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iNEMI High-Reliability Task Force
Position Statement on RoHS5 & RoHS6 Subassembly Modules

Background

The RoHS Directive, which goes into effect on July 1, 2006, bans or severely limits the use of six materials in "electronic and electrical equipment," and lead (Pb) is one of those materials. However, the directive provides for exemptions for Pb-containing solders used in certain high-reliability electronics, such as telecom network infrastructure products. Other high-reliability applications, such as automotive electronics, are not covered by RoHS.

OEMs whose products qualify for the Pb exemptions (and who choose to take advantage of those exemptions) will be producing products that, while not Pb-free[1], are nonetheless RoHS-compliant. These manufacturers will continue to require SnPb-compatible components for exempted products. They may also choose to accept subassemblies, such as hard disk drives and power modules, that are RoHS-compliant, but may or may not be Pb-free.

For purposes of this document, we will use the following definitions:

Subassembly module: Any electronic assembly consisting of components (mechanical and/or electrical) that is preassembled with solder alloys, with the purpose of being attached or connected to another soldered assembly at a later time (see Figure 1).

RoHS5 modules (5 of 6 materials): Subassembly modules or products that are RoHS-compliant, but contain Pb (under an applicable RoHS exemption). For example, these products may be soldered with SnPb, and may include soldered component finishes that include Pb.

RoHS6 modules (6 of 6 materials): Subassembly modules or products that are soldered with Pb-free solder and are fully RoHS-compliant (including being Pb-free).

There is confusion and inconsistency relative to the acceptance of RoHS5 or RoHS6 compliant components. This issue is further complicated when components are included inside subassemblies such as power modules, SFP optical receivers, etc.

The iNEMI High-Reliability Task Force has developed this position paper to provide guidelines to both users and suppliers regarding the assembly process and reliability requirements for RoHS5 and RoHS6 components, with specific emphasis on subassemblies. This paper will not address RoHS requirements for individual components, i.e. discretes, ICs, etc. as these are already addressed in other documents.

It is our position that, if RoHS6 subassemblies are to be used in RoHS5 products, the RoHS6 subassemblies should be thoroughly qualified to ensure that they will meet the higher reliability requirements of the RoHS5 product. The following recommendations are made to assist suppliers of subassembly modules in meeting the needs of the high-reliability community.

[1] For purposes of this paper, "Pb-free" (or "lead-free") does **not** mean that no lead is present, but rather it means that the concentration level of lead in a homogeneous material is less than 1000 ppm by weight.

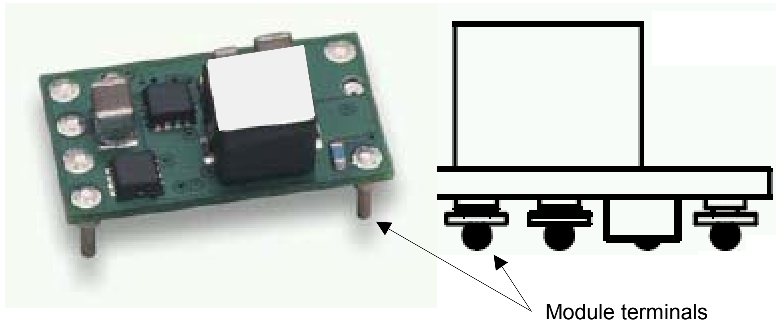

Figure 1. Examples of subassembly modules.

Recommendations:

For all components used internal to RoHS5 or RoHS6 subassemblies

1) BGAs should be compatible with the assembly process. Specifically, for SnPb assembly process, only BGAs with SnPb solder balls are generally considered acceptable. Similarly for Pb-free SnAgCu (SAC) assembly, only BGAs with SAC solder balls are generally considered acceptable. Mixing SnPb solder balls with SAC alloy solder or SAC solder balls with SnPb solder is generally not acceptable, based on today's knowledge of process robustness and reliability impact.

2) Pb-free Sn finishes on leaded and discrete components should only be used when these finishes include suitable tin whisker mitigation practices (see IPC/JEDEC JP002) and have passed Class 2 level tin whisker acceptance testing requirements, as outlined in JEDEC standard JESD-201. (Class 2 includes business critical applications such as telecom infrastructure equipment, high-end servers, automotive, etc.) Subassembly suppliers should also require this level of testing from their component suppliers, and we recommend that they maintain an auditable process to ensure compliance with this requirement. See IPC/JEDEC JP002 and the iNEMI Tin Whisker User Group's "Recommendations on Lead-Free Finishes for Components Used in High-Reliability Products" (v3, updated May 2005) for guidance on specific finishes relative to tin whiskers. The iNEMI recommendations are available online at:(http://thor.inemi.org/webdownload/projects/ese/tin_whiskers/User_Group_mitigation_May05.pdf)

3) SnBi finishes may be unacceptable on Alloy 42 leadframe components, depending on the application. SnBi with concentrations of Bi above 4% are not preferred when soldered with SnPb (see IPC/JEDEC JP002). Suppliers should work with their customers to determine acceptability for specific applications.

