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White Paper

A Change in Paradigm: Maximum Tin Whisker Lengths Just Got Longer

Gerd Fischer, PhD, and Bob Esser, PhD

5110 Roanoke Place, Suite 101 College Park, Maryland 20740
Phone (301) 474-0607 Fax (240) 757-0053
www.DfRSolutions.com

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A DfR client recently reported failures at customer sites approximately 2 to 6 months after the product was released into the field. The device is a high reliability product and therefore the first two failures were immediately identified by the customer and returned to the equipment manufacturer. Since the initial events, additional failures have occurred and the equipment manufacturer is considering what actions may be necessary.

Analysis

Initial troubleshooting identified a potential shorting condition as the failure mode. Locating electrical shorts can be extremely problematic, but a through examination of the product identified anomalies emanating from a flexible film connector (FFC) contact receptacle. Closer inspection using a higher magnification stereoscope identified tin whiskers growing from the surface of the tin plating and bridging the distance between two receptacles. An example is shown in Figure 1. Follow-up analysis using scanning electron microscopy (SEM) and energy dispersive spectroscopy (EDS) confirmed these findings. An example of these results is shown in Figure 2.

This tin whisker event is of particular concern to DfR Solutions because this contact receptacle used a mitigated tin plating. As seen in Figure 3, cross-sections identified 67 microinches (1.5 microns) of nickel underplate. This is below the latest recommendations from iNEMI (Smetana, Global SMT, June 2007) and the requirements of ATIS (PP-0600009.2007), but is in the range of standard practice within the industry (1 to 1.5 microns) and is well above the minimum requirements specified by JEDEC JP-002 (0.5 microns). In addition, the manufacturer indicated the tin plating was of the matte variety.

There are no other obvious accelerants within the manufacturing or use environments. The whiskers, as seen in Figure 2, are emanating from the punched surface, not the bent knee, so the influence of compressive stresses would seem to be ruled out. The punching operation required to form the half-circle was performed before the plating operation. The manufacturing of the assembly was performed at an international contract manufacturer and the use environment of the product in question is relatively bengin (controlled temperature and humidity in most applications, no adjacent heat sources, limited vibration or shock).

It is especially concerning that the short-term length of these whiskers seems to exceed the 0 ppm failure rate proscribed by Hilty of Tyco Monte Carlo simulation (IPC/JEDEC Lead-Free Symposium, April 2005)(see Figure 4), which is one of the drivers for the current RoHS exemption for fine-pitch components. In addition, given the relatively short time period between production and failure, there is a strong indication that these whiskers could have grown longer, possibly 500 microns or longer, with sufficient time.

Field Experience: Tin Whiskers

Is this failure unique or is part of an increasing trend? DfR Solutions has increasingly been the organization selected to assist with tin whisker issues across the electronics industry. As a focal point, we have been able to review a number of tin whisker induced failures (see Figure 5) and have begun to identify a concerning trend. Within our purview, connectors seem to be the location of the majority of failures that have occurred in the field.

Given these observations, DfR has recently modified its guidance on tin whisker mitigation.

Tin Whisker Mitigation

Current, DfR advises companies that mitigation of components with lead spacings greater than 500 microns may not be necessary if the plating is matte tin and the manufacturer demonstrates some evidence of control (either through process control or periodic testing). Leads with welding operations or pressure contacts do not fall under that recommendation.

DfR is now modifying our approach and we now recommend that NO tin-plated connectors be used unless physical barriers are present between leads/pins or the spacing between leads is at least 1000 to 2000 microns (driven by degree of risk aversion).

If you or your associates require any additional advice, testing, or analysis of this critical issue, please feel free to contact the authors of this white paper.

