Lead-Free Alloy for High-Reliability, High-Temperature Applications

Abstract

Although lead has long been banned from electronics products, there are still a number of challenges that exist with use of lead-free materials for specific applications. While the common tin/silver/copper alloy has been a suitable replacement for production, it proves less than ideal for applications demanding extreme reliability, temperature resistance or vibration resistance.

In light of these challenges, specialists worked to create an alloy that could meet high-temperature, high reliability requirements for applications such as the automotive, aerospace and military industries while remaining solderable at a reasonable temperature. It was necessary that the material be lead free, work in an operating temperature of less than 150°C, and be affordable while meeting RoHS standards.

Development Approach

Knowledge of existing alloys and possible modifications thereof offered a research baseline, and the team of specialist determined that the alloy's requirements would necessitate a multi-element approach. The base would be SnAg3.8Cu0.7 (SAC387), but with modified properties achieved through the addition of other elements. Once methods of refinement were decided, a range of alloying elements were analyzed and three were ultimately selected which would raise creep resistance while maintaining an acceptable melting temperature. These materials included bismuth (Bi), antimony (Sb), and nickel (Ni). Now that the elements had been determined, the new goal would be to combine them in proper balance together.

By fine-tuning the ratio of elements in this six-part alloy, the final composition met requirements for increase in creep strength as well as reflow temperature maintenance. Wetting balance was also tested to determine the minimum soldering temperature at which wetting could be successfully achieved while still ensuring high reliability at elevated temperatures.

Production in High Volume and Subsequent Testing

The next step in alloy analysis was the manufacturability and metallurgy, to be performed by the development team. This would include spread, solder balling, thermal cycling reliability, shear strength, vibration, drop and voiding analysis, during which the multi-component alloy demonstrated performance consistently superior to that of SAC387.

Conclusion

Through the joint efforts of industry and academia, researches had successfully created a lead-free alloy engineered to perform in high operating temperatures with reflow at the same temperature as traditional SAC alloys. This new multi-component alloy would further increase reliability for a range of applications, such as automotive, aerospace and defense, with improved reliability and comparable vibration resistance.

Note: Because the alloy contains bismuth, manufacturers should ensure components and boards are free of lead, as use with this alloy could result in low melting eutectic, leading to failed joints in lower temperatures.

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