Study Some Structural and Optical Properties of Copper Nano Film

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ABSTRACT

Copper films have been widely used as electrodes and interconnection wires in integrated electronic circuits and other application. In this research has been deposition films of copper in the system of evaporation assisted laser Nedmyum - Yak pulse with a wavelength (nm 1064) and energy (400 mJ) and enabled quality factor is the rate of frequency (3Hz) and long pulse 10 nanoseconds, and by (50 p) pulse deposition of nano-membranes of high purity copper from the substrate of the glass in the temperatures reached ((100,200, 300 C •) in a vacuum (10-3 m bar) and then make a heat treatment at temperatures (300 C º) films . Some structural ,optical and electrical properties has been inspected films prepared. The results showed that the structures(XRD , AFM, Optical microscopy) of thins is strongly dependent on the temperature of the substrate. Also results of the optic transmission reach more than 90%,electrical resistivity decreased with increased temperature of substrate . Making these films suitable for many conductive electrode diverse applications.
Key Word:- nano film, transmittance, annealing, XRD.

1.INTRODUCTION

Nd: YAG laser is an inexpensive, efficient, highly reproducible thin-film growth technique that has been widely adopted in many industrial applications, including semiconductor chip fabrication. Although extremely diverse thin-film materials have been successfully fabricated by sputtering processes, the most straightforward application of sputtering is metal film deposition by using a metal target under high vacuum conditions[1]. Copper may be the most widely studied metal films, and they have been extensively used as interconnection wires in semiconductor chips[2].

However, it can be quite difficult to produce high-quality films of Cu, because the metal atoms (and metal clusters) in the chamber and on the film surface are highly vulnerable to oxidation by the presence of residual oxygen in the chamber [3]. Se. Lee et al,[4] study sputtering technique for Cu thin film was epitaxially grown on an Al2O3 (sapphire) (0001) substrate, and had high crystalline orientation along the (111) direction. M Fenn et al [5]study electrical resistivity and temperature coefficient of resistivity (TCR) of Cu and Nb thin films have been measured over a range of layer thicknesses between 5.6 nm and 1106 nm. E. Schmiedla et al. [6] study resistivity of ultra-thin metal films is much higher than theoretically predicted by the scattering hypothesis. The effect is discussed with respect to the variation of film thickness for copper films deposited under ultra-high vacuum conditions on glass substrates. The interpretation on the basis of a statistical model leads to reasonable results even when the variation of temperature is included into consideration. Additional information is obtained from photoelectric and field effect measurements. V. Timoshevskii et al. [7] find that atomic-scale surface roughness dramatically affects the electrical conductivity of thin films. Atomic clusters, 1–3 atoms high, deposited on the flat Cu₁001ˇ surface of an 11 monolayer thick film lead to a 30−40% reduction of its conductance. This is attributed to the destruction of isotropic Fermi surface sheets. The goals of this paper is to fabrication copper nano powder by evaporation technique , and study some of their properties.

2.EXPERIMENTAL WORK

Preparation of substrates:

The substrates that used is laboratory glass sheet slides with diminutions of in standard dimension as (3x2x0.2) cm and purity (99.99%) .And clean by alcohol 99% with ultrasonic waves produced by Cerry PUL 125 device for 15 minutes in order to remove the impurities and residuals from their surfaces and distilled water ,then dying in air. Using thermal acuum evaporation system type EDWARDS with Mo- boat , Figure 1, deposition rate was 2 nm/sec at (10-2 m bar) .The distance from the substrate to evaporation source about (3 cm) with powder (400 mJ) at different temperature(100,200,300 T Cº) .

