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Study the Nano-structures of Copper Thin Layers of Different Thicknesses Deposited on Glass Substrate

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Abstract: Copper nano layers of different 30 nm, 50 nm, and 70 nm thicknesses, almost at normal deposition angle, and with the same deposition rate, were deposited on glass substrates, at 100 ˚C temperature, under UHV conditions. The nano-structures of coated layers were determined by AFM, XRD and spectrophotometer methods. The thickness and temperature have showed an important role on topography, crystallization and also optical properties of the layers.

Key words: AFM; XRD; spectrophotometer; Copper.

INTRODUCTION

In modern world superficial changes become an important and basic process. Nano layers have tiny nano-structures and in terms of structure is created by tiny nano distribution or by a controlled process, a nano-structure during deposition is established and it consists of physical and chemical or in combination of chemical and physical techniques (Posadowski, 2001). Films of thin nano layer has electronic usage and lay on surface under layer (Posadowski, 1999). Metal nano-particles as well as their oxides, sulfides and alloys can be prepared by physical, chemical or in combination of chemical and physical techniques (Heath, 1999; Rao, 2000). Their size-dependent properties reveal remarkable optical properties as seen for semiconductor nano crystals or quantum dots, which were discovered in the early 1980s by Bruis (Nimal, 1999) Henglein (1988) and Grtzel (1991). The study of the physical properties of thin metallic films is important due to its multiple technological applications. Among the variety of methods used for the growing of thin metallic films, high-vaccum thermal (Johan, 1991) evaporation, has proved to be an efficient technique and widely used in both research and industry (Martin, 1995; Posadowski, 1995). Copper is a orange or brown metal, due to a complex of the positive properties (high electric conductivity, thermal conductivity, plasticity, resistant against corrosion, malleability, flexibility and etc) has found wide application in various areas of a science, technique, the industry and a life. Expansion of application ranges of copper telescopes new scientific and technical problems, in particular, studying of change of product properties on a nano size copper film basis in requirements of aggressive action of a surrounding medium (Indutnyi, 1992; Surovoi, 2006; Njeh, 2002; Borisova, 2006). And due to its better conductance than Aluminum, copper usage in IC for construction of particle slivers instead of Aluminum is increasing. Copper has best resistance in electromagnet, tension, well immigration and a low electric resistance in action important. Low electric resistance means that lower metal parcels and power can carry steady current and this action lead metal to lower level with high speed and low cost (Vinci, 1995; Gutman, 1995). So copper is replacing Aluminum in microelectronic inter connections because copper circuits are faster and last longer. The copper is electroplated inside trenches and holes in insulators (Rosenberg, 2000). Recently have been found that by use of copper in orbit, microprocessors be able to act with low power in high speeds. In this work we want to study the influence of thickness on nano-structure of produced layers, and also crystallographic directions and Reflectance and Transmittance of these nano layers, and their dependence to mentioned parameters.

2. Experimental Details:

Copper nano layers of 30 nm, 50 nm and 70 nm thicknesses were deposited on glass substrates at 100 Celsius degree temperature. The residual gas was composed of H_2, H_2O, CO and CO_2 as detected by the quad ro pole mass spectrometer. The substrate was at 8.5º to the direction of the evaporated beam and the distance between the evaporation crucible and substrate was 45 cm. Just before use all glass substrates were ultrasonically cleaned in heated acetone, and then in ethanol.

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Other deposition conditions were the same during coating. Vacuum pressure was about 3×10^{-5} torr and deposition rate was 2 A˚/sec. Thickness of the layers were determined by quartz crystal technique.

The nano-structure of these films were obtained using a Philips XRD X'pert MPD Diffractometer (CuK_{α} radiation) with a step size of 0.03 and count time of 1s per step, while the surface physical morphology and roughness were obtained by means of AFM (Dual Scope ™ DS 95-200/50) analysis. The reflectance and transmittance of the films were measured using (HitachiU -3310) instrument. The spectra of layers were in the range of 300-1100 nm wave length range (VIS).

RESULTS AND DISCUSSION

Figure 1, shows the morphology of produced layers by AFM method. Figure 1(a), shows AFM image of copper thin layer of 30 nm thickness, at 100˚C temperature. As it can be seen the surface is full of needle-like grains with little voids between them and the surface is smooth. By increasing the thickness to 50 nm, bigger grains form and morphology of layer changes and roughness increases (Figure 1 (b)). Figure 1(c), shows the topography of cooper thin layer of 70 nm thickness, as it can be seen by increasing thickness, needle-like grains convert to cone-like grains, and roughness of the layer increases again.

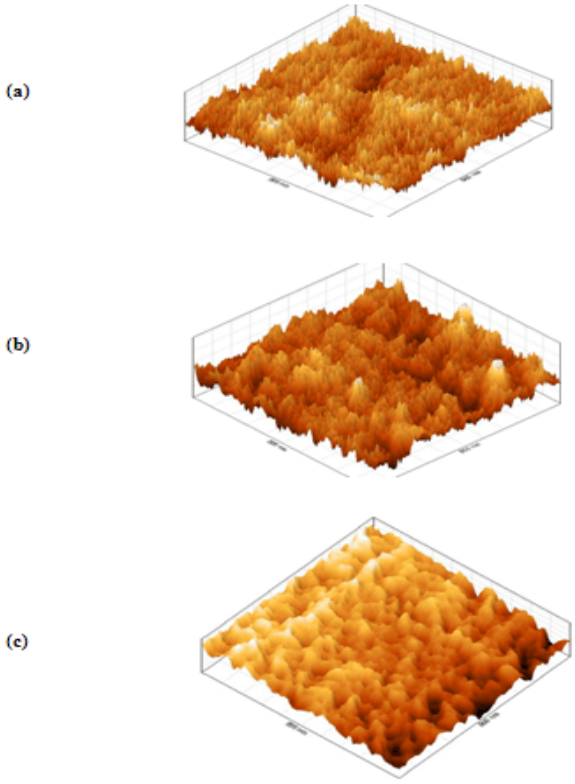

Fig. 1: AFM images of copper nano layers of (a) 30 nm ; (b) 50 nm and (c) 70 nm thicknesses deposited at 100 ˚C temperature.

