Solving Today's Test Challenges: Razor Sharp Probes

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Abstract

Solving today's In-Circuit Test Challenges on Difficult to Probe PCB Targets

Due to In-Circuit Test issues probing difficult to penetrate processes such as Pb-free solder, OSP (Organic Solderability Preservative), Immersion Au (Gold), Ag (Silver), Sn (Tin) and No-Clean, as well as the different manufacturing process variations like wave, select wave and reflow (single and double), new innovative razor sharp probe tip styles were developed (Figure 1). It was determined that a probe tip that has the qualities of a sharp blade edge would help to penetrate these problem processes. Edge sharpness has been determined to be a critical factor in the successful penetration of these processes within via and test pad applications. In addition, due to the sharpness of the edge, the penetration is effective even off center of the test via or in the pad area as well. Most tips used to probe vias today contain a single point design with the mentality that this sharp single point will break thru these board processes/contaminants. However, in most cases a single point probe will bottom out in the pool of flux contained within the via resulting in poor electrical contact. A razor sharp tip style will better penetrate these hard to probe fluxes and contaminants without bottoming out. Typically, Test Engineers would be forced to increase the probe spring force to break-through these contaminants, but high-density PCB's do not allow the use of higher spring forces due to the increased possibility of board flex which can cause damage to expensive boards. The use of the razor sharp probes does not require a higher spring force and in some cases the spring force can be reduced. Because of these innovative tip styles, first pass yields are significantly increased, repeated fixture actuations are not needed, false failure rates and NDF's (No Defects Found) are reduced, all of which results in less test time and faster board throughput which ultimately lowers board test costs.

Figure 1 - Razor sharp steel tips

Introduction

Probing Problem Processes

The development of the razor sharp steel tip designs were needed because of the challenges of penetrating 'problem processes'. They were designed to reduce the false test failures and increase probe life when probing problem processes such as Pb-free, OSP and No-clean in production test environments on test vias and test pads.

When probing Pb-free solder, the fluxes are much harder to penetrate because they must withstand the higher reflow temperatures of lead free solders compared to conventional leaded solders. Boards often are processed with multiple reflow requirements that further decrease the ability to make a reliable contact during test (Figure 2).

For OSP (Organic Solderability Protectant) coatings, which are increasingly being used due to the advantages they offer the PCB manufacturing process, the thin layer may be difficult to penetrate (Figure 3). A typical probe choice would be a single point probe with a higher spring force. This is not always a valid option mainly because of board densities and possible board flex. The sharpness of the razor sharp steel tipped probes penetrates this layer without having to increase spring force.

The No-clean process has also been a concern at the ICT level because aggressive probing is required due to the nature of no-clean which can be too gummy, excessive or too hard to penetrate (Figure 4).

For all of these finishes, a razor sharp steel tip probes cuts through, reducing the need for repeated fixture actuations, higher spring forces and frequent probe change-outs.

Figure 2 -Lead-free, pasted OSP via.

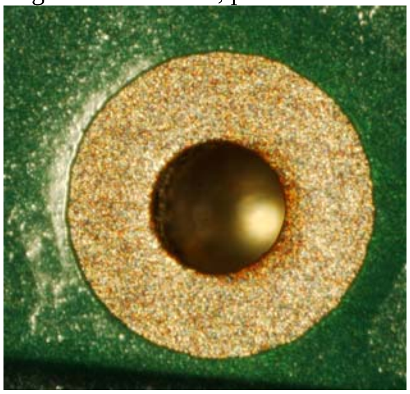

Figure 3 –OSP via (backside of pasted via).

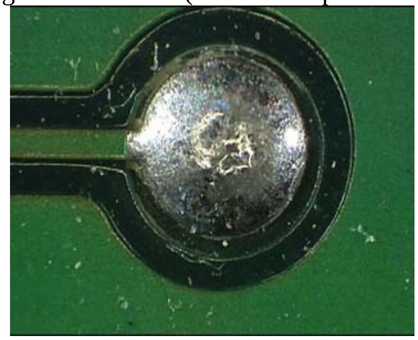

Figure 4 –No-clean, domed solder pad.

Development of the Razor Sharp Steel Tips

The razor sharp steel tip design was based on both feedback from customers and the knowledge that was gained during the development of original blade tip designs. Original blades were both headed and headless and were made from hardened steel. Steel is the probe plunger material of choice when hard and abrasive test contacts are encountered in high volume production testing. The standard plunger material, Beryllium Copper, is more suitable for lower volume test environments with clean processes.

The two main beneficial features of standard blade tip designs, when used to contact vias, are the 90° cutting angle of the tips and the two cutting edges. The two cutting edges of the blade tip style further increase the amount of penetration compared to a conventional three-sided chisel. For example, given a 6 oz probe with a three-sided chisel, we will have 2 oz of spring force available per cutting edge. When the same spring is used with a two-sided blade, the spring force available per cutting edge is increased to 3 oz, a 50% increase. This feature alone has made the blade tip styles very successful.

The original blade probes are cut with conventional methods in high speed machining operations. By improving upon these methods and refining the processes that define and produce the required tip geometries, it is now possible to produce a very sharp cutting edge able to withstand the repeated contact with both plated and unplated contact surfaces.

Variety of Razor Sharp Tip Angles
As a result of the many process and target variations, it became necessary to develop a number of razor sharp tip angles for versatility in contacting flat test pads, solder filled vias as well as, unfilled vias.

The 150º razor sharp steel tip design takes the best features of the original blade design and incorporates a shallower 150º degree angle which reduces the chance of contacting contaminants in a filled via (figures 5 & 6). For a concave solder pasted via, the shallow angle allows the razor sharp edges to avoid the center pool of flux and cut into the face of the target.

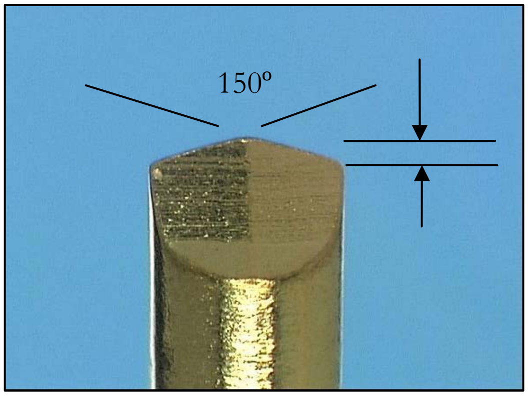

Figure 5 – Front view of 150º razor sharp steel tip design.

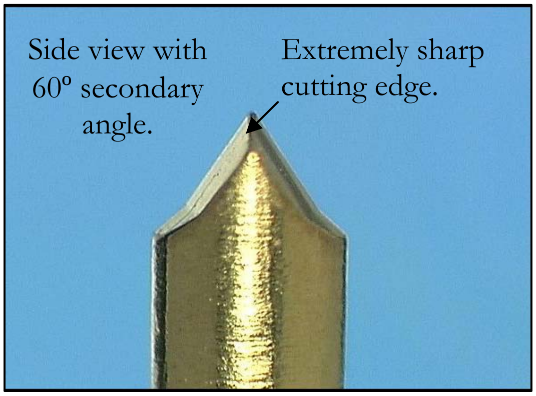

Figure 6 – Side view of 150º razor sharp steel tip design.

In a situation where there is an unfilled (unpasted) via, or a flat test pad, a 90º razor sharp tip may be more effective. The 90º angle creates a sharp center point for test pads while maintaining the razor sharp edges necessary to cut into an open, unfilled via hole (figures 7 & 8).

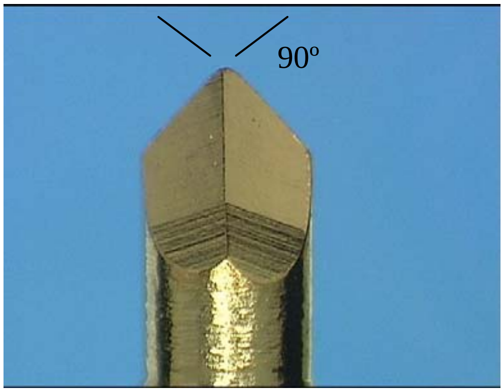

Figure 7 – Front view of 90º razor sharp steel tip design.

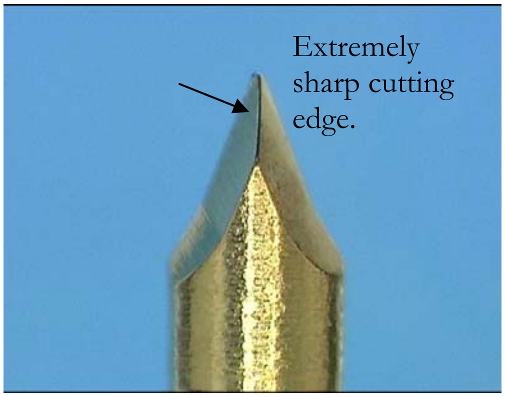

Figure 8 – Side view of 90º razor sharp steel tip design.

For extreme cases, where an excessive amount of solder results in a "dome" shaped target, a steeper 40º angle razor sharp tip was developed (Figure 9 & 10). The sharp center point cuts into the solder dome and reduces the likelihood of deflecting off of the target. This sharp center point also makes this an effective choice for probing test pads.

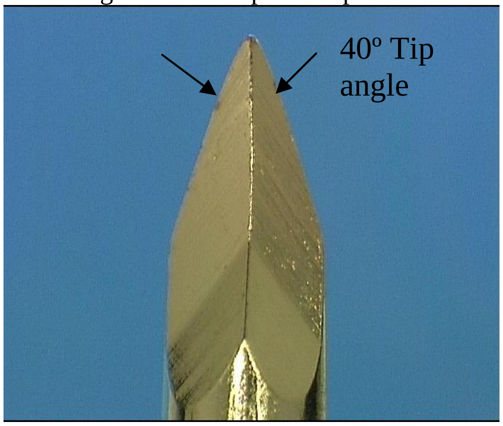

Figure 9 – Front view of 40º razor sharp steel tip design.

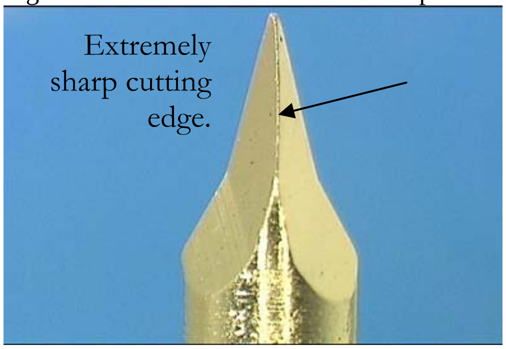

Figure 10 – Side view of 40º razor sharp steel tip design.

Internal Performance Testing of Razor Tips

In order to validate the performance of the razor sharp steel tips, resistance and life testing was performed using QA Technology's designed and built vacuum test system, which included PCB indexing ability coupled with a resistance test measurement electrical interface. The board carrier moved the board in both an X & Y direction allowing full access to the test vehicle thus maximizing the board coverage. By varying the test spacing, via size, etc, the test system was able to simulate the majority of test applications and variables found in the typical test board manufacturing environment. Once a board design was laid out, PCB manufacturers were used to build the test vehicles (Figures 11 & 12). To insure that the registration between the probes and the vias was maintained, optical holes were utilized. Once the boards were designed, multiple finishes were applied to simulate real-world board finish applications. Because of the versatility of the system, board actuation and other parameters could be tightly controlled.

Internal Performance Testing of Razor Tips

For Performance Testing of the razor sharp steel tip, each test vehicle via was cycled one time only per probe, then indexed to a new position and cycled again taking a new resistance measurement each time. Each probe was cycled to hit (100) one hundred individual vias.

Figure 11 – Test Vehicles.

