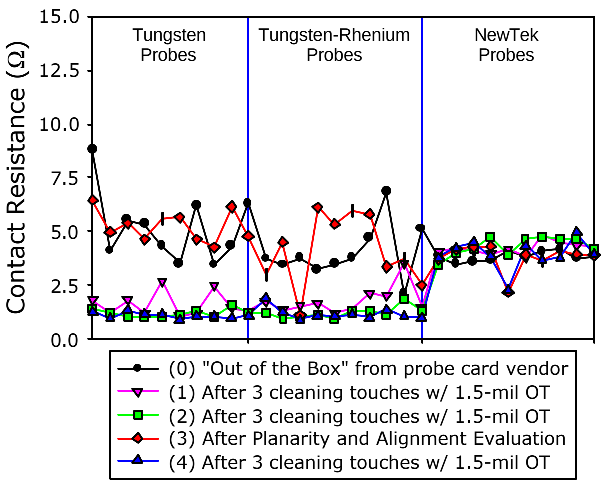
Effects of "On the Shelf" Probe Tip Oxidation on Contact Resistance

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 50-60Å 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-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 560-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 ($\sigma_{oxide\text{-}film}$) over the contact area ($A_{contact}$) according to:

$$C_{RES} = \frac{\overbrace{(\rho_{probe} + \rho_{substrate})}^{CONSTRICTION-RESISTANCE}}{4na} + \frac{\sigma_{oxide-film}}{\underbrace{A_{contact}}_{FILM-RESISTANCE}}$$

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-hors 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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