AC-Electrical Properties of Silver Plated Probe Needles

Benefits of silver-plated tungsten (W) and tungsten-rhenium (WRe) probe needles can be realized in high frequency AC-applications. This is somewhat expected since AC- signal theory indicates that a highly conductive outer material layer with a shallow skin depth, such as a silver-plating, can dramatically reduce the AC-resistivity and signal loss of a probe due to the "skin effect".

All electrical currents generate magnetic fields that in turn affect current flow. For an AC-signal, the residual magnetic field pushes the current flow towards the outside of the conductor. As the test frequency increases, more of the current is forced through an increasingly smaller cross-sectional area until the entire current flows through a very narrow skin at the surface – this is known as the skin effect. This effect results in the attenuation of the signal's higher frequency components as well as increasing probe AC-resistivity. This can be significant for wafer testing, i.e. the effective bandwidth of the probe is reduced and an "electrically short" length becomes longer.

The skin depth of a material is a function of the electrical conductivity and not of the plating thickness. Since materials with low resistivity values (Table 1) have "shallower" frequency-dependent skin depths, the skin depth of silver will be considerably less than that of nickel, tungsten, or tungsten-rhenium. Furthermore, the silver skin depth is significantly smaller than any currently available plate thicknesses.

Tungsten	Tungsten-Rhenium	Plated Nickel	Plated Silver
5.5–5.9 μΩ-cm	9.2–10.1 μΩ-cm	7–40 μΩ-cm	1.6–3.2 μΩ-cm

Table 1 - Resistivity of probe needles and plating materials.

Although plating thickness will not affect the AC results, it is important to note, that the silver-plate thickness is a critical variable for DC-applications (as discussed in the *July 1998 APS Technical Bulletin*). In order to maximize the benefits of the silver-plate for high power and ground pins, APS plates probes needles with a minimum thickness of 200-μin.

Advanced Probing Systems, Inc., worked to evaluate the influence of the plating materials on probe AC-electrical behavior in 50-Ω and 100-Ω impedance environments. As result, GigaTest Labs, Inc., performed simulations over a frequency range of 100-kHz to 5-GHz for 5, 6, and 7-mil diameters, nickel and silver-plated W and WRe-probe needles. The plated probes were modeled using "standard" transmission approximations with the assumption of a 100-μin plate thickness.

If the characteristic impedance of the probes is normalized to 50-Ω, the signal loss of the silver-plated probes is 50 to 60% less than that of nickel-plated probes (Table 2). This simulation ensures that any electrical performance differences are due only to the different needle and plating materials. The differences are primarily due to the better conductivity of silver as compared to nickel.

Plated Probe	Loss at 1 GHz (dB)		Loss at 2 GHz (dB)	
	Nickel	*Silver*	*Nickel*	*Silver*
W005	0.8	0.4	1.1	0.5
W006	0.6	0.3	0.9	0.4
W007	0.5	0.3	0.8	0.4
WRe005	0.8	0.4	1.2	0.5
WRe006	0.7	0.3	1.0	0.4
WRe007	0.6	0.3	0.8	0.4

Table 2 - Resistivity of probe needles and plating.

If a 100-Ω impedance environment is assumed, the time-domain response (TDR) results of the nickel and silver-plated probes are almost identical. Any differences in signal loss between the plated probes are greatly overshadowed by the higher system impedance. Based on these results, the material and plating of the probes are found to have only secondary effects on the bandwidth. At higher frequencies, the probes exhibited such high impedance that their resistance was negligible when compared to their inductance.

When current passes through a conductor such as a probe, a magnetic field is setup around it. As this magnetic field builds, it induces a voltage in any conductor close by, as well as in the original conductor. This inductance tends to oppose the current that produced it. If the probes within a card were shielded (or coaxial), the induced current flow could be reduced since the magnetic fields cancel one another. Within a probe card, it is conceivable that the probe layout may mimic various "transmission line-like" configurations, e.g., two wire or co-planar transmission lines. If this is indeed the case, a "pseudo-controlled" impedance environment might be present.

For cards where the silver-plated probe layout within the epoxy ring resembles a transmission line configuration, some high frequency benefits (e.g. improved signal integrity) may be experienced during test.

ADVANCED PROBING SYSTEMS, INC.
PO BOX 17548 ▲ BOULDER, COLORADO 80308-7548 ▲ PHONE: 303-939-9384 ▲ FAX: 303-939-9032