بسم الله الرحمن الرحيم

وزارة التعليم العالي والبحث العلمي جمهورية العراق
جامعة القادسية / كليــة العلـوم
مجلة القادسية / العلوم الصرفة
هيئـة التحرير

MINISTRY OF EDUCATION
& SCIENTIFIC RESERG
UNIVERSITY OF AL-QADISIYA
COLLAGE OF SCIENES
JOURNAL OF AL-QADISIYA
PURE SCIENES
EDITION BOARD

العدد ٢٠٠٦ ق/ ١١٢
التاريخ ٢/ ٩/ ٢٠١٨

استمارة قبول البحث والنشر

إلى / الاستاذ الدكتور عبد الحسين عباس خضير المحترم

جامعة القادسية / كلية التربية
الست شيماء راجح تالي المحترمة
جامعة القادسية / كلية التربية

م/ قبـول نشـر

نـهديكم أطيب التحيات:
تدارست هيئة التحرير بحثكم الموسوم :-

STUDY THE EFFECT OF MAGNET IC FIELD ON THE PROPERTIES OF SILVER THIN FILMS PREPARED BY . DC SPUTTERING

والمقدم للنشر في مجله القادسية للعلوم الصرفة وبعد الاطلاع على اراء المقيمين واستنادا الى ما قررته هيئه التحرير في جلستها الرابعة المنعقدة في ٦/ ٥/ ٢٠١٧ ما يلي :-

- قبول البحث في المجلة وسوف ينشر في المجلد (٢٣) العدد (٣) لسنة ٢٠١٨

أ.د. حسن عباس حبيب
رئيس التحرير
٢/ ٩/ ٢٠١٨

STUDY THE EFFECT OF MAGNET IC FIELD ON THE PROPERTIES OF SILVER THIN FILMS PREPARED BY DC SPUTTERING .

Dr. Abdulhussain A .Khadayeir[1] , shimaa Rajh .Taly [1]

[1](Physics Department ,College of Education / University of AI-Qadisiyah ,Iraq Country)

E-mail : abdulhussain.khadyair @ qu .edu .iq

E-mail : rajh74111@gmail.com

ABSTRACT: Silver thin films by Dc sputtering method on glass substrate for different deposition times (10,30 and 60)sec have been prepared and deposited . The thicknesses of Ag thin films measured by using an optical interferometer method employing He-Ne laser (632.8)nm wavelength . Thin films thicknesses without magnetic field was (84,89 and 94)nm while with magnetic field was(127,269 and 290)nm for same times. Structure and Optical properties have been analyzed by using XRD and UV-V spectroscopy and XRD analysis show that thin films were face centered cubic structure. Absorption and Transmittance spectra of silver thin films were recorded in the wavelength range between 300nm to1100nm . High absorption coefficient of silver thin films determined from the analysis of absorption spectra . The electrical properties show the resistivity inversely proportional with silver thin films thickness.

KEYWORD: Structure and Optical properties ,Ag thin films , DC sputtering ,

1-INTRODUCTION

The electrical and structural properties of thin metal films can be effected by a large number of parameters such as time ,surface, thickness and other parameter. A composition of two or more thin film phases of metal can improve the structural ,electrical and optical properties . The wide uses of silver thin films is in knowledge of microelectronics, capacitors and transistors , because of their excellent physical and electrical properties[1,2]. Silver has many interesting attributes, like excellent high frequently virtues , highest electrical conductivity , low resistivity, and a rather high melting [3] .the inset of Ag particles into thin films cans enhancement film conductivity[4]. Silver is one of the best conducting metals and widely used in the modern world for electrical conduction in multiple industries and applications , including light-emitting diodes (LED) and flat-panel displays (FPD)[5].Ag thin films have also been widely applied in optical applications, mainly due to their high transparency and neutral color in the visible range, they also exhibit extremely high reflectivity near infrared (IR) and IR of spectrum[6]. These properties make Ag thin films ideal candidates for low-thermal-emissivity coatings on glass panels, leading to energy-efficient windows for residential and commercial buildings . For the lest twenty years, low- thermal-emissivity coatings have motivated an intense research activated to improve the growth mode and optical properties of Ag thin films ,ultimately leading to substantial energy savings[7] . Silver thin films had been prepared by several techniques such as DC and RF magnetron sputtering , chemical vapor deposition(CVD) , pulsed laser deposition(PLD) , ion-assisted deposition and electron beam evaporation [8] .In the present investigation ,DC magnetron sputtering was used to prepare Ag films and study its effects on thickness films.

