Introduction to Thermal Evaporation (35 points)

Figure I: Cooke Thermal Evaporator

Purpose: This lab will overview the values, gauges, and components of a thermal evaporator and demonstrate how metal is deposited using this tool.

Rationale: A thermal evaporator is a relatively inexpensive and easy way to deposit low melting point metals. Students should have a thorough understanding of the operation of a thermal evaporator after completing this activity.

Introduction: In evaporation the source metal is heated under vacuum until it vaporizes. The vapor travels in a straight line until it reaches the substrate and condenses. This technique of metal deposition is widely used because it is a relatively inexpensive and simple process. In an evaporator, the metal heating source can be filament or electron gun based. Both systems utilize high vacuum chambers to maintain the appropriate mean free path (MFP). In order to achieve a successful deposition, the MFP must exceed the distance between the source and the substrate. One drawback of evaporation versus other PVD techniques is that alloys cannot be deposited efficiently because of thermal segregation. Other shortcomings are the inability to fill high aspect ratio holes and produce conformal step coverage.

A filament is a simple heat source. The source material is placed in a metal coil, or boat usually made of tungsten because of its high melting point. A high current is passed through the coil heating the metal until it becomes liquid and eventually vaporizes. Despite the ease of thermal evaporation, filament heating can be difficult to control, and refractory metals such as titanium cannot be deposited due to their high melting point. In addition, the evaporation process is susceptible to contamination from unwanted vapors emitted by the heated filament.

Figure 1 shows an image of the Cooke Thermal Evaporator. Watch the video at the link below which outlines the mechanism and operation of this equipment. After watching the video answer the lab questions on ANGEL.

http://www.engr.psu.edu/mediaportal/flvplayer.aspx?FileID=8e8351bc-ecb7-42ef-aff3-b

Questions (TO BE ANSWERED ON ANGEL, NO HARD COPY REQUIRED)

1. What is the crossover pressure for the Cooke evaporator?
2. What is the max deposition pressure for the Cooke evaporator?
3. What gauge is used to read monitor high vacuum pressures on this system?
4. What is the melting temperature of aluminum (^{o}C)?
5. What are the specific material properties that need to be inputted into the CTM controller in order for the CTM to properly measure the thickness of the deposited metal?
6. What type of crystal does the CTM use to measure the amount of deposited material?
7. What is the range for an acceptable rate of deposition?
8. What apparatus is the source material loaded into for thermal evaporation?
9. What are the two most important roles of the shutter during metal deposition?
10. When can the ion gauge be turned on?
11. What is the cool down time for the evaporator?
12. Why is the cool down time for the evaporator important?
13. Why can't alloys be deposited using a thermal evaporator?
14. Why is the system left under high vacuum after operation?
15. What recipe was followed to obtain a deposition rate?
16. What is sprayed on the glass panels following evaporation in order to clean them?
17. Which materials can be deposited in a thermal evaporator?