SnAgCu/Cu和 SnAgCu/Au/Ni/Cu表面贴装元件焊点高温存贮试验分析

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摘 要: 研究了 SnAgCu/Cu及 SnAgCu/Au/Ni/Cu表面贴装元件焊点在高温存贮试验条件下抗剪强度的变化规律。结果表明, SnAgCu/Cu及 SnAgCu/Au/Ni/Cu焊点抗剪强度随保温时间的延长降低, SnAgCu/Cu焊点的抗剪强度高于 SnAgCu/Au/Ni/Cu焊点的抗剪强度。SnAgCu/Cu及 SnAgCu/Au/Ni/Cu焊点的断口形貌分析表明, 断裂大多数都发生在贴装元件端头金属化层内, 少数发生在钎料与焊盘的界面以及焊点内部。

关键词: 抗剪强度; SnAgCu钎料; 焊点; 高温存贮

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0 序 言

在一个大规模集成电路中少则几十个焊点, 多则达到几百个甚至几千个焊点, 而在巨型计算机的印刷线路板上的焊点数目达到上万个。这些焊点最主要的功能是实现芯片与外电路之间、元器件之间的电气连接。功能虽然简单, 但其影响却至关重要, 只要有一个焊点失效就有可能导致整个元器件或整机工作不正常[1~3]。在电子元器件或电子整机的所有故障原因中, 60%以上为焊点失效所造成[4,5]。随着电子工业的大规模发展, 对电子产品可靠性的要求越来越高, 因此, 研究提高焊点可靠性的问题是一项极其重要的课题。依据相关标准规定检验焊点可靠性的试验方法很多, 高温存贮试验是重要的试验内容之一。高温存贮试验主要针对焊接组件在不施加电应力的条件下, 测定连续高温条件下对焊接组件中焊点失效率的影响。由于不需要施加电应力, 因此文中试验的操作相对简单易行。

已有研究工作表明[6], SnAgCu在 Au/Ni/Cu焊盘上的润湿性优于在 Cu焊盘上的润湿性。作者在此基础上研究了 SnAgCu/Cu及 SnAgCu/Au/Ni/Cu表面贴装电容经高温(150℃)存贮试验后, 其焊点抗剪强度及微结构的变化情况, 可为 Sn-Ag-Cu钎料用于上述两种焊盘结构的可靠性及可行性提供试验依据。

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1 试验方法

试验选用的表面贴装元件为 0805电容, 所用钎料为 Sn3.0Ag0.5Cu。用模板将钎料均匀地印刷在微波电路板对应的焊盘上, 贴好元件, 在 OMNIEL07型红外热风再流焊炉中进行再流焊接, 最高焊接温度为 260℃。将焊接后的样品放入 1011型烘箱, 在 150℃的空气条件下分别保温 0天, 1天, 5天, 10天和 20天后取出, 采用微焊点强度测试仪测试贴装元件焊点的抗剪强度, 并在光学显微镜下观察断口的微观形貌。

2 试验结果及分析

2.1 焊点抗剪强度及断口形貌

图 1所示为 SnAgCu/Cu和 SnAgCu/Au/Ni/Cu焊点的抗剪强度随高温存贮保温时间的延长而变化的关系曲线。

图 2、图 3、图 4分别为 SnAgCu/Cu焊点和 SnAgCu/Au/Ni/Cu焊点试验前、高温存贮 10天及高温存贮 20天后的断口光学显微照片。

2.2 分析与讨论

2.2.1 抗剪强度分析

由图 1可知, 两种焊点的抗剪强度均随高温存贮时间的延长而降低, 但 SnAgCu/Cu焊点的强度比 SnAgCu/Au/Ni/Cu焊点的高。SnAgCu/Cu焊点高温存贮 20天后抗剪强度由原来的 65MPa降为

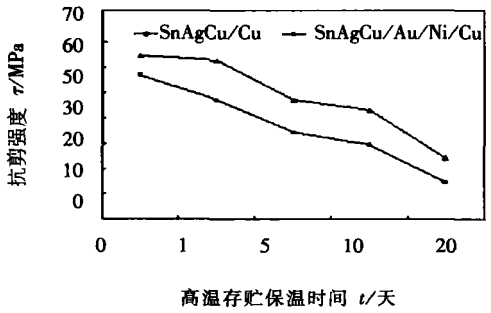

图 1　SnAgCu/Cu和 SnAgCu/Au/Ni/Cu焊点的抗剪强度与高温存贮保温时间的关系曲线

Fig. 1　Variation shear strengths of SnAgCu/Cu and SnAgCu/Au/Ni/Cu soldered joints with high temperature storage time