John McNulty, jmcnulty@dfrsolutions.com
Gerd Fischer, gfischer@dfrsolutions.com
Bob Esser, besser@dfrsolutions.com

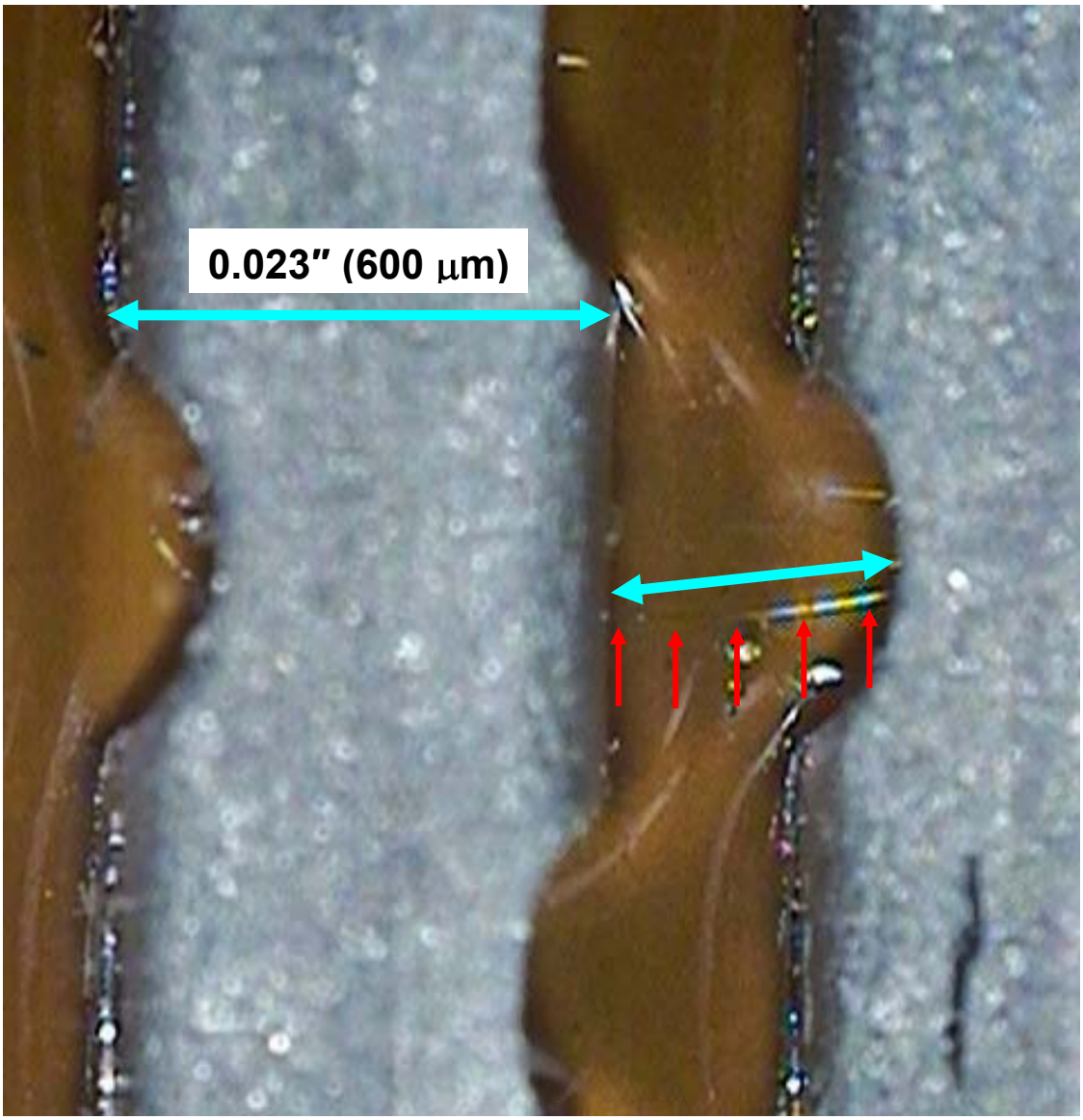

Figure 1: Stereoscopic image of tin whisker bridging two FFC contact receptacles. The red arrows mark the tin whisker. Total whisker length is 350 to 375 microns.