Magnetron sputtering is one of well – developed method for thin film fabrication ,its extensive use in industrial application depends on the ability of obtaining high quality films with high value of deposition rate [9]. F.Penning was the first Physicist suggested to use magnetron sputtering for the film deposition as early as 1935 , it is important not only for industrial application but also for scientific and technology research [10]. In a basic sputtering process , a target (or source) material to be deposition onto substrate , is bombarded by energetic ions typically inert gas ions such as Argon (Ar^+) . The strong collisions of these inert gas ions with target atoms causes the removal of target atoms which condense on the substrate as a thin film of stoichiometry similar to that of target material [11] . Magnetron sputtering systems produce a strong magnetic field near the target area which causes the mobile electrons to spiral along magnetic flux lines near the target . This arrangement confines the plasma in near the target area without causing the damage to the thin films being formed on the substrate and maintains on thickness uniformity of deposition thin film [12].

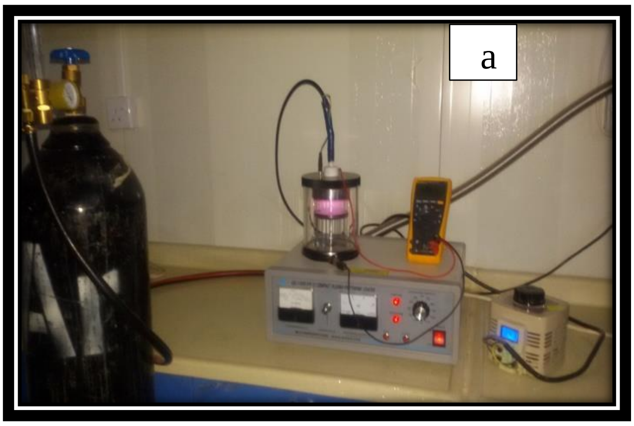
2- EXPERIMENTAL

2-1 Materials and method:

In the first step, Ag films were deposition on glass substrates by using DC magnetron sputtering using SPC-12 system compact plasma Sputtering coater origin (MTR Corporation , CA 94804, USA). and by addition coil to produce variable magnetic field and permanent magnetic field , the sputtering target was of the metal silver with purity of 99.9%. the deposition chamber has been evacuated to base pressure of 4×10^{-2} mmHg. After introduction of the sputtering gas (Ar 99.9%) into the chamber ,the deposition pressure was 8×10^{-2} mmHg and the deposition time for all films were (10,30 and 60) sec ,the distance between the target and substrate was (4cm) . The thicknesses of Ag films was(127,269 and 290) nm . In the second step, we used the method of plasma sputtering without magnetic field at the same deposition conditions for deposition Ag films , where the thicknesses of thin films was (84 ,89 and 94) nm in this method. The crystal structures of thin films analyzed by X-ray diffraction (XRD) using the device carries the following specifications (TYPE: XRD-6000, SHIMADZU, JAPANESE ORIGIN, TARGET: Cu Kα, $\lambda = (1.5406)$ Å, Speed: (5) deg / min, voltage: (40) KV, current: (30) MA, range (2θ): 30-100 deg The optical properties of Ag thin films analyzed by using UV-Vis spectra .The electrical properties of the prepared thin films were studied .

2-2Thin films thickness measurements:

The thickness of Ag thin films were measured by using an optical interferometer method employing He-Ne laser (632.8)nm wavelength with incident angle 45^0 .



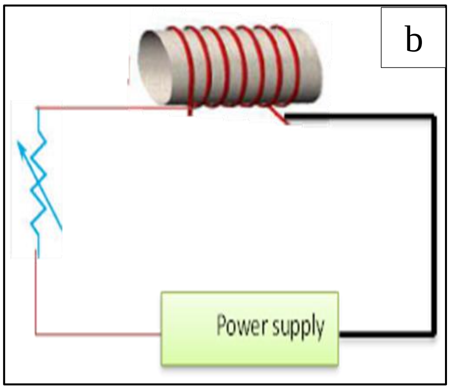


Figure.(1): (a) sputtering system and (b) the electrical circuit of the coil .

