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Contact Resistance after Oxidation for a Selection of DNI Alloys

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The contact resistance of a system remains a significant engineering consideration for electrical contact safety and reliability in various environments. Contact resistance results from the bulk material resistance, the presence of resistive films on material surfaces (film tunnel resistance), and the limited area of true contact that exists between two touching members (constriction resistance) in a system. The theory of contact resistance is discussed in depth in a previously published Tech Brief.[1]

This article is primarily focused on the contribution to contact resistance arising from resistive films on the surface of the sample. There are numerous types of surface films possible depending on the surface structure of the material. Non-noble metals form surface oxide and sulfide films upon reaction with gases and other environmental constituents. These types of films are thick (>100 Å) and insulating due to film tunnel resistance. Noble metals develop thinner chemisorbed films of environmental particles over time (<30 Å), but are not prone to oxidation, because their high electronegativity values make them less likely to form bonds with oxygen.[2]

Higher contact loads and operating potentials are generally able to pierce through and dismantle these resistive surface films. This does not occur in lower energy contact systems (<30 mV), and they are therefore significantly affected by thick surface films, wear, and environmental contaminants. Noble metal contacts are used for these low contact load and low energy applications where the resistive film remains undisrupted, the focus of this Tech Brief.

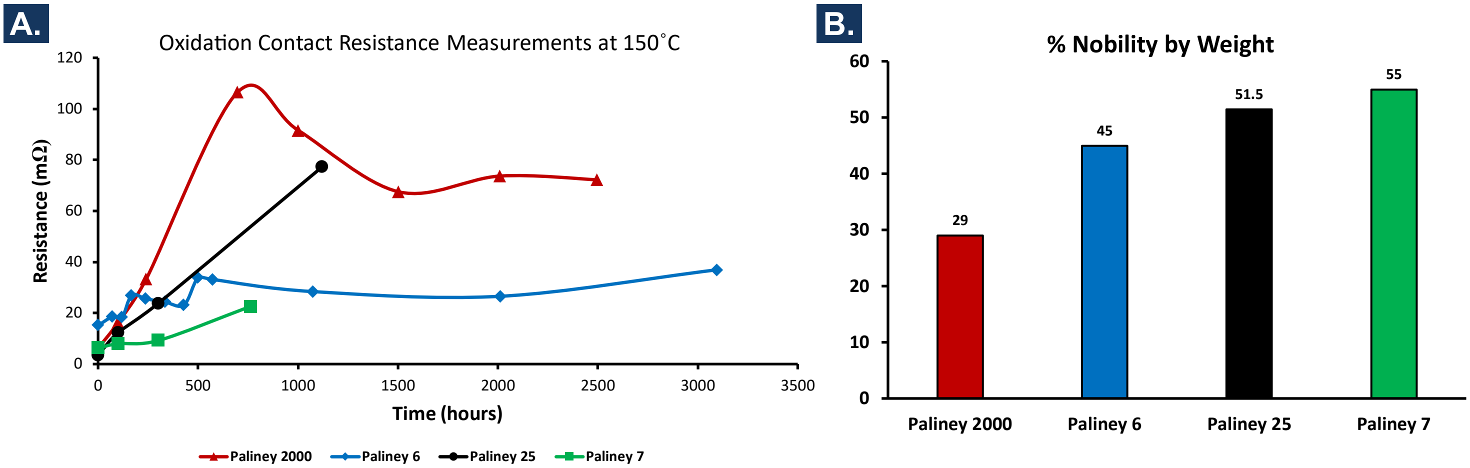

Figure 1: A. *Plot of resistance over time for a selection of DNI alloys aged at 150˚C.* ***B.*** *Percentage nobility by weight for Paliney 2000, Paliney 6, Paliney 25, and Paliney 7.*

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Continued from Page 1

Deringer-Ney Inc. (DNI) measures contact resistance using a static dry-circuit contact resistance based measurement at 20 mV maximum voltage which utilizes a radiused Neyoro™ G upper contact probe (0.2 inch diameter) with a 31 gram-force load and a micro ohmmeter. Resistance measurements taken over time for a selection of increasingly noble DNI Paliney® (palladium-based) alloys at 150˚C are shown in **Figure 1A**. The noble weight % of each of these alloys is shown in **Figure 1B**. Increasing noble metal content in an alloy results in decreased resistance after oxidation at 150˚C with the exception of Paliney 25. Although Paliney 25 has the second highest noble metal weight percentage, it also contains the highest percentage of copper out of the group of Paliney alloys presented. The copper in this alloy may be contributing to increased oxide film formation.

