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Study the Structural Properties of Au Thin Film Deposited on Poly Vinyl Alcohol Prepared by Plasma Sputtering Method

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KEYWORDS:

- Au films
- Plasma
- Poly vinyl alcohol
- Sputtering
- Morphology

ABSTRACT

In this research, preparation of Au films on poly vinyl alcohol (PVA) substrates by using plasma direct current glow discharge sputtering (FT-IR)results for poly vinyl alcohol showed matching the sites of the active groups of the polymer with its chemical composition X-ray diffraction (XRD) showed that the thin films had a polycrystalline while the surface roughness was diagnosed using an atomic force microscopy (AFM)the where the results showed that the roughness increased from (30.099-55.221)nm with increasing the thickness from (90-195)nm. Scanning electron microscope(SEM)showed that nanoparticles with a spherical shape the particles aggregates to form larger clusters with increased film thickness.

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دراسة الخصائص التركيبية لأغشية الذهب المرسّبة على قواعد من بولي فينيل الكحول المحضّرة بطريقة الترذيذ بالبلازما

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الكلمات المفتاحية:

- أغشية الذهب
- بلازما
- بولي فينيل الكحول
- ترذيذ
- مورفولوجي

الـــخُـــلاصـــة

في هذا البحث تم تحضير أغشية(Au) المرسّبة على بولي فينيل الكحول (PVA) باستخدام بلازما التفريغ الوهاج بالتيار المستمر، وأظهرت نتائج التشخيص(FT-IR)، لبولي فينيل الكحول تطابق مواقع المجاميع الفعالة للبوليمر مع تركيبه الكيميائي، وحيود الاشعة السينية (XRD) أن الأغشية المحضرة ذات تركيب متعددة التبلور، خشونة السطح تم تشخيصها باستخدام جهاز مجهر القوى الذرية (AFM)، حيث ان النتائج اظهرت أن الخشونة ازدادت من nm (30.099-55.221)مع زيادة السمك من nm (90-195) المجهر الألكتروني الماسح (SEM) أظهر بأن الجسيمات النانوية ذات شكل كروي ،و الجسيمات تجتمع لتشكل تجمعات أكبر مع زيادة سمك الغشاء.

1. Introduction

Plasma is an ionization gas made up of a high proportion of atoms of the material found in the form of positive ions with negative electrons separated from them and the molecules rare equal with collective effect [1].

Plasma represents 99% ingredients of the universe[2]. The films are defined as materials prepared in the form of a layer or several layers with controlled by deposition particles, atoms or ions on a solid substrate and provided the thickness should not exceed one micron[3]. The techniques of the preparation of thin films developed and used many methods of preparation including chemical methods of chemical spray pyrolysis, electrochemical deposition and the physical methods of thermal evaporation, and method of sputtering[4]. Sputtering is a process occurs when the surface of a particular material is exposed to the bombardment of particles loaded with enough energy to separate atoms from the surface of the material and leave the surface updated to eat the surface of the target [**5**].the sputtering is considered as one of the physical methods of deposition of thin films[**6**]. In this work was the study of the effect of some parameters of plasma glow discharge and pressure of work and the time of deposition on the structure and morphology of gold films prepared sputtering manner and precipitated on PVA substrate. and that of being a great importance because of its broad spectrum of applications they are used in micro electro mechanical systems and nano electro mechanical systems, sensors , electronic textiles, or devices for surface-enhanced Raman scattering, etc. [**7**].The polymer used in the research poly vinyl alcohol is white colour granules [**8**]. It has the ability to melt in water it also has the advantage of being resistant to the work of oils and solvents and has wide uses in that it enters the manufacture of paper textile and others[**9**].