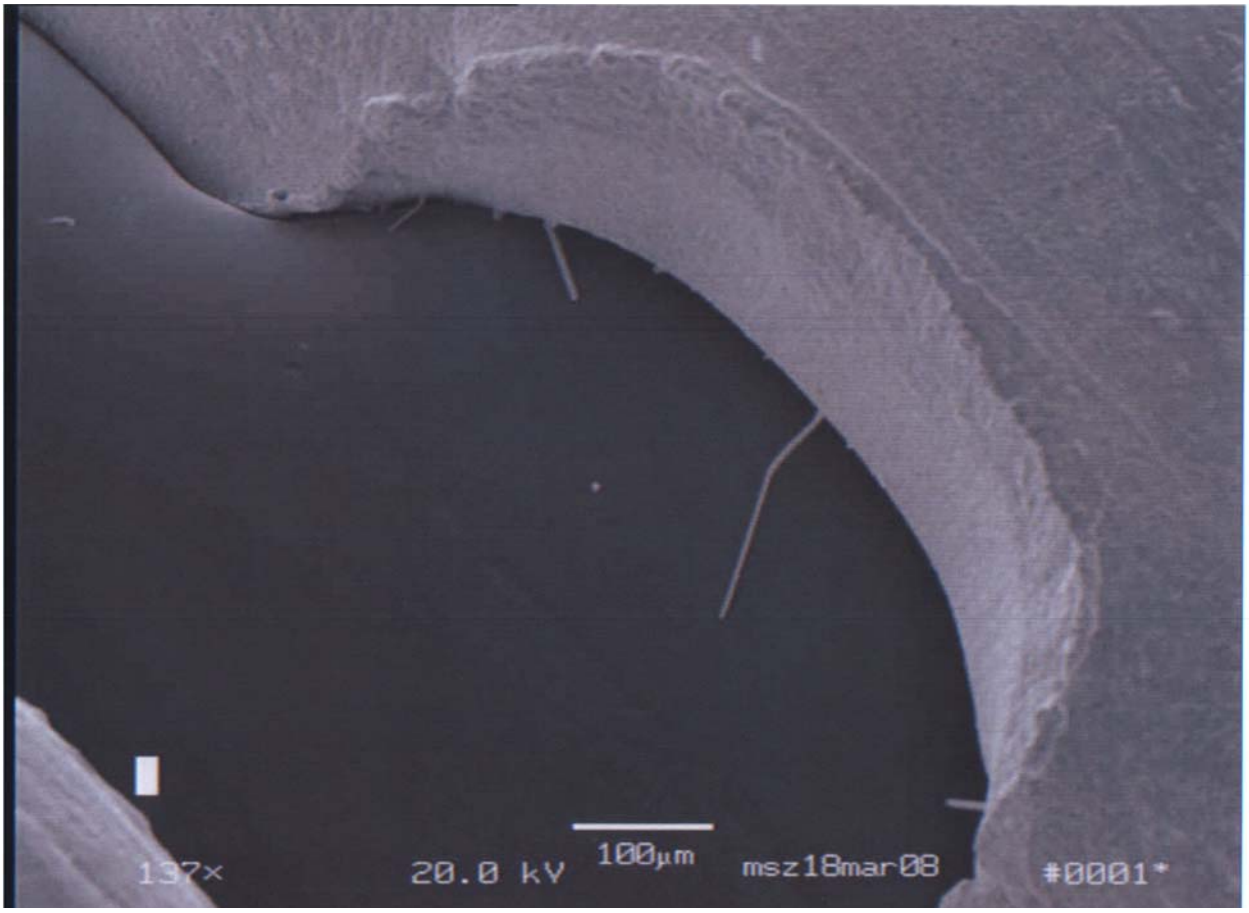

Figure 2: Electron micrograph of tin whisker emanating from the surface of a tin-plated FFC contact receptacle. Maximum distance between the two receptacles is approximately 375 to 400 microns.