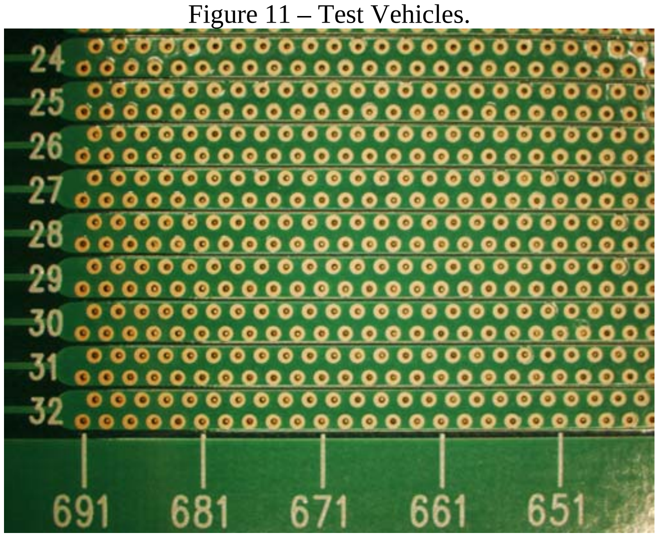

Figure 12 – Test vehicle layout.

Performance Testing Summary

In Performance Testing test vehicles fabricated with Alpha OM338-PT Pin-Testable solder paste, the 100mil the razor sharp steel tip consistently and significantly outperformed conventional blade tip styles with a failure rate well under 0.5% with many at 0%. Conventional blade probes ranged from 4% to 45%. Even when testing test vehicles fabricated with a difficult to penetrate Alpha OM338 solder paste, the100mil razor sharp tip probes significantly outperformed conventional blade tip styles with a 1.5% to 8% failure rate. Conventional probes ranged from 22% to 70% failure rate.

Internal Life Testing of Razor Tips

For Life Cycle Testing, each probe was cycled six hundred ninety-one (691) times per test vehicle collecting resistance measurements at each new via location. In order to simulate extended wear of the tips, the same board was then fed through the test apparatus again, cycling each position ten (10) times before indexing to the next via, resulting in each probe cycling six thousand, nine-hundred and ten (6,910) times. Then using the same probes, seven (7) new test vehicles were probed until completing approximately fifty-four thousand (54,000) cycles per probe (Figure 13).

Figure 13- Razor sharp steel tip probes after 54,000 cycles still performing with a single actuation.

Life Test Result Summary

In Life Cycle Testing, using test vehicles fabricated with Alpha OM338-PT Pin-Testable solder paste; the 100mil razor sharp tip probe maintained a failure rate well under 0.5% with many at 0% after 54,000 hits. General observations during testing indicated excellent performance of the 100mil probe not only when hitting a typical appropriately pasted and reflowed via on center, but when the probe hit off center on the solder pasted pad area; resistance was still many times at 0% failure rate.

Beta Site Testing of Razor Sharp Steel Tips

Production quantities of the razor sharp steel tip were produced and sent to customers for Beta testing. Three independent studies were performed at two different contract manufacturers in China. For the first study, the razor sharp steel tip was compared to a standard blade probe with identical 8.1 ounce springs. The board was cycled and the success rate was recorded. If after the first actuation it did not pass, the board was actuated again. If the board did not pass after five actuations it was considered a failure. The total success rate was based on five (5) actuations. The second and third beta testing compared conventional 8.1 ounce blade to the razor probe with a 6.5 ounce spring.

Beta Site Test Results of Razor Sharp Steel Tips (Table 1)

For the first beta site, the razor sharp steel tip achieved 100% success rate after two actuations, with a 96% success rate on the first actuation and the remaining 4% on the second actuation. The conventional blade achieved only 95% even after five actuations. The second beta site the razor sharp steel tip with a 6.5 ounce achieved 100% success rate on the first actuation versus the conventional 8.1 ounce which achieved 100% success rate after four (4) actuations. The third beta test results show the razor sharp steel tip with a 6.5 ounce spring force achieving 100% success after two actuations versus the conventional 8.1 ounce spring force probe which achieved a 36% success rate after five actuations

