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Structural Properties of NiTi nano Alloys Under Different Deposition Angles

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ABSTRACT
Background: Atomic Force Microscopy (AFM) and X-Ray diffraction (XRD) are two effective methods, for obtaining nano structures of nano layers and nano particles. Also by AFM method we can calculate roughness, image profile, image voltage profile and phase images. XRD method also can obtain crystallographic of produced layers and nano particles and Miler indices. There for these two analysis along with each other can determine the properties of productions. For example electric conductivity, height of grains, homogeneous and heterogeneous productions. **Objective:** To investigate about structural properties of NiTi alloys under different deposition angles a physical vapor deposition method (heat evaporation) were used for production of alloys on glass substrates. The thickness of alloys were about 25 nm that prepared under different deposition angles. **Results:** Two and tree dimensional AFM images of NiTi/glass under 30 degree and vertical deposition angles were obtained. Two and tree phase images of produced alloys were obtained. Image profiles and image voltage profiles also XRD patterns were obtained. **Conclusion:** There are NiTi clusters and void area on surface of 30 degree deposited layer that tends to production of heterogeneous layer and needle like Nickel Titanium grains on surface of vertical deposited layer that tends to production of homogeneous layer. The grain size was nano metric for vertical deposited layer and the cluster size was about 110 nm for 30 degree deposited layer. There were a low and continues value of voltage for both produced NiTi/glass layers. Crystallographic property were investigated by XRD method and 25 nm thickness at room temperature NiTi/glass layers were amorphous.

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INTRODUCTION

Thin film shape memory structures have attracted considerable interest for microscale actuation as they do not suffer from this limitation due to their exceedingly low thermal mass. Most of the researches in this field have examined thin films in which shape memory properties are homogeneous throughout the film. Beside the shape memory effect there is a significant attention on super elastic effect. In particular there is a great interest in applications in improving the wear resistance of NiTi surfaces (Li, 1998; Gialanella *et al*., 2008; Tan *et al*., 2002). Ishida *et al*. (Ishida and Sato, 2003; Ishida *et al*., 1995; Ishida *et al*., 1996) had studied the effects of furnace, solid-phase crystallization (SPC) parameters, such as annealing temperature and dwell time on the resulting shape memory properties of NiTi sputtered thin films. The effect of grain size on martensitic phase transformation temperatures was investigated by Gil *et al*. (Gil *et al*., 1995). Due to properties like ability to recover large transformation work, high actuation/weight ratio, shape recovery, damping capacity, chemical resistance, biocompatibility and pseudo elasticity, NiTi is in great interest of researches (Fua *et al*., 2004). The microstructure and properties of NiTi is dependent on composition, thermo mechanical treatment, heat evolution and prevailing stable and/or pseudo-stable phase presence (Zhan *et al*., 2006). In recent years, applications of NiTi thin films are getting more extensive covering different fields such as micro sensors, light valves, nerve clamps, microelectrodes, micro wrappers, micro valves, micro pumps, invasive instruments, actuated micro endoscopes, implantable drug delivery devices, nanoscale shape memory actuators, sensor microarray for infrared radiation and on-off optical switches of spatial light modulators which is because of fast sensing power and high actuation speed (Chan *et al*., 2006; Wood *et al*., 2008). NiTi thin films inheriting the R-phase structure propose desirable functional behaviours applicable to the newly made micro-actuator systems (Bellouard, 2008).

The aim of this work is to produce ZnS nano layers by using heat evaporation method under vertical deposition angle and investigate about their structural properties.

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Experimental Details:

Nickel Titanium nano-layers were deposited on glass substrates (18× 18 × 1 mm, cut from microscope slide) by using resistive evaporation method, from tungsten boats, at room temperature. The evaporated materials were a mixed powder of Nickel and Titanium with 98% purity for both. An ETS160 (Vacuum Evaporation System) coating plant with a base pressure of 10^{-5} mbar was used. Prior to deposition, 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 obtained 25 nm. The structure of these films were studied by 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 was obtained by means of AFM (Dual Scope ™ DS 95-200/50) analysis.

RESULTS AND DISCUSSION

Figures 1 and 2 show thre dimensional AFM images of NiTi/glass nano layers at 30 degree and vertical deposition angle, respectively. All other deposition conditions were the same and thichness of nano layers were about 25 nm. Figure 1 shows a heterogeneous layer and as it can be seen there are clusters of NiTi on surface and voids between them. Figure 2 shows almost a homogeneous layer. As it can be seen from figure 2, surface is full of NiTi needle like grains, there for incident angle tends to production of a heterogeneous layer.