Figure 2 shows roughness of the layers of different thicknesses. By increasing the thickness, roughness also increases. As it can be seen, 100 ˚C temperature is not high enough for suitable surface diffusion, to form piles. Figure 3, shows XRD patterns of produced layers. As it can be seen in Figure 3(a), the layer of 30 nm thickness is amorphous and there is no any clear crystalline peak. By increasing thickness to 50 nm and 70 nm (Figure 3(b) and 3(c) respectively) layers begin to get crystalline, and two (111) and (200) crystallographic directions are appeared. Figure 4 (a) and 4 (b), show the Reflectance and Transmittance of produced layers respectively, in visible light wavelength range. As it can be seen, by increasing thickness, because of migration of voids and continuation of deposition, voids decreases and nano-structure of layers get more completed which tends to higher reflectance and lower transmittance in produced layers.

Because of nano-metric thicknesses of layers, the transmittance rate is high up to 80% at about 700 nm wave length. In Figure 4 (a) and 4 (b), in some wavelengths, curves cross each other that is a reason for depends of curves to wavelength.

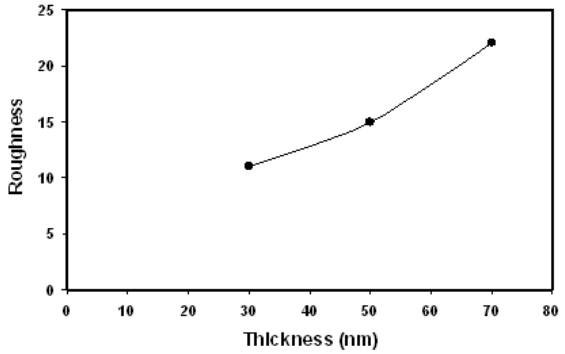

Fig. 2: Roughness diagram of copper nano layers of 30 nm; 50 nm and 70 nm thicknesses deposited at 100 ˚C temperature.

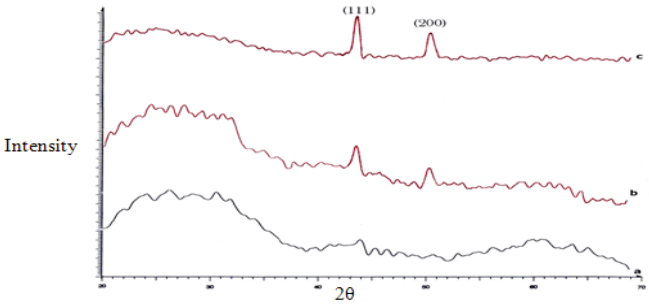

Fig. 3: XRD patterns of copper nano layers of (a) 30 nm ; (b) 50 nm and (c) 70 nm thicknesses deposited at 100 ˚C temperature.

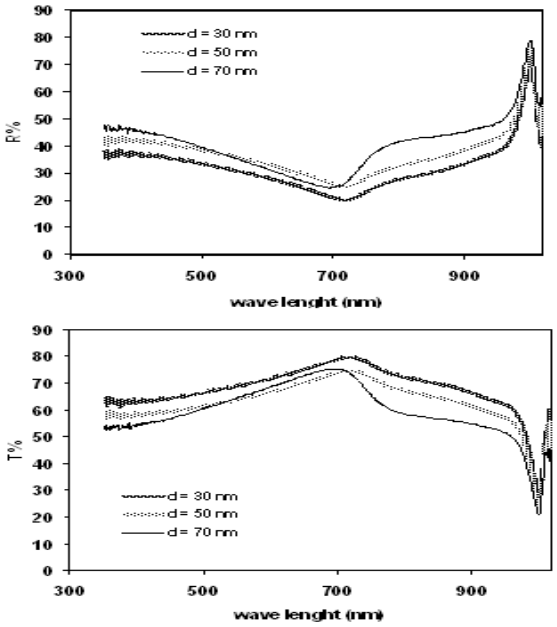

Fig. 4: Reflectance and Transmittance diagram of copper nano layers of 30 nm; 50 nm and 70 nm thicknesses deposited at 100 ˚C temperature.

Summery:

Copper nano layers of different 30 nm, 50 nm, and 70 nm thicknesses, at the same deposition conditions, were coated on glass substrates, at 100˚C temperature, under UHV conditions. Their nano-structures were determined by AFM, XRD and spectrophotometer methods. By increasing thickness, morphology of layers convert from needle-like structures to cone-like structures and roughness increases. Cooper thin layer of 30 nm thickness is amorphous. By increasing the thickness at 100 ˚C temperature, because of migration of voids and completion of layers formation, two (111) and (200) crystallographic directions appear. Because of migration of voids and continuation of deposition, by increasing thickness, voids decrease on layers, which tends to higher transmittance and lower reflectance of produced layers in this work.

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