Table 1- Beta Site Results

	Beta Site 1		Beta Site 2 (Reduced Spring Forces)		Beta Site 3 (Reduced Spring Forces)	
	Conventional Blade 8.1oz	Razor 8.1oz	Conventional Blade 8.1oz	Razor 6.5oz	Conventional Blade 8.1oz	Razor 6.5oz
1st Pass	55 %	96 %	82 %	100 %	11 %	96 %
2nd Pass	30 %	4 %	12 %		17 %	4 %
3rd Pass	10 %		0 %		4 %	
4th Pass	0 %		6 %		0 %	
5th Pass	0%				4 %	
Total Success Rate	95%	100%	100%	100%	36%	100%

Summary of the Proven Benefits of Using Razor Sharp Tips (Table 2)

In-circuit testing can be a bottle-neck at the production line. In an effort to reduce inventory, while still meeting the customers shipping deadlines it is very important to streamline the board manufacturing and assembly processes. Every time a board fails test it must be reworked and/or re-tested taking time and disrupting the workflow. Like any automated manufacturing process, there will be process related problems, but by reducing the false test failure rates these problems will be greatly reduced.

By using the razor sharp tip test probes the manufacturing line will see immediate benefits. By increasing the first pass yields, workflow on the production line is improved. Our beta testing showed a positive impact on this by achieving a 100% pass rate after only two fixture actuations, while the conventional blade tip styles still had false test failures even after five actuations. By reducing the number of actuations per board the test department will see an increase in the number of boards tested before the probes will need to be changed out. This not only extends the time between scheduled maintenance but also has a positive impact on future fixture maintenance relating to probe and fixture expenditures.

Table 2- Increased board throughput

	Fixture Actuations	Cycle Life	Boards Tested
Standard Steel Blade	5	60,000	12,000
Steel Razor	2	60,000	30,000

In the end, an immediate savings is realized due to increased first pass yields, reduced no defects found (NDF's) faster board throughput, extended probe life and reduced fixture maintenance. This benefits both the contract manufacturers (CM's) and the original equipment manufacturers (OEM's).

For the board designer and test fixture manufacturer, the benefits include improved electrical contact on pads and vias when using the mandated Pb-free solder and flux processes. Board flex is reduced and/or eliminated because of the ability of using the razor sharp tip probes with lower spring forces when contacting high density contacts (Figure 14). As you can see, the razor sharp steel tip has an important place in the future of in-circuit test.

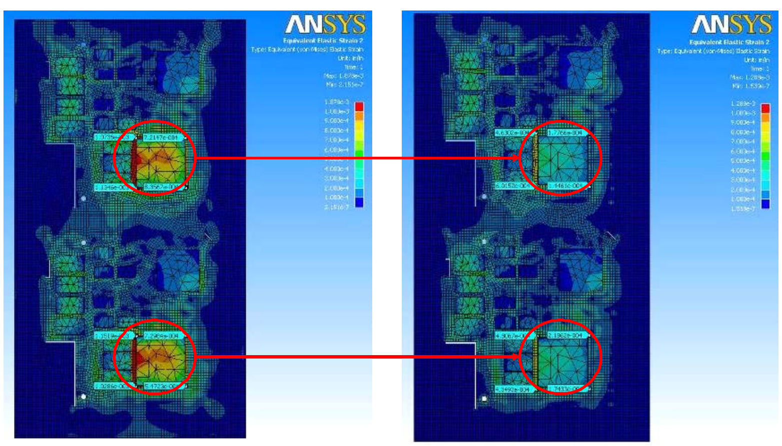

Figure 14- Example of the benefit of using a lower spring force, thereby reducing board flex.

Stacey Marotta is employed by QA Technology Co. Inc. as an Applications Engineer. During her eight years at QA she has focused her efforts on proper recommendations of probes and sockets for both domestic and international in-circuit test customers. She is a graduate of the University of Southern Maine with a Bachelor of Science degree. Stacey can be reached direct at (603) 601-0154, email: smarotta@qatech.com

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