Exploring a Technique for Depositing Aluminum

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For basic exposure to the necessary technique of depositing a metal onto a surface, aluminum was deposited onto glass. By measuring resistance one can attempt to measure the layer thickness during and after the deposit takes place. As expected, the evaporated aluminum closed the open circuit across the glass and allowed continuity showing there was a complete layer. However, in this instance the thickness calculation was inaccurate.

I. INTRODUCTION

Many times there will be a need to deposit a metal onto a surface. Whether the deposited layer will be used as a base for deposits of other materials, exploring masking techniques, or the final sample for testing purposes, many of these things have the same starting methods. This was a hands on approach to become familiar on a broad level with the concept of evaporating a metal, in this case aluminum, to deposit onto a non-conducting surface, a glass microscope slide.

II. EQUATIONS AND OTHER

The aluminum melted, boiled and evaporated at which point it coated the slide placed above it providing a path for continuity instead of the open circuit with just the glass slide. First, evaporation was done with the sample area covered and without the wire contacts so a contact patch between the slide and the contact wire would be in place for later use.

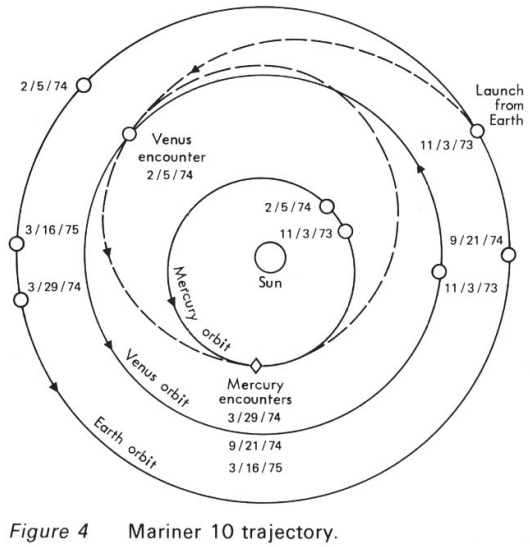

FIG. 1: The orbit of Mariner 10 on the way to Mercury.

Without this step no continuity would occur because the contact wire would be resting against only the glass. For the second evaporation the contacts were in place and resistance was measured across the evaporated patch.

Using the equation:

$$H = \frac{\rho L}{RW} \tag{1}$$

where H is the thickness of the evaporated layer, ρ is resistivity of aluminum $2.82x10{-}8$ Ω m [1], L is length between contacts 4.05 cm, R is resistance, W is the width of the slide 2.53 cm. H was calculated from R and thickness was plotted.

III. DISCUSSION OF RESULTS

The resulting plot for thickness changes very rapidly. See table 1 and figure 2 . After 35 seconds the resistance read zero Ω.

Time (Sec)	Resistance (MΩ)	Thickness (fm)
0	8.5±0.1	5.4
5	7.7±0.1	6.0
10	7.0±0.1	6.7
15	6.0±0.1	7.7
20	5.2±0.1	8.9
25	4.0±0.1	12
30	3.1±0.1	15
35	1.7±0.1	27

TABLE I: Data values for resistance used to calculate the changing thickness of an aluminum layer deposited on a glass microscope sample slide

There is a significant error because even though the aluminum layer on the slide was visible by eye, the thickness values calculated are smaller by a factor of $1x10^4$ m than the diameter of an atom, approximately $1x10^{-10}$ m. The calculated thickness values are closer to the order of the nucleus which is $1x10{-}14$ m [2].

The value for ρ of aluminum is a large source of error. Because resistivity increases with temperature $2.8x10{-}8$ Ω m was not an accurate value. This experiment underwent a large temperature change from room temperature to the approximately 940 degrees Kelvin required to melt aluminum. That would mean a large change in

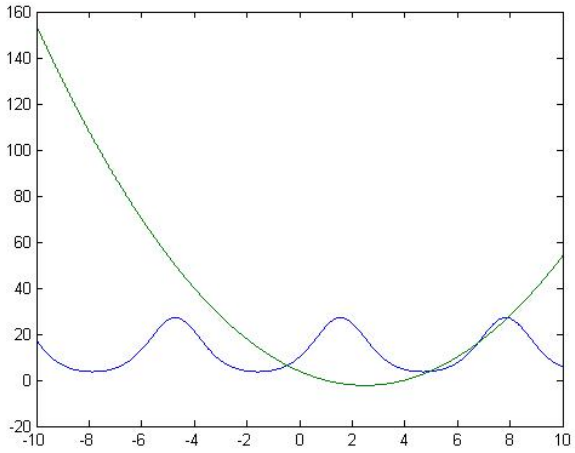

FIG. 2: A plot of two functions. Where they cross is a zero.

ρ. Also, the temperature was not known when the aluminum condensed on the glass. The temperature was not a constant as the aluminum condensed because hot evaporated aluminum contacted the aluminum already on the glass which was at a different temperature. There was no way found to get an accurate value of ρ for this experiment. Another source of error for the resistivity is that the exact type of aluminum was not known. Aluminum has so may alloys and all vary so much in there material properties.

For this lab another source of error was that the aluminum deposited was not of uniform thickness. This would lead to inaccurate resistance readings. The circuit is going to take the path of least resistance. With a continually varying path due to changing thickness there was no constant path for a resistance reading. Also, the resistance of the wiring system of the circuit connected to the slide was not measured. It may be substantial because it has wire running from the slide to a metal post passing through the vacuum chamber connected to more wire connected to the external meter and that is on each leg from the meter to the slide. It was ignored here because it was assumed to be small compared to the resistance value of an open circuit piece of glass.

An item for change in this experiment is the type of ceramic vessel used. The first types used were of low quality and were destroyed by the voltage needed to evaporate a substantial amount of aluminum. A second type of vessel was used that was more durable in the later half of the experiment.

[1] Physics Factbook, (2004) . *Resistivity of Aluminum*, http://hypertextbook.com/facts/2004/ValPolyakov.shtml

[2] Serway Moses Moyer, (1989) . *Modern Physics*, pg 375 and Inside Front Cover