Table 1.Deposition parameters of Ag thin films .

sample condition	Base pressure (mmHg)	Work pressure (mmHg)	Voltage (V)	Current (mA)	Deposition time (sec)	Thickness (nm)
without M.F	4×10^{-2}	8×10^{-2}	216	15	10 ,30,60	84 ,89,94
with M.F (100)Gauss	4×10^{-2}	8×10^{-2}	189	20	10 ,30,60	127,269,269

3- RESULT AND DISCUSSION

3-1 Structure properties :

Figure 2, shows the X-ray diffraction pattern of Ag thin films deposition on glass substrates and different with thicknesses (t=269 nm, t=290 nm) . the polycrystalline Ag films can be observed and the peak namely the (111), (200), (220), (311) illustrates in fig.2,according to ICDD numbered card (00-004-0783), cubic type the (111) Ag peak intensity was larger than that of the other peaks because the (111) direction to Ag films has lowest surface energy , and we calculate the lattice constant of the Ag films prepared for installation cube from equation (1) [13].

$$d_{hkl} = \frac{a}{\sqrt{h^2+k^2+l^2}} \quad .... (1)$$

Where:(hkl) are Miller coefficients, (a) is lattice constant and d_{hkl} is the distance between the plans(hkl). The average crystallite size to the prevailing direction (111) was calculated from equation(1) , while the average grain size calculated from the following equation [14] .

$$D_{av} = \frac{0.09\,\lambda}{B\,COS\theta} \quad ....(2)$$

Where D_{av}: is the grain size , λ is the wavelength of cu-kα radiation used(λ =1.5406 Å), β: is full width half maximum intensity (FWHM) and θ is the Bragg angle.

We notice that the average grain size leads to increases thickness of films and also leads to increase the surface roughness and increase the homogeneity of the film as shown in Table(2).This result corresponds with research [8] .