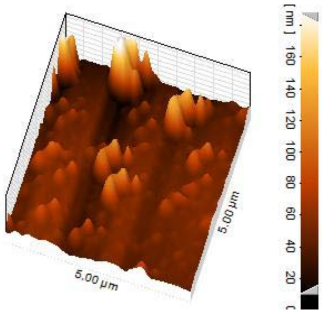

Fig. 1: Tree dimensional AFM image of NiTi/glass under 30 degree deposition angle.

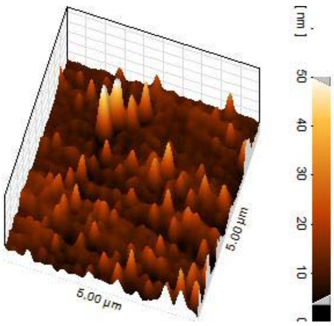

Fig. 2: Tree dimensional AFM image of NiTi/glass under vertical deposition angle.

Figuers 3 and 4 show two deminsional AFM images of NiTi/glass nano layers along with two different identified grainas for 30 degree and verticl deposition angles respectevily. From figure 3 sperated clusters and from figure 4 cross section of NiTi grains are obvious, that are in agreement with figures 1 and 2.

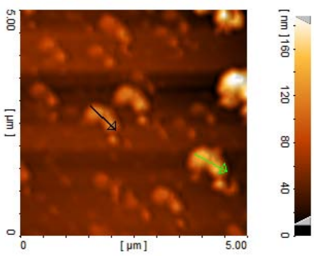

Fig. 3: Two dimensional AFM image of NiTi/glass under 30 degree deposition angle.

Journal of Applied Science and Agriculture, 9(1) January 2014, Pages: 218-222

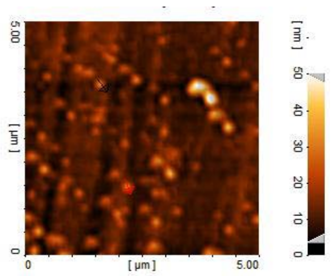

Fig. 4: Tree dimensional AFM image of NiTi/glass under vertical deposition angle.

Figure 5 shows the image profile of NiTi/glass layer under 30 degree deposition angle, for two identified area in figure 3. As it can be seen there are two clusters in cualessance with each other and ecxept nano metric thichness of produced layer (25 nm) each of clusters have about 110 nm height that is a result of incident angle all grains are deposited in same area and a heterogeneuos layer is produced.

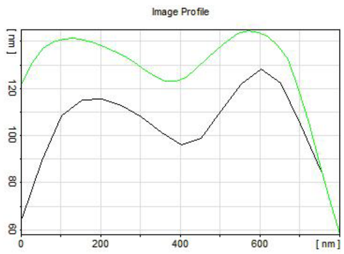

Fig. 5: The image profile of NiTi/glass under 30 degree deposition angle.

Figure 6 shows the image profile of NiTi/glass layer under ideal conditions for two identified area in figure 4. As it can be seen there are single grains with a hight about 3o nm that is a result of vertical deposition angle and tends to production of homogeneous layer.

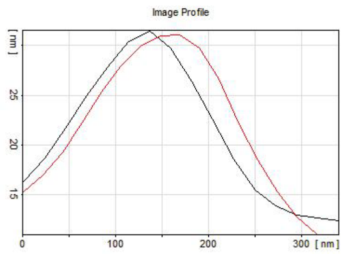

Fig. 6: The image profile of NiTi/glass under vertical deposition angle.

Figures 7 and 8 show three dimensional phase image of produced layers under 30 degree and vertical deposition angle respectively. In figure 7 there are two different colors very obvious that means of presense of NiTi clusters and voids on surface but in figure 8 the color of the layer is almost the same that is because of homogenous NiTi layer.

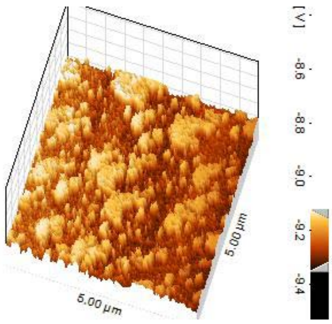

Fig. 7: Tree dimensional phase image of NiTi/glass under 30 degree deposition angle.

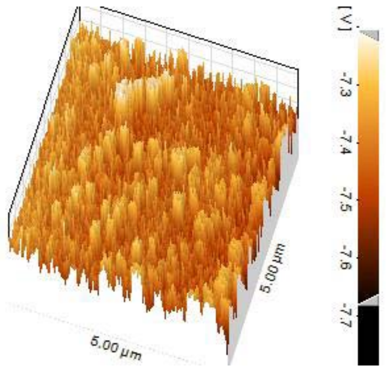

Fig. 8: Tree dimensional phase image of NiTi/glass under vertical deposition angle.

