Investigation of Nichrome Resistor fabrication problems

A comprehensive campaign regarding nichrome deposition using metallisation tools available in the James Watt Nanofabrication Center

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Project Specification
The experiment was conducted for a duration of thirteen weeks. Each week a 3 inch silicon wafer was deposited with 75 nm of nichrome using the two electron beam metallisation tools (Plassys II & IV MEB 5505). Before and after deposition, the wafer’s curvature was measured using a stylus profiler (Dektak), and stress measurements calculated. Resistivity was measured using a four point probe, and plotted in a graph beside stress measurements.

To check resistance measurements, a set of 10, 25 and 50 μm wires were fabricated and measured using a probe station.

EDX and XPS measurements were done on the wafers to determine the composition before and after the project duration.

Project Specification
The evaporation of nichrome is carried out by using an ingot of nichrome from a supplier which is fitted inside a crucible and then melted using an electron gun. A shutter separating the process chamber and load-lock chamber is used to control the rate and time of nichrome deposition.

Before and after deposition, the curvature of the wafer is measured using Dektak. For purposes of this experiment a 20 second scan of a 3 cm length on the wafer was used to measure the stress of the nichrome film on the wafer. The stress of the film is calculated based upon the change in curvature and material properties of the film and substrate.

XPS (X-ray photon spectroscopy) involves bombarding the nichrome film with X rays and measuring the elemental composition and chemical state of the photoelectrons which escape from the film.

EDX (Energy-dispersive X-ray spectroscopy) relies on comparing emitted X rays with those of an element in the X ray spectrum (as each element has its own unique X-ray peaks). The electron beam lithography tool was used to fabricate resistors on a silicon wafer. The resistors are manufactured by having an electron beam hit a resist laden substrate at a dose specified by the design beforehand. After lithography, the resist is developed and nichrome evaporated on the sample. Post deposition, metal lift-off takes place and the resistors are tested.

Results and Discussion

From the stress measurements graph seen above, there is an increase in tensile stress in the film over the duration of the project. For resistivity, the sharp decrease after week 6 can be attributed to the fact that emission rates were higher during the same time, with the rate staying the same.

EDX (left) and XPS (right) measurements are shown below.

In EDX measurements, the chromium percentage increases by 0.8% over 13 weeks. For XPS, the nickel percentage significantly increases (by 19.3%) during the same period due to the oxide formation in the ingot decreasing in the latter stages of the project.

Conclusions
Throughout the duration of the project, it is clear that a sharp change in nickel to chrome ratios takes place. This also affects the ratio of deposited nichrome on the wafers. This change in metal ratios causes the variation in resistivity and stress measurements on nichrome wafers.

References:
Plassys 4 image taken from Kelvin Nanotechnology Website. (www.kelvinnanotechnology.com)
Dektak image procured from Rensselaer Polytechnic Institute. (www.rpi.edu)
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