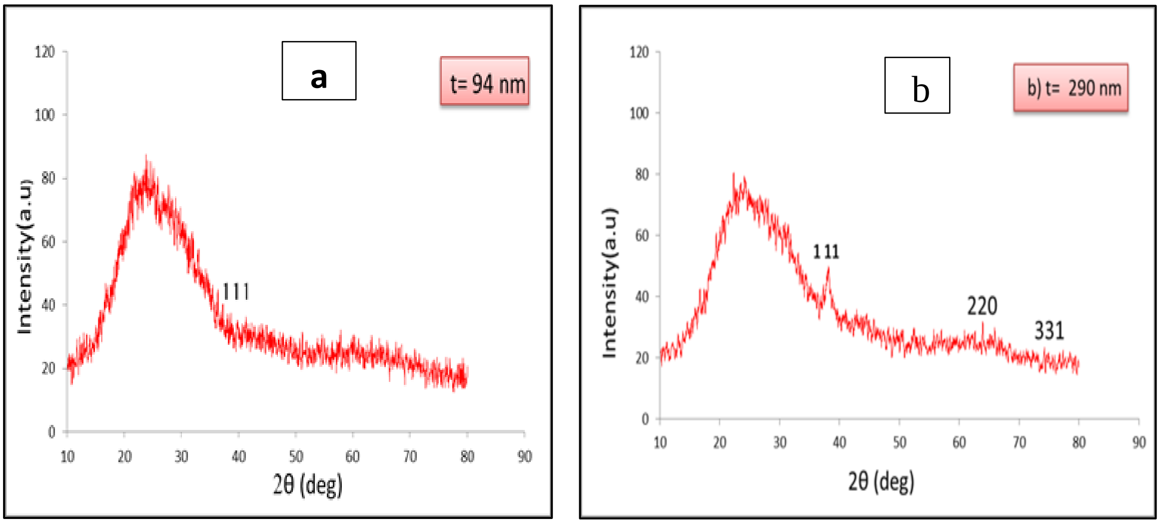


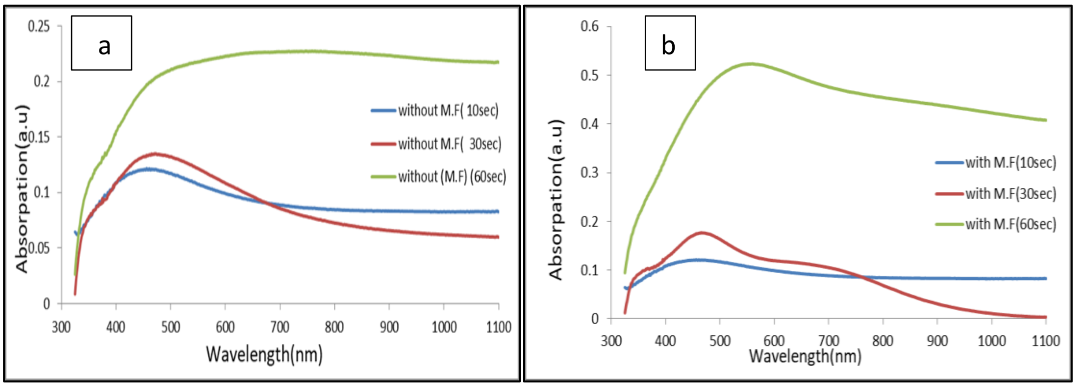
Figure (2) : The XRD patter of as deposition Ag films on glass substrate :(a) without magnetic field and (b) within magnetic field.

Table(2) values structure from XRD for prevailing direction(111) of silver thin films

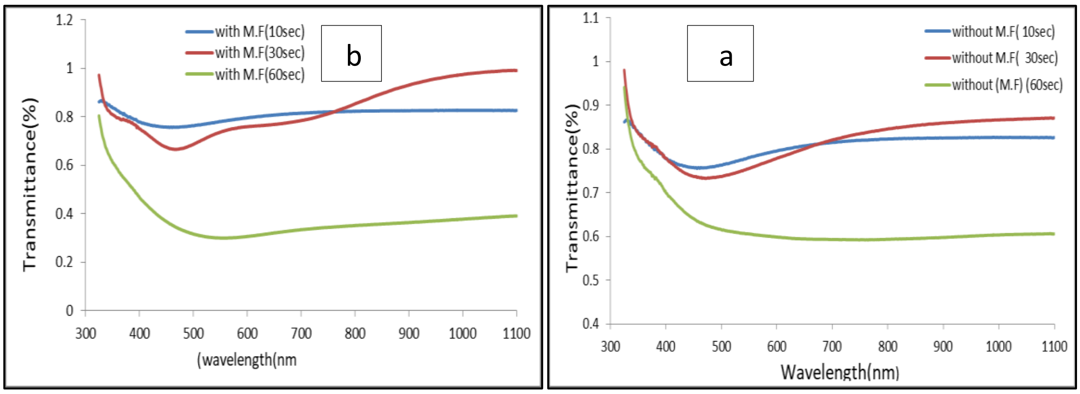
sample Ag	2θ(deg)	2θ(deg) ICDD	d(A)	hkl	$a_0(A^0)$	The Average grain size (nm)
sample a t=94nm	38.80	38.11	2.309	111	4.0875	144.976
	44.13	44.27	2.044	200		
	64.28	64.42	1.445	220		
	77.44	77.47	1.231	311		
sample b t=290nm	38.11	38.11	2.359	111		
	44.27	44.27	2.0438	200		
	64.42	64.42	1.445	220		
	77.47	77.47	1.230	311		

3- 2 Optical properties:

The optical measurement of the prepared films carried out using UV-Vis-NIR (300-1100) nm Spectroscope and the spectral dependence of the transmittance (T) and absorption(A) for all Ag films . The absorption spectra of Ag thin films as a function of wavelength ranging from(300-1100)nm are shows in figure (3). The films show surface resonance peak observed at 450 nm . The absorption increase with deposition time and thin films thickness . Figure (4) Shows the transmittance spectra at same wavelength to1100nm . The ranging from 300nm transmittance shows opposite behavior of optical absorption and transmittance decreases at the short wavelength until to reaches the lowest value of wavelength(400)nm and proportional with wavelength , thickness and time . Optical reflectance , optical constants includes absorption Coefficient (α) as a function of wavelength calculated by using absorption and transmittance spectra.



