Minimization of Hydrocarbon Accumulation on Nanomanipulator Probe Tips

G. McMahon,* Christopher G.. Morgan,** and Ronald Vane**
* Nanofabrication Cleanroom Facility, Boston College, Newton, MA 02459
** XEI Scientific, Inc., Redwood City, CA 94063

Introduction

Electrical characterization of nanodevices is out of necessity frequently performed in-situ within an SEM, dual beam or even a TEM with the aid of nanomanipulators. Although nanomanipulator technology is maturing and their use rapidly gaining popularity, there remain several areas where improvement in the reproducibility of measurement could be facilitated. One well known problem is that of establishing Ohmic contacts to the device to be measured [1]. For the case where tungsten probe tips are used, poor electrical contact can be a result of debris build-up on the tip, the presence of an oxide layer left over from the probe tip preparation method [2], and the focus of this study: Electron beam induced hydrocarbon layer accumulation.

In this work, we examine the effectiveness of downstream cleaning by oxygen radicals generated by a plasma device for the prevention of hydrocarbon buildup on clean tungsten probe tips.

Methods

The control measurements were performed in the following manner: New W probe tips (GGB Industries Inc., Naples FL) were removed from their Argon filled package, rinsed in distilled water, rinsed in isopropyl alcohol, and then blown dry with nitrogen. All four tips were installed into four Kleindiek MM3A micromanipulators within a JEOL 4500 Multibeam specimen chamber and the system evacuated to 1 x 10^{-3} Pa. Two probes were placed on either end of a 52 Ω surface mount resistor and two point measurements were performed using a Keithley 2612A sourcemeter. The current was swept

Methods (continued)

from -100 μA to +100 μA and the voltage drop measured and resistance calculated. After this measurement, the magnification on one probe was increased to 15,000X, the probe lifted until it was no longer contacting the surface, and left under the beam for 15 minutes. After this time, the probe was replaced back on the surface, and the electrical properties measured again. The process was repeated several times to investigate the cumulative effect on the probe tip after several 15 minute increments under the beam at 15,000X.

A similar protocol was used to investigate the effect of the plasma cleaning treatment: All four probes were removed from the chamber, rinsed in distilled water, then in isopropyl alcohol, and finally blown dry with nitrogen and re-installed in the chamber. Pumping was initiated and the Evactron 25 De-Contaminator RF Plasma Cleaning System (XEI Scientific Inc., Redwood City, CA) was run for 20 minutes at a power of 14W at a pressure of 53 Pa. Following the plasma treatment, the Evactron then purged the chamber with dry nitrogen for 5 minutes at a pressure of 80 Pa before completing its cycle and allowing the dual beam instrument to continue pumping until a vacuum of 1 x 10^{-3} Pa was obtained. The probes were then set up in the same manner as before, and the exact same procedure was used (15 minute intervals, 15,000X, 15kV and the same spot size). Although it was not possible to measure the SEM beam current directly, the spot size setting and lens current in the LaB_6 source were identical for all measurements.

Results

The results of the resistance measurements from the control and the Evactron cleaning experiments are shown in Table 1.

TABLE 1: Resistance Measurements from Control and Evactron Cleaning Experiments

-	Measured Resistance (Ω)	
Cumulative Time Under SEM Electron Beam at 15kX magnification (minutes)	Control	Evactron Cleaning
15	55	55
30	56	56
45	64	56
60	11,600 Tip sputter cleaned with FIB from one side	58
75	55	60
90	56	68
105	2900	81
120	7850	82 Acquire FIB image; no focusing; single raster pass
135	14,000	59
150	-	62

Results (continued)

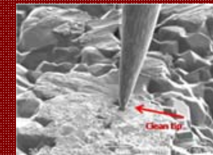

FIG. 1. Clean probe tip contacting resistor surface at beginning of experiment.

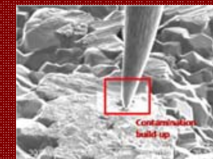

FIG. 2. Control experiment. Probe tip after 45 minutes under the SEM beam at 15,000X.

FIG. 3. Evactron cleaning experiment. Probe tip after 120 minutes under the SEM beam at 15,000X.

Conclusions

We have observed a very positive effect of Evactron downstream plasma cleaning in the prevention of hydrocarbon buildup. The large effect observed in this study diminishes as the Evactron is run a few times resulting in the maintenance of a clean vacuum environment.

[1] Y. Peng et al., *Journal of Physics: Conference Series* 126 (2008) 012031.
[2] Z. Saghi et al., *Appl. Phys. Lett.* 91 (2007) 251906.