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Probing the World of Microelectronics

PROBE TIPS #10

A Technical Bulletin for Probing Applications

Tip Material, Size & Shape

Tip Material

The most frequently selected tip material is tungsten. It wears well due to its great hardness and is resistant to fatigue thus consistently providing repeatable contact force. Tungsten tips last longer than beryllium copper (BeCu) or palladium, given the same contact force. Tungsten however has a major disadvantage in some probing applications giving high inconsistent and unrepeatable contact resistance. Clean tungsten probe tips have about 250 milliohms of contact resistance on aluminum. During use, Aluminum Oxide and other contaminants tend to accumulate on and within the probe tip. Tungsten material tends to be very porous and the Oxide builds up between the twisted strands creating the high contact resistance. Contact resistance can vary from probe to probe by several ohms and even measure open at the specified prober overtravel due to accumulating contamination on the tip. Obviously, wafer yield correlation problems and actual yield loss may result.

Tungsten is not suitable probe tip material when probing gold and other precious metals. The use of gold material typically implies high reliability and high cost devices. Lower resistance tip materials should be selected to insure maximum yield. Tungsten is not suitable material for high temperature testing due to the rapid acceleration of oxide buildup and the frequent tip cleaning which would be necessary. Tungsten is not a suitable material for high current probing due to the initially higher contact resistance and the potential for arching.

So what is tungsten good for? It is a great material for jellybean probing (probing of high volume low cost devices) where yields are proven and long probe tip life is more important than contact resistance. Beryllium copper is a softer material than tungsten and therefore will wear faster resulting in a shorter useful probe life. However, BeCu has a number of highly desirable characteristics. The most notable being consistently low repeatable contact resistance, typically 100 milliohms when probing gold and 200 milliohms when probing aluminum. BeCu is the material of choice for high quality contacts in switches and other applications where dependable contact is required. The scrubbing action of the probe tip during prober overtravel creates a self-cleaning probe. The action polishes the probe tip by wearing away a little metal, but keeps the contact surface clean for low resistance. Since contact resistance is lower and stable, less prober overdrive can be applied yet still provide good, repeatable contact. From a practical point of view, excellent system planarization allows automatic probing with only 2 mils of overdrive. At this overdrive setting BeCu probes will last as long or longer than tungsten probes at 4mils of overdrive. In one application, nearly two million touchdowns were recorded using BeCu tips. However, assuming they will wear faster, any extra cost associated with more frequent BeCu probe replacement will be paid back many times through yield improvements. Always select BeCu probes when probing gold and other precious metal pads.

Palladium is another material which has found some acceptance in probing and many of its characteristics are similar to BeCu. Palladium, however, has a relatively low module of elasticity and therefore is less resistant to fatigue. Consequently it is difficult to maintain planarization with palladium and probes are easily damaged. (See Accuprobe's Technical Bulletin on contact resistance for technical details)

Tough Tip is an Accuprobe brand name for Tungsten/Rhenium alloy, which offers slightly higher contact resistance but provides a more stable contact resistance through use than conventional Tungsten. This stability provides considerably longer runs between tip cleaning thus improving production throughput and yield.

Tough Copper is an Accuprobe brand name for specially hardened BeCu tips, which offer all the same characteristics of normal BeCu except that they offer higher contact force and comparatively longer probe life over normal BeCu.

Tip Diameter

The size of the tip selected is typically determined by the size of the test or bond pad which it will contact.
As a rule of thumb, the tip diameter size should be no larger than one half the bond pad size. This will generally insure that the tip will not scrub off the pad assuming that the tip is placed in the approximate center of the pad and normal overdrive is used. As device geometry's shrink and pad sizes approach 50 microns and smaller, the rule of thumb is tossed out as a practical matter in favor of a little more scientific approach to the problem.

The smallest practical tip size is .0005 inch (12.5 microns) in tungsten and .001 inch (25.4 microns) in BeCu.
These tip sizes may have to violate the rule of thumb when probing 30 micron pads. Such super small test pads are beginning to appear for parametric testing in the streets between individual devices on a wafer. When working with such small targets prober overdrive must be controlled very closely. There is typically a 10:1 ratio of prober overdrive to forward scrub motion of the probe. Assuming a 1mil tip on a 1.5 mil pad, 4 mils of overdrive will cause a .4 mil scrub. This motion barely allows the probe to stay within the test pad. In this instance if the test pad also has some overlapping glassivation, this already marginal, at best, situation becomes completely impossible. However, if overdrive were reduced to 2 mils resulting in a .2 mil scrub the situation would still be quite difficult but not impossible. Under such circumstances it should be clearly understood that planarization becomes a super critical variable which also must be tightly controlled.

Tip diameter has a substantial impact on contact pressure. As the tip diameter increases the contact force per mil of overtravel decreases according to the formula $P=F/A$ (P) pressure is defined as (f) force per unit area (A). Tip area (A) is proportional to the square of the tip diameter (D). Fundamentally, the smaller the tip the higher the contact pressure per mil of overtravel.

Tip Shape

The shape of a probe tip has an impact on the physical dynamics of the contact and the test results obtained. There are four common tip shapes found in use for semiconductor testing.

SHARP- This shape is typically used in analytical probing for sub-micron contact. The nature of the contact is penetration. It is not a suitable tip shape for production probing with fixed pattern probe cards.

RADIUS- This tip shape was commonly selected for small IC bond pads. However, with the advent of SPC (Statistical Process Control) it has become evident that the rapid flattening of the tangent tip surface contributes negatively to yield. This rapid change in effective tip diameter has a corresponding rapid change in the contact dynamics such as tip penetration and contact force. This condition exists until the tip wears in and provides a consistent contact surface.

SEMI-RADIUS- This shape is similar to radius tips and is usually found on tip sizes larger than 2 mils in diameter. Probe contact is similar to radius tips but lacks the delicacy which can be achieved with true radius tips.

FLAT- This shape is just what the name implies and represents the most common tip shape found in Wafer Sort today. This tip shape is typically formed by sanding the tip to a desired tip diameter along its taper. Flat tips are most always found on Epoxy Ring style probe cards. Since the end of a flat tip on a new card assembly contacts the pad at a slight angle, it is recommended to initially scrub the tips on an abrasive surface such as Accuprobe Resistox. This sands the tip down insuring flush contact with the bond pad.

In reviewing various manufacturers' literature, little information is provided with regard to probe tip shape selection. The new Gallium Arsenide devices and smaller IC geometries require the gentle tough of small flat or full radius tips. Larger more durable devices, such as hybrid circuits, can also benefit from a geometrically stable flat tip.

Conclusion

For most applications involving fixed pattern probing always, select flat tips. This is particularly important for test pads where probe marks must be kept to an absolute minimum to facilitate bonding.

(For more information see Accuprobe's <u>Technical Bulletins</u> describing probe mark analysis.)