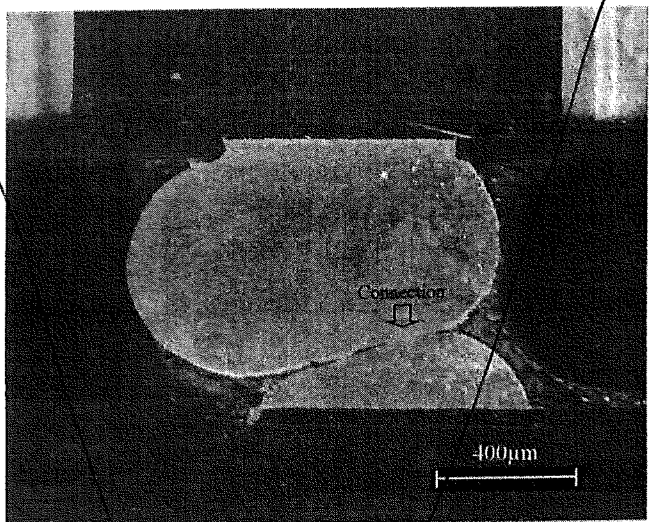

Fig. 12 Optical cross section view shows the nearly open solder joint

Summary

The major challenge for PBGA assembly is to inspect the solder joints and perform touch-up. Controlling the open defect is very important in the PBGA assembling process. Besides the defects of the incoming components, three kinds of failure mechanisms are responsible for the open defect: insufficient heating in the solder melting phase, poor thermal stability of PCB and PBGA and insufficient amount of printing solder paste. According to the failure mechanism, by adequately adjusting the reflow time, maximum temperature, soaking time and falling slope during reflow, and cleaning the stencil properly during printing, the occurrence of open defects can be reduced substantially.

Acknowledgments

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Thermoelectric Behavior of Solder

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The absolute thermoelectric power of tin-lead eutectic solder is $-5\ \mu V/°C$. *The voltage generated by a temperature gradient in solder may affect the performance of microelectronics.*

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Keywords: Solder, Tin Lead, Thermoelectric, Seebeck, Thermopower

Introduction

Solder is widely used as a thermal interface material for improving the thermal contact between components, such as that between a substrate and a heat sink in an electronic package. In this application, the solder encounters a temperature gradient, which can generate a voltage due to the thermoelectric behavior of solder. The thermoelectric behavior of concern here is the Seebeck effect, which refers to the generation of a voltage due to a temperature gradient, which causes the movement of charge carriers from the hot point to the cold point. This voltage, though small for most metals, can be of concern to the performance of microelectronics. In particular, the voltage may affect the electrical grounding, especially in cases where the heat sink is used for grounding and solder is used as a thermal interface material.

Because of the absence of prior work on the thermoelectric effect of solder, this paper is aimed at studying this phenomenon.

Experimental Methods

The solder was 63Sn-37Pb eutectic alloy (V-LEE) from Lee Solder Inc., Seagoville, TX.

Thermopower measurement was performed on rectangular samples of size $75\times15\times15$ mm, such that heat (up to 125°C) was applied at one of the 15×15 mm ends of a sample by contacting this end with a resistance heated platen of size much larger than 15×15 mm. The other end of the sample was near room temperature. The thermal contact between the platen and the sample end was enhanced by using a copper foil covering the 15×15 mm end surface of the sample as well as the four side surfaces for a length of $\sim$4 mm from the end surface. Silver paint was applied between the foil and the sample surface covered by the foil to further enhance the thermal contact. Underneath the copper foil was a copper wire which had been wrapped around the perimeter of the sample for the purpose of voltage measurement. Silver paint was present between the copper wire and the sample surface under the wire. The other end of the rectangular sample was similarly wrapped with copper wire and then covered with copper foil. The copper wires from the two ends were fed to a Keithley 2001 multimeter for voltage measurement. A T-type thermocouple was attached to the copper foil at each of the two ends of the sample for measuring the temperatures of the two ends. Voltage and temperature measurements were done simultaneously using the multimeter. The voltage difference divided by the temperature difference yielded the Seebeck coefficient with copper as

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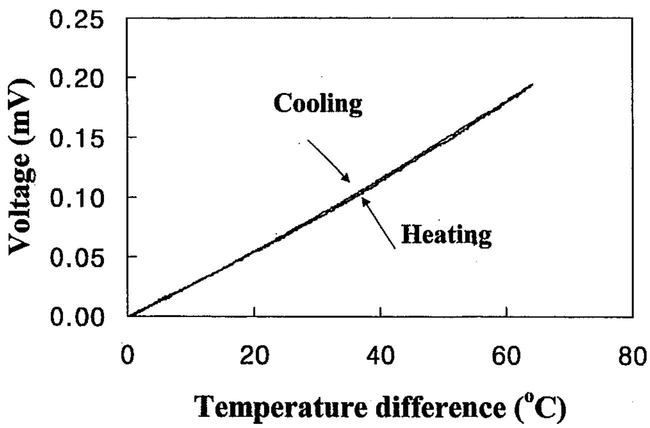

Fig. 1 Measured Seebeck voltage versus temperature difference during heating and subsequent cooling

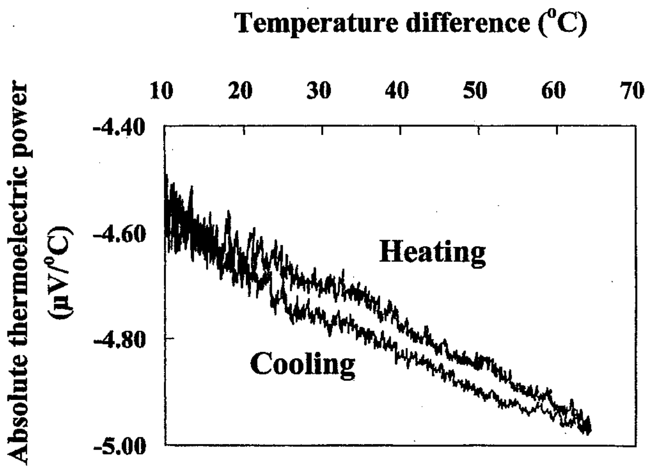

Fig. 2 Absolute thermoelectric power versus temperature difference during heating and subsequent cooling

the reference, since the copper wires at the two ends of a sample were at different temperatures. This Seebeck coefficient minus the absolute thermoelectric power of copper (+1.94 μV/°C at 300 K) [1] is the absolute thermoelectric power of the sample. Each sample was heated at one end at a rate of 1.11°C/s and then cooled with the power of the platen turned off. The heating rate was constant, but the cooling rate was not.

Results

Figure 1 shows the measured voltage versus temperature difference during heating and cooling. The curves during heating and cooling overlapped, indicating reversibility. The slope increased with increasing temperature difference. Figure 2 shows the absolute thermoelectric power versus temperature difference. The absolute thermoelectric power increased in magnitude as the temperature difference increased. For the same temperature difference, the magnitude was slightly higher during cooling than during heating. The highest magnitude was -4.9 μV/°C. This value is small in magnitude compared to those of commercial thermoelectric materials, but it can still be of concern to the performance of microelectronics. For example, a temperature difference of 10°C will cause a voltage difference of -49 μV.

Conclusions

The absolute thermoelectric power of tin-lead eutectic solder is -5 μV/°C.

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