For subassembly modules meeting RoHS5 or RoHS6 requirements

Plated leads or pins (the module terminals) that will be attached to the printed circuit assembly should be backward compatible with SnPb assembly processes.

1) SnBi finishes may be unacceptable on Alloy 42 leadframe components, depending on the application. SnBi with concentrations of Bi above 4% are not preferred when soldered with SnPb (see IPC/JEDEC JP002). Suppliers should work with their customers to determine acceptability for specific applications.

2) If the plated leads or pins used on the module terminal are Pb-free Sn finishes, the supplier should use a suitable tin whisker mitigation practice (see IPC/JEDEC JP002) and provide data demonstrating compliance with the Class 2 level tin whisker acceptance testing requirements of JEDEC standard JESD-201 or the iNEMI Tin Whisker Acceptance Test Requirements (http://thor.inemi.org/webdownload/projects/ese/tin_whiskers/Tin_Whisker_Accept_paper.pdf) . See IPC/JEDEC JP002 and the iNEMI Tin Whisker User Position Statement for guidance on specific finishes relative to tin whiskers.

3) The MSL rating of the module (per IPC/JEDEC J-STD-020) should be based on the worst case MSL rated component used in the module. MSL rating should be provided for SnPb and SAC assembly if applicable to the module. Additionally, the module should meet the temperature requirements of IPC/JEDEC J-STD-020 (revision C or later) for the appropriate SnPb and/or SAC assembly process.

4) Suppliers should understand the solder hierarchy of their modules and consider the implications of potential multiple reflows of components.

For RoHS6 Subassembly Modules

These subassemblies are RoHS6 modules with Pb-free module terminals, and the subassembly of the module is built with Pb-free solder and processes.

1) PWBs internal to the module should be manufactured using materials compatible with high-temperature Pb-free soldering. For modules that go through an additional reflow step, these may include non-dicy Phenolic based FR4 materials, ceramics and other high temperature materials. Dicy[2] cured FR4 designed for use with SnPb assembly is generally not acceptable for high layer count boards assembled with Pb-free solder.

2) PWB surface finishes also need to be compatible with the Pb-free solder alloy and higher temperature reflow soldering process used.

3) All components used internal to the module and the module itself should meet the temperature and MSL requirements of J-STD-020 (revision C or later). Although J-STD-020 only applies directly to plastic encapsulated packages, the temperature and moisture sensitivity levels of this specification accurately reflect the component thermal durability requirements demanded by Pb-free soldering processes.

4) High-reliability products typically require very long field lifetimes, typically ranging from 10 to 25 years with very low failure rates. There are still some unknown factors relative to SAC solder joint reliability which the industry needs to work together on in order to gain a comprehensive understanding of their impact. These factors include, but are not limited to, Kirkendall voiding[3], lack of generally accepted SAC acceleration factors relating thermal cycle reliability tests to field conditions, pad crater cracks, and solder cracking through microvoids. Examples of some of these issues are shown in Figures 2-4. Suppliers should consider increasing their qualification testing and analysis to reduce the risk of these concerns on their Pb-free subassemblies. Examples of this would include comparative testing directly against

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[2] Dicy = Dicyandiamide, also called cyanoguanidine, is used in the production of wide range of organic chemicals including epoxy laminates for circuit boards.

[3] The voiding issue identified here has not been conclusively attributed to the Kirkendall effect. However, at this time, this is the term typically used to describe these voids, and is how they are referred to in this document. The key feature of these voids is that they occur within or below the Cu_3Sn intermetallic layer in the base metal, not in the SAC solder joint.

SnPb control samples, aging components 1000 hours at 125°C prior to other thermal cycle or drop/shock testing, and cross-sectioning of solder joints after aging.

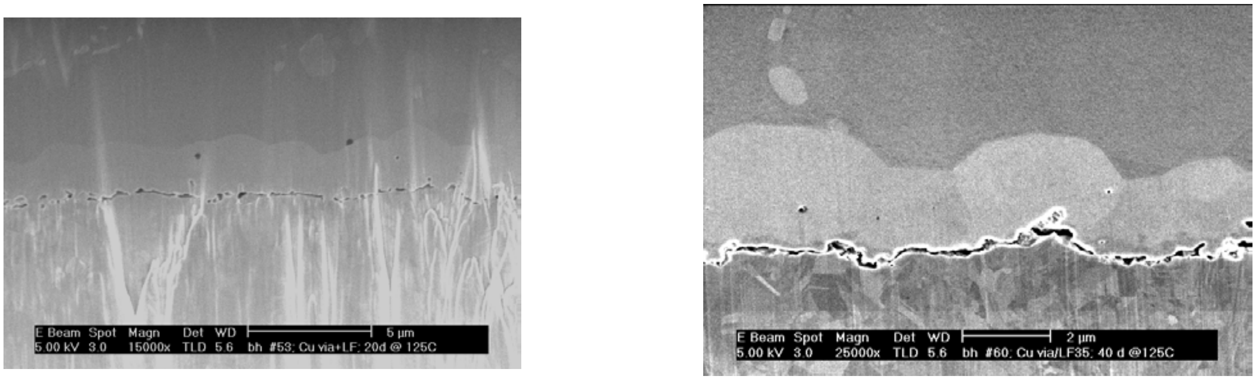

Figure 2. Example of Kirkendall Voiding at Cu to Cu_3Sn / Cu_6Sn_5 Interface: Left, after 20 days at 125°C. Right, after 40 days @125°C. (Source: Texas Instruments)

