

## **Recommendations to Electronics Industry Component Supply Base iNEMI High-Reliability RoHS Task Force August 19, 2005**

As the deadline for the European Union's Restriction of Hazardous Substances (RoHS) Directive grows nearer, the electronics industry is working toward eliminating lead (Pb) used in its processes, components and materials. However, this conversion is causing concern among many manufacturers, especially those companies producing high-reliability, long-service-life products. Many of the changes being made within the supply chain are driven by high-volume, low-cost applications, which do not have stringent reliability requirements. In particular, there are two critical areas where requirements need to be addressed by manufacturers and their suppliers. These are:

- Continued availability of tin-lead (SnPb)-compatible components for exempted products, especially ball grid array (BGA) components.
- Use of mitigation practices to minimize formation of tin whiskers and verification of effectiveness through testing.

The iNEMI High-Reliability (Hi-Rel) 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. The group is also committed to working with the appropriate standards bodies to ensure that formal standards support evolving manufacturing needs. The Task Force has developed the following recommendations to address these areas of concern.

### **BGA Components**

Certain products are currently exempt under EU RoHS and will be allowed continued use of lead (Pb) in solder for reliability purposes. These products include servers, storage and storage array systems, plus network infrastructure equipment for switching, signaling and transmission as well as network management for telecommunication. In addition, the EU Directive states that exemptions "should be permitted if substitution is not possible from the scientific and technical point of view or if the negative environmental or health impacts caused by substitution are likely to outweigh the human and environmental benefits of the substitution."

As a result of these exemptions, many manufacturers will continue to need SnPb-compatible components. In particular, the high-reliability electronic equipment producer community and its

supporting EMS providers will require a continued supply of SnPb solder ball BGA components in addition to SAC solder ball BGA components. This critical supply-chain requirement specifically includes high-volume commercial BGA technologies, such as DDR2/DDR3 and RDRAM memory, logic chip sets, and microprocessors, as well as other lower-volume BGA components.

This need will exist for the duration of the Pb-solder exemption for server, storage, and telecommunication infrastructure applications; any exemption changes are not expected to be implemented for another two to three years after the stated review dates. In addition, high-reliability equipment producers supporting the aerospace, military, medical, and monitoring and control equipment industries, which are also exempt or “out of scope” under RoHS, have strong reasons for maintaining the use of SnPb assembly. Furthermore, SnPb ball BGAs will be required for the service life of products assembled with SnPb (i.e., to allow for ongoing repair). Industry experience has shown that the attachment of tin-silver-copper (SnAgCu or SAC) BGA components using SnPb eutectic solder produces solder interconnects that are prone to variable quality and reliability. These results are based on observations across a broad range of components, assembly temperatures and use conditions. These interconnects are also considerably more sensitive to fundamental process parameters, such as reflow temperature profile and solder paste volume.

In summary, the high-reliability electronic equipment producer community requires a continued supply of SnPb ball BGA components for use in exempt SnPb circuit board assemblies to maintain the high level of product quality and reliability demanded by their customers. The primary motivation for the Pb solder exemption within the EU RoHS Directive is to minimize the technical risk of compliance in high-reliability applications. iNEMI and its members recognize this legitimate and critical industry need and urge the component supplier community to support SnPb ball BGA interconnects until the quality and reliability issues of SAC ball BGAs and SAC circuit board assemblies are resolved.

### **Tin Whisker Mitigation & Testing**

Unalloyed tin electroplating has a long history of whisker formation and growth that has resulted in reliability problems for various types of electronic equipment. The predominant whisker mitigation strategy for more than 50 years has been the addition of Pb to the tin plating. The EU RoHS Directive requirement to eliminate Pb in electronic products has led many component suppliers to propose the removal of Pb from SnPb plating, leaving essentially pure tin. This approach is the most convenient and least costly strategy for the majority of component manufacturers to meet the EU RoHS Directive requirements. However, especially for the high-reliability user community, the pure tin strategy presents reliability risks due to the whisker-forming tendencies of pure tin and tin alloy plating.

There is currently no complete understanding of whisker formation and growth fundamentals. Nor is there a standard set of tests that can accelerate whisker formation and growth with any

reasonable degree of certainty and correlate results directly to use environment and service conditions. This lack of standards for tin whisker mitigation and acceptance testing is creating problems in the industry. Suppliers have no choice but to push forward with lead-free solutions. However, end-user requirements for plating types, tin-whisker mitigation practices and tin-whisker qualification testing vary greatly.

The iNEMI High Reliability (Hi-Rel) Task Force members rely upon components with SnPb termination finishes to provide predictable, reliable, and reproducible soldered connections. These companies have invoked the European Union's Pb-in-solder exemption (allowing the continuing use of SnPb solder) to ensure high product reliability until better data is available to provide confidence in the evolving Pb-free solder alternatives. However, this strategy has been compromised by the supply chain's rapid replacement of SnPb finishes of known reliability and performance with either pure tin or tin alloys, which have a higher risk factor for whisker reliability problems such as short circuits.

The market dynamics driving the transition to Pb-free solders and finishes are both complex and costly, with two different sets of customer demand. One set is from the consumer electronics market, which needs inexpensive Pb-free termination finishes without the same level of high-reliability requirements; the other is from the smaller high-reliability market. Economic realities are driving most component suppliers to offer Sn and/or high Sn content (>95%) Pb-free finishes, and the availability of multiple surface finishes will not be a long-term option in most cases. There is, therefore, the need to reach an accord that will support the requirements of both the high-reliability and consumer electronics segments by ensuring that suppliers will provide the least whisker-prone finishes possible.

The iNEMI Hi-Rel Task Force supports the position that Sn and/or high Sn content (>95%) Pb-free finishes must employ whisker-mitigation practices such as Ni underlay or annealing to improve whisker mitigation for high-reliability applications as described in the iNEMI User Group documentation.

[http://thor.inemi.org/webdownload/projects/ese/tin\\_whiskers/User\\_Group\\_mitigation\\_May05.pdf](http://thor.inemi.org/webdownload/projects/ese/tin_whiskers/User_Group_mitigation_May05.pdf)

The Task Force also fully supports the position that, since these mitigation techniques may vary significantly in effectiveness, depending upon their particular implementation, supporting measurements (i.e., testing) are necessary to provide objective evidence of mitigation efficacy.

In order to minimize the risk of tin whiskers in high-reliability products, the companies of the iNEMI Hi-Rel Task Force will require electronic component suppliers to implement the following recommendations for high reliability applications:

1. Adopt one of the iNEMI-recognized whisker mitigation practices as an integral part of Sn and/or high Sn content (>95%) Pb-free plating processes.

[http://thor.inemi.org/webdownload/projects/ese/tin\\_whiskers/User\\_Group\\_mitigation\\_May05.pdf](http://thor.inemi.org/webdownload/projects/ese/tin_whiskers/User_Group_mitigation_May05.pdf)

2. Perform testing and adhere to the qualification criteria of either of these protocols:
  - a. iNEMI Tin Whisker Acceptance Test Requirements (latest version is July 28, 2004; note: Reference 3.2 in this document has been modified so that JESD22-A-121 supersedes the iNEMI document "Tin Whisker Growth Tests, September 2003.").  
[http://thor.inemi.org/webdownload/projects/ese/tin\\_whiskers/Tin\\_Whisker\\_Accept\\_paper.pdf](http://thor.inemi.org/webdownload/projects/ese/tin_whiskers/Tin_Whisker_Accept_paper.pdf)
  - b. Final agreement of the JEDEC tin-whisker acceptance ballot (JESD-201A) qualification criteria in conjunction with the JESD22-A-121 test method. (Although there continues to be controversy over whisker measurement protocols and acceptance criteria, the Task Force believes that the protocol developed by iNEMI, and supported by JEDEC in its JESD22-A-121 test method, is the best means available at this time for demonstrating the whisker-formation propensity for any given Sn and/or high Sn content (>95%) Pb-free finish.).
3. Continue to provide an alternative non-whiskering finish, such as SnPb or NiPdAu, until the requirements of the iNEMI/JEDEC acceptance tests have been met.

The following companies support the concepts as stated above.

### **Members of the iNEMI High-Reliability RoHS Task Force**

Agilent Technologies, Inc.  
Alcatel  
Andrew Corporation  
Cisco Systems, Inc.  
Celestica, Inc.  
Delphi Electronics & Safety  
Hewlett Packard Company  
IBM Corporation

Intel Corporation  
Jabil Circuit, Inc.  
Lucent Technologies  
Plexus Corp.  
Sanmina-SCI Corporation  
Solectron Corporation  
Sun Microsystems, Inc.