Figure(3) UV-Vis Absorption of Ag thin films (a) without magnetic field and (b) within magnetic field



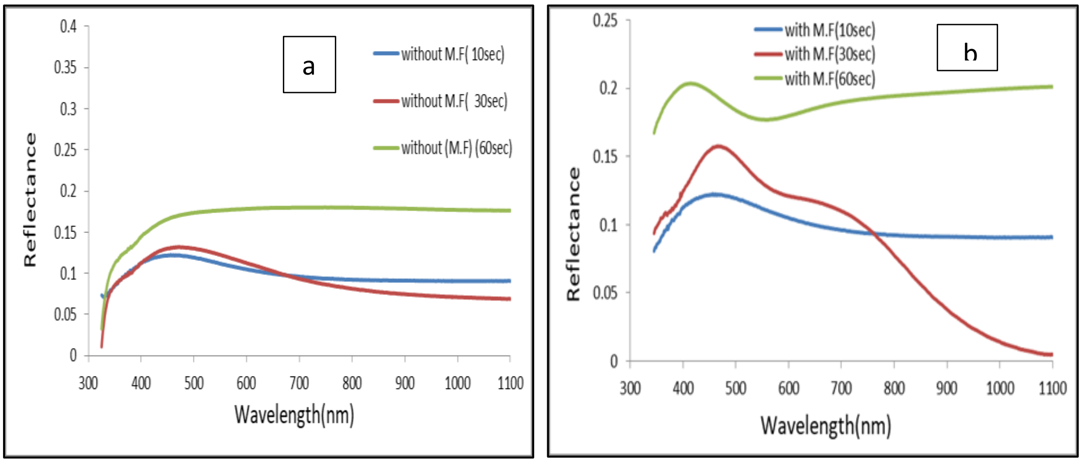
Figure(4) UV-Vis transmittance of Ag thin films (a) without magnetic field and (b) within magnetic field.

3-2-1 Calculation of reflectivity:

The reflectivity of silver Ag films was calculated with and without magnetic field from absorption (A) spectra and transmittance(T) form equation (3) [15] .

$$R=1-A-T \qquad ..(3)$$

Figure(5) ,shows the reflectivity film as a function of wavelength with and without magnetic field , we can observe that the values of reflectivity rise until to reach their highest value at short wavelength(400)nm and then begin to decrease with increasing wavelength.



Figure(5) reflectivity spectra of Ag thin films (a) without magnetic field and (b) within magnetic field .

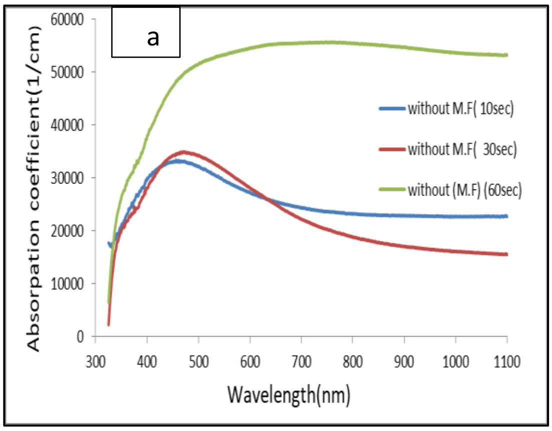
3-2-2 Calculation of absorption coefficient (α):

The absorption coefficient of silver films calculated from the following equation [16]:

$\alpha=2.303\ A/t$ ....(4)

where A is the absorption and t is thin film thickness in (nm) unit.

Figure(6) shows absorption coefficient as a function of wavelength for the samples with different deposition times and thicknesses. Absorption coefficient increases at short wavelength until reach to the highest peak at (400) , than decrease with wavelength The absorption coefficient decreases gradually with thin film thickness and time for some thin films . High absorption coefficient of silver thin films (about $10^4\ cm^{-1}$) . .



