PVD: Gold Nucleation Analysis (35 points)

Objective: The objective of this online lab is to investigate surface mobility properties and analyze surface nucleation as a result of heat treatment.

The student will watch a series of videos pertaining to the processing, annealing, and subsequent analysis of PVD gold thin films. These videos will provide detailed insight onto each step of the overall process. After watching the videos the student will be required to answer review questions on ANGEL.

Background: Deposited thin films have clear stages of growth. Nucleation sites form first as atoms adsorb and cluster together on the surface to minimize energy. There are physical and chemical forces involved with the desorption process, but thermal energy allows for surface mobility to occur. These nucleation sites form on the surface, until a complete monolayer forms.

Due to the size of the nucleation sites, there is an optical effect that takes place causing the surface to appear different colors. Light interacts with the surface and certain wavelengths of light get absorbed by the sites. That energy induces an oscillation of the free electrons on the surface, creating a surface plasmon effect. Surface plasmons are collectively oscillating electromagnetic waves that can be used to increase the sensitivity of surface detection methods.

Experiment: During this exercise, colloidal gold nanoparticles will be synthesized and characterized using the Veeco di Innova atomic force microscope.

Step 1: Prepare and clean the glass substrates

Before depositing the gold onto the glass substrates it is necessary to clean them. Watch the cleaning of the glass substrates at the link below:

http://www.engr.psu.edu/mediaportal/flvplayer.aspx?FileID=8f5ca367-38a0-4608-a975-d

Step 2: Sputter gold onto the glass substrates

Next, a sputtering tool will be used to deposit ~50 Å of gold onto the two glass substrates. It is important to note that once the samples are unloaded they are not disturbed and that the slides are not placed upside down since the gold is only weekly bonded and therefore easily scratched from the surface. Watch the gold deposition process at the link below:

http://www.engr.psu.edu/mediaportal/flvplayer.aspx?FileID=3659464e-81c0-40a8-9e55-9

Step 3: Anneal the film

Next, one of the samples will be annealed on the hotplate while the other will be left as a control. Watch the thermal anneal process at the following link:

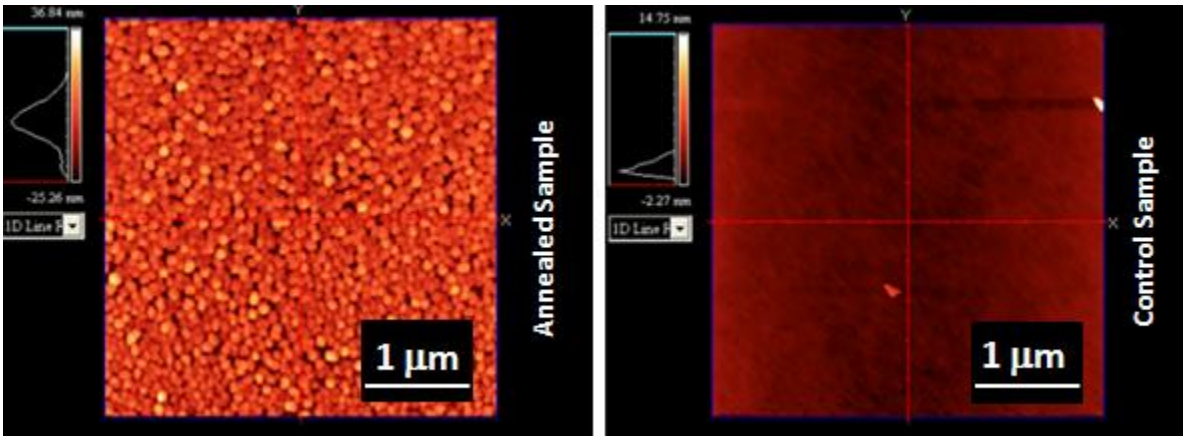
http://www.engr.psu.edu/mediaportal/flvplayer.aspx?FileID=cc8f26f6-9a69-4f90-a017-8

Step 4: Characterize both samples using the atomic force microscope (Veeco di Innova)

Lastly, both samples will be characterized using the atomic force microscope. Watch this final characterization step at the link below:

http://www.engr.psu.edu/mediaportal/flvplayer.aspx?FileID=48e32293-2052-4b54-b0b5-4

A comparison of the images obtained during this step is shown below. Note the control sample (right) is almost atomically smooth whereas the annealed sample (left) shows large clusters of gold as a result of thermally induced nucleation. The macroscopic result of this nucleation is a visible color change between the two samples.



Questions to be answered on ANGEL (NO HARD COPY REQUIRED)

1. What sequence of chemicals was used to clean the glass substrates? (2)
2. What processing conditions were used to deposit the gold film? (3)
3. What time and temperature was the film annealed at following gold deposition? (3)
4. How does heat facilitate surface mobility? (3)
5. How do the annealed and non-annealed samples differ at the macroscale? (3)
6. Describe what happens to the film as it is being thermally annealed. (3)
7. How would this experiment change if the samples were sputtered under the same conditions for 3min? (3)
8. What mode of AFM was used to analyze the samples? (3)
9. What was the temperature setting on the hotplate that afforded a temperature of 400°C? (3)
10. How were the samples mounted for AFM observation? (3)
11. What signals were acquired during the AFM scan? (3)
12. What scan parameters were used during the imaging of the samples? (3)