Calculation of Optical Parameters of Titanium Nano-layers with Different Deposition Angles

Haleh Kangarlou, Maryam Motallebi Aghgonbad

***Abstract*— Titanium nano-layers were prepared on glass substrates by physical vapor deposition method, under HV conditions, with different deposition angles of 0, 10, 15 and 20 degrees, at room temperature. Thickness of titanium nano-layers was obtained 83.7 nm, by quartz crystal technique. Absorbance, reflectance and transmittance of these layers were measured by spectrophotometer in visible spectral range. The optical parameters were obtained by kramers-kronig method. The aim of this work is to use different deposition angles for titanium nano-layers and investigate the relation between nano structure and optical properties.**

***Index Terms*— Titanium Nanolayers, Optical Properties, Kramers-Kronig**

I. Introduction

TITANIUM due to the good mechanical properties and high corrosion resistance is used in aerospace, chemical processes and biomedical industries [1, 2]. Because of its good biocompatibility, it has been used widely as an implant material in human body and also in dental and orthopedic fields [3, 4]. Titanium and its alloys have low density compared to steels [5]. Pure titanium is a highly reactive metal [2]. Its high corrosion resistance is because of the spontaneous formation on the metal surface of the barrier-type oxide, which is chemically very stable and its thickness is in the order of few nm [6]. As a structural material, titanium has gained increasing importance, and extensive information has been reported on most of its physical and chemical properties. Recently, preparing good titanium films with surfaces more defined than those of polished bulk metal is easier because of the advances in the evaporation technique [7]. Thin films of titanium deposited on glass and other dielectric substrates under not ultrahigh vacuum possess a transient surface layer from the side of vacuum (air), as well as from the side of substrate. Titanium oxides are used as coatings in various technical units, as absorbers of gases in high-vacuum pumps, etc [8].

II. METHOD

Titanium nano-layers were prepared on glass substrates (1 x 20 x 20 mm) by ETS160 system with a base pressure of 2.5×10^{-5} torr. The purity of titanium was 95%. Deposition angles were 0, 10, 15 and 20 degrees. Before deposition process, glass substrates were cleaned by ultrasonic bath technique. Deposition rate, 0.5 A˚/s, and temperature of substrates, 300 ˚K, were kept unchanged for all samples. Thickness of layers was determined 83.7 nm by quartz crystal technique. Reflectance and transmittance of samples were measured in the range of UV-VIS (300-1100 nm). Lynch's data were used on the remaining reflectance range. Optical constants of titanium nano-layers were obtained by using kramers-kronig relations through computer programming.

III. OPTICAL ANALYSIS OF SAMPLES

Figure 1 shows transmittance curves of titanium layers prepared with different deposition angles on glass substrates. As we see, with increasing deposition angle, transmittance increases because of the formation of void fractions on the substrate and undesirable conditions. In figure 2, reflectance of the layers on glass substrate is shown. We can see that with increasing deposition angle and increasing formation of void fractions on the substrate, reflectance decreases. Figure 3(a) and 3(b) shows the real and imaginary parts of refractive index (n) respectively. Figure 3(a) shows the real part of refractive index (n) in terms of energy, which has been calculated by kramers-kronig relations in visible light range. Lynch's results are also included for comparison. The general trend of our results is similar to those of Lynch's. With increasing deposition angle we do not see any constant increasing or decreasing trend for real part of refractive index. This is because of undesirable deposition conditions on one hand and receiving property of titanium on the other hand, and therefore more increasing deposition of impurities on the substrate. Figure 3(b) shows the imaginary part of the refractive index (k) in terms of energy for the layers produced in this research. The general trend of our results is similar to those of Lynch's. As we can see, with increasing deposition angle and increasing formation of void fractions on the substrate, transmittance increases, reflectance decreases and the imaginary part of refractive index (k) has a decreasing trend. In figure 4(a) and 4(b), the real and imaginary parts of dielectric constant for produced titanium samples on glass substrates with different deposition angles, has been shown. Figure 4(a) refers to the real part of dielectric constant (ε_1). The general trend of our results is similar to those of Lynch's. As we see, in general with increasing deposition angle and increasing the formation of void fractions and deposition of impurities on the substrate, conductivity of the layers increases. Figure 4(b) shows

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imaginary part of the dielectric constant (ε_2). With increasing deposition angle we can see a decreasing trend in the curves. Figure 5 shows the absorption coefficient (α) of the layers in terms of energy. The general trend of our results is similar to those of Lynch's. As we can see, with increasing deposition angle and increasing formation of void fractions on the substrate, transmittance increases and therefore absorbance coefficient decreases.

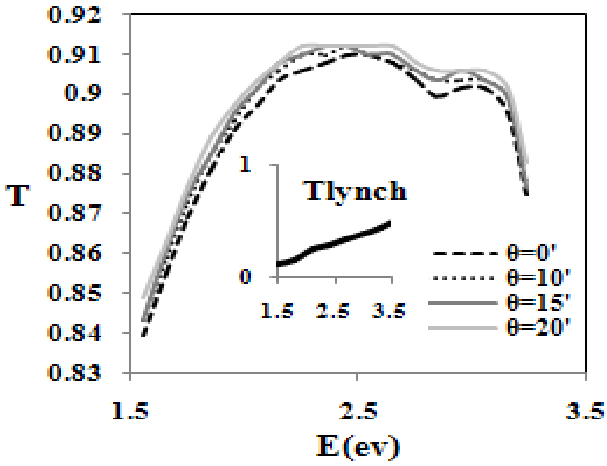


Fig .1. Transmittance curves of titanium layers with different deposition angels

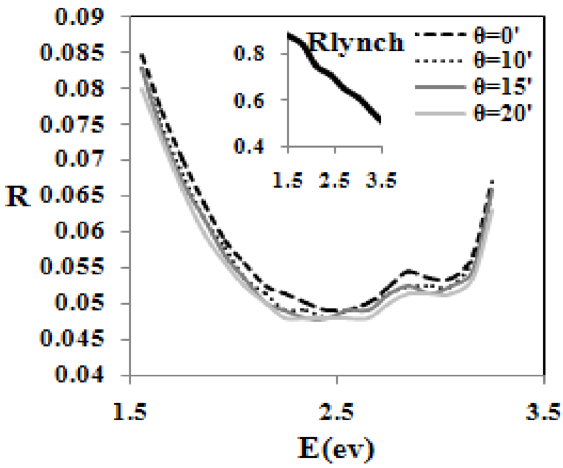


Fig .2. Reflectance of the layers with different deposition angles

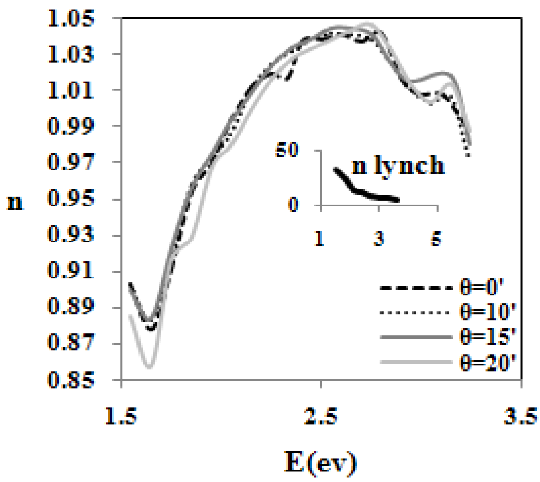


Fig. 3(a).The real part of refractive index (n) in terms of energy

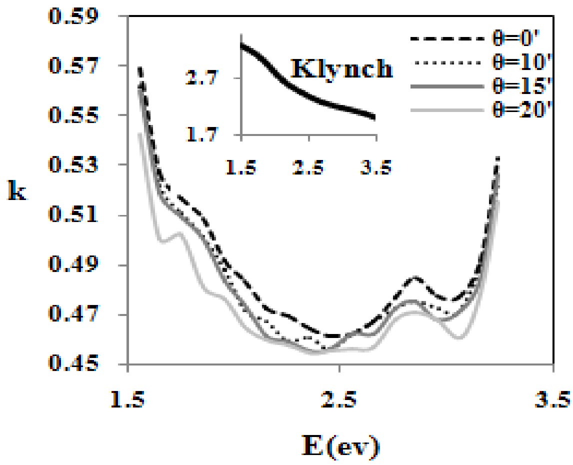
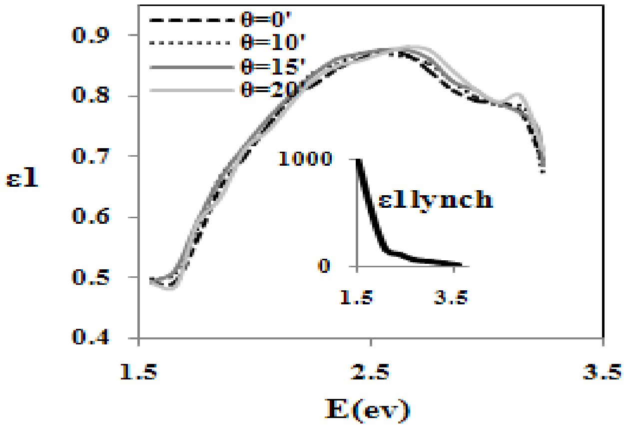


Fig.3(b). The imaginary part of refractive index (n) in terms of energy



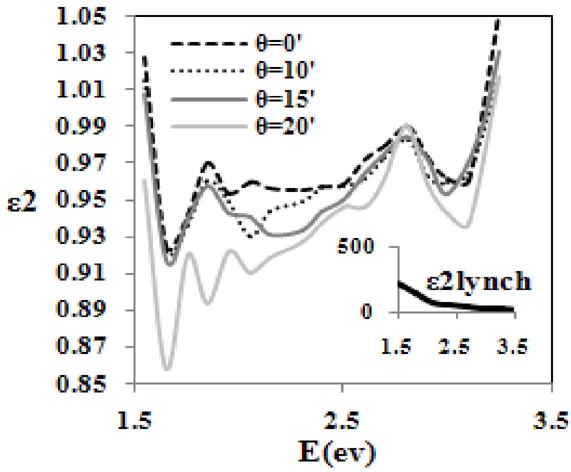


Fig..4(b). The imaginary parts of dielectric constant for produced titanium

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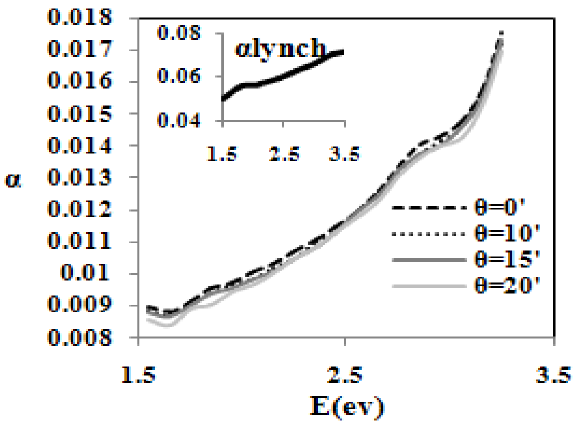

Fig. 5. the absorption coefficient (α) of the layers in terms of energy

IV. CONCLUSION

Titanium nano-layers are produced on glass substrate under high vacuum conditions by using physical vapor deposition of titanium powder (95% purity) at room temperature, with thickness of 83.7 nm and in deposition angles of 0, 10, 15 and 20 degrees. Reflectance curves are measured in wavelength range of 300-1100 nm. Remaining reflectance spectra was found with using Lynch's data. By using kramers-kronig relations optical constants were calculated for the samples. With increasing deposition angle, because of increasing formation of void fractions, transmittance increases and reflectance has a decreasing trend. With increasing deposition angle we do not see any special increasing or decreasing trend for the real part of refractive index (n) but the imaginary part shows a decreasing trend.
For dielectric function with increasing deposition angle, the real part (ε_1) shows an increasing trend and the imaginary part (ε_2) shows a decreasing trend. Also with increasing deposition angle, because of increasing formation of void fractions, absorbance coefficient shows a decreasing trend. By changing several optical parameters, the appliance of each layer is different in several industries.

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