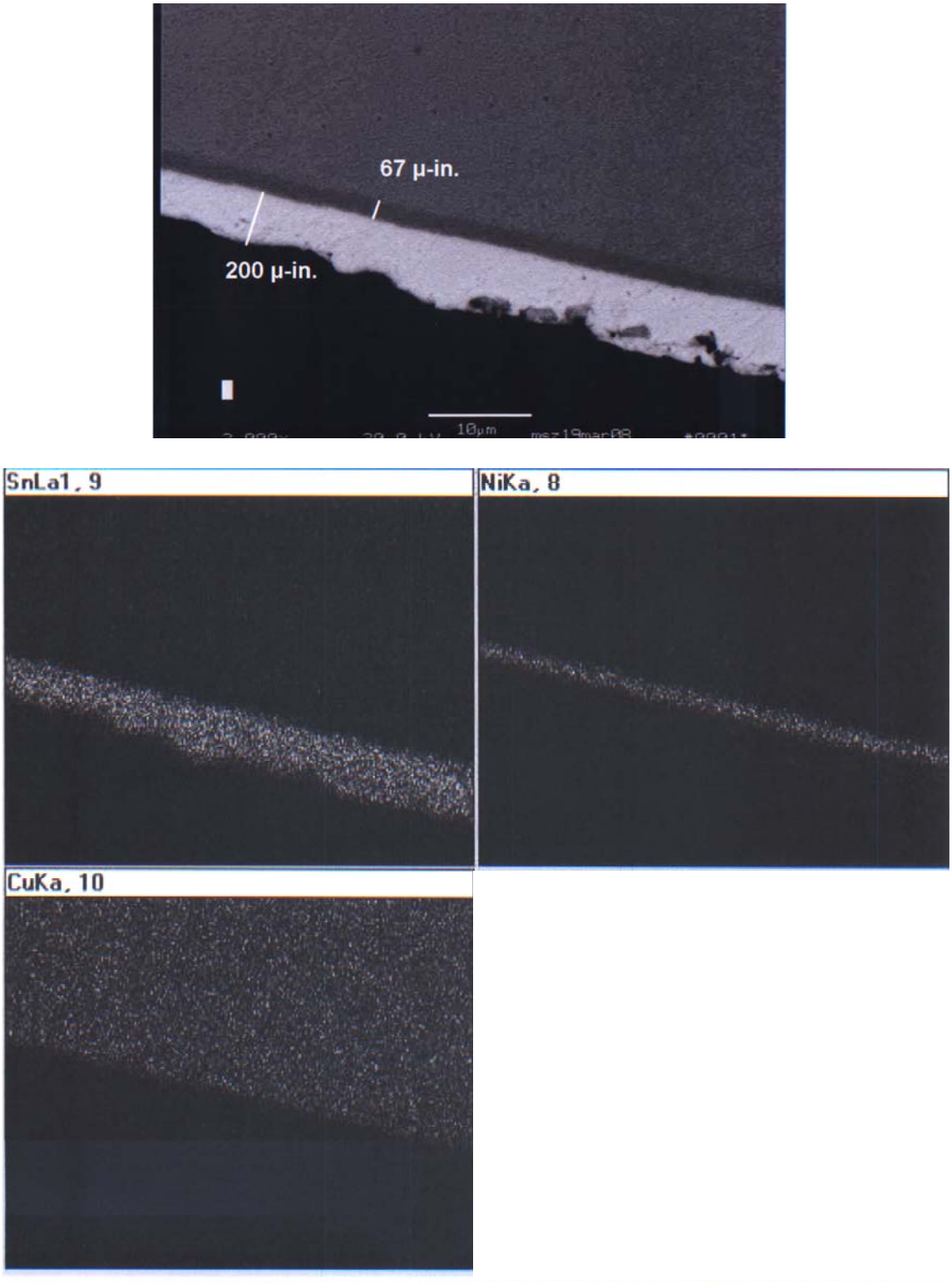

Figure 3: Electron micrographs and elemental maps of cross-sectioned plated surface

