Comparing Contact Performance on PCBA using Conventional Testpads and Bead Probes

White Paper

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Introduction

This white paper captures the details of an evaluation performed on the notebook motherboard of a leading Original Equipment Manufacturer using Agilent *Medalist* Bead Probes Technology. The evaluation was carried out in mid 2007 and the technology has since been used in mass production in the high volume manufacturing arena.

Summary :

The results obtained from the evaluation were in line with findings reported in the Agilent *Medalist* Bead Probe Handbook[1]: Usage of bead probes resulted in equal or better contact resistance compared to traditional testpads. (See APPENDIX for readings captured.)

It is worthy to note that there were no major changes to the surface mount technology (SMT) process despite implementing the new bead probe methodology. In fact, the solder paste that was used to create the beads was the same solder paste the manufacturer would normally use on a non-beaded board. Two brands of solder paste, Senju and Kester, were listed on the manufacturer's approved vendor list. During this evaluation, the manufacturer used the Senju solder paste (M705-GRN360-K2-V).

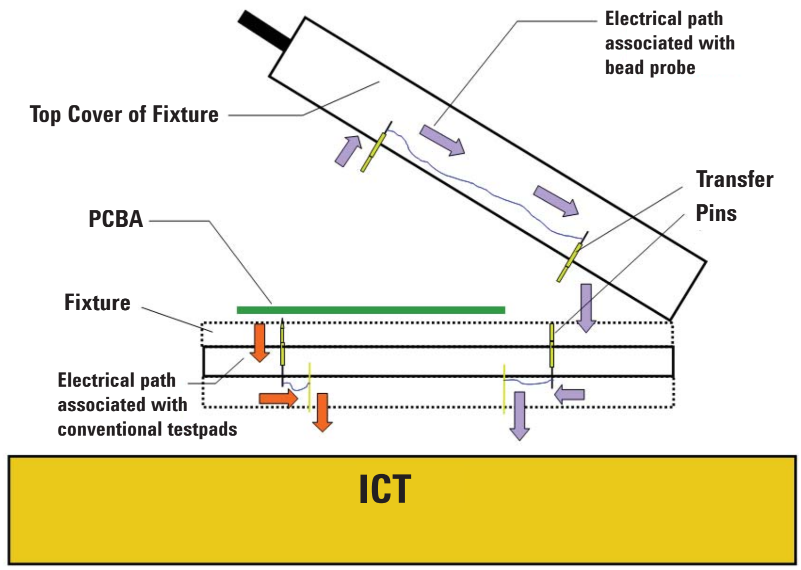

Figure 1 : Electrical path associated with the bead probe locations and conventional test pads

Good contact was made right from the first actuation at in-circuit test (ICT). Multiple actuations were not needed. During resistance test, bead probes performed marginally better than test points. Some of the wiring paths associated with the bead probes were longer as the headless test probes used were on the top cover of the fixture and went through transfer pins to the ICT system (refer to Figure 1). Even under this circumstance where the electrical path is longer and needing to traverse across transfer probes, bead probes still showed that it can perform better than test pads.

1. All Agilent Bead Probe licensees will receive a handbook "Bead Probe Handbook : Successfully Implementing Agilent *Medalist* Bead Probes In Practice"

Evaluation Details:

Quantity of boards ran:	30pcs
Trace width:	4mil
Solder mask opening:	7mil X 20mil
Stencil aperture:	16mil X 16mil X 5mil Laser-etched
No. of beads per board:	87 (Only data for 83 beads were captured due to an engineering change order)
PCB surface finish:	OSP

