IPC SOLDER PRODUCTS VALUE COUNCIL

ASSOCIATION CONNECTING ELECTRONICS INDUSTRIES®

Round Robin Testing and Analysis of Lead Free Solder Pastes with Alloys of Tin, Silver and Copper

Final Report

A Research Report by the Lead Free Technical Subcommittee

IPC SOLDER PRODUCTS VALUE COUNCIL

IPC Solder Products Value Council Mission Statement

In support of IPC's mission statement, IPC solder manufacturers recognize that the PCB and electronics assembly industries, comprised of the entire supply chain, must grow profitably. The IPC Solder Products Value Council (SPVC) Steering Committee's objective is to identify and execute programs designed to enhance the competitive position of solder manufacturers and their customers.

Acknowledgement

It is estimated that nearly $1 million has been spent to conduct this round robin lead free testing program. Each and all members of the IPC SPVC contributed not only funds but a significant amount of staff time in support of this program. However, like any program of this magnitude, the following companies and individuals have contributed to the program's success. The Council wishes to thank George Wenger and Pat Solan, Andrew Corporation; Engent AAT; Jasbir Bath, Solectron Corporation; Dongkai Shangguan, Flextronics International; Hallmark Circuits; Jean-Paul Clech; and Dean May, Crane Division-Naval Surface Warfare Center.

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Executive Summary

As was previously mentioned, the IPC SPVC Lead Free Technical Subcommittee chose, because of its widespread use, the tin, silver, copper family of lead free alloys. The Council assumed that although the high content silver alloys (3.8 % silver or greater) were being promoted as an alloy of choice, it appeared that the lower silver (96.5/3.0/0.5 Tin/Silver/Copper commonly called SAC 305) lead free alloy would perform equally as well at lower cost.

Standard tin lead eutectic solder (SnPb) solder, as a part of this study, was used as a control. However, the members of the technical committee did not intend for the test program to be a head to head comparison between lead free and SnPb solder but an analysis of the tin/silver/copper (SAC) alloy family.

The committee, working with the appropriate company or organization, then chose the testing protocol and reviewed each step of the testing program. The results of each phase of the six-phase test program can be summarized as follows:

- **Assembly performance screening to compare alloys:** *No statistically significant difference* was found in alloy performance when data from participating locations was compared. Experimentally the alloy properties of melt temperature (DSC), time to reach zero and maximum force in wetting balance testing and solder spread as determined by area and diameter were found to not be statistically different. In some cases, a specific location found differences but when the data was averaged between locations for the same alloy, no statistical difference could be found.
- **Down selection of the solder pastes for assembly:** *No difference* was found between alloys for the pastes tested for assembly performance.
- **Assembly of test vehicles using SAC alloys with SnPb eutectic solder as a control:** *No difference* was found in process ability or defect rate between the alloys as assembled at two separate test locations using two separate test vehicles. Although the materials' performance was distinguishable from SnPb eutectic solder, there was no difference between the lead free SAC alloys studied.
- B**aseline metallographic analysis of the assembled test vehicles:** *No metallurgical difference* was found between the SAC alloys after assembly and before thermal cycling.
- **Thermal cycling testing:** *All three SAC alloys showed similar failure rates for similar packages.* These rates were distinguishable from the behavior of SnPb solder but were not distinguishable from one another. When the data collected in this study was compared to data collected in previous studies using the NEMI 95.5/3.9/0.6 SAC alloy, the results of the different studies were not distinguishable by alloy.
- **Metallographic analysis as a function of thermal cycling:** Metallographic analysis was performed at every 500 thermal cycles. Results showed *there was no significant difference between SAC alloy structures* with thermal cycling.

Not only does the report contain all the research generated from the testing program but the authors of this report have also included a "Lessons Learned" Chapter. These lessons include information on component types, the solder joint and thermal testing.

The Council is quite proud of the work it has accomplished. As a result, and perhaps unlike other organizations, all the data tables collected from the research are contained in the report.

A key by-product of this testing program was the data gathered on the much debated issue of solder joint voiding. Based on comparison of number and size of solder joint voids to thermal cycle interconnection failure data, there is no evidence that solder joint voiding has any significant impact on solder joint reliability.

In conclusion, based on the results of this study, it is the recommendation of the IPC SPVC that, due to lower cost and equivalent performance, the 96.5/3.0/0.5 SAC alloy be the lead free solder paste alloy of choice for the electronics industry.