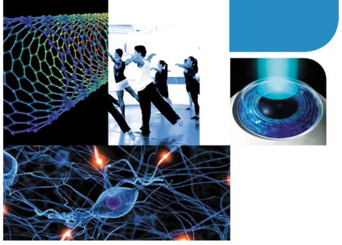

Interrelationship of thermal parameters and microstructure of Bi-Zn solder alloys

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Abstract

Due to the health and environmental concerns associated with the lead usage, the research on alternative alloys for replacing lead-based solders is a global demand. In this sense, particular lead-free alloys compositions have been suited for specific needs and the options have been broadening when elements other than tin are used as the base component, such as indium, gold and bismuth.Thus, this study aims to contribute towards understanding the influence of thermal parameters on the resulting microstructure of the eutectic alloy Bi-2.7wt% Zn solidified in an unsteady-state upward directional solidification device. The obtained microstructure presented a completely eutectic morphology along the casting length, consisting of Bi-rich and Zn-rich phases, which experiences morphology transition as the thermal parameters vary during the solidification process.

Key words: *Bismuth, solder alloy, solidification.*

Introduction

The demand for lead-free alloys results from the prohibition, in many countries, of Pb incorporation in several products, mainly electronics, due to its adverse effects on human health and environmental contamination[1]. Bi-Zn system alloys, in special at the eutectic composition, due to their low melting temperature, become potential candidates for high-temperature lead-free solders (230 to 350ºC).

Results and Discussion

In order to promote directional solidification, it was used directional solidification apparatus that permits a water-cooled directional solidification system, which enables a wide range of cooling rates to be investigate in a single experiment (including those typical of soldering practice). The Figure 1 shows the cooling curves of Bi-2.7wt.%Zn alloy directional cooled.

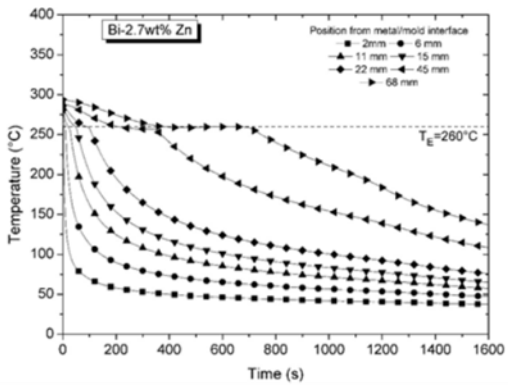

Figure 1. Experimental cooling curves for Bi-2.7wt.%Zn.

It can be noted from Figure 2 that the length scale of the microstructure is strongly dependent on the solidification thermal parameters, V_E and $\dot{T}_E$. Hence, as the cooling rate is high close to the bottom of the DS casting and decreases toward the top, the interphase spacing increases as a result. As can be observed in Figure 2, the microstructure is entirely formed by the eutectic phase. It can be seen that for positions (P) near the cooled interface, i.e. for high cooling rates, the microstructure is characterized by small Zn-rich fibers homogeneously distributed throughout the Bi-rich phase. Nevertheless, with the decrease in the cooling rate, the Zn-rich fibers tend to coalesce, and long fibers typify the microstructure associated with low cooling rates regions.

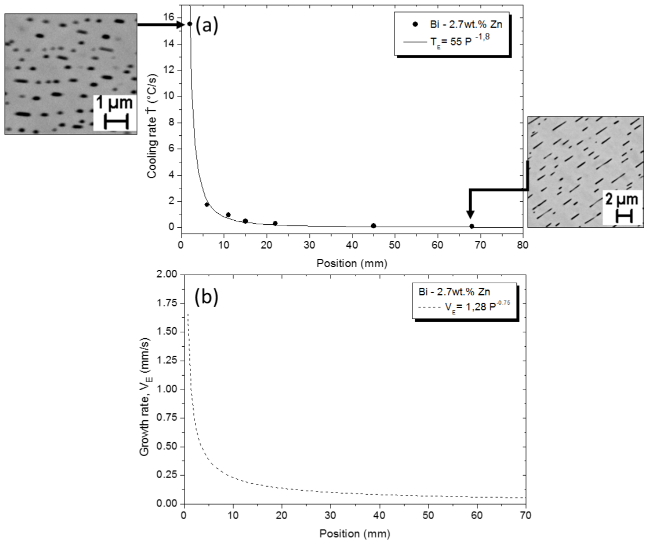

Figure 2. Thermal parameters profiles (a) experimental cooling rate against position; and (b) growth rate as a function of position.

Conclusions

The following conclusions can be drawn from the present experimental study:

- Closest to the metal/mold interface positions, the cooling rate is higher due to the intense heat extracted by the refrigerated base. As a result, interphase spacing (λ_{eut}) is smaller. As the solid layer increase, the heat transfer efficiency tends to decrease, increasing the interphase spacing.
- The values of λ_{eut} increase due to lower V_E and $\dot{T}_E$ values.

Acknowledgement

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[1] K.J. Puttlitz, K.A. Stalter, Handbook of Lead-Free Solder Technology for Microelectronic Assemblies, CRC Press, New York, 2004.