摘要

本實驗主要利用 Cu／Molten SnPb／Cu 的反應偶進行通電，探討在兩端為銅導線的熔融銲料中，電子流推動銅原子的能力，藉以了解銅原子於液態銲料中受電子流影響而加速擴散之行為。

實驗條件主要可分為液態反應與固態反應：「液態反應」中設定溫度為 230 ℃，對『銅／液態銲料／銅』的系統分別進行通電與熱處理反應，以得到不同反應時間的結果。另一方面，「固態反應」則設定溫度為 160 ℃，對『銅／固態銲料／銅』的系統中分別進行通電與熱處理反應，其中通電電流密度皆為 7.2×10^3 A/cm^2。而藉由觀察通電下陰極與陽極端介金屬生成與銅消耗的情形來比較其中的差異性。

實驗結果發現，在 Cu／Molten SnPb／Cu 系統中通電時，陰極端導線會有大量銅消耗，而陽極端則有大量介金屬的情形，顯示電子流的流動下會使陰極端銅導線快速溶解與消耗，並推擠銅原子加速擴散到陽極端，而生成大量介金屬 Cu_6Sn_5，其現象與「不通電液態銲料反應」及「固態銲料下通電」的結果差距甚大，其銅導線消耗之厚度差距可達 10 倍之多。而這個結果也說明了：在『銅／銲料／銅』的反應中，當銲料是處於液態並給予一電流時，電子流會加速陰極端銅導線的溶解與擴散，進而導致大量的銅消耗。

另外，在 160 ℃的固態通電實驗中，在陽極端會有鉛相聚集的行為，乃是因為在此溫度下 Pb 原子的移動會較 Sn 原子來地快。同時也發現到陽極端介金屬厚度較陰極端要來的厚，推論同樣是電子流導致陰極端銅原子擴散的原因，不過在固態下此銅遷移的現象和先前液態通電相比，有極端的差異性存在。

Abstract

In this study, we used the 『Cu / Molten SnPb / Cu』 structure to investigate the polarity effect of electromigration. By the result, we found that electronic current will accelerate the diffusion behavior of Cu in molten solder severely.

The experiment condition was including two parts, which was “liquid-state reaction” and “solid-state reaction”. In liquid-state reaction, the sample was annealed at 230 °C with and without current stressing. In solid reaction, the sample was annealed at 160 °C with and without current stressing. Here the current density was 7.2×10^3 A/cm^2. By the observation of the result, we compared the polarity effect of electromigration on the thickness of intermetallic compound (IMC) formation and the dissolution of Cu at the cathode and the anode site.

In the Cu / molten SnPb / Cu system of electromigration, the rapid dissolution of Cu at the cathode site and the plenty formation of IMC at the anode site was found obviously. It was concluded that Cu atoms were dissolved quickly into the molten solder, and the dissolved Cu atoms were driven to the anode side by electronic current immediately.

In addition, we reduced the experiment temperature to 160 °C and take the solid sample under current stressing. Electromigration indeed affects the formation of IMC at the anode and the cathode site. It enhances the growth of IMC at the anode side and inhibits the growth at the cathode side when compared with the no-current case. As the time of current stressing increased, the propagation of Pb-rich phase was found at the anode side. This is because Pb is the dominant diffusing species at temperatures above 120 °C.