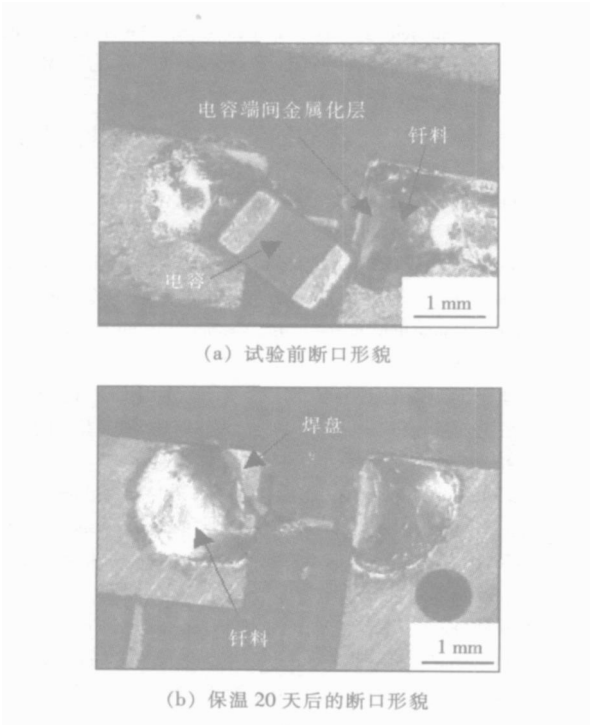

图 2　SnAgCu/Cu焊点高温存贮试验前及保温 20天后的断口形貌

Fig. 2　Fracture appearances of SnAgCu/Cu soldered joint before high temperature storage and after 20 days

25MPa下降了 62%。而 SnAgCu/Au/Ni/Cu焊点高温存贮 20天后抗剪强度由原来的 58MPa降为 15MPa下降了 74%。可见 SnAgCu/Au/Ni/Cu焊点受高温存贮的影响较大。亦有研究工作表明[7]，SnAgCu/Cu焊点处 Sn-Ag-Cu钎料与 Cu界面的化合物主要为 Cu_6Sn_5及少量的 Cu_3Sn；而对在 Au/Ni/Cu焊盘上进行的研究表明[8]，SnAgCu/Au/Ni/Cu焊点中 Sn-Ag-Cu钎料与 Au/Ni/Cu界面生成

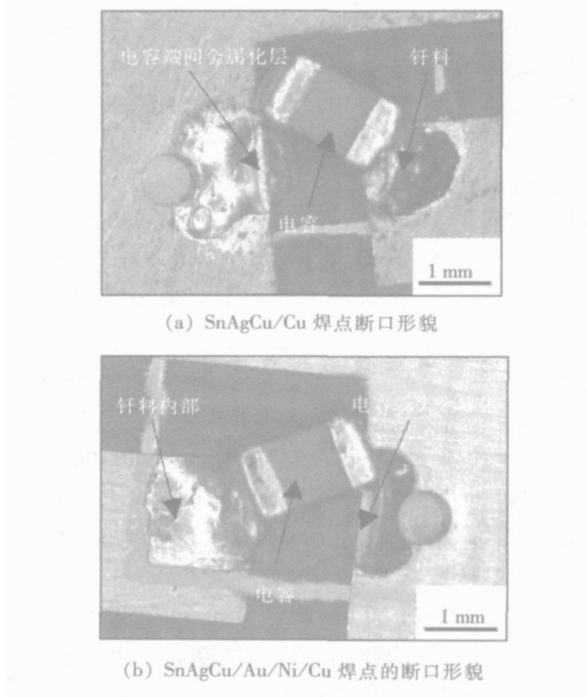

图 3　SnAgCu/Cu焊点及 SnAgCu/Au/Ni/Cu焊点保温 10天后的断口形貌

Fig. 3　Fracture appearances of SnAgCu/Cu and SnAgCu/Au/Ni/Cu soldered joint stored at high temperature for 10 days

