EasyChair Preprint

№ 1834

Enhancement of CdO film Via Li Additive: Structural and Optical Properties

Reem Ali, Khansaa Sharba, Muhammad Al-Timimi, Khalid Abass, Nadir Habubi, Ismaeel Al-Baidhany and Sami Chiad

EasyChair preprints are intended for rapid dissemination of research results and are integrated with the rest of EasyChair.

November 5, 2019

Enhancement of CdO film Via Li Additive: Structural and Optical Properties

Reem Sami Ali[1], Khansaa Saleem Sharba[2], Muhammad Hameed Al-Timimi[3], Khalid Haneen Abass[4], Nadir Fadhil Habubi[5] , Ismaeel A. Al-Baidhany[5], Sami Salman Chiad[5]*.

[1]Department of Physics, College of Science, Mustansiriyah University, Baghdad, Iraq, reemphy81@uomustansiriyah.edu.iq.

[2] The General Directorate of Education in Babil, Ministry of Education in Iraq, Iraq, khanhun_sl@yahoo.com

[3]Department of Physics, College of Science, University of Diyala, Iraq, muhammadtimimi@yahoo.com

[4]Department of Physics, College of Education for Pure Sciences, University of Babylon, Iraq, pure.khalid.haneen@uobabylon.edu.iq.

[5]Department of Physics, College of Education ,Mustansiriyah University, Baghdad, Iraq, nadirfadhil@uomustansiriyah.edu.iq, ismaeel_2000@uomustansiriyah.edu.iq, dr.sami@uomustansiriyah.edu.iq.

***Author for correspondence: E-mail: dr.sami@uomustansiriyah.edu.iq.**

Abstract

Chemical spraypyrolysis technique was used to prepare thin film of purenanostructured CdO and nanostructured Li-doped CdO with volumetric concentration of (1 and 3.%). By using XRD, the prepared films on glass substrate have been studied and found to be cubic structure.Through the use of UV-Visible spectrophotometer has determined the optical parameters like transmittance and optical constants. The optical energy gap of CdO was decreased from 3.92 eV for pure CdO film to 3.8 eV for the CdO:3%Li film.

Key words: CdO:Li thin film, chemical spray pyrolysis, energy gap ,structural and optical.

Introduction

The technologies of thin film have an importance role specifically in the field of optical coating, microelectronics, integrated optics and superconductors [1]. The transparent conducting oxides (TCOs) like CdO, ZnO, InO, TiO_2 و, were extensively studied in optoelectronic devices,[2]. Cadmium oxide (CdO) attracted the attention of researchers in recent years for their potential use in various applications [3]. The CdO is an II-VI semiconductor, it is an n-type with a simple cubic structure with a direct band gap of 2.3 eV [4-5], low resistivity, high optical transmittance in visible region [6], high density (8150 Kg/m^3) [7], and high melting point (900-1000 °C) [8]. Many techniques that used to prepare CdO film like SILAR method [9], solvothermal method [10], chemical bath deposition[11], chemical spray pyrolysis (CSP) [12]. In the present work, Chemical spray pyrolysis that used to make the CdO films with various Li content, From structural and optical properties it can candedate the films in many applications acording to its structure and optical properties.

Experimental

Chemical pyrolysis (CdO) and thin film of CdO and Li-doped CdO with volumetric concentration of (1, 2, and 3.%) were prepared on a glass substrate at preheated to 400 ^{o}C by using CPS method. The structural properties of the CdO:Li was studied by (X-Ray) Diffractometer, and scans are performed between 2θ values of 20^{o} and 70^{o}. The optical absorption spectra are registered between 300-800 nm of wavelengthusing Shimadzu UV-Visible Spectrophotometer at room temperature. AFM (AA 3000 Scanning Probe Microscope) was utilized to study deposited thin films surface.

Results and discussion

The structure of CdO:Li films with a variety of contents of Li is determined by X-ray diffraction (XRD). The diffraction angle which is investigated with the intensity of peaks is determined as in the Fig.1. From the figure, the predominant peak is (111) corresponding to the 2θ = 33° corresponding to the polycrystalline CdO film with other peaks that are determined. The crystallite size (D) of CdO:Li thin films were determined via scherrer formula [13,14]:

$$D = \frac{k\lambda}{B\cos\theta} \qquad (1)$$

where k is a constant (0.9), λ (0.154 nm) represent the x-ray wavelength used, B is FWHM, and θ is the angle of Bragg's diffraction. The crystallite size has been decreased from 65.83 nm of the pure CdO film to 48.70 nm of the film CdO:3%Li indicate that the deposited film were nanostructured.

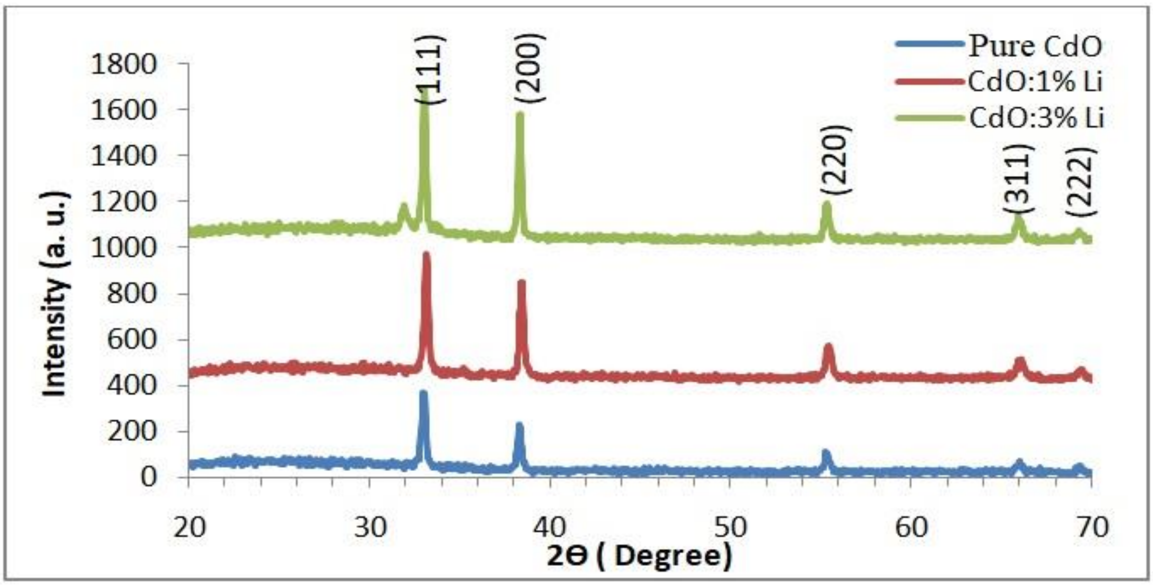
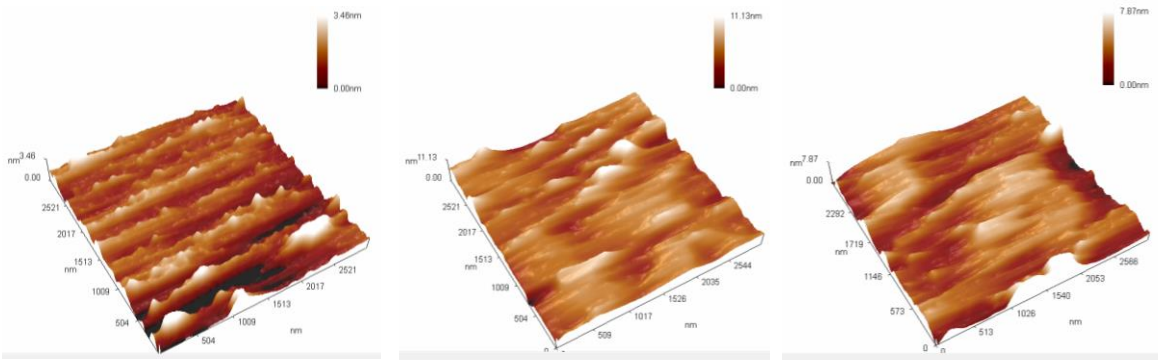


Fig.1: XRD pattern of CdO film with various content of Li.

Fig. 2: Atomic force microscope image of a) CdO b) CdO:1%Li c) CdO:3%Li films.

From the figare, the films seem homogenious because there is no craks and pinhole, and smoth because the ten hight point ranged from 1.73 nm to 6.87 nm. The roughness average S_a is increased with the increasing of Li content, also the root mean square S_q. The AFM data are listed in Table 1.



a b c

Fig. 2 illuatrate the Atomic Force Microscope (AFM) images.

Table 1: AFM data of CdO:Li films

Film	**(Sa) (nm)**	**(Sq) (nm)**	**Ten point height (Sz) (nm)**
CdO	0.48	0.65	1.73
CdO:1%Li	0.99	1.30	2.58
CdO:3%Li	0.98	1.23	6.97

The transmittance (T) can determined from the relation (2) that depends on the absorption (A)[15]:

$$T = 10^{-A} \quad (2)$$

Fig.2 illustrates transmittance spectra of pure CdO:Li thin films against wavelength. From the figure, the transmittance has been decreased with the increasing of Li doping, this is caused by adding of Li including electrons in the outer orbits, which can be absorb the incident photons make these films more absorber and less transmittance.

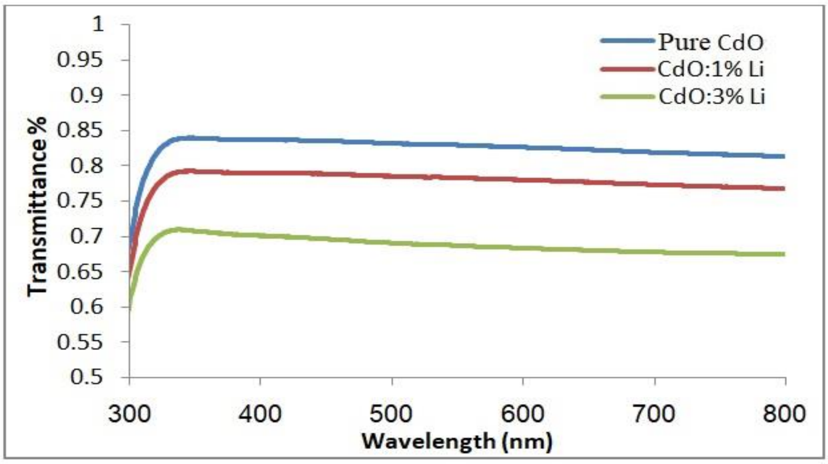


Fig.2: Transmittancespectra of CdO film with various content of Li.

It can calculate the absorption coefficient (α) from the following formula [15]:

$$\alpha = \frac{2.303A}{t} \qquad (3)$$

where A and t are the absorbance and thickness of film respectivily.

The absorption coefficient (α) of pure and CdO:Li thin films versus wavelength were presented in the Fig.3. The α helps to have a knowledge about kind of transition. The values of α of the prepared films (CdO:Li) (Fig.3) refer to the direct transition ($\alpha > 10^4$) cm^{-1}[16].

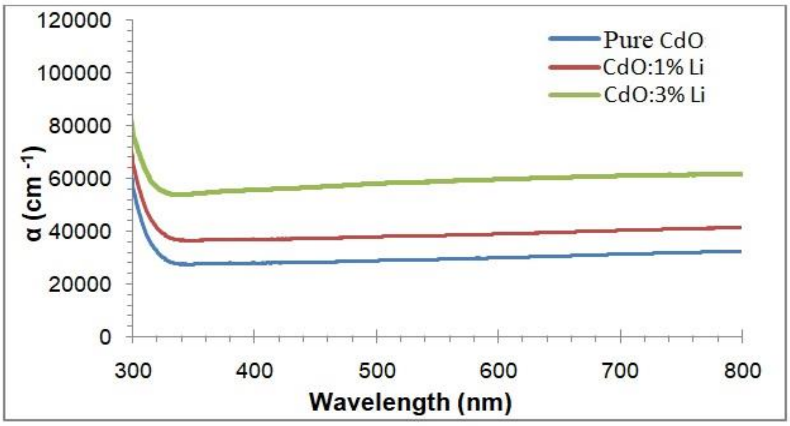


Fig.3: Absorptioncoefficient of CdO film with various content of Li.

The energy gap (E_g) of pure and CdO:Li thin films can be determined from the relation [16]:

$$\alpha h\upsilon = A(h\upsilon - Eg)^n \qquad (4)$$

where hυ represents the photon energy and A is a constant, for a direct transition n = $\frac{1}{2}$ or $\frac{2}{3}$ [17]. The value of energy gap can determined from he plot $(\alpha h\upsilon)^2$and hυ as in

Fig.4. The values of E_g were decreased from 3.92 eV for pure CdO film to 3.8 eV for the CdO:3%Li film.

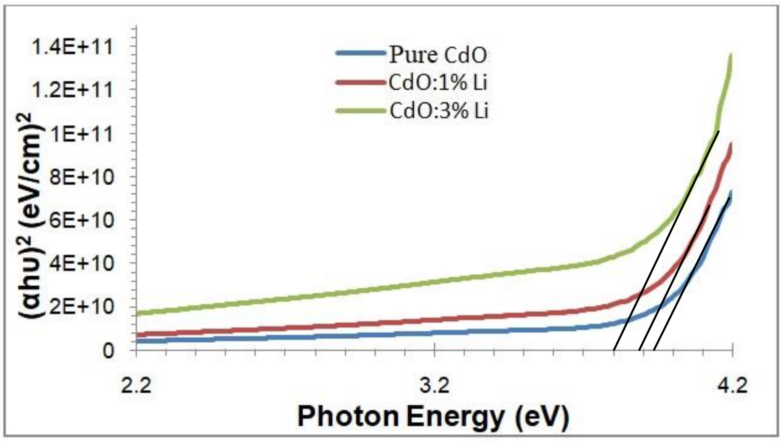


Fig.4: $(\alpha h\upsilon)^2$ versus photon energy of CdO film with various content of Li.

Fig.5 represent the link between extinction coefficient and wavelength. The extinction coffecient (k) can be calculated from the relationship [18]:

$$k_o = \frac{\alpha\lambda}{4\pi} \qquad (5)$$

where α represents the absorption cofficient.

From the figure, the k_o increases with the increasing of wavelength. In addition, the k_o increases with the increasing of Li concentration in CdO:Li films.

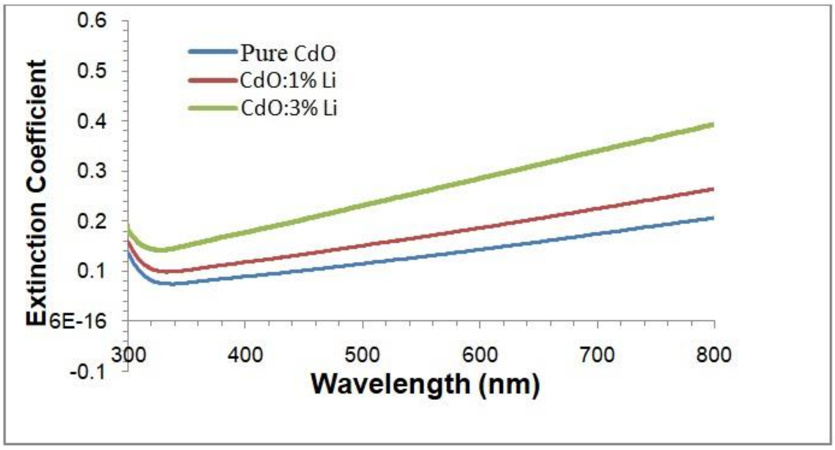


Fig.5: Extinction coefficient of CdO film with various content of Li.

The variations of refractive index (n) with wavelength of CdO:Li films which were approximately estimated are illustrated in Fig.6. From the figure, it is clear that n behaviour is decreases with increasing wavelength; whereas the increase with Li concentration can be noticed. At higher wavelength, the CdO:Li films illustrated refractive index approaching to be constant.

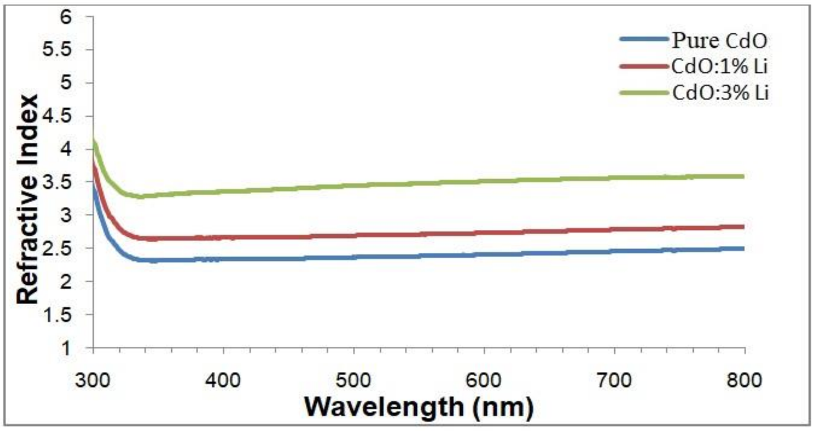


Fig.6: Refractive index of CdO film with various content of Li.

The real (ε_i) and imagenary (ε_r) dielectric constant that calculated from the relationships [19]:

$$\varepsilon_i = n^2 - k^2 \qquad (6)$$

$$\varepsilon_r = 2nk \qquad (7)$$

where k is extinction cofficient. The ε_i and ε_r were illustrated in Figs.7 and 8.

The complex dielectric constant for a wavelength range between 300-800 nm, is important standard for the choosing of fabricated films for different applications. The general behaviour of the prepared films increased ε_i and ε_r with the increasing of Li doping in the CdO:Li films, refer to the increase of electrical polarization.

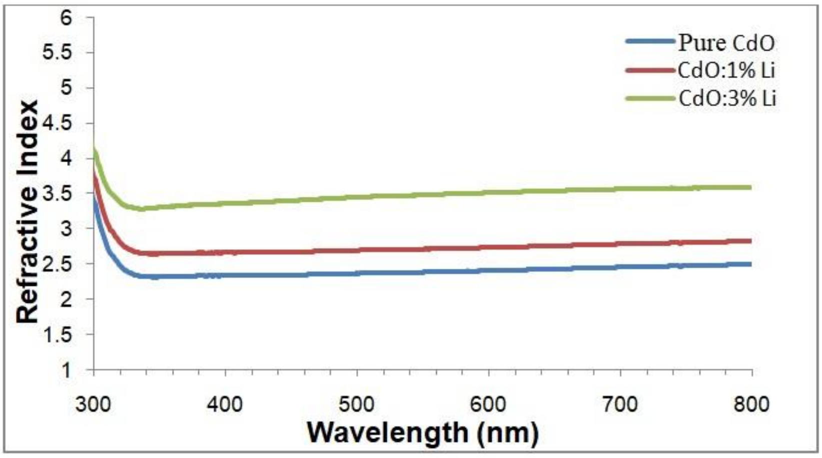


Fig.7: Absorbancespectra of CdO film with various content of Li.

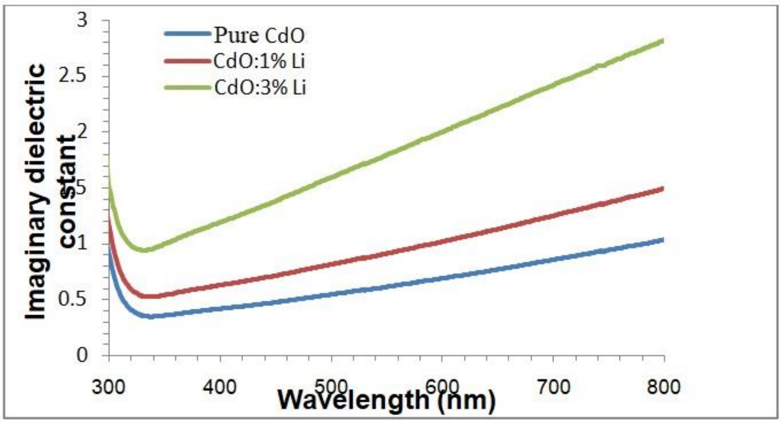


Fig.8: The imaginary dielectric constant of CdO film with various content of Li.

4 -Conclusion

The structure of polycrystalline CdO:Li films that prepared using chemical spray pyrolysis on glass substrate which are examined by XRD. From UV-Visible spectrophotometer, the absorbance and transmittance spectra are determined. Absorbance increased with the increasing of Li doping, while transmittance decreased. The optical energy gap decreased with the increasing of Li doping to be 3.8 eV for the CdO:3%Li film. The optical constants also determined.

Acknowledgment

Authors would like to extend their thanks and gratitude to the Mustansiriyah University.

References

[1] R. L. Mishra, , A. K. SHarma, and S. G. Prakash, "Gas Sensitivityand Characterizationof Cadmium Oxide (CdO) Semiconducting Thin Film Deposited by Spray Pyrolysis Technique", Digest Journal of Nanomaterials and Biostructures, 4(3) (2009) 511-518.

[2] N. Manjula and A.R. Balu, "CdO Thin Films Fabricated by a Simplified Spray Technique Using Perfume Atomizer with Different Molar Concentrations of Cadmium Acetate for Optoelectronic Applications", International Journal of Chemical and Physical Sciences, 3 (4) (2014) 54-62.

[3] Hussain S. Akbar, "CO_2 Laser Influence on the Structural Properties of CdO Thin Films Prepared by Chemical Spray Pyrolysis (CSP) Method", Australian Journal of Basic and Applied Sciences,10 (4) (2016) 167-170.

[4] B. Gokul, P. Matheswaran, and R. Sathyamoorthy, "Influence of Annealing on Physical Properties of CdO Thin Films Preparedby SILAR Method", J. Mater. Sci. Technol., 29 (1) (2013) 17-21.

[5] Khalid Haneen Abass, "Effect of the cobalt additive on the urbach energy and dispersionparameters of cadmium oxide thin films", Physical Chemistry An Indian Journal, 10(1) (2015) 1-6.

[6] Khalid Haneen Abass and Duha M. A. Latif, "The Urbach Energy and Dispersion Parameters dependence of Substrate Temperature of CdO Thin Films Prepared by Chemical Spray Pyrolysis", International Journal of ChemTech Research, 9 (9) (2016) 332-338.

[7] M. Zaien, N. M. Ahmed, and Z.Hassan, "Fabrication and Characterization of an n-CdO/p-Si Solar Cell by Thermal Evaporation in a Vacuum", Int. J. Electrochem. Sci., 8 (2013) 6988-6996.

