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EFFECT OF ANNEALING TEMPERATURE ON THE STRUCTURAL AND MORPHOLOGICAL PROPERTIES OF SILVER NANO LAYERS DEPOSITED ON COPPER OXIDE

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ABSTRACT

In this investigation in the first step, the Cu thin films have been deposited on silicon substrates by means of DC magnetron sputtering method in fixed conditions.Then, for preparation of CuO thin films the thermal oxidation of Cu films under the oxygen flow at 300ºC for 4 h were done in electrical furnace.In the second step the Ag thin films have been deposited on CuO thin films by means of DC magnetron sputtering method in fixed conditions. Then they have been annealed at different temperatures such as 100°C, 200°C and 300°C for 4 hours. The effect of annealing temperatures on the structural and morphological properties of the films was investigated by different analysis, such as X-ray diffraction (XRD) and atomic force microscope (AFM). The XRD analysis showed three peaks belongs to Ag (111), Ag_2O (200) and CuO (-111).The AFM analysis exhibited that, annealing temperature influenced the surface morphology of the films.

Keywords: Ag-CuO thin film, Annealing temperature, DC magnetron sputtering, Structural properties, Surface morphology.

1. INTRODUCTION

Nowadays, thin films are important in nano and microelectronic systems. Eckertova [1] the thin films of Ag-CuO applied in antibacterial and photocatalystic coats as semiconductor of P-type. Because of good electrical and optical properties of AgCuO composites, those can be applied in solar cells and lithium batteries, too [2]; [3]. In this study, initially Cu thin films are deposited by DC magnetron sputtering [4] then oxidation is done in electrical furnace in presence of oxygen in 300 ºC for 4h. In next step, the Ag film had deposited on CuO layer using DC magnetron sputtering technique. Finally, the samples are annealed in electrical furnace in

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different temperatures. Then effect of anneal temperature on structural and morphological properties of surface are investigated by XRD and AFM analysis [5]; [6]; [7].

2. EXPERIMENTAL

In this work, initially thin films of Cu are deposited on silicon substrate with Cu target (99.99%). Before deposition, the substrates were cleaned in acetone and alcohol solutions in ultrasonic bath for 10 min. In next step, to oxidation of Cu layers, the samples were placed in electrical furnace in presence of oxygen in 300 ºC for 4h. Then, the Ag nano layers (the thickness of 80 nm) deposited on CuO thin layers by DC magnetron sputtering. Finally, the Ag-CuO were annealed in electrical furnace in different temperatures for 4h. The samples were denominated as S_1: without anneal, S_2: 100 ºC, S_3: 200 ºC and S_4: 300 ºC. The conditions of the deposition thin films are in table 1.

Table-1. The conditions of the deposition thin films.

The experimental conditions		
Target	**Cu**	**Ag**
Substrate	Silicon	CuO
The distance between the substrates and the target (cm)	7	7
Initial pressure (mbar)	5.7×10^{-5}	5×10^{-5}
partial pressure of argon (mbar)	7×10^{-2}	5×10^{-2}
Time of sputtering	120	33
sputtering current	65	40
sputtering voltage	200	150

3. RESULTS AND DISCUSSIONS

3.1. XRD Analysis

The XRD pattern of the CuO deposited on silicon substrate is shown in Fig. 1. Tow peaks of CuO(111) and CuO(-111) show the deposition CuO on silicon substrate and the sharp peak in 32.9º is related to silicon substrate, too.

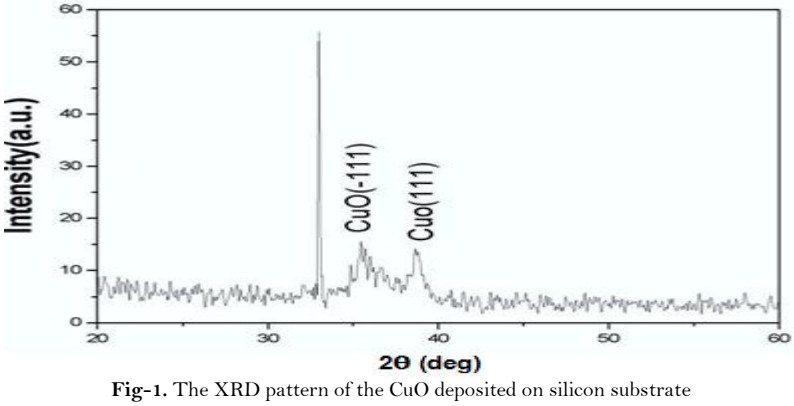

Fig-1. The XRD pattern of the CuO deposited on silicon substrate

Fig. 2 show XRD patterns of Ag-CuO thin films deposited on silicon substrate and annealed at various temperatures. In all samples, there are peaks of Ag(111), Ag_2O(200) and CuO(-111). By increasing annealing temperature, the intensity of the peaks increased in the samples of S_2 to S_4. On the other hand, the crystal structure of Ag and Ag_2O films improved in 300ºC temperature.