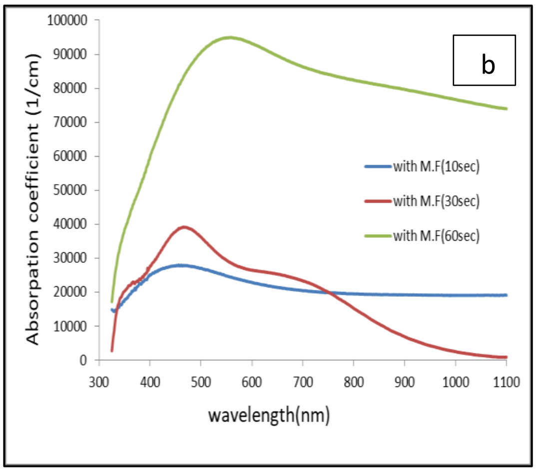


Figure (6): Absorption coefficient of Ag thin films (a) without magnetic field and (b) within magnetic field

3-3 Electrical properties :

The electrical properties of Ag thin metal films with different thicknesses of Ag measured by using two points prope directly connected to the avometer, where the resistance between the two propes is measured and then the electrical conductivity calculated from the following equations[17] :

$$R=\rho \frac{L}{Wt} \quad ...(5)$$

$$\sigma = \frac{1}{\rho} \quad ...(6)$$

Where R is resistance(Ω) ,w is width of thin film(cm) ,t is thickness of thin film(cm) , ρ is the electrical resistivity (Ω.m) and σ is the electrical conductivity $(\Omega.m)^{-1}$.

Figure (7a) and (7b) show the dependency of the Ag films resistance on thickness. So, the Ag thin films resistivity decreases with increasing Ag films thickness . This result agrees with research [1] . While the electrical conductivity will increasing with thin films thickness.

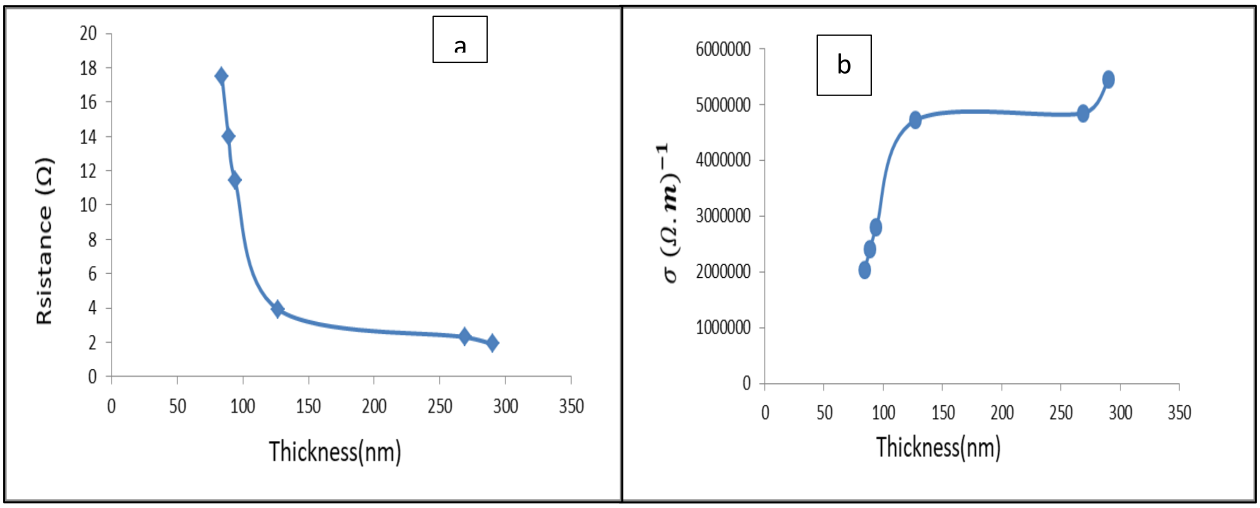


figure (7) :(a) resistanc e and (b) electrical conductivtity

4-CONCLUSION

The XRD results show that Ag films have polycrystalline structure with characteristic peaks of Ag and have face centered cubic structure. The optical properties showed that absorption coefficient increased with the increasing wavelength and the presence of absorption peaks above (400)nm . The electrical results show that the resistance decrease with thin films thickness and the electrical conductivity increasing with thin films thickness.

REFERENCES

[1]Moghri Moazzen ,M ,A .Taiedyzadeh ,P &Borgher ,S,M. (2017) ."Electrical and structural properties of the Ta/Ag thin films prepared by DC magnetron sputtering ". Journal of physics ,869 .

[2]Ashcroft ,N,W & Mermin,D ,W.(1976). Solid state physical . Books Cole. Harcourt, Inc . 726-755 .

[3] Bock,F,X . Christensen,T,M & Rivers,S,B.(2004). "Growth and structure of silver and silver oxide thin films on sapphire",Thin Solid films ". 468: 57-64.