Nd: YAG laser (**1.064 µm**) Second Harmonic Generation (SHG) was used for the deposition of Cu on different substrates temperature. Power density (0.8- 1.8) J/cm2,pulse width: 10ns,repetition frequency: (6) Hz ,cooling method: inner circulation water cooling .Annealing process was done in vacuum furnace type (IVOCLAR type Programat X1,Germany) Inspection: In order to study the structural properties, the nature and the crystal growth of the deposited films at different depositing conditions, X-ray diffraction measurements have been done by using Philips PW 1050 X-ray diffractometer of 1.54 Å from Cu-kα. In order to observe the surface topography of deposited thin films, Atomic

Force Microscopy(AFM) micrographs were taken with a digital Intruments, type (AA3000,Angstrom Advanced Inc. USA) . Visual inspection was conducted for samples deposited on glass using the device (optical microscope) with magnification (500X). Double–beam **UV-**Vib optical test by using (CECIL7200) spectrophotometer from (300-900 nm). To measure the transmittance and absorption of Copper deposited at different conditions it was used UV-VIS Spectrophotometer (type SP8001 Metertech, U.S.A). The transmittance and reflectance data can be used to calculate absorption coefficients of the films at different wavelength. Which have been used to determine the band gap E**g** . For their measurement of electrical resistance Keithley device of type (Fluke 8846A - 6.5 digit precision multimeters, U.S.A).

3.RESULT AN AND DESCUSTION

Figure 2 shows the XRD chart of Cu nano powder at different annealing temperature. The data of the figures were listed in table 1, after comparing with ASTM card (No.). The structure of Se is hexagonal and the lattice constant and internal stress is listed in table2. And notice that the increase in crystallization with increasing annealing temperature up to 150 °C beyond any degree 200 we do not find a significant effect of Temperature increase, and values in Table 1 illustrate this result in a more.

Average Grain Size (g) .
The average grain size (g) , which can be estimated using the Scherrer's formula : **[1]**
$$g =(0.94 \, \lambda) / [\Delta (2 \, \theta) \cos\theta] \qquad (1)$$

where :
λ **:** is the x-ray wavelength ($\mathring{A}$) . $\Delta (2 \, \theta)$: FWHM (radian) .
θ **:** Bragg diffraction angle of the XRD peak (degree) .
Thickness was (**** nm)

The following figure (4) show the transmission of Cu thin films deposited at different temperature, transmission spectra for film deposited at 100 C show almost same transmission value with high transparence reach to about 100%. Transmission value state to decrease at increase substrate temperature to about 200 C due to increase film thickness which related to increasing the desorption ability of the substrate at this temperature , this followed by slight increase of transmission spectra specially at long wavelength value this might due to decrease in the film thickness at high temperature because, they reevaborate away from the hot substrate, instead of being adsorbed by this substrate [1]

The optical absorption of Cu thin films deposited at temperatures between 100 C and 300C in the wavelength range 350-900 nm was investigated as shown in Fig. 5. The spectra of Cu films is calculate according to the following relationship [2]

$$\propto = \frac{1}{t} \ln \frac{1}{T}$$

Where t is film thickness , T transmission spectra
The optical band gaps (Eg) of the films can be obtained according to its depence on α and energy hv of the inci- dent photon, as expressed by following equation :

$$\propto hv = B \left(hv - E_g \right)^n$$

where hv is the energy of incidence photon, Eg is the value of the optical energy gap between the valence band and the condition band, B is a constant that depends on the electronic transition probability and the exponent is a parameter which depends on the type of electronic transition responsible for absorption. Values of n = 2 and n = 1/2 correspond, respectively, to allowed indirect and allowed direct optical transitions. The usual method for the determination of the value of Eg involves plotting $(\alpha hv)1/n$ against (hv). In this study the most satisfactory results were obtained by plotting $(\alpha hv)2$ as a function of the photon energy (hv). Such plots have been shown in Figure (6) [3]. The energy gap value is decrease the increase with increase substrate temperature this might due to the variation of crystallite of the thin films at different temperature, because Optical properties of a material depend upon the interaction of the material with electric field of the electromagnetic wave [4].