Figures 9 and 10 show the two dimensional phase image of produced layers for 30 degree and vertical depositions along with two identified areas one for grain and one for void in each layer, respectively. These analysis are in agreement with figures 7 and 8.

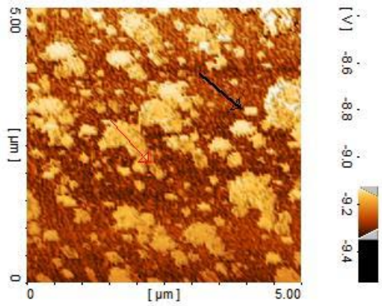

Fig. 9: Two dimensional phase image of NiTi/glass under 30 degree deposition angle.

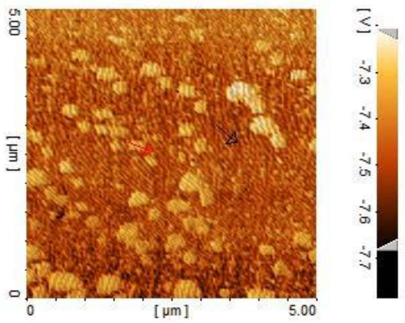

Fig. 10: Two dimensional phase image of NiTi/glass under vertical deposition angle.

Figures 11 and 12 show voltage image profiles of NiTi/glass produced layers for 30 degree and vertical depositions. in both figures there are a little and continues voltage for identified areas but as a result the amout of voltage for vertical deposited layer is more than other NiTi layer. that is because of seperated clusters and voids and impurities on the surface of 30 degree deposited laye.

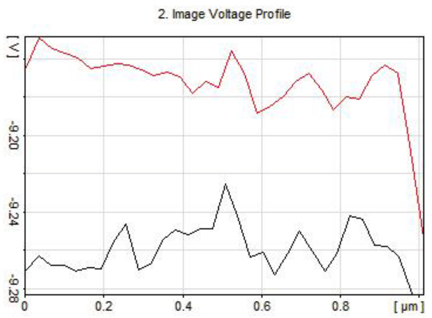

Fig. 11: The image voltage profile of NiTi/glass under 30 degree deposition angle.

Journal of Applied Science and Agriculture, 9(1) January 2014, Pages: 218-222

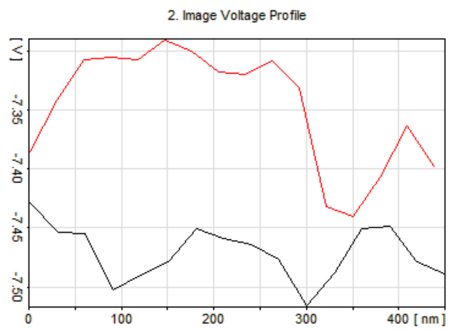

Fig. 12: The image voltage profile of NiTi/glass under vertical deposition angle.

Figure 13 shows the X-ray diffraction for produced layers in this work. As it can be seen because of nano metric thichness (25 nm) and specially the low temperature (room temperature) of deposition both layers are amorphous. XRD peaks are very noisy and ther is a wide peak between 10 to 20 degree that belongs to amorphous glass substrate.

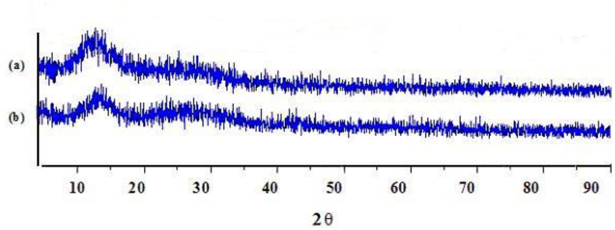

Fig. 13: The X-ray diffraction for NiTi/glass layers.

Conclusion:

Titanium nano layers of 25 nm thickness on glass substrate at room temperature and HV conditions were produced by PVD method. Structural properties, image profile and voltage image profile of produced layers were investigated by AFM method. There are NiTi clusters and void area on surface of 30 degree deposited layer that tends to production of heterogeneous layer and needle like Nickel Titanium grains on surface of vertical deposited layer that tends to production of homogeneous layer. The grain size was nano metric for vertical deposited layer and the cluster size was about 110 nm for 30 degree deposited layer. There were a low and continues value of voltage for both produced NiTi/glass layers. Crystallographic property were investigated by XRD method and 25 nm thickness at room temperature NiTi/glass layers were amorphous.

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