2. Practical Part

In this work, High purity 99.9% of Au was deposited on PVA substrate and with different circumstances it was got a different thickness, using the method of plasma sputtering using SPC-١٢ system Compact Plasma Sputtering Coater origin (MTR Corporation, CA 94804 USA). A poly vinyl alcohol was prepared through dissolution (0.5g) of PVA in size (15ml) of distilled water by using the electric mixing device (magnetic stirrer) and at a temperature 90^0C to get a homogeneous solution. A mercurial thermometer has been used to measure the temperature of the solution . After making sure that the solubility of all solution is in distilled water, it is left to cool down, then we use casting method for the preparation of the solution on the glass substrates (Petridish) after being purified of impurities using distilled water detergents and acetone and put it in a water bath ultrasonic works for 15 minutes the we dry it by using pieces of soft clothes after that we pour the solution on glass substrates . after ending up pouring process, we leave the glass substrates in room temperature and duration of three days to dry and after the end of that period they are taken out and cut in to pieces suitable for measurement. The action steps in plasma sputtering system and through parameter glow discharge control (pressure and the time of deposition) with the installation of the rest of the parameters are as follows: first was to determine the distance between the electrode by 4cm and install the substrate to be deposition of material on them and then evacuated plasma chamber through a mechanical pump to a pressure of (1× 10-2Torr) to be introduced Argon gas through pressure needle value to (2× 10-2Torr) and during a specific period of time for the deposition of (50s) were obtained on the film thickness (90nm) either at the same conditions, but an increase of the allotted time for the deposition to(110s) film Au output was the thickness of (140nm) and at the same circumstances, (but by increasing the specified time of deposition to 160 s), the thickness of the film will be (195nm). Then the education and preservation of samples pending a necessary tests, where tests were conducted X-ray diffraction (XRD) using the device carries the following specifications type: XRD-6000, shimadzu, japanese origin, target: Cu Kα,wave lentgth: (1.5406) Å, speed: (5) deg / min,

voltage: (40) KV, current: (30) Ma, range (2θ): 30-100 deg,) As well as an atomic force microscope measurements AFM microscope type (nano company: phywe, German origin) The measurements of the electron microscope of the SEM Scanner type (type: inspect -550, Magnification: 300,000X, Accelerates Field: 10 KV, Company: FEI- Netherlands -Holland).

3. Results and Discussion

This work was conducted in several tests to determine the effects of fixed pressure, and increase the time period for the deposition lead to increase the sputtering rate, thereby increasing the thickness of the film [10] on the structure and morphology Au films prepared sputtering plasma glow discharge on the polymers (PVA)substrate. These tests are represented by:

X-ray diffraction (XRD):

Figure (1) shows the X-ray diffraction pattern of Au thin films precipitated on polymer (PVA)substrates and thickness (t = 195nm) and through analysis shows compatibility with ICDD numbered card (00-004-0784) where he notes that the material of the installation Polycrystalline ,type cubic with a sharp apex (111), and when increasing the thickness increases the growth of the peaks and increase the intensity so you look more distinct when the larger

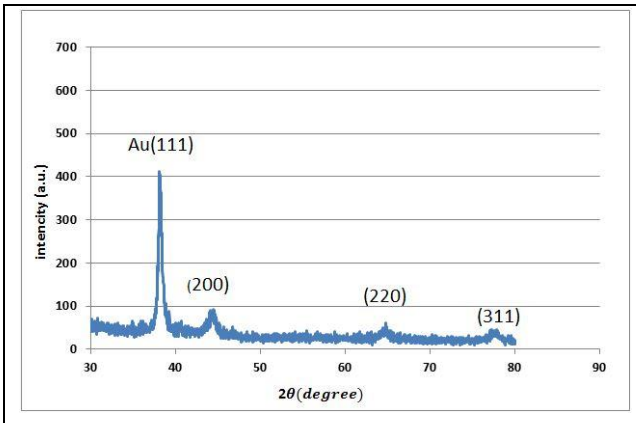


Figure (1): X-ray diffraction pattern of(Au) films of (195 nm)thickness.

thickness. It has been a constant expense of the lattice of the film prepare for installation cubic of the equation (1) [11] have shown diffraction calculations of X-rays that fixed lattice have to adopt very few on the thickness of the film by increasing the film thickness is reduced slightly and this corresponds to the researcher. [10]

$$dhkl = \frac{ao}{\sqrt{h^2+k^2+l^2}} \quad \text{---------- (1)}$$

Where: (hkl): Miller. coefficients were calculated Average grain size to the prevailing direction (111) of the equation (2) and found that the Average grain size increases with the thickness, which leads to increased surface roughness greater the thickness and therefore increasing the homogeneity of the film, and this corresponds to Researcher [7]