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4.CONCLUSIONS

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Table 1 XRD data of Copper thin film

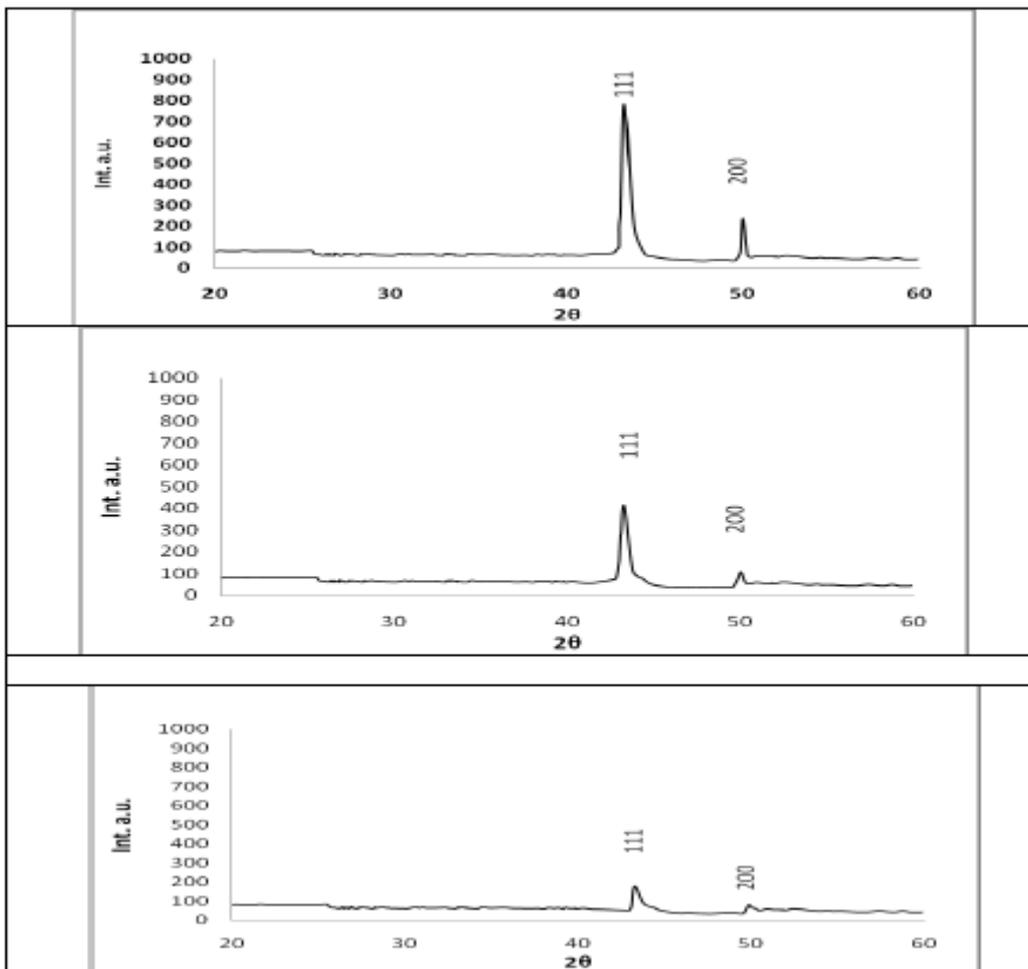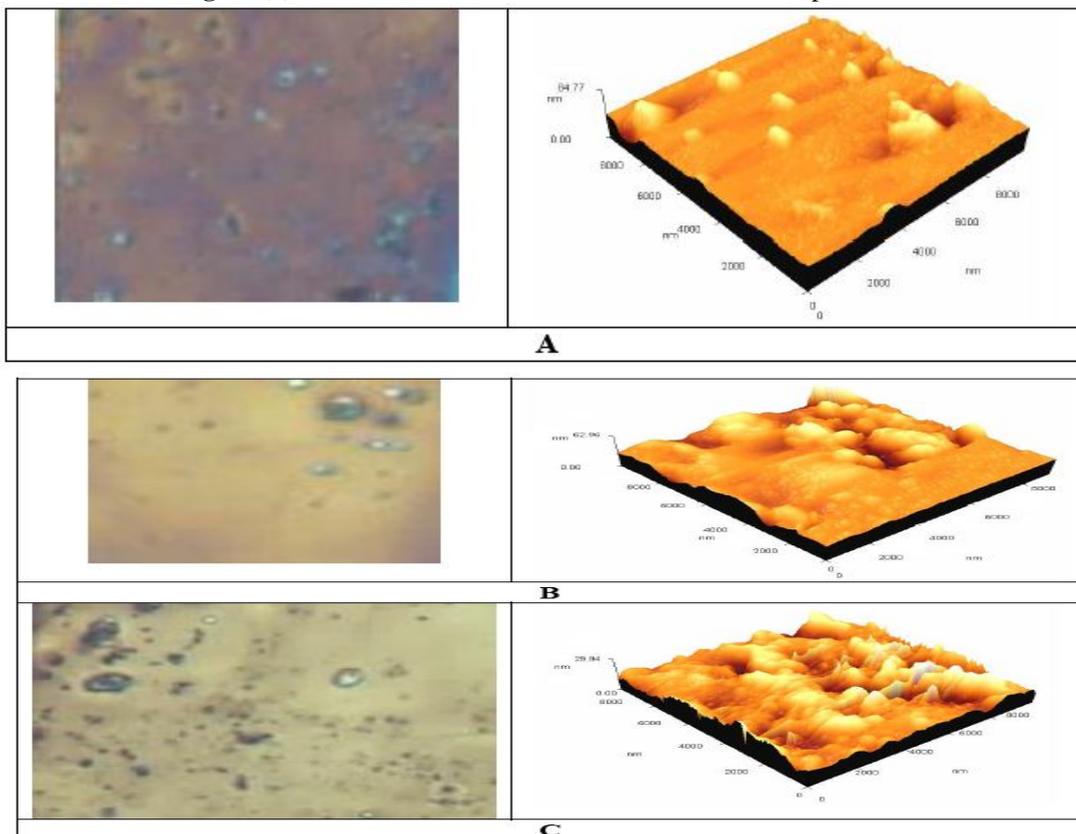| $2\theta_{ASTM}$	I_{ASTM} %	hkl	$T\ C°$					
			100		200		300	
			$2\theta_m$	I_m %	$2\theta_m$	I_m %	$2\theta_m$	I_m %
43.298	100	111	43.295	100	43.296	100	43.297	100
50.434	46	200	50.425	27	50.43	31	50.431	32
74.133	20	220	---	---	---	---	---	---

