# 中文摘要

在電子原件封裝的接點中金、銅、鎳、錫是常見的元素，本論文以Au/Sn/Ni、Au/SnPb/Ni、Ni/Sn/Cu以及Au/Sn/Cu擴散偶試著來探其相互間的關係，由於在接點迴銲的過程中，這些元素已經快速的反應，為使反應的現象更為釐清清處，本論文的實驗試品是利用電鍍的方法在銅或鎳的基板上電鍍我們所需的擴散偶，由此方式製做有兩項主要的優點，一、此試片可以單純只觀察熱處理的結果並摒除迴銲過程的影響，二、由於使用電鍍的方式製作，可以有效的控制Sn與SnPb的厚度，這樣既可做定量的計算。將這些擴散偶置於 160°C做熱處理，來探討元素兩端的交互影響，並與單一的Sn/Cu與Sn/Ni作為對照組來討論。

由實驗結果顯示，雖然擴散偶兩端的元素中間隔了一層Sn 或SnPb，在熱處理 1 hr內，即可以看到兩端元素的相互作用，在長時間的熱處理後，可以觀察到許多有趣的現象，在Au/Sn/Ni及Au/PbSn/Ni擴散偶中$AuSn_4$會穿越Sn或PbSn層生成於$Ni_3Sn_4$與solder的界面上，在Ni/Sn/Cu擴散偶中Cu會穿越Sn層生成$(Cu,Ni)_6Sn_5$於Ni與solder的界面上，原本的於Sn/Ni擴散偶中會生成的$Ni_3Sn_4$被$(Cu,Ni)_6Sn_5$取代，在Au/Sn/Cu擴散偶中Cu會穿越Sn層生成$(Cu,Au)_6Sn_5$於Au與solder的界面上，並且 $AuSn_4$被$(Cu,Au)_6Sn_5$取代。由以上結果可得知，在Au、Cu、Ni、Sn四元素中，$Cu_6Sn_5$為主要生成介金屬，在其次是$AuSn_4$，最後是$Ni_3Sn_4$。

# Abstract

The Au, Cu, Ni and Sn are the most common materials in the solder joints of electronic packages. In this thesis, the Au/Sn/Ni, Au/SnPb/Ni, Ni/Sn/Cu and Au/Sn/Cu ternary diffusion couples were used to investigate the solder volume effect on the cross-interaction. All the materials were electroplated on the structure. The diffusion couples were aged at 160°C for different periods of time. With this technique, the diffusion couples were assembled without experiencing any high temperature process, such as reflow, which would have accelerated the interaction and caused difficulties in analysis.

This thsis revealed that the cross-interaction of Au/Sn/Ni and Au/SnPb/Ni could occur in as short time. The difference in migration kinetics of $AuSn_4$ in eutectic PbSn and SnAg was ascribed to the difference in the magnitudes of the Au flux and the Ni flux. In eutectic PbSn, the Au flux was much greater than that of the Ni flux, and the Au and Ni flux were of the same order of magnitude in eutectic SnAg. The relative magnitude of the Au and Ni flux changed in eutectic PbSn and SnAg because the homologous temperatures of PbSn and SnAg were different.

The cross-interaction of Ni/Sn/Cu could occur in as short as 30 min. A detailed atomic flux analysis showed that the Cu flux through the Sn layer was about 25-40 times higher than the Ni flux. Moreover, it was found that $(Cu_{1-x}Ni_x)_6Sn_5$ on the Ni side reduced the consumption rate of the Ni layer, and the cross-interaction also reduced the $Cu_3Sn$ thickness on the Cu side.

The cross-interaction of Au/Sn/Cu could occur in as short as 1 hr. Evidence of this cross-interaction included the formation of $(Cu_{1-x}Au_x)_6Sn_5$ on the Au side of the diffusion couples as well as on the Cu side. The reaction products on the

Au side included the Au-Sn binary compounds. Between the Au-Sn compounds and the Sn was $(Cu_{1-x}Au_x)_6Sn_5$. The reaction products on the Cu side initially was only $(Cu_{1-x}Au_x)_6Sn_5$, but a layer of Au-free $Cu_3Sn$ eventually formed between $(Cu_{1-x}Au_x)_6Sn_5$ and Cu. The results of this study show that the cross-interaction of Au and Cu in solders is extremely rapid, and cannot be ignored in those solder joints that have both elements present.

**Keywords:** Au-Sn-Ni, Au-Sn-Cu, Ni-Sn-Cu, interfacial reaction, lead-free solder.