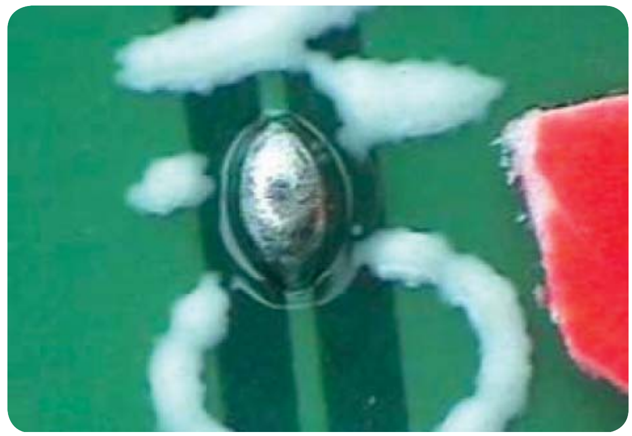

Figure 2 : Bead probes before actuation at ICT

Figure 3 : Bead probes after one actuation at ICT

Fixture and Probes Details

Test probes on bead probe locations

Spring force:	8 oz
Head style:	Headless (100mil and 75mil) (refer to figure 4.)
Location:	Top and bottom

Fixture description:

- Top probe guide plate
- Bushing to reduce top cover shakes
- Chiseled test probes for conventional testpads
- All test probes for conventional testpads were located at the bottom

Figure 4 : Headless test probes were used on bead probe locations.

Figure 5 : The fixture used in the bead probe evaluation.

While performing the fixture buy-off at the fixture house, it was noticed that a cluster of beads appeared to have been pushed out of their positions.(refer to Figure 6).

Further investigation revealed the cause to be tilted test probes and targeting inaccuracy. The fixture vendor subsequently performed targeting accuracy tests and re-aligned the test probes and that resolved the matter.

As an added precaution and best practice, the fixture house was advised to use flat-headed test probes which have larger head diameters instead of headless test probes. This allowed higher tolerance against targeting inaccuracy.

Also, a bushing was added to the top cover of the fixture to prevent lateral shakes that may have contributed to the problem.

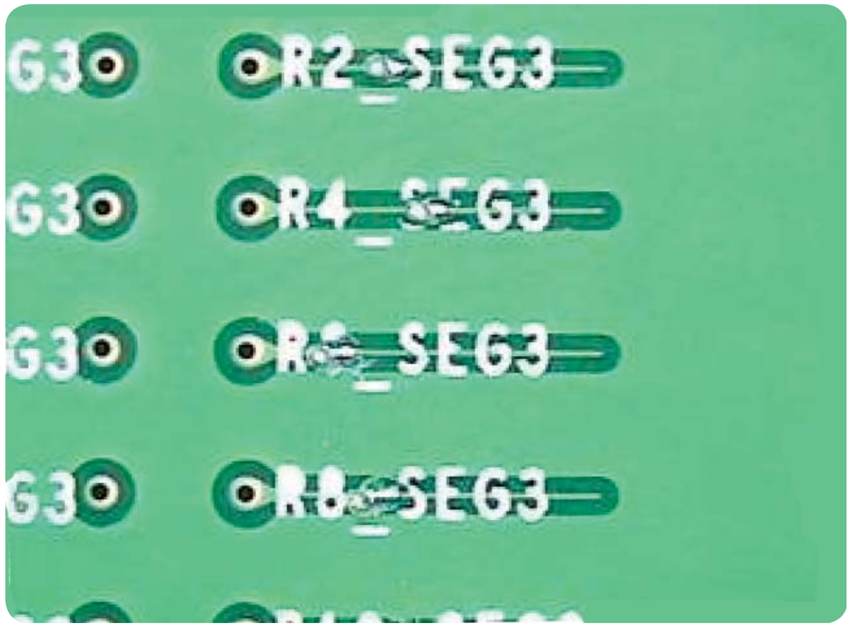

Figure 6 : A cluster of bead probes being pushed out of their position

Solder paste specifications:

Vendor:	Senju
Alloy:	Sn96.5% Ag3% Cu0.5% (Lead free)
Type:	No-clean
Product part number:	M705-GRN360-K2-V

The bulk of the time was taken getting the upstream portion of line ready for production, in particular at the paste printing machine. This is no different from the usual process. Paste bricks printed onto the board were tested with a visual inspection machine to determine paste height consistency and to verify if it was within tolerance margin and consistent throughout the board.