Figure 1. Nd-Yag Laser system

Figure (2) XRD of Cu nano Film at deffrent substrate temperature.

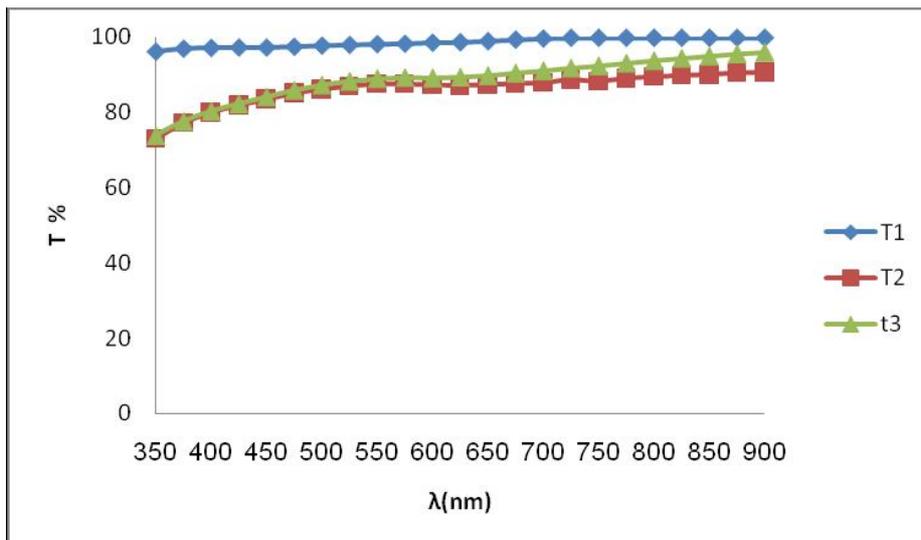**Figure(3)** 2D and 3D picture of Cu nano Film at deffrent substrate temperature.

