Ordered Growth on Nanostructured Glass Surfaces

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Abstract:

This project investigated the possibility of creating ordered structures on corrugated glass substrates. The process involved creating corrugations with amplitude of ~ 1.5 nm and wavelength of ~ 50 nm by bombarding the surface of the glass with 0.45 keV Ar^+ ions at 45° from the normal angle. Then small amounts of gold, with thicknesses ranging from 5-15 Å, were deposited onto the corrugated glass surfaces through thermal and E-gun evaporation at various angles. We investigated the changes in the positions of the deposited gold particles through a series of annealing processes and characterization utilizing atomic force microscopy (AFM).

We also studied various ways to create higher amplitude corrugations through depositing SiO_2 in an off-angle geometry at various thicknesses ranging from 5 to 30 Å. These surfaces were also characterized by AFM.

Introduction:

The process of creating sputter-induced corrugated surfaces on amorphous, crystalline and metal surfaces is an established process which can be controlled in order to create surface corrugations with a desired wavelength and amplitude.

These corrugated surfaces can potentially be used as a method of self-organization and self-orientation of various deposited thin molecular films. Therefore, studying the formation of nano-particles after deposition and their response to the curvature of corrugated surfaces is an essential part of developing a method to control the size and distribution of the nano-particles formed.

The size and position of formed nano-particles is depended on the thickness of deposited material as well as the curvature of the surface. Figure 1 compares different thicknesses of material deposited on corrugations with the same amplitude and wavelength. The particles' response to the surface morphology was studied. As the deposited thickness increases, the particles tend to form bigger particles and their response to the surface curvature becomes minimal.

The annealing process provides enough energy for these formed nano-particles to respond to surface curvature. In Figure 2, the annealing processes for

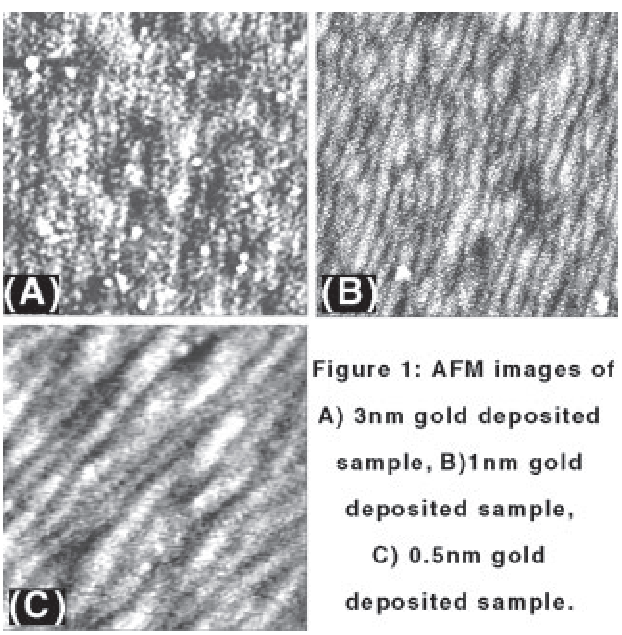


Figure 1: AFM images of A) 3nm gold deposited sample, B)1nm gold deposited sample, C) 0.5nm gold deposited sample.

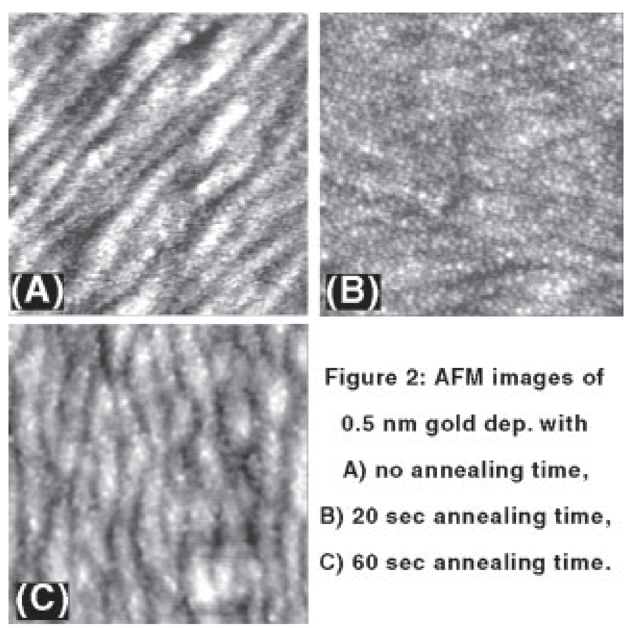


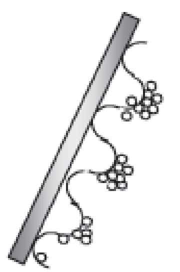
Figure 2: AFM images of 0.5 nm gold dep. with A) no annealing time, B) 20 sec annealing time, C) 60 sec annealing time.

