光電封裝中金錫銲料微結構之研究

由於金屬銲料比其他高分子的焊接材料有較好的機械性質與導熱、導電能力，所以對於更需要導熱性質好與傳輸速率更快的光電封裝中，金屬銲料爲光電封裝中主流的封裝材料。在硬銲銲料中，又以機械性質好且低熔點的 Au20Sn (wt.%)銲料，較爲廣泛的應用在對焊接溫度敏感的元件封裝中。而薄膜的 Au20Sn 銲料不但可以增加導熱速率，且在光纖被動對準步驟中，更可以將垂直高度誤差的情形減至最低。又由於銲料的微結構對於銲點的機械性質有相當程度的影響，因此我們先將三明治結構 Sn/Au/Ni (2.5/3.75/2 mm) 和 Sn/Au/Cu (1.83/2.74/5.8 mm) 鍍在 Si 上， Au 和 Sn 的總組成是 Au20Sn (wt.%) 。結果顯示銲料的微結構可以利用不同的焊接條件控制。當焊接條件是在 290oC、2 分鐘時，由於溫度高於熔點所以銲點是爲液態，所以微結構是兩相混合的共晶結構 (Au5Sn and AuSn)。Ni 墊層與 Cu 墊層唯一的不同，是 AuSn 會與 Ni 墊層相接，而融入 AuSn 之 Ni 會降低 Gibbs free energy。同樣地在 Au20Sn/Cu 系統中，Au5Sn 會與 Cu 墊層相接，融入之 Cu 會降低 Gibbs free energy。當焊接條件是在 240oC、2 分鐘時，由於幾乎是固固反應，所以微結構是層狀結構 (AuSn/Au5Sn/Ni or Cu)。

當 AuSn/Au5Sn/Ni 層狀的微結構放在 240oC 熱處理，在 9 小時之內，AuSn 會與 Au5Sn 交換位置，變成 Au5Sn/AuSn/Ni。而此兩層交換位置的驅動力，是 AuSn 想要尋找更多的 Ni。且從短時間的結果顯示，兩層交換位置的擴散機制是：在 Au5Sn 中，Sn 是主要的擴散元素。而在 Au20Sn/Ni 與 Au20Sn/Cu 兩個系統中，Au20Sn 在 Ni 墊層上微結構的熱穩定性比 Au20Sn 在 Cu 墊層上的微結構還好。且在熱處理 1000 小時後，Ni 墊層的消耗 (0.8mm)比 Cu 墊層的消耗 (4.8mm)來的少許多。

Study the Microstructure of Au20Sn Solder in the Optoelectronic Packaging

The good mechanical property, high thermal conductivity and high electrical conductivity of alloy make it widely used in optoelectronic packaging. Among of all hard solders, Au20Sn (wt.%) solder has the lowest melting point and good high strength and therefore is useful for devices sensitive to high processing temperature. Thin film Au20Sn solder layer not only can spread heat from the bonded device to the substrate quickly, but also can reduce the misalignment of z-position in passive alignment of fiber. It has been reported microstructure of solder may influence the reliability of solder. In this study, the microstructures of the eutectic Au20Sn (wt.%) solder developed on the Cu and Ni substrates were studied. The Sn/Au/Ni sandwich structure (2.5/3.75/2 mm) and the Sn/Au/Ni sandwich structure (1.83/2.74/5.8 mm) were deposited on Si wafers first. The overall composition of the Au and Sn layers corresponded to the Au20Sn binary eutectic. The microstructures of the Au20Sn solder on the Cu and Ni substrates could be controlled by using different bonding conditions. When the bonding condition was 290oC for 2 min, the microstructure of Au20Sn/Cu and Au20Sn/Ni was a two-phase (Au5Sn and AuSn) eutectic microstructure. When the bonding condition was 240oC for 2 minutes, the AuSn/Au5Sn/Cu and AuSn/Au5Sn/Ni layered microstructure formed. The major difference between Au20Sn/Ni and Au20Sn/Cu is that (Au, Ni)Sn preferred to form next to Ni and (Au, Cu)5Sn preferred to form next to Cu due to the different solubility of Ni and Cu in AuSn and Au5Sn. It is because a ternary intermetallic compound often has a lower Gibbs free energy compared to a binary compound of the same structure from the entropy argument.

After bonding, the Au20Sn/Cu and Au20Sn/Ni diffusion couples were subjected to aging at 240oC. In the Au20Sn/Ni system, the AuSn layer gradually exchanged its position with the Au5Sn layer, and eventually formed an Au5Sn/AuSn/Ni three-layer structure in less than 9 hours. The driving force for Au5Sn and AuSn to exchange their positions is for the AuSn phase to seek more Ni. From the result of short time reaction, the diffusion mechanism for the exchange of AuSn and Au5Sn is the diffusion of Sn through Au5Sn. The thermal stability of Au20Sn/Ni was better than that of Au20Sn/Cu. Moreover, less Ni was consumed compared to that of Cu. This indicates that Ni is a more effective diffusion barrier material for the Au20Sn solder.