$$\mathbf{D_{av}} = \frac{0.9\lambda}{B\cos\theta} \quad \text{---------- (2)}$$

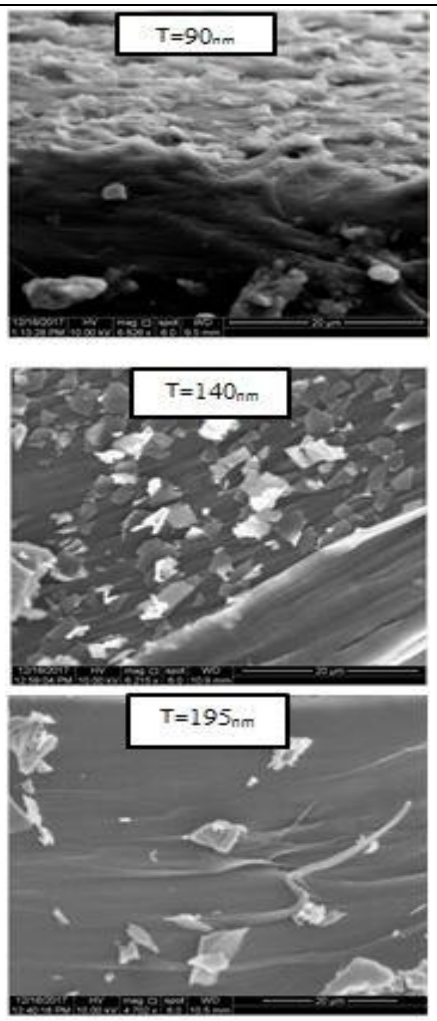
Where B: full width at half maximum (FWHM) measured radial units, λ: the wavelength of the beam falling, θ : Bragg angle. As in Table 1.

Table 1: shows the results of the XRD test of the Au films.

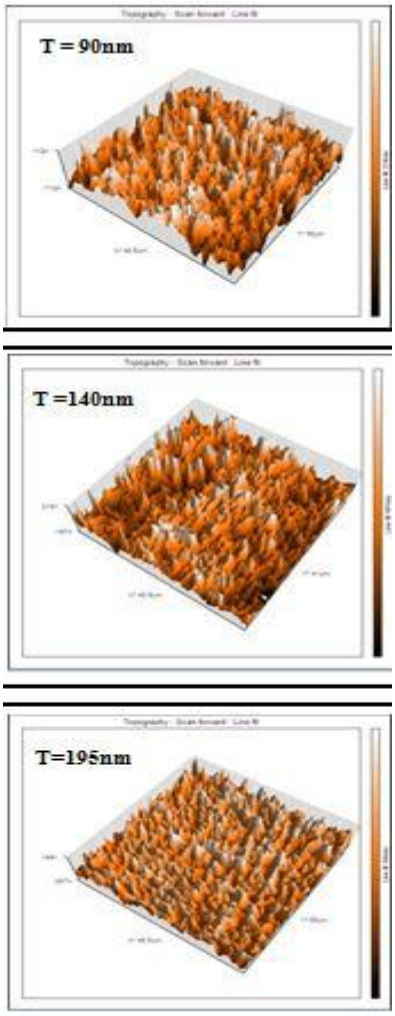
sample Au	2θ(deg)	2θ(deg) ICDD	d(A)	hkl	a_0 (Å)	The Average grain size (nm)
sample Au t=195 nm	38.18	38.18	2.35	111	4.07	154.89
	44.38	44.39	2.03	200		
	64.58	64.57	1.44	220		
	77.54	77.54	1.23	311		

4. Morphology Analysis

Figure (2) show images SEM films Au precipitated on substrate polymer (PVA) and prepared sputtering in a manner different thickness where the thickness was increase granules size increasing this is consistent with the researcher [10].



Figure(2): Show images of Au films (SEM) at different thickness.



Figure(3): show images of Au films (AFM) at different thickness.

Figure (3) show the images three dimensional AFM films Au precipitated on substrate polymer different thickness.

where it can be note increasing the square root of the rate of surface roughness (RMS) with increasing thickness, as shown in Table (2) where the increase refers to the increase in surface roughness of the films and this confirms the results of examination of XRD, which refers to increase the granular size and thus surface roughness increase film thickness record, increasing the thickness of the top lead to increased homogeneity of the film and this corresponds to the researcher [10].

Table (1): Shows the Results AFM of Au films at different thickness.

Sample	Roughness average nm	Root mean square nm
t=90 nm	30.099	39.206
t=140 nm	47.61	64.723
t=195 nm	55.221	69.042

5. Conclusions

In this study, Au thin films were deposition on polymers substrate using plasma direct current glow discharge sputtering the structure of Au films was analysis by XRD , AFM,SEM. The (XRD) results showed films were found to be polycrystalline, and the preferred tendency for growth (111). The films prepared by the Atomic Force Microscope (AFM) were diagnosed the surface roughness

and the root mean square were found to increase with increasing thickness. The films prepared by Scanning electron microscopy (SEM) were diagnosed the granules size increases by increases thickness of the film.

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