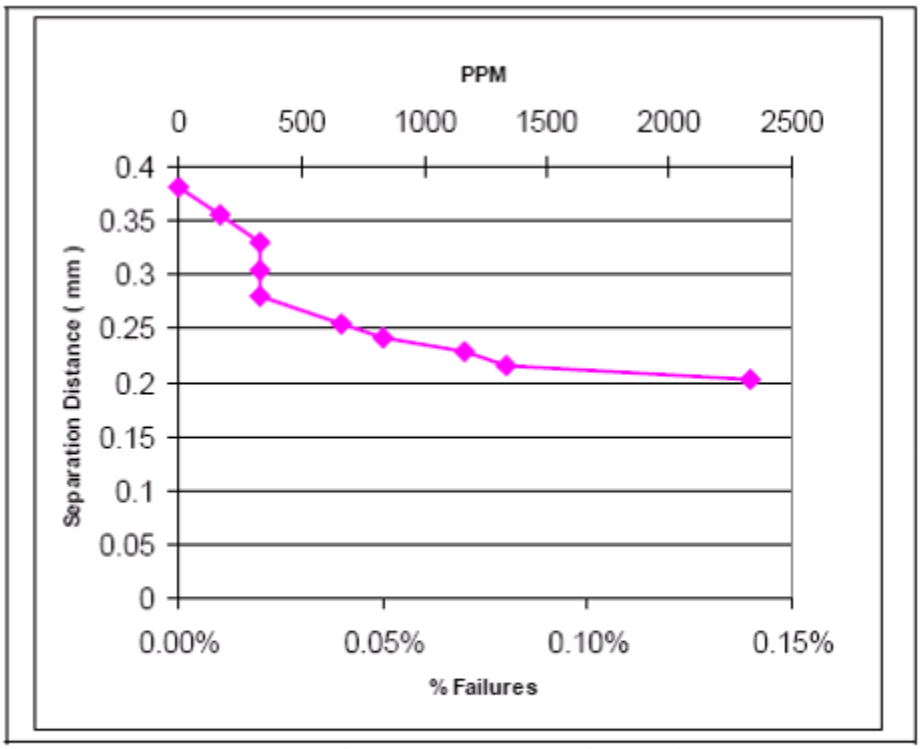

Figure 9. Simulated failure rate chart for whisker mitigated tin showing greater resolution at low defect levels. A separation distance of about 380 µm is required to get to 0ppm failure rates.

Figure 4: Probability of failure as a function of separation distance based on Monte Carlo simulation (Hilty, 2005)

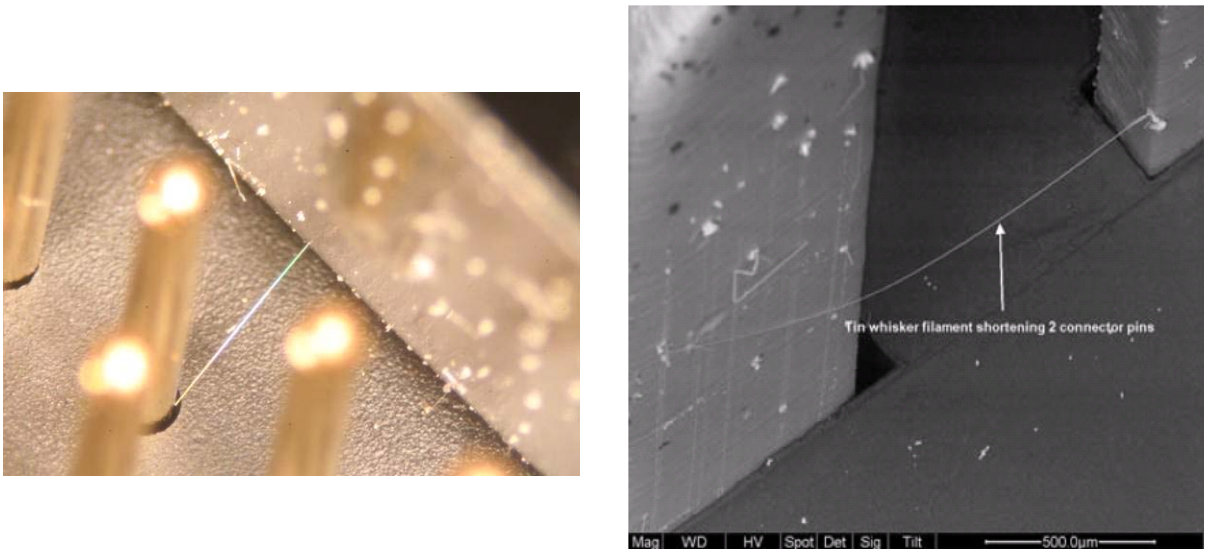

Figure 5: Images of tin whiskers that induced field failures in DfR clients

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