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Production and Structural Changes of Nickel Nitride Films as a Function of Deposition Angle

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Abstract

Nickel Nitride thin films of 90 nm thickness at two different deposition angles of 30 and 40 degrees were deposited on glass substrates at room temperature, by using resistive evaporation method under UHV conditions. The structural details were determined by AFM and XRD methods. The optical spectra were measured by spectrophotometer in the spectral range of 300 −1100 nm wave length (UV-VIS). The relation between nanostructures and optical properties with deposition angle were discussed.

Keywords: Nickel Nitride; AFM; XRD; Spectrophotometer.

INTRODUCTION

Thin films have many applications in various fields. Because of larger area-to-volume ratio typical for those films, as compared to that of the bulk materials, their physical properties are usually different from the properties inherent to the bulk materials [1]. Surface coating of materials to produce novel nanostructured thin films is currently an active area of research, because of newly obtained physical and chemical properties and their wide applications in optics, photonics, catalysis and biochemistry [2]. As a consequence, many preparation methods of thin films are well developed, such as pulsed laser deposition (PLD) technique [2] and dc magnetron sputtering [3] and physical vapour deposition (PVD) method [4]. PVD is considered to be a technique which can provide not only metallic, but also alloyed and ceramic coatings with a virtually unlimited range of chemical composition and therefore controlled protective, mechanical and wear-resistant properties [4]. It is shown that the nanostructure of thin films is strongly affected by film preparation procedures and deposition condition. For example substrate temperature [5] and angle of incidence [6] have important effects on the morphology and nanostructure of thin films. Pure nickel is ductile and resistant to corrosion in air or water. Because of that and its relatively high melting point, specific structural, electrical and mechanical properties nickel has many applications as protective thin film/coating in fabrication of microelectronics and medical devices, micro sensors and etc [7]. Nickel thin film using vacuum deposition is one of the important materials in solar thermal energy conversion. For example, it was used as an infrared reflecting layer in black chrome solar selective surfaces and was used as a solar absorbing material for flat panel solar hot water collectors. In these applications, the important parameter of the material is its optical constants in the wavelength region from visible to far infrared [3].

MATERIALS AND METHODS

Nickel Nitride films were deposited on glass substrates (18× 18 × 1 mm, cut from microscope slide) by using resistive evaporation method, from Tungsten boats, at room temperature, of two different deposition 30 and 40 degree deposition angles. The evaporated materials were green pieces of Nickel Nitride crystals. An ETS 160 (Vacuum Evaporation System) coating plant with a base pressure of 4.3×10^{-5} mbar, was used. Deposition rate were 11 A/sec. Prior to deposition, all glass substrates were ultrasonically cleaned in heated acetone first and then in ethanol. The substrate holder was a disk of 36.5 cm in diameter with adjustable height up to 45 cm and also adjustable holders for placing any kind of substrates. Thicknesses of layers were determined by quartz crystal microbalance technique. Thickness of layers were 90 nm. The other deposition conditions such as deposition rate, vacuum pressure, and substrate temperature were the same in all tests. The surface physical morphology and roughness were obtained by means of AFM (Dual Scope ™ DS 95-200/50) analysis. The nanostructure 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 1 s per step.

The transmittance of films was measured using UV-VIS spectrophotometer (Hitachi U − 3310) instrument. The spectra of layers were in range of 300−1100 nm wavelength (UV-VIS).

RESULT AND DISCUSSION

Figure 1 show, three dimensional AFM images and phase images of Ni(NO_3)/glass layers, of 90 nm thickness at two different deposition angles, as 30 and 40 degrees.

Figure 1(a) shows morphology of layer with 30 degree deposition angle, As it can be seen almost all the surface is covered with small grains and in some areas, bigger domed grains formed and layer is not smooth enough but its almost homogenous. By increasing deposition angle to 40 degree the grain's size increases and more voids form between them (Figure (1)b) and as it can be seen, some kind of nano sculptures has been formed.

Figures 1(c) and 1(d), show phase images of Ni(NO_3)/ glass produced layers, in this work. As it can be seen from comparison between figure 1(c) and figure 1(d), layer with 30 degree deposition angle is more homogeneous with less voids and layer with 40 degree deposition angle is heterogeneous with more voids on later. Figure 2 show roughness versus deposition angle for Ni(NO_3)/glass produced layers, in this work. As it can be seen by increasing deposition angle, roughness of layer increases, that is because, there are more domed grains on surface and we are encountered with a heterogeneous layer that is in agreement with AFM images.