Below are the dimensions taken for a typical paste brick for a bead probe on the board:

Area = 172 mil2
Height = 5.99 mil
Volume = 1030 mil3

Considering the size of the stencil aperture used, we were expecting a transfer ratio of 0.7 (see Table 1 below). The volume of solder paste that was transferred onto the PCB however, suggested a higher transfer ratio of 0.8.

$$\text{Transferred ratio} = \frac{\text{Volume of paste transferred on PCB}}{\text{Volume of paste in the stencil aperture}} = \frac{1030}{16X16X5} = 0.8$$

The reason for the disparity is because the transfer ratio relationship is slightly different from solder paste to solder paste. The transfer ratio used in Table 1 (taken from the handbook) is only used for illustration and to show how the calculations are made and the factors involved.

So, as a best practice, it is advisable for manufacturers to get the transfer ratio table of the solder paste they intend to use, prior to implementation. Another best practice for first-time implementers is to start with smaller stencil apertures as the apertures can be enlarged if needed, but not the other way around.

But having said the above bead probe can be rather forgiving and tolerant to deviations such as these. This works to our advantage.

After Reflow

Because this is a no-clean process, a flux ring is seen under a microscope around the bead probe. The top of the bead appears shiny. The quantity of flux residue is what would be considered acceptable for bead-probing.

The bead probes that were produced appeared a little fat but are still acceptable. Visually, the beads appeared to be twice the width of the traces they were located on (refer Figure 2 and 3). We have to note however, that the transparent flux residue encircling the beads can sometimes portray the bead to be larger that it actually is.

The following calculations are made so that it can be shown how the stencil aperture size affects the size of the bead probe. Certain parameters (e.g. Transfer Ratio, Metal/Flux volume ratio) can vary from solder paste to solder paste. Therefore it is advisable to consult the solder paste vendor prior to an evaluation.

Theoretical Calculations

With Stencil aperture =	16mil X 16mil X 5mil
Print Area Ratio (from handbook) =	0.8
Transfer Ratio (from handbook) =	0.70

So, only 70% of the solder paste volume in the stencil aperture will be transferred onto the PCB.

Meaning,

Volume of paste on PCB =	0.7 x (16 x 16 x 5)
=	896

Typical, only half of the volume remains after reflow as the flux evaporates, leaving only the metal content.

So,

Volume of solder after reflow =	½ x 896
=	448

Assuming a rectangular cube shape for the bead probe, this will produce a bead of 4 x 20 x 5.6

Table 1 : Theoretical bead probe calculations

In-Circuit Test

Two board directories were created, with one using testpads for access and the other using bead probes.

Resistor tests were selected as the manufacturer's key performance comparison metric. Both test pads and bead probes measurement were performed as a 2-wire measurement. A total of 83 resistor tests (originally there were 87 but 4 taken out due to an engineering change order) accessible both by testpads and bead probes were measured for the internal resistance between IC pins.

Result

Good contacts were made even on first actuation at ICT. No multiple actuations were needed.

The results of resistance measurements using both testpads and bead probes are shown below (refer to Figures 7 and 8. For complete readings, please refer to the APPENDIX). Bead# 62 showed a spike in the resistance measurement. Remember this is a measurement of the internal resistance of the IC pins. It is unclear why this is so but we have to note that the spike is evident in both access methods (testpads and bead probes). Our key measure of the evaluation is the relative contact performance between testpads and bead probes; which is what we will examine here.

As these two graphs demonstrate, it is difficult to see the difference between the two as they look almost identical.

For clarity, a new graph is plotted (Figure 9) to show the difference between the measurement from the testpads and bead probes. The value shown is (Rtestpad – Rbeadprobe). As can be seen from the graph, the measurement recorded from the testpads are generally higher than those of bead probes.

Though this difference is only very small, it can be concluded that bead probes gives an equal or better contact resistance compared to testpads.

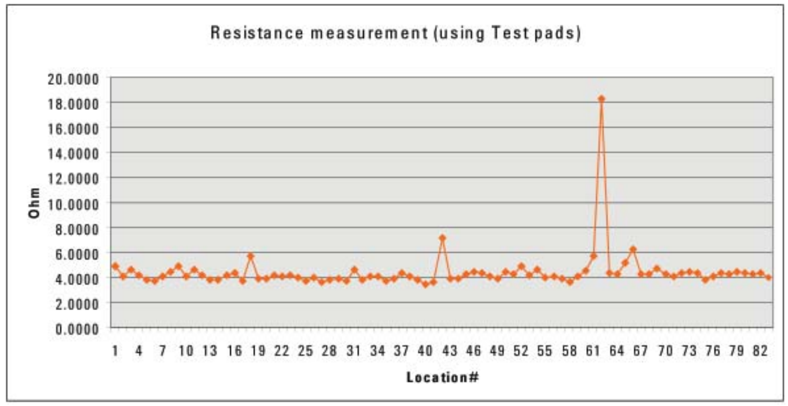

Figure 7 : Measurement of internal IC resistance using testpads as test access

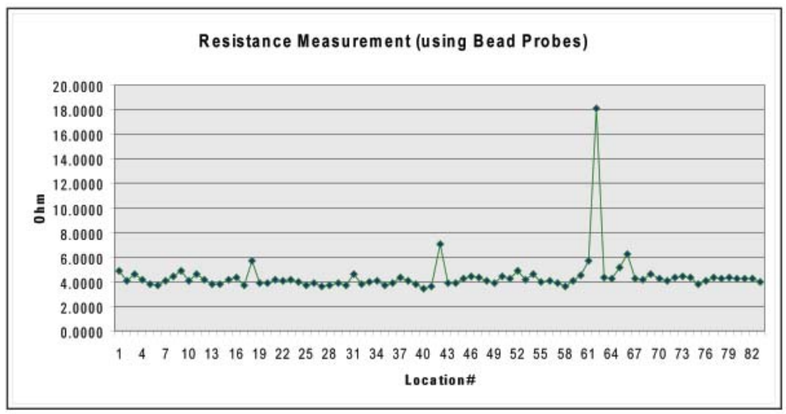

Figure 8 : Measurement of internal IC resistance using bead probes as test access

