中文摘要

由於鉛污染問題，現今已用無鉛銲料取代鉛錫銲料，但無鉛化製程仍有可靠度上的問題，例如封裝適合性、孔洞的形成等。在銲點 Cu_3Sn/Cu 界面處，我們有時可以觀察到一整排 Kirkendall’s voids，這些孔洞的形成是造成產品失效的主要兇手，而由於 Kirkendall’s voids 只會生長在 Cu_3Sn 介金屬層上，因此，Cu_3Sn 生長型態與 Kirkendall’s voids 的形成是息息相關的，本實驗觀察的重點即在於 Cu_3Sn 生長。

為了改善無鉛銲料的品質，減少介金屬 Cu_3Sn 生成，添加微量元素於銲料中將有助於降低 Cu_3Sn 生成厚度，本實驗室先前研究結果發現，添加 0.1%的 Ni 於 Sn3.5Ag 銲料中，能有效降低 Cu_3Sn 生成。在本研究中，將所添加微量元素的量縮小到 0.1%以下，觀察其是否仍具有相同效果。另一方面，我們也添加 Fe、Co 兩種微量元素和 Ni 做比較，本實驗目的為探討添加微量 Fe、Co、Ni 於銲料中，與 Cu 墊層進行銲接與熱處理反應時對界面生成物的影響。

實驗結果顯示當我們把微量元素 Fe、Co、Ni 的使用量縮小的情況下，仍具有抑制 Cu_3Sn 生長，但卻增加 Cu_6Sn_5 形成。在 160°C 下當熱處理時間超過 1000 小時，在 Sn2.5Ag-xNi 與 Cu 墊層反應的試片中，Cu_3Sn/Cu 界面處有 Kirkendall’s voids 生長，而由於孔洞生長的位置靠近 Cu 墊層，因此我們推測在 Cu_3Sn 層裡，Cu 原子擴散的速度比 Sn 原子快；另外，在 Sn2.5Ag0.8Cu-xNi 與 Cu 墊層反應的試片中，在銲點界面處並沒有孔洞的生成，本實驗結果推測銲料中 Cu 含量應是其中一個控制孔洞生成的因子。

Sn2.5Ag-xNi 與 Cu 墊層反應中，在界面生成物 Cu_6Sn_5 上有兩層 Ni 分佈，靠近銲料端的 Cu_6Sn_5 Ni 含量比靠近 Cu 墊層端的 Cu_6Sn_5 Ni 含量多，這是由於在冷卻過程中，銲料中部分 Ni 回到界面所致；而在 Sn2.5Ag0.8Cu-xNi 與 Cu 墊層反應中，界面生成物 Cu_6Sn_5 沒有 Ni 分層情形，因為 Sn2.5Ag0.8Cu 銲料中本身含有 Cu，與 Cu 墊層銲接時銲料內部生成的 Cu_6Sn_5 多，部分的 Ni 溶解到銲料內的 Cu_6Sn_5 中，以致於冷卻過程中，回到界面上的 Ni 少，才不會有分層的情形。

本實驗之主要目的即是探討 Fe、Co、Ni 的添加對無鉛銲料與 Cu 界面反應之影響。研究目標是去深入了解加入第四元素對 Cu_6Sn_5、Cu_3Sn、及 Kirkendall’s voids 生長之影響，進而找出最佳之無鉛銲料合金組成。

ABSTRACT

Owing to the ban of lead, the conventional lead-bearing solder has been replaced by lead-free solder. The drive for lead-free solders in the microelectronics industry presents some reliability challenges. Examples include package compatibility, creep, and Kirkendall's voids. Along the Cu_3Sn/Cu interface, we can find a series of Kirkendall's voids. These Kirkendall's voids were the true culprit responsible for the weakening of the interface. It is widely accepted that the formation of these Kirkendall's voids is related to the growth of Cu_3Sn.

In order to promote the quality of lead-free solder, minor elements addition can reduce the Cu_3Sn thickness. Recently, our research group showed that a 0.1 wt.% Ni addition to SnAg could reduce the Cu_3Sn thickness during the solder/Cu reaction. We want to extend this past result to find out the minimum level of Ni addition that still retains this beneficial effect. In addition, we will also investigate whether the elements, Fe, and Co will have a similar effect. The objective of this study is to investigate the effects of minor Fe, Co, and Ni on the soldering and aging reactions between lead-free solders and Cu.

The experimental result shows that the presence of Ni can in fact reduce the growth rate of Cu_3Sn but increase the formation of Cu_6Sn_5. Moreover, the presence of Fe and Co can have the some effect. We can find the Kirkendall's voids in the reaction between Sn2.5Ag-xNi (x=0~0.1wt. %) and electroplated Cu at 160 ^{o}C for excess 1000 hr. The observation of Kirkendall's void formation near the Cu_3Sn/Cu is direct evidence of Cu diffusion since we can use the voids to serve as diffusion markers. On the side, we didn't find voids in the reaction between Sn2.5Ag0.8Cu-xNi (x=0~0.1wt. %) and electroplated Cu. The growth of voids is complicated. We consider that the Cu concentration in the solders

is the factor to control the void formation.

In the Sn2.5Ag-xNi solders, the addition of Ni also produces two distinct Cu_6Sn_5 regions at the interface. The outer region contains more Ni, and the inner region contains less Ni. Cooling conditions changed the Ni content of the Cu_6Sn_5 formed at the interface. Besides, the Sn2.5Ag0.8Cu-xNi solders didn't have two different Ni content in the Cu_6Sn_5. This is because there are more Cu_6Sn_5 precipitated in the Sn2.5Ag0.8Cu-xNi than in Sn2.5Ag-xNi solders. A part of Ni could be dissolved in the Cu_6Sn_5. Therefore, a few Ni could come back to interface.