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Figure (4) Transmission spectra for Cu films at different substrate temperature
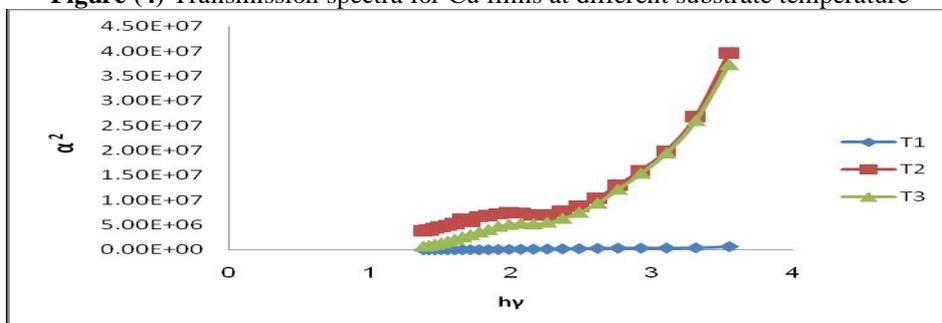
Figure (5) Absorption coefficient for Cu thin films at different substrate temperature.
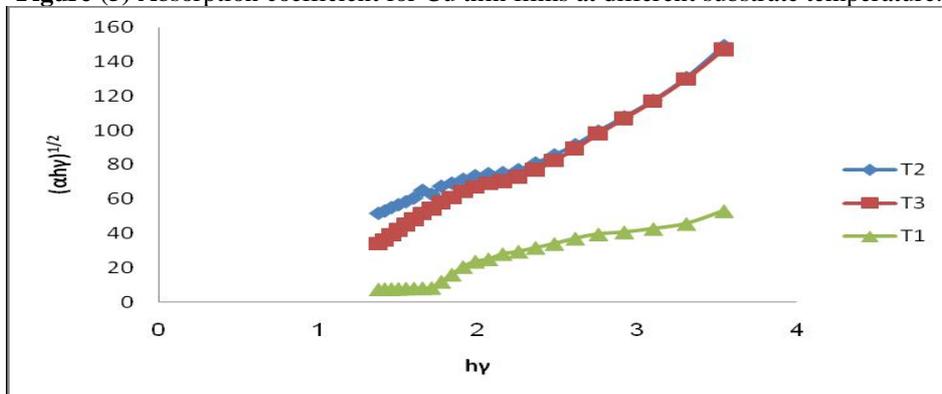

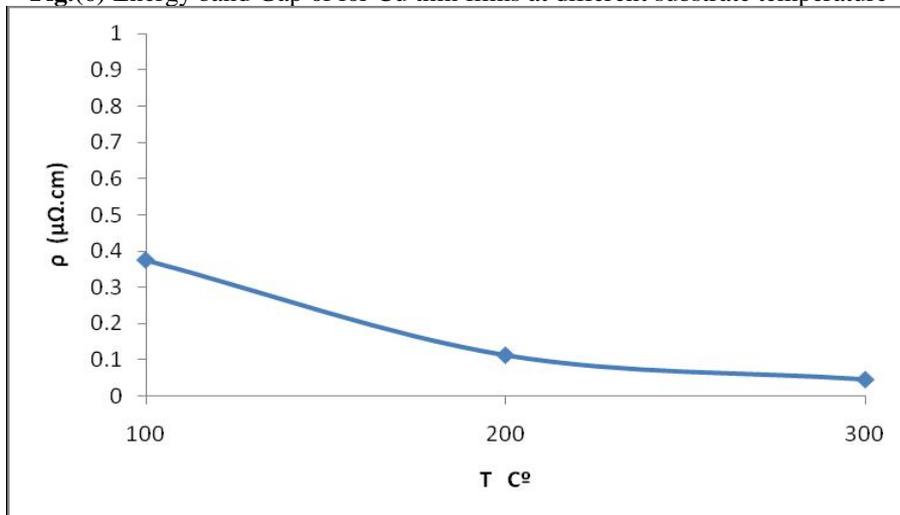**Fig.(6)** Energy band Gap of for Cu thin films at different substrate temperature

Fig.(7)

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