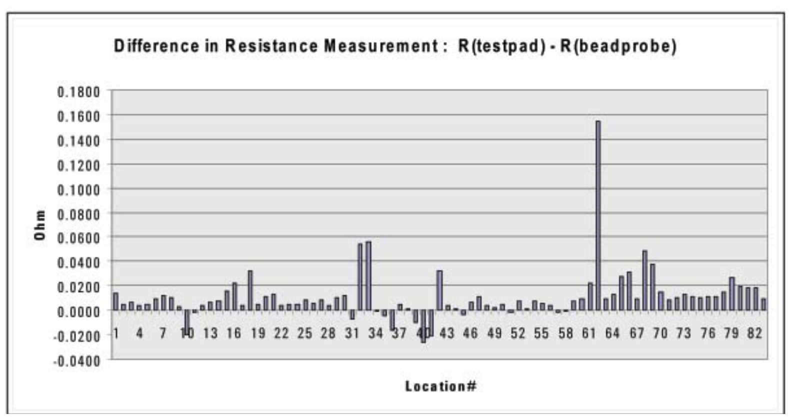

Figure 9 : Measurement

Appendix

Location #	Readings from regular TestPads, RTP (ohm)	Readings from Bead Probes, RBP (ohm)	Difference (RTP - RBP) (ohm)
1	4.9197	4.9061	0.0136
2	4.0370	4.0324	0.0046
3	4.6540	4.6475	0.0065
4	4.1958	4.1916	0.0042
5	3.8140	3.8093	0.0047
6	3.7350	3.7257	0.0093
7	4.0630	4.0510	0.0120
8	4.4502	4.4402	0.0100
9	4.8893	4.8867	0.0026
10	4.0734	4.0934	-0.0200
11	4.5842	4.5858	-0.0016
12	4.1357	4.1320	0.0037
13	3.7651	3.7581	0.0070
14	3.7780	3.7709	0.0071
15	4.1685	4.1528	0.0157
16	4.3671	4.3447	0.0224
17	3.7028	3.6990	0.0038
18	5.7165	5.6840	0.0325
19	3.8709	3.8665	0.0044
20	3.8783	3.8668	0.0115
21	4.1700	4.1572	0.0128
22	4.0328	4.0289	0.0039
23	4.1277	4.1226	0.0051
24	3.9615	3.9569	0.0046
25	3.7352	3.7264	0.0088
26	3.9387	3.9335	0.0052
27	3.6327	3.6239	0.0088
28	3.7561	3.7522	0.0039
29	3.8671	3.8572	0.0099
30	3.7258	3.7140	0.0118
31	4.6308	4.6376	-0.0068
32	3.8161	3.7618	0.0543
33	4.0359	3.9800	0.0559
34	4.0457	4.0461	-0.0004
35	3.7094	3.7138	-0.0044
36	3.8985	3.9147	-0.0162
37	4.3790	4.3747	0.0043
38	4.0544	4.0536	0.0008
39	3.8164	3.8259	-0.0095
40	3.4164	3.4428	-0.0264
41	3.5897	3.6108	-0.0211
42	7.1208	7.0891	0.0317

Location #	Readings from regular TestPads, RTP (ohm)	Readings from Bead Probes, RBP (ohm)	Difference (RTP - RBP) (ohm)
43		3.9219	3.9184 0.0035
44	3.9223	3.9216	0.0007
45	4.2142	4.2180	-0.0038
46	4.4531	4.4468	0.0063
47	4.3437	4.3325	0.0112
48	4.0643	4.0603	0.0040
49	3.8524	3.8505	0.0019
50	4.4767	4.4717	0.0050
51	4.2562	4.2577	-0.0015
52	4.9318	4.9243	0.0075
53	4.1459	4.1449	0.0010
54	4.5989	4.5911	0.0078
55	3.9702	3.9646	0.0056
56	4.1004	4.0965	0.0039
57	3.8831	3.8844	-0.0013
58	3.6230	3.6239	-0.0009
59	4.0861	4.0789	0.0072
60	4.5062	4.4967	0.0095
61	5.6821	5.6596	0.0225
62	18.2500	18.0960	0.1540
63	4.3232	4.3139	0.0093
64	4.2885	4.2756	0.0129
65	5.1957	5.1683	0.0274
66	6.2426	6.2114	0.0312
67	4.2424	4.2334	0.0090
68	4.2392	4.1907	0.0485
69	4.6668	4.6293	0.0375
70	4.2297	4.2146	0.0151
71	4.1109	4.1029	0.0080
72	4.3614	4.3514	0.0100
73	4.4710	4.4581	0.0129
74	4.3709	4.3595	0.0114
75	3.8100	3.7995	0.0105
76	4.0410	4.0300	0.0110
77	4.3863	4.3755	0.0108
78	4.2605	4.2454	0.0151
79	4.4070	4.3803	0.0267
80	4.3089	4.2894	0.0195
81	4.2926	4.2741	0.0185
82	4.3157	4.2971	0.0186
83	4.0199	4.0106	0.0093

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Revised: October 6, 2008

Printed in USA, October 31, 2008
5989-9918EN

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