used in various applications, Ge-vacancy effect on optical properties of GeAs2 was studied, and two Ge-vacancy V-Ge1 and V-Ge2 are considered here. It is found that the formation energy (Ef) of Ge-vacancy is lower than 0 which indicate that Ge-vacancy in GeAs2 are thermodynamically stable, and (Ef) in V-Ge1 lower than in V-Ge2 which indicate that V-Ge1 is more stable becoause the calculated bond length of GeAs2 for V-Ge1 is shorter than that of V- Ge2. The removal of Ge atom will enhance the localized hybridization. As result the absorption peak of V-Ge1 is 4.53 eV and for V-Ge2 is 4.49 Ge-vacancy decrease the absorption coefficient of GeAs2, and the storage optical properties of GeAs2 are better than GeAs2 with Ge-vacancy. [5]

➢ *The Effect of Rare Earth (RE) Doping:*

The effect of rare earth (RE) doping in particular Dy3+ doping in Cds nanoparticle on optical properties of this semiconductor were studied. Doping Dy3+ in CdS enhance the band gap energy(Eg) from 2.44 eV to 2.55 eV due to the (1) formation of sulphur vacancy due to charge imbalance between Cd2+ and Dy3+, and (2) decrease in particle size with doping, this decrease in particle size can be explained by the shrinkage of the unit cell due the lower ionic radii of Dy3+ than Cd2+.These sulphur vacancy acts as a trap states for the photogenarated electron resulting in yellow emission, the yellow luminescence make them good candidate for yellow laser and for white lightemitting diode. [6]

➢ *Effects of Annealing Atmosphere:*

The Zn 0.95 Cu0.02Cr0.03O nanoparticles are synthesized by the sol–gel method, this method has the advantages of low cost, simple deposition procedure, easier composition control, and low processing temperature. The effect of annealing atmosphere on the optical properties in Zn0.95Cu0.02Cr0.03O were studied. The UV emission peak of the samples annealed in air and argon are located at 400.03 nm and 400.24 nm, respectively. UV emission peak of the samples annealed in argon exhibit red-shift. The intensities of the UV emission and broad green band increase severely with annealing atmosphere change from air to argon. [7].

➢ *Effect of Using Elements that belong to Group I:*

Elements that belong to Group I such as gold (Au), Copper (Cu) and silver (Ag) are used as a dopants in II-VI semiconductors due to energy band gap engineering, resistivity reduction as well as structural changes. Effect of group one dopant in particular Ag dopant in CdS thin films on optical properties were studied. There was no significance difference in the refractive indexes of as-deposited and Ag-doped films. There is a significant increase in the energy band gap due to Ag-doping – the energy band gap was increased from the value of 2.15 eV–2.45 eV due to defects generation with in energy band gap as the fermi level is changed after Ag-doping [8].

➢ *Effect of the Presence of CeO2 as a Passive Agent:*

Effect of the presence of CeO2 as a passive agent in Li2-Al2O3-SiO2-TiO2 (LAST) material on optical properties was investigated. Optical properties have been studied using UV-Vis and FTIR absorption spectra. Licciardello's formula was used to study the variation of energy level in the presence of CeO2. In many amorphous material, variation of absorption coefficient with photon energy discussed in three region, will be used in determination of optical band gap. Fermi energyis important in understanding optical properties of solids, as a result, when the CeO2 increase theoptical band gap reduced to 2.42 eV which is a specific characterization of semiconductor material, and the Fermi energy reduced with the lower intensity [9].

➢ *Optical Properties of Organic Semiconductor:*

Optical properties of organic semiconductor was investigated, perylene-monoimide (PMI) and perylene-diimide (PDI) was prepared by drop-casting method and the analyzed their optical properties and find their optical parameters such as absorption coefficient, extinction coefficient, reflective index, and dielectric content. Fundamental absorption edge at 500nm then at longer wavelength the absorption decrease. At longer wave lengths, absorbance for both samples approximate to the same value. Optical band gap energy of PMI and PDI thin films is found as 2.30 eV and 2.39 eV respectively. Extinction coefficient (k) decrease with increasing the wavelength for PMI, the values of k have greater than those of PMI [10].

V. CONCLUSION

Optical properties of semiconductors can be changed and improved by several conditions and effects that have been investigated, as the influence of the increasing in gamma irradiation dose that leads to decrease in optical energy gap and oscillator parameters, increase in reflective index, and extinction coefficient. Using Surfactant leads to reduce in band gap energy and absorption value. The annealing temperature does not modify the optical parameters of the semiconductor. Preparation method of samples of semiconductors can affect the band gab energy, when using SSR and SG preparation methods we get different reading of band gap energy. Ge-vacancy decrease

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the absorption coefficient of GeAs2, and the storage optical properties of GeAs2 are better than GeAs2 with Ge-vacancy. Using rare earth (RE) doping in particular Dy3+ doping enhance the optical band gap energy. Using elements that belong to group I as Ag leads to increase in the energy band gap, no significance difference in the refractive indexes. Effect of the presence of CeO2 as a passive agent, when the CeO2 increase the optical band gap reduced.

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