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Study the Nano-Structures of Cooper Thin Films as a Function of Depletion Angle

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Abstract: Cooper thin films of 54.3 nm thickness were prepared by resistive evaporation method under HV conditions with three different deposition angles namely, vertical, 25° and 35° at the room temperature and on glass substrates. The nano-structures of these layers are studied by AFM and XRD methods. The aim of this research is to investigate correlation between nano-structures and depletion angle in HV condition. All the layers are amorphous and by increasing the depletion angle bigger grains produced and more voids will be configured between them. At vertical depletion angle, roughness of the surface increases and also we encounter with more transmission and less reflection at VIS light wavelength.

Key words: Thin film, AFM, XRD, HV condition, nano-structures, Iran

INTRODUCTION

One of the major advances in the history of technology that is surface engineering was the knowledge regarding protection of a surface from environmental attack by application of an organic, inorganic or metallic coating, thereby extending the life of not just the surface but the entire component or equipment. The most common reasons for altering the surface are to improve corrosion resistance, control friction and wear and alter dimension or to alter physical properties (reflection, color, conductivity). As applied to materials, surface engineering may be coatings or special surface treatments. They include processes such as diffusion treatments, selective hardening, plating, hard facing, thermal spray coatings, high-energy treatments such as laser processing and organic coatings such as paints and plastic laminates (Jehn, 2000; Zubielewicz and Krolikowska, 2009; Ruff and Kreider, 1997; Seok *et al*., 2001; Basu *et al*., 2007). Studies of nano-structured thin films have been attracting considerable attention from the researches (Hernandez-Velez, 2006; Bicelli *et al*., 2008; Karami *et al*., 2009). Film thickness, deposition rate and method of coating play important role on microstructure as well as macroscopic properties of films (Kirk *et al*., 1979; Kundu *et al*., 1998). 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, 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 *et al*., 1992). 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 *et al*., 1995). The aim of this research is to investigate correlation between nano-structures and depletion angle in HV condition.

MATERIALS AND METHODS

Cooper thin films at three different angles were deposited on glass substrates (18×18×1 mm cut from microscope slide) using resistive evaporation method at room temperature. The purity of cooper powder was 95%. An ETS 160 (Vacuum evaporation system) coating plant with a base pressure of 2.5×10^{-5} mbar was used. Prior to deposition, all glass substrates were ultrasonically cleaned in heated acetone then ethanol. The substrate holder was a disk of 36.5 cm in diameter with adjustable height up to 50 cm and also adjustable keepers for placing any kind of substrates. The distance between the center of the evaporation boat and the center of the substrate was 45 cm. Thickness of layers were determined by quartz crystal technique. The other deposition conditions such as deposition rate, vacuum pressure and substrate temperature was same in all layers. The layers with known vertical, 25° and 35° were produced on 300 K (room temperature). Transmittance of the films was measured using UV-VIS spectrophotometer (Hitachi U-3310) instrument. The spectrum of layers were in the range of 300-1100 nm wavelength (UV-VIS).

RESULTS AND DISCUSSION

Figure 1 shows the topography of thin cooper films on glass substrate at 3 different depletion angel. Figure 1a

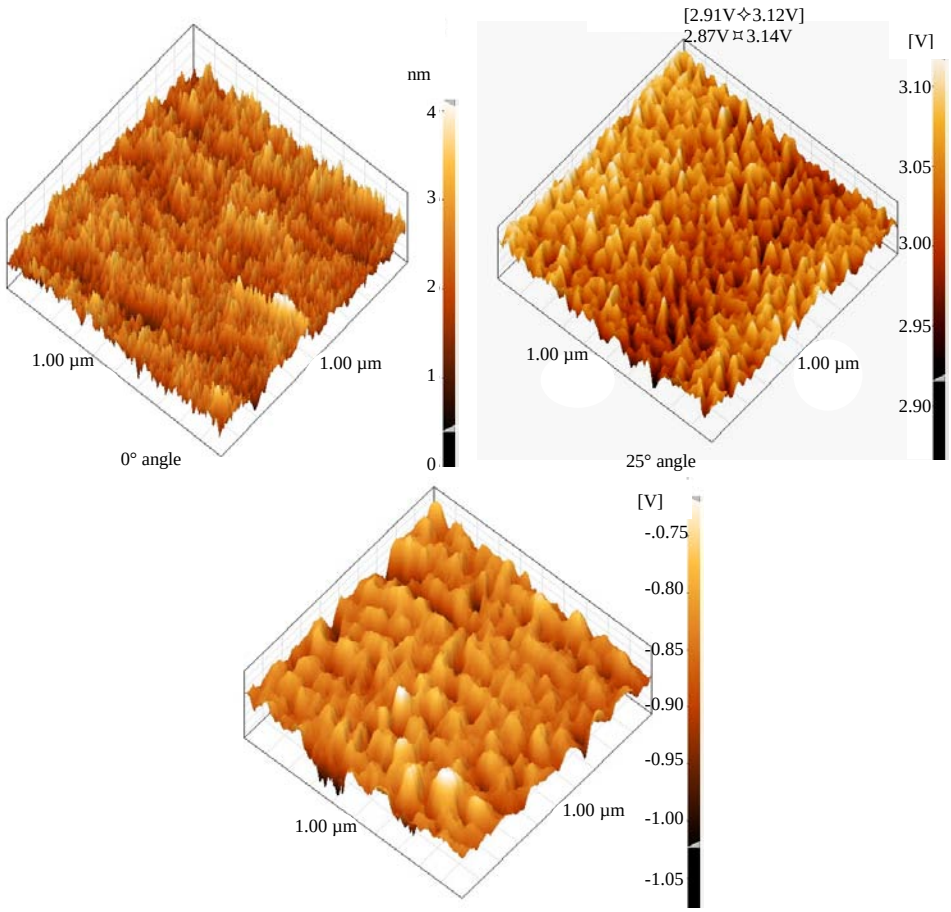

Fig. 1: 3D AFM images of Cu/glass flms; a) 0°; b) 25° and c) 35°

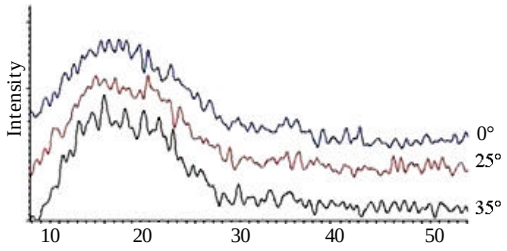

Fig. 2: XRD pattern of Cu/glass films; 0°, 25° and 35°, respectively from top to below

shows the AFM structure of layer with 54.3 nm at vertical depletion angle. The surface has many small dome spots with voids among them and by increasing deposition angle to 25°, more spots and voids appeared (Fig. 1b). At 35°, the surface has more dome spots and voids (Fig. 1c). So by increasing the depletion, angle more holes are produced and the roughness of surface increases. Figure 2 shows the crystalline structure of cooper nano layers on glassy substrate. Cooper nano layers on glassy substrates with 54.3 nm thickness at room temperature and 3 different depletion angle with 95% purity are produced. The nano-structures of these layers are investigated by AFM and XRD methods. AFM images of layers illustrate that by increasing depletion angle more voids on layers and between spots are produced and roughness of surface increases. Due to low thickness of layers, the structures are needle-like. Because of low thickness of layers and low substrate temperature no specific structural phase is produced and the layer is amorphous but at vertical depletion angle, the structure is approximately amorphous with small picks at some points and this is because of better depletion angle condition.

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