In **Figure 2** the film resistance of base metal and DNI alloys are plotted from different time intervals after oxidation at 200˚C. Paired 0.015 inch diameter contacts were exposed to to 200˚C and tested with a 5 gram load at 15 mV. The alloys are listed from left to right in order of increasing noble weight percent. The DNI Paliney alloys and the Neyoro alloys exhibit film resistance values that are orders of magnitude lower than the non-noble alloys. As nobility of the alloy increases, the film resistances generally decrease due to lack of oxide film growth. Two exceptions to this statement are Paliney 7 and Neyoro 69. These two alloys have higher weight percentages of platinum when compared to Paliney 6 and 8 and Neyoro 28 and 28A, respectively. Platinum is thought to have a higher tendency of film formation due to its partially filled d-orbital as compared to gold and palladium which have filled d-orbitals.[3]

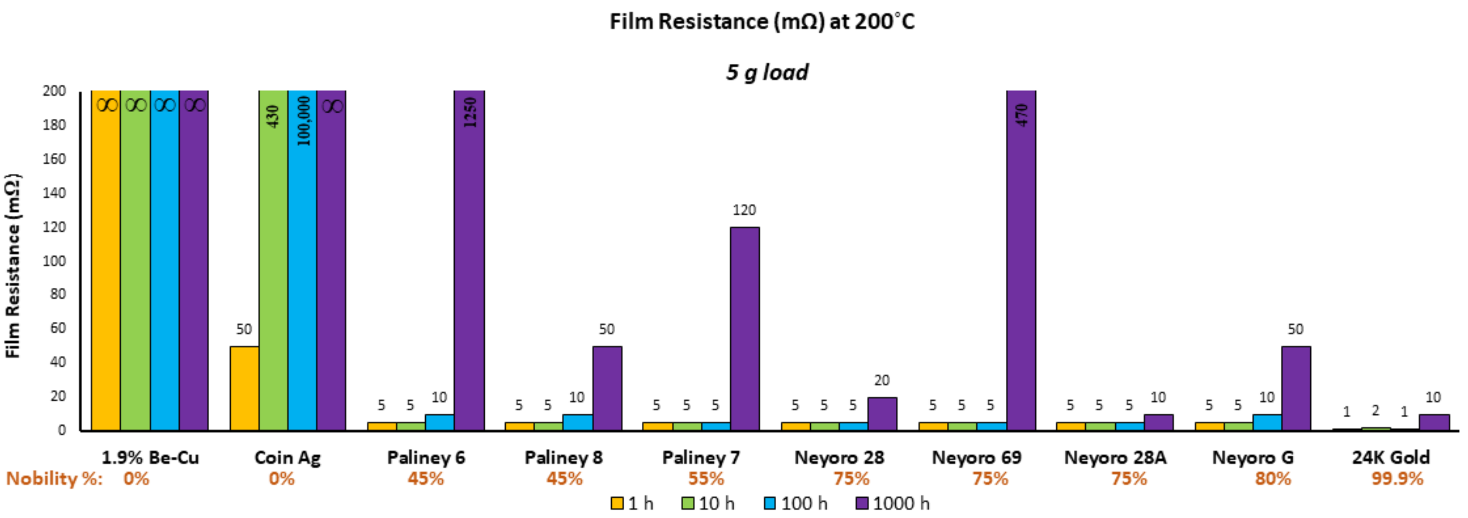

Figure 2: *Measured film resistance over time at 200˚C using a 5 gram-force load for an assortment of DNI alloys arranged in increasing nobility weight percent order. Film resistance values have been written inside bars that are cutoff to better show lesser film resistances. Data taken from Pitney, 1973.[4]*

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Continued from Page 2

Contact resistance is an important factor in electrical contact design for both standard electrical systems and micro-electromechanical systems (MEMS). The judicious use of noble metal alloys is a key component in constructing reliable electrical contacts in systems where forces and power levels are too low to disrupt insulating oxide films. Properly engineering systems to minimize contact resistance where necessary is an important safety and sustainability measure in which Deringer-Ney is well practiced.

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