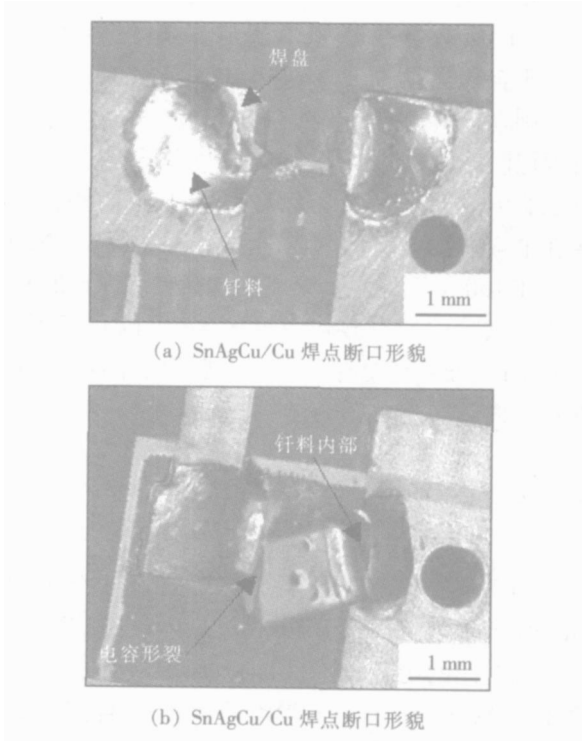

图 4　SnAgCu/Cu焊点及 SnAgCu/Au/Ni/Cu焊点保温 20天后的断口形貌

Fig. 4　Fracture appearances of SnAgCu/Cu and SnAgCu/Au/Ni/Cu soldered joint stored at high temperature for 20 days

的化合物主要为 Ni_3Sn_4。这些化合物虽起到了一定的机械连接及电气连接作用。但是在高温存贮试验条件下,随着保温时间的延长,这些化合物层会逐渐长大增厚,从而导致焊点的强度降低。Yang[9]等人发现,选用轧制 Cu(试验亦采用 Cu焊盘)时在化合物层不会有空洞生成。因此,这与 kirkendall效应有关。对于 Au/Ni焊盘,在焊接过程中 Au会完全溶解并以固溶体形式弥散于钎料中。由于 Au层很薄(试验中 Au层厚度为 0.5 μm),对焊点可靠性不会造成影响[10]。但是化合物主要是由 Ni和 Sn相互扩散而形成的,且随高温存贮时间的延长它们的扩散会更加活跃,因此在一定条件下甚至可以观察到 kirkendall空洞[11]。这就是 SnAgCu/Au/Ni/Cu焊点的抗剪强度低于 SnAgCu/Cu焊点的抗剪强度的原因。

2.2.2 断口分析

由图 2a可以观察到,焊点的断裂发生在电容端头金属化层内,并且 SnAgCu/Cu焊点保温 1天、5天、10天的断裂均发生在电容端头金属化层内;由图 2b可以观察到,焊点的断裂发生在钎料与焊盘界面。可见,在 150 ℃下保温(高温存贮)20天后钎料/焊盘界面的 Cu和 Sn的金属化合物逐渐增厚,晶粒逐渐粗大,因此对焊点强度影响较大。图 3a中 SnAgCu/Cu焊点在保温 10天后其断口仍发生在电容端头金属化层内。但图 3b中 SnAgCu/Au/Ni/Cu焊点则在钎料内部也发生一定程度的开裂,可见随着保温时间的延长,SnAgCu/Au/Ni/Cu焊点受高温存贮影响较大。图 4a可以观察到,焊点的断裂仍发生在电容端头金属化层内,同样 SnAgCu/Au/Ni/Cu焊点在 150 ℃下保温 1天、5天、10天后焊点的断裂方式与试验前的一致。但由图 4b可以观察到,在 150 ℃下保温(高温存贮)20天后焊点的断裂发生在钎料内部。

3 结 论

(1)在 150 ℃保温(高温存贮)条件下,SnAgCu/Cu及 SnAgCu/Au/Ni/Cu焊点的抗剪强度随保温时间的延长均降低,SnAgCu/Cu焊点的强度高于 SnAgCu/Au/Ni/Cu焊点的强度,并且前者受高温存贮的影响较后者小。

(2)断口分析表明,在高温存贮试验前及分别保温 1天、5天、10天后,SnAgCu/Cu及 SnAgCu/Au/Ni/Cu焊点断裂均发生在元件端头的金属化层内。高温存贮 20天后,SnAgCu/Cu焊点断裂在钎料/焊盘界面,而 SnAgCu/Au/Ni/Cu焊点则断裂在钎料内部。

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Abstract: According to the brazing techniques of large scale generators and high power transformers, a 20 kHz/40 kW superaudio frequency inverted welding power supply was dasigned. It used PSM (Pulse Symmetrical Modulated) power control inverter. The serial-resonant full bridge inverter executes both power converting and power adjusting. The main switches of the inverter are controlled according to the PSM and the inverter always works at resonant with the same pace of the load and work in shutting off at ZCS and ZVS while switching on and off. The inverter is with unity power factor and raises efficiency.

Key words: Welding; Inverter; ZCS; Exceed Audio Frequency Induction; Generator; Transformer

Mechanical properties and microstructure of TIG+MIG welded joint of T91 steel CHANG Tie-jun[1], GONG Zheng-chun[2], LI Zi-feng[1], WANG Chang-bai[1] (1. School of Mechanical and Electric Engineering, Harbin Engineering University, Harbin 150001, China; 2. Harbin Boiler Company Ltd., Harbin 150046, China). p59-61, 88

Abstract: The mechanical properties, creep strength and high temperature ageing of TIG+MIG welded joint of T91 steel were tested. Microstