脈衝式 YAG 雷射應用於共晶錫球無助銲劑迴銲接合之研究

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摘　要

本實驗研究以脈衝式YAG雷射（Pulse YAG Laser）進行共晶錫球（Eutectic Solder Ball）在銅銲墊上之無助銲劑迴銲接合（Fluxless Reflow Soldering），以了解雷射功率、脈衝寬度與迴銲次數等製程條件對銲點外觀形貌、微觀結構與接合強度之影響。實驗結果顯示，雷射迴銲所形成之銲點高寬比低於傳統迴銲之銲點，在較低功率及較大脈衝寬度（即較長的加熱時間）的迴銲條件下可得到較平整的銲點外觀、較均勻之微觀結構及較佳之接合強度。掃描式電子顯微鏡（Scanning Electron Microscopy，SEM）之觀察發現銲點與基板界面的介金屬層（Intermetallic Compound，IMC）以厚度小於１μm的Cu_6Sn_5相爲主；隨著雷射功率的增加，其IMC逐漸轉以棒狀或樹枝狀沿冷卻方向成長；經多次雷射脈衝迴銲的銲點內則會出現棒狀的Cu_3Sn相。推力測試（Shear Test）對接合強度之測試顯示，脈衝雷射銲點可達到的平均剪力約 9.6 Nt/mm^2，爲工業標準的 1.8 倍，破斷面的觀察發現其有效銲點皆因錫球受剪應力破裂（Ball Shear），表面呈現韌性破斷（Ductile Fracture），符合JEDEC所制定 BGA推球規範之破裂模式一型態；而不良銲點則皆因錫球與銲墊間缺乏完整之潤濕（即規範之破裂模式三型態），且破斷面隨潤濕程度及受熱均勻程度的影響呈現數種不同的形貌，實驗分析結果顯示銅/銲錫界面的潤濕狀況及雷射光束入射的相對位置爲影響此一無助銲劑迴銲接合良率的主因。

A Study of Fluxless Reflow Soldering of Eutectic Solder Ball

Using Pulse YAG Laser

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Abstract

This work studied the fluxless reflow soldering of eutectic solder ball on copper (Cu) pad utilizing pulse YAG laser. The effects of soldering conditions including laser power density, pulse width (*i.e.*, the irradiation time) and reflow times on the morphology, microstructure and shear strength of solder joint were investigated. The experimental results revealed that the solder joints exhibit better shape and bonding strength when they were soldered at the conditions of lower power density and larger pulse width. The observation using scanning electron microscopy (SEM) and energy dispersive spectroscopy (EDS) revealed that the layer-like intermetallic compound (IMC) is mainly Cu_6Sn_5 phase of thickness less than 1 μm. With the increase of power density, the morphology of IMCs became rod-like or dendrites and the IMCs grew along the cooling direction. For the solder joints subjected to multiple laser pulse soldering, the rod-like Cu_3Sn phase was observed. Shear test was adopted to evaluate the bonding strength of laser-soldered joints. The joints exhibited the average shear strength of 9.6 Nt/mm^2, about 1.8 times over than the industry standards (5.40 Nt/mm^2). The cross-sectional morphology observation indicated that all successful joints fractured inside the solder joints due to shear force and the ductile fracture feature fitted to the fracture mode #1 of JEDEC shear test standard. As to the

unsuccessful joints, they failed due to incomplete wetting that fitted to the fracture mode #3 of JEDEC standard. The morphology of fracture surfaces varied according to the degree of wetting of solder on Cu pad and the mount of heat absorbed during soldering. The analytical results indicated that the wetting behaviors of solder on Cu pad and the relative position of the incident laser beams are the two major factors affecting the yield of the fluxless reflow soldering utilizing pulse YAG laser.