[8] Matthew David Femi, Adrian Ohwofosirai, Aboritoli Sunday, Ogah Sunday B. A. Ezekoye F. I. Ezema, and R. U. Osuji, "Variation of the Optical Conductivity, Dielectric Function and the Energy Bandgap of CdO Using Cadmium AcetateDehydrate", International Journal of Advances in Electrical andElectronics Engineering, 2 (2) (2013) 337-331.

[9] A. Hosseinian, A. R. Mahjoub, and M. Movahedi, "Low temperature synthesis and characterization of nanocrystalline CdO film by using a solvothermal method without any additives", Journal of Applied Chemical Researches, 4 (14) (2010) 43-46.

[10] B. A. Ezekoye, V. A. Ezekoye, P. O. Offor, and S. C. Utazi, "Synthesis, structural and optical characterizations of cadmium oxide (CdO) thin films by chemical bath deposition (CBD) technique", International Journal of Physical Sciences, 8(31) (2013)1597-1601.

[11] Duha M A Latif, Sami S Chiad, Muhssen S Erhayief, Khalid H Abass, Nadir F Habubi, and Hadi A Hussin, Effects of $FeCl_3$ additives on optical parameters of PVA, Journal of Physics: Conf. series, 1003 (2018).

[12] Ehssan S Hassan, Tahseen H Mubarak, Kha,lid H Abass, Sami S Chiad, Nadir F Habubi, Maher H Rahid, Abdulhussain A Khadayeir, Mohamed O Dawod, and Ismaeel A Al-Baidhany, "Structural, Morphological and Optical Characterization of Tin Doped Zinc Oxide Thin Film by (SPT)", Journal of Physics: Conference Series, 1234 (2019).

[13] Abdulhussain A Khadayeir, Ehssan S Hassan, Sami S Chiad, Nadir F Habubi, Khalid H Abass, Maher H Rahid, Tahseen H Mubarak, Mohamed O Dawod, and Ismaeel A Al-Baidhany, "Structural and Optical Properties of Boron Doped Cadmium Oxide", Journal of Physics: Conference Series, 1234 (2019).

[14] Khalid Haneen Abass, Anmar Adil, and Musaab Khudhur Mohammed, " Fabrication and Enhancement of SnS:Ag/Si Solar Cell Via Thermal Evaporation Technique", Journal of Engineering and Applied Sciences, Vol.13, No.4, pp.919-925, 2018.

[15] K. A. Mishjil, S. S. Chiad, K. H. Abass, and N. F. Habubi, “Effect of Al Doping on Structural and optical Parameters of ZnO Thin Films”, Materials focus, 5 (6) (2016) 471-475.

[16] Khalid Haneen Abass, Mohammed H. Shinen, and Ayad F. Alkaim, Preparation of TiO_2 Nanolayers via Sol-Gel Method and Study the Optoelectronic Properties as Solar Cell Application, Journal of Engineering and Applied Sciences, Vol.13, No.22, pp.9631-9637, 2018.

[17] Khalid H. Abass and Musaab Khudhur Mohammed, "Fabrication of ZnO:Al/Si Solar Cell and Enhancement its Efficiency Via Al-Doping", Nano Biomed. Eng., 2019, Vol. 11, Iss. 2, 170-177.

[18] Akeel Shakir Alkelaby, Khalid Haneen Abass, Tahseen H. Mubarak, Nadir Fadhil Habubi, Sami Salman Chiad, Ismaeel Al-Baidhany," Effect of MnCl2 Additive on Optical and Dispersion Parameters of Poly methyl Methacrylate Films". Journal of Global Pharma Technology,.2019, pp.346-352.

[19] A. A. Khadayeir, Khalid Haneen Abass, S. S. Chiad, M. Kh. Mohammed, N. F. Habubi, T. Kh. Hameed, and I. A. Al-Baidhany, "Study the influence of Antimony Trioxide (Sb_2O_3) on optical properties of (PVA-PVP) composite", Journal of Engineering and Applied Sciences, Vol.13, No.22, pp.9689-9692, 2018.