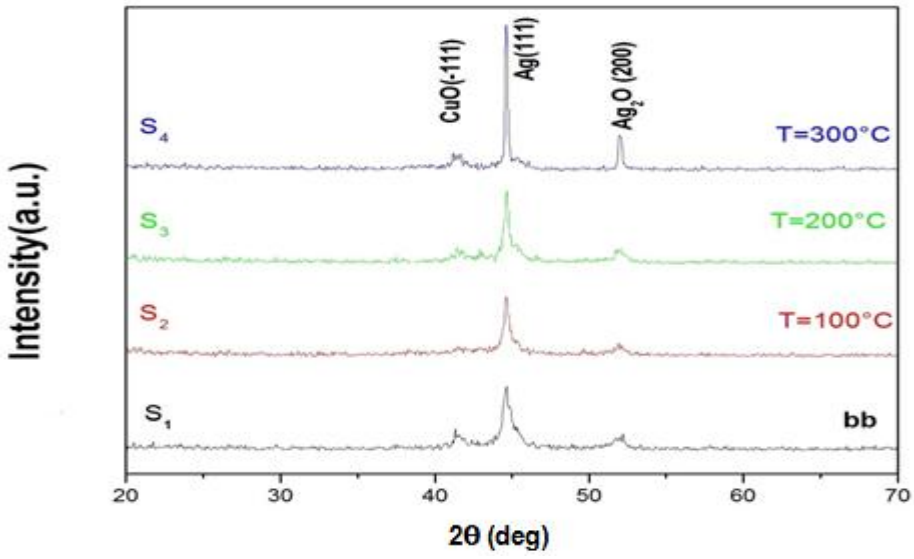

Fig-2. The XRD pattern of the thin films of Ag-CuO

The Ag crystals sizes that grow in direction (111) are determined by using scherrer formula [8].

$D=0.94\ \lambda / \beta \cos\theta$

In the above equation, λ is X-ray wavelength used in XRD, β, peak width at half maximum (FWHM) and θ, scattering angle. The results are recorded in table 2.

Table-2. The size of Ag (111) crystals

Sample	2θ(°)	Phase	D(nm)
S1	44.621	Ag(111)	17.33
S2	44.667	Ag(111)	20.75
S3	44.661	Ag(111)	27.71
S4	44.665	Ag(111)	41.49

3.2. AFM Analysis

The surface morphology of the thin films and the distribution of grains were analyzed with the AFM. Fig. 3 show the AFM images of the Ag-CuO films deposited on silicon substrate at annealing various temperatures. In S_1 sample, the distribution of grains is uniform and there is vacuity between the grains. In S_2 sample, the grains enlarged and are grown as conical and there are fine grains alongside of coarse grains. By increasing annealing temperature in S_3 and S_4 samples, surface is more uniform (S_4 sample). AFM images shown that by increasing annealing temperature, the density of layers is increased.

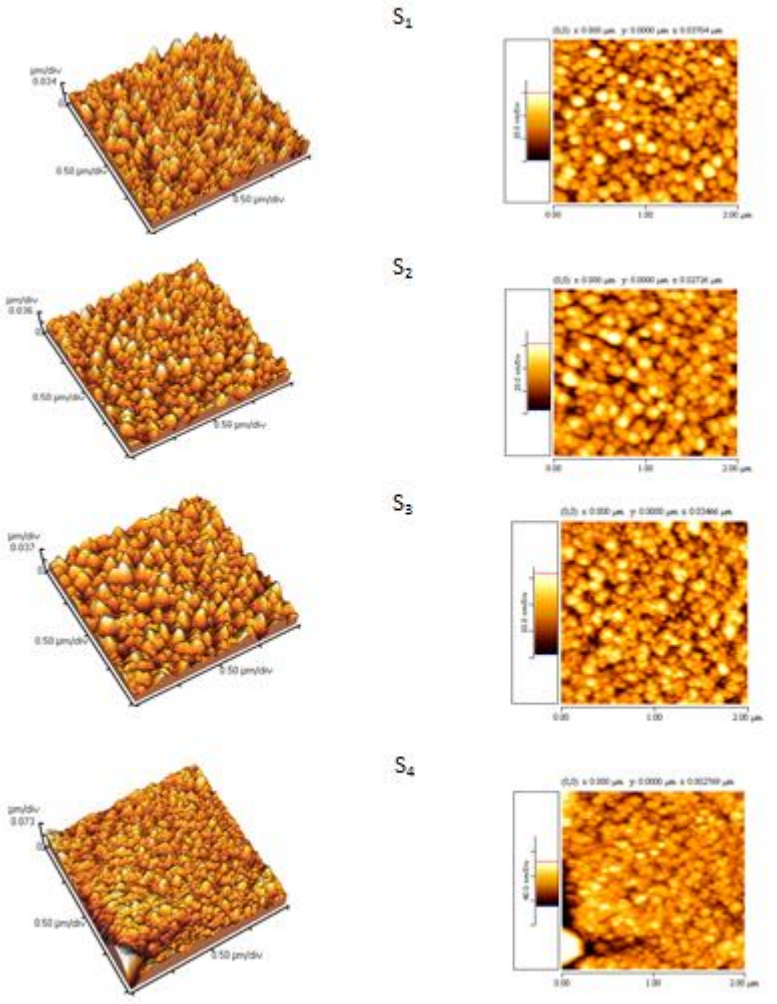

Fig-3. AFM images of the Ag-CuO films deposited on silicon substrate

4. CONCLUSION

In this study, the Ag-CuO thin layers were prepared. Then effect of annealing temperature on thin layers was investigated. The results of XRD analysis show that CuO phase formed in direction of (111) and (-111). In the Ag-CuO thin layers, the phase of Ag(111), Ag_2O(200) and CuO(-111) observed too. Generally, by increasing annealing temperature, the layers crystal structure was improved and the intensity of the peaks increased. AFM analysis also shown that surface morphology were strongly influenced by annealing temperature and by increasing annealing temperature, the layers and grain size are being denser and bigger respectively.

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