Structural Changes of Ti Films Under Different Substrate Temperatures

1Elham Soltanalizadeh and 2Marzieh Nazary Nia

1Department of physics, Islamic Azad University, Ardabil Branch, Ardabil, Iran.
2Department of physics, Islamic Azad University, Hamedan science and research pards Branch, Hamedan, Iran.

Abstract: Titanium layers of 100 nm thicknesses with same deposition angle, deposition rate and almost same high vacuum pressure were deposited on glass substrates at three different substrate temperatures as room temperature(28°C), 100°C and 200°C. The nano-structure of layers were studied by using AFM and XRD methods. Optical Reflectance were studied by spectrophotometer method. Roughness of the layers were plotted and studied. Correlation between nano-structures and optical reflectance versus different substrate temperatures were investigated. Substrate temperature and getting property of Titanium atoms play an important role on structural properties and Reflectance of layers.

Key words: Titanium, AFM, XRD, Spectrophotometer.

INTRODUCTION

Thin films are thin materials layers ranging from a nanometer to several micrometers in thickness. They are used in variety of applications such as tooling, biomedical implants, electronic parts, microsystems and magnetic devices (Rao, C.S., C.E. Reddy, 2009). Film composition, microstructure and density are very much dependent on preparation methods and conditions. Therefore thin film characterization plays an important role in the understanding and development of thin films and related components and devices (Xie, H., 2008). For example substrate temperature (Ida, T., H. Toraya, 2002), angle of incidence (Yau, J.K., S.A. Howard, 1989) and deposition rate (Howard, S.A., R.L. Snyder, 1989; Enzo, S., 1989) have important effects on the morphology and nanostructure of thin films. Because of good mechanical properties, like a very high specific strength and remarkable corrosion resistance, titanium and its alloys have been widely used in several industries, such as aerospace engineering, motor science, and chemical engineering sectors and have been applied in medical science as human joint replacements and dental implants (Song, Y.H., 2007). Films of titanium are widely used as coatings in various technical units, as absorbers of gases in high-vacuum pumps, etc. (Lendel, V.V., 2010). The chemical stability of titanium results the presence of a thin but stable surface oxide film, typically a few nanometers thick (Turcio-Ortega, D., 2008). Titanium oxide (TiO2) is one of the transparent conductive oxides (TCOs). The oxide films are stable, strongly adherent to the substrate, mechanically hard and resistant to moisture and acids. Transparent conductive oxides (TCOs) are unusual materials that are both electrically conductive and visually transparent (Igwe, H.U., 2010).

The aim of this work is to prepare Titanium thin layers in presence of different substrate temperatures and investigate the nano structural and optical changes in produced layers.

MATERIALS AND METHODS

Titanium films of 100 nm thickness were deposited on glass substrates at three different 28°C(room temperature), 100°C and 200°C. The residual gas was composed mainly of H₂, H₂O, CO and CO₂ as detected by the quadrupole mass spectrometer. The substrate normal was at 7 degree to the direction of the evaporated beam and distance between evaporation crucible and substrate was found to be 45 cm.

Just before use all glass substrates were ultrasonically cleaned in heated acetone, then ethanol. Other deposition conditions were the same during coating. Vacuum pressure was about 10⁻⁶ torr and deposition rate was about 1 A/sec for all produced layers. Thickness of the layers were determined by using quartz crystal microbalance. The structure of these films were studied by using a Philips XRD X’pert MPD Diffractometer (CuKα radiation) with a step size of 0.03 and count time of 1s per step, while the surface physical morphology and roughness was obtained by means of AFM (Dual Scope™ DS 95-200/50) analysis. Reflectance of the films were measured by using UV-VIS spectrophotometer (Hitachi U-3310) instrument.

RESULTS AND DISCUSSION

Figure 1(a-c) shows, AFM images for the layers produced in this work. Figure 1(a), shows the topography of deposited Ti film, at room temperature of 100 nm thickness. As it can be seen, surface is full of needle like grains with 20 nm roughness.
Fig. 1: AFM images of Titanium/glass of 100 nm thicknesses at, (a) room temperature; (b) 100 C and (c) 200 C.
By increasing substrate temperature to 100°C for same other deposition conditions and same 100 nm thickness, grains are still needle like but a little bigger and that is because of migration of the grains (Figure 1 (b)). Roughness of this sample is about 30 nm. In Figure 1 (c), substrate temperature increase to 200°C for 100 nm titanium layer with other same deposition conditions, as it can be seen in this samples grains are bigger and we are encountered with big conic grains, that is because of surface diffusion of grains and coalescence between them. Roughness increases to 50 nm for figure 1 (c). As it can be seen substrate temperature has very important role on topography of the layers.

Figure 2 shows, diagram of roughness for the layers produced in this work. As it can be seen from figure 2, roughness increases by increasing substrate temperature. That is exactly in agreement with AFM images.

![Roughness Diagram](image)

**Fig. 2:** Roughness diagram of the Titanium/glass at different temperatures.

Figure 3 (a-c) shows, XRD patterns for the layers produced in this work. As it can be seen, from figure 3 (a), titanium produced layer at room temperature is amorphous. By increasing substrate temperature to 100°C in figure 3 (b) and to 200°C in figure 3 (c), because of gettering property of titanium atoms, there is a small peak at 38 degree that depends to titanium dioxide layers, crystallographic direction of TiO₂ is A(004). By increasing substrate temperature anatase peak seems even shaper. XRD patterns are very noisy and there is a wide peak at 15 degree that all depends to amorphous glass substrate. Figure 4 shows, Reflection curves of the layers produced in this work, as it can be seen by increasing substrate temperature, reflectance decreases, that is because of surface diffusion and coalescence of the grains that tends to bigger grains and formation of more voids between them, so transmittance increases and reflectance decreases.

![XRD Patterns](image)

**Fig. 3:** XRD patterns of Titanium/glass of 100 nm thicknesses at, (a) room temperature; (b) 100 C and (c) 200 C.

**Summary:**

Morphology, crystallographic direction and optical properties of Titanium layers of same thickness and different substrate temperatures were obtained. This was accomplished by the studying the relationship between AFM and XRD results, and in addition Reflection of layers. The morphology of the Titanium of 100 nm
thickness by increasing substrate temperature, changes from needle like grains to canonical grains. Roughness increases by increasing substrate temperature. Temperature play very important role on morphology and crystallographic direction of layers. At low temperature layer is amorphous at higher 100°C and 200°C because of gettering property of titanium atoms, A(004) crystallographic direction is forming. Reflectivity curves have decreasing trend by increasing substrate temperature. That is because of surface diffusion and formation of more voids on substrate. Structural and optical reflectivity curves are in very good agreement with each other.

Fig. 4: Reflectance diagram of the Titanium/glass at different temperatures.

REFERENCES