5 Å deposited gold is compared as the annealing time increased from 10 to 60 seconds. Increase in the anneal time results in increase in the size of the particles as is apparent in the figures.

Procedure:

Corning code 1737, boroaluminosilicate glass pieces were washed with acetone and isopropyl alcohol and blown dry with dry nitrogen. The pieces then were placed in a Veeco Ion Mill with an incoming ion angle of 45° where they were bombarded at 450 V and 80 mA for 20 minutes. The resulting corrugations had a wavelength of approximately 50 nm, and amplitude of 1.5 nm.

The corrugated samples were then placed in CVC 4500 evaporator where small amounts of gold with thicknesses ranging from 5 to 15 Å were thermally deposited onto the corrugated glass surface at normal incident angles. A series of annealing processes and characterization was then performed. Samples were placed in an RTA (Rapid Thermal Anneal) oven for various times ranging from 10-60 seconds at 450°C. Characterization was performed after each annealing time utilizing AFM.



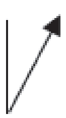


Figure 3: Off-normal angle geometry used for SiO_2 deposition.

In another set of samples, after the corrugations were made utilizing the same set up as described above, the samples were placed in CVC 4500 where small amounts of SiO_2 ranging from 5 to 30 Å were deposited on the corrugated surface in off-angle geometry. Figure 3 shows the set up used for this deposition. Samples were placed at 11° away from normal which corresponds to the maximum curvature of the corrugated glass surface, and is required for the shadowing effect to be apparent. The samples were placed away from the center of the deposition chamber to which angle we added.

Results and Conclusions:

The effect of thickness variation in the deposition process has been investigated and studied. Also, providing thermal energy for the formed gold particles, their response to the curvature of the surface has been investigated.

In off-angle geometry deposition, the shadowing-effect in deposition SiO_2 on corrugated glass surface has been successfully observed and studied, and an asymmetrical structure, and height increase in the deposited corrugated glass has been identified.

Future Work:

More control over the off-angle geometry deposition is favorable since small changes in the deposition angle can cause the shadowing effect to be less effective.

Also, deposition while the sample is being heated can provide enough energy for the particles to respond to the curvature of the surface during formation. Through this process we might be able to avoid the annealing process.

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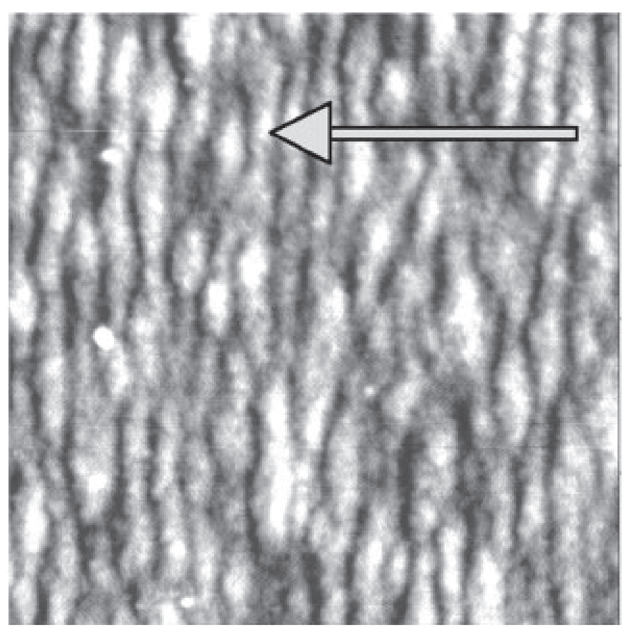

Figure 4: AFM image of the sample with 5 Å SiO_2 deposited in an off-angle geometry. The arrow shows the direction of SiO_2 deposition.