[4]Mardani,S .Vallin,O & Timo,J.(2014). "Morphological instability of Ag films caused by phase transition in the underlying Ta barrier layer". Applied Physic latters , 105.

[5] Guowen Ding . Clavero ,C . Schweigert ,D & Minh Le .(2015)." Thickness and microstructure effect in the optical and electrical properties of silver thin films " AIP ADVANCES, 5.

[6] Kato,K . Omoto,H . Tomioka ,K & Takamatsu,A.(2011). " Thickness and microstructure effects in the optical properties of silver thin films " Sol. Energy mater .Sol.Cells . 98(8): 2352-2356 .

[7] Fox,M.(2001). Optical properties of solids . Oxford University press .

[8]Hajakbari ,F& Ensadoust,M,.(2016). " study of thermal annealing effect on the properties of silver thin films prepared by DC magnetron sputtering " .ACTA.Physica Polonica .129. (4) .

[9] Ozimek,M .Wijczynski,W & Szubzda,B.(2016). " Magnetic thin film deposition with pulsed magnetron sputtering : deposition and film thickness distribution ". IOP Conf . Series .113.

[10] Alexeeva,O ,K & Fateev,V,N.(2016). " Application of the magnetron sputtering for nanostructured electrocatalysts synthesis ".International journal of hydrogen energy . 41 :3373-3386. .

[11]Maurya,D,K .A.Sardarinejad,A & Alameh ,K.(2014) ." Recent Developments in R.F Magnetron sputtering thin films for pH Sensing application –An overview " Coatings . 4: 756-771.

[12] Kelly,P,J & Arnell ,R,D.(200). " Magnetron sputtering :A review of recent developments and application " .Vacuum .56 : 159-172

[13] Kittel,G.(2005). Introduction to Solid State Physics . Eighth Edition , John Wiley and Sons .

[14] Cullity,B,D & Stock,S,R .(2001). Elements of X- Ray Diffraction 3 rd Ed, Prentice Hall, New York,

[15] O. Stenz,O.(2005). "The Physics of Thin Film Optical Spectra" . An Introduction . Winzerlaer Str. 10, 07745 Jena . Germany .

[16] Aita,C,R.(1986). "Optical behavior of sputter of vanadium pentoxide " .Journal Appl physical. 60 (2): 749- 753 .

[17] Nelis,T& Payling,R.(2003). "Glow Discharge Optical Emission Spectroscopy" . The Royal Society of Chemistry.

دراسة تأثير المجال المغناطيسي على خواص أغشية الفضة الرقيقة المحضرة بطريقة الترذيذ بالتيار المستمر

د.عبد الحسين عباس خضير   شيماء راجح تالي

جامعة القادسية / كلية التربية – قسم الفيزياء

E-mail : abdulhussain.khadyair @ qu .edu .iq

E-mail : rajh74111@gmail.com

الخلاصة

تم تحضير اغشية الفضة الرقيقة بطريقة الترذيذ بالتيار لمستمر و المرسبة على قواعد من الزجاج الازمنة مختلف (10,20 ,30 sec) . تم قياس سمك اغشية الفضة الرقيقة بطريقة التداخل البصري والمتضمنة الليزر الهليوم –نيون ذات طول موجي (632.8nm) , وكان سمك الاغشية المحضرة بوجود وعدم وجود مجال مغناطيسي على التوالي (127,269,290nm) , (84,89,94nm) . تم تحليل الخواص التركيبية والبصرية بواسطة حيود الاشعة السينية XRD والطيف المرئي UV-V واظهر تحليل XRD بأن الاغشية ذات تركيب مكعب ممركز الوجه. وقد تم قياس طيفي الامتصاصية والنفاذية في مدى طول موجي بين (300-1100nm) , وتم تحديد معامل الامتصاص العالي الاغشية الفضة الرقيقة من تحليل أطياف الامتصاصية ويبلغ حوالي (10^4 cm^{-1}) . واظهرت الخواص الكهربائية بأن المقاومة تقل بزيادة سمك الاغشية الرقيقة .

الكلمات المفتاحية : الخواص التركيبية والبصرية , اغشية الفضة الرقيقة , الترذيذ بالتيار المستمر .