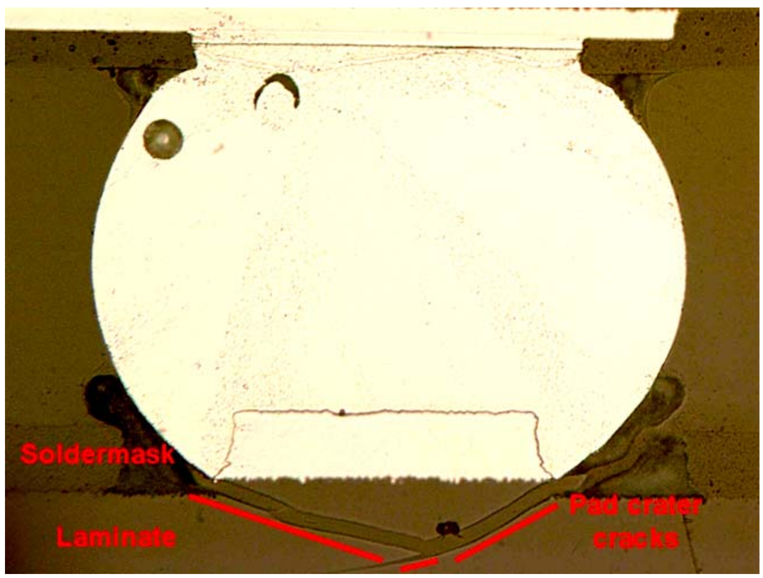

Figure 3. Example of Pad Crater Cracks

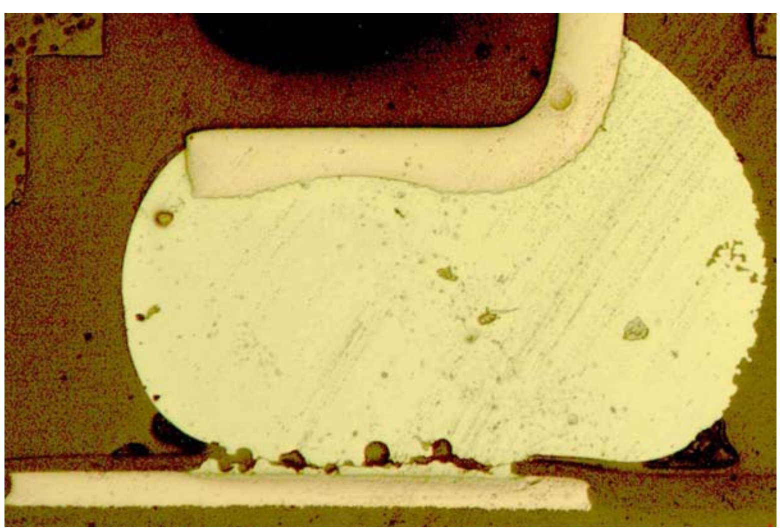

Figure 4. Example of Solder Cracking through Microvoids

iNEMI Hi-Reliability Task Force

The following companies support the conclusions of this document:

Agilent Technologies, Inc.
Alcatel
Cisco Systems, Inc.
Celestica, Inc.
Delphi Electronics & Safety
Hewlett-Packard Company
Intel Corporation
Jabil Circuit, Inc.
Lucent Technologies
Plexus Corp.
Sanmina-SCI Corporation
Sun Microsystems, Inc.

About the iNEMI High-Reliability Task Force

The iNEMI High-Reliability Task Force consists of electronic product manufacturers (OEMs and EMS providers) whose products are characterized by long service life and high-reliability requirements. For companies in these high-reliability markets, maintaining high product reliability is absolutely critical to company survival. Moreover, long-term field reliability data and thermal fatigue acceleration models for SAC-soldered assemblies are not yet adequate to support the design and verification of complex Pb-free assemblies. Thus there is a complete commitment to protect hard-fought reputations for helping customers achieve high-availability solutions.

REFERENCES

JESD201, "Environmental Acceptance Requirements for Tin Whisker Susceptibility of Tin and Tin Alloy Surface Finishes" http://www.jedec.org/DOWNLOAD/search/JESD201.pdf

JP002, "Current Tin Whiskers Theory and Mitigation Practices Guideline" http://www.jedec.org/DOWNLOAD/search/JP002.pdf

iNEMI's "Recommendations on Lead-Free Finishes for Components Used in High-Reliability Products" (v3, updated May 2005) (http://thor.inemi.org/webdownload/projects/ese/tin_whiskers/User_Group_mitigation_May05.pdf)

iNEMI Tin Whisker Acceptance Test Requirements (iNEMI Tin Whisker User Group, July 28, 2004) (http://thor.inemi.org/webdownload/projects/ese/tin_whiskers/Tin_Whisker_Accept_paper.pdf