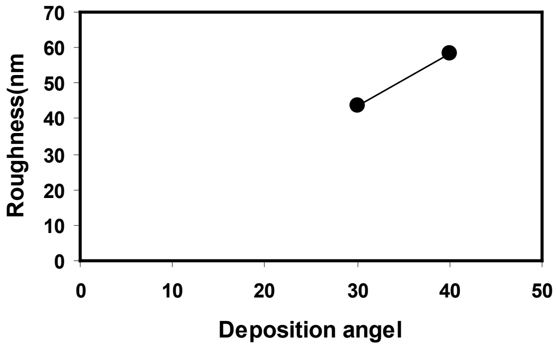


Fig.2. The roughness versus deposition angle for Ni(NO_3)/glass produced layers.

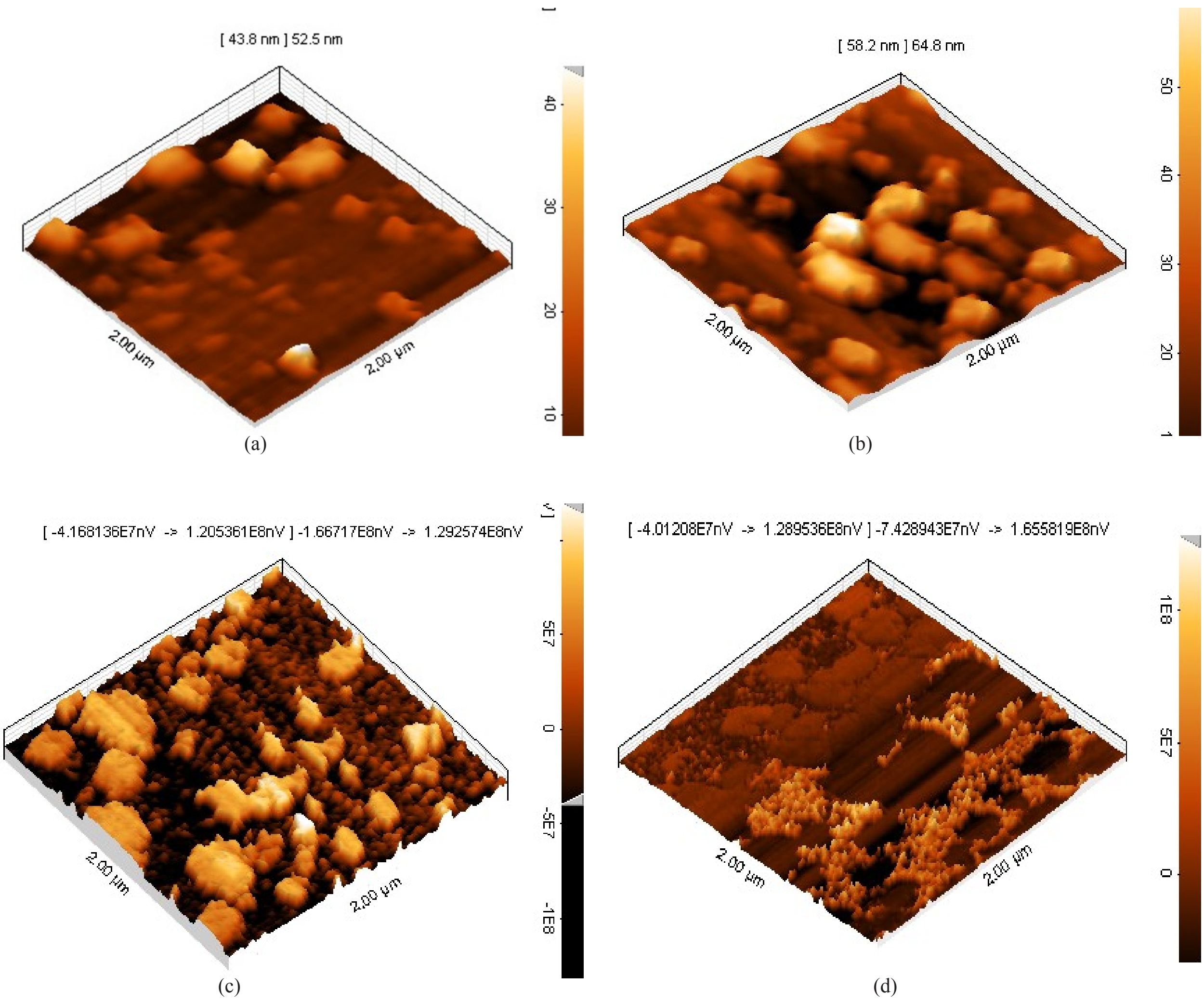
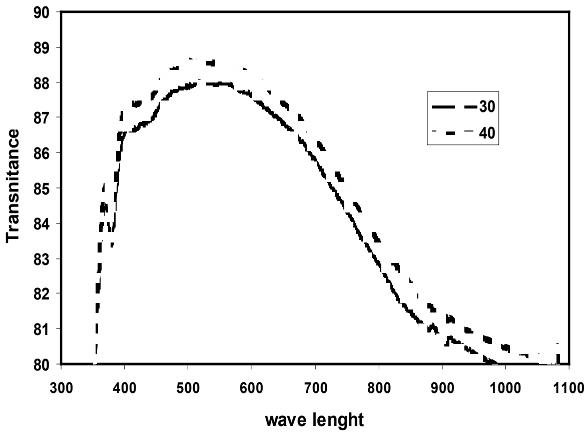
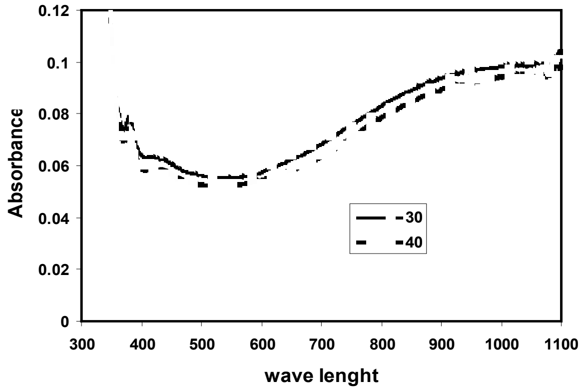


Fig.1. The three dimensional AFM images and phase images of Ni(NO3)/glass layers, of 90 nm thickness at two different deposition angles, as 30 and 40 degrees.



(a)



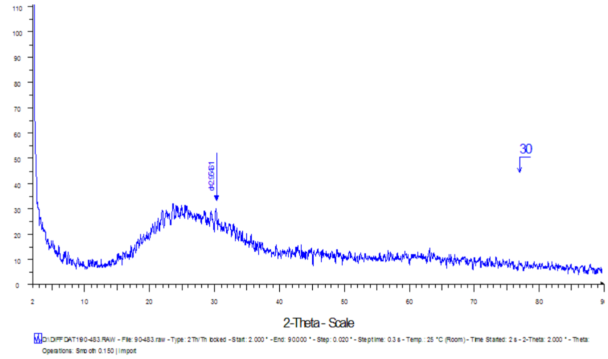
(b)

Fig.3. a) Transmittance and b) Absorbance, versus wave length for the layers.

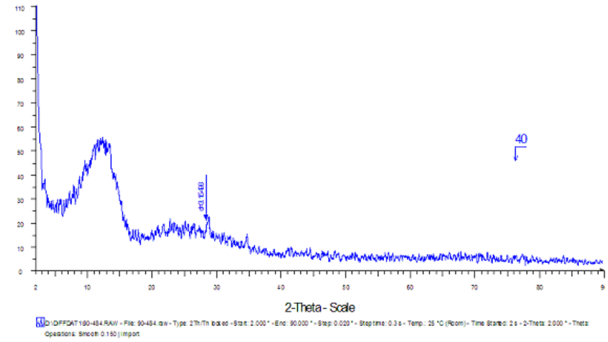
Figure 3(a) and 3(b) show, Transmittance and Absorbance versus wave length for the layers produced in this work respectively. As it can be seen from figure 3(a) by increasing deposition angle because of formation more voids on layer, transmittance increases and Absorbance decreases (figure 3(b)). Deposition angle show clear effect on optical properties. Figures 4(a) and 4(b) show XRD patterns for the layers produced in this work. In figure 4(a) there is one small crystallographic peak that depends to $Ni(NO_3)$layer, but in figure 4(b) this peak is bigger and more clear, that shows by increasing deposition angle layer gets crystalline in this work, although deposition conditions are not the best (best deposition condition is at vertical deposition angle) so there is a special crystallographic direction for growing grains.

CONCLUSION

Nickel Nitride thin films of 90 nm thickness at two different deposition angles of 30 and 40 degrees were deposited on glass substrates at room temperature, by using resistive evaporation method. Nickel Nitride thin films were transparent in visible light wavelength range. There was a good agreement between voids on layers (as it can be seen from AFM images) for optical transmittance and structural properties. By increasing, deposition angle, more voids form on layers(as it can be seen from AFM images) that tend to production of heterogeneous layer. By increasing deposition angle roughness increases. By increasing deposition angle layers got crystalline for nickel nitride layers produced in this work that it can be seen from XRD patterns. Deposition angle is an important factor for changing structure of thin films, and it is one of main factors for producing nano sculptures and heterogeneous thin layers. Optical and structural properties of the layers produced in this work, were in agreement with each other.



(a)



(b)

Fig.4. The XRD patterns for the layers produced in this work.

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