Adherent tungstenates, composed predominantly of WO and WO$_2$, will affect initial contact resistance (C$_{RES}$) measurements in a production environment. Within 1-2 hours of exposure to ambient air, a 50-60 Å thick oxide layer will form on tungsten (W) and tungsten-rhenium (WRe) probe tip surfaces according to a parabolic oxidation law. Consequently, it may be necessary to clean probe tips before wafer testing after relatively short periods of storage and downtime.

To study the effects of tungstenates on C$_{RES}$ magnitude, several 40-pin probe cards were built using tungsten (W), tungsten-rhenium (WRe), and NewTek-Probes™ – a proprietary, non-oxidizing probe material. Probe card metrology was performed with a standard analyzer.

All C$_{RES}$ measurements were made on a WC-check plate at a 3-mil overtravel with a 30-mA forcing current. Abrasive cleaning was performed using a 3-mil overtravel with a 30-mA forcing current. Abrasive cleaning was performed using a 3-µm grit burnishing pad. It is important to note that before the metrological evaluation, the probe tips NEVER made contact with an aluminum (Al) wafer.

C$_{RES}$ variations obtained for each probe during several test cycles are shown in the figure.

Characteristics of each data curve are described as follows:

0. “Out of the Box” measurements were made upon receipt of the probe card. Average C$_{RES}$ values for W, WRe, and NewTek probes were approximately 5.2-Ω, 4.0-Ω, and 3.8-Ω, respectively.

1. The probe tips were abrasively cleaned with three touchdowns on the burnishing pad and a 1.5-mil overtravel. For “clean” probe tip surfaces, the average C$_{RES}$ values on the check-plate were 1.6-Ω, 1.5-Ω, and 3.7-Ω, respectively. Removal of material from the W and WRe-tip surfaces resulted in C$_{RES}$ measurements significantly lower than the initial values. NewTek-Probe C$_{RES}$ values were relatively unaffected by the cleaning step.

**Sidebar** – On an Al-substrate, such as a wafer, the C$_{RES}$ values for “clean” W, WRe, and NewTek-Probes typically ranged around 250-mΩ, 220-mΩ, and 360-mΩ, respectively.

C$_{RES}$ between probe tip and contact substrate is comprised of a constriction resistance which is a function of the probe and substrate resistivities ($\rho_{probe} + \rho_{substrate}$), the number and diameter of the contact a-Spots ($n \times a$) as well as the oxide film resistance ($\sigma_{oxide-film}$) over the contact area ($A_{contact}$) according to:

$$ C_{RES} = \frac{\rho_{probe} + \rho_{substrate}}{4na} + \frac{\sigma_{oxide-film}}{A_{contact}} $$

Thus, the bulk resistivity of the substrate material can dramatically also affect the C$_{RES}$ magnitude.

2. A second cleaning step was performed to remove any remaining contaminants from the tip surfaces.

3. Once the tips were “clean”, the planarity, alignment, tip diameter, contact force, and leakage of the probe card were evaluated. The final test step was a C$_{RES}$ measurement. It took less than 4-hrs to complete the probe card metrology. The W and WRe-probes C$_{RES}$ measurements were comparable to the “Out of the Box” values. C$_{RES}$ of the non-oxidizing NewTek probes still remained unaffected.

4. A final light burnishing was performed and the W and WRe-probes recovered C$_{RES}$ values comparable to those of “clean” probes.

W and WRe follow highly temperature dependent oxidation laws between 30 and 300°C. Similar to Andersen (SWTW-1998), the present results demonstrate the presence of an insulative film on “virgin” W and WRe-probe tips at room temperature. At elevated temperatures, the effect of tungstenate type and growth rate on C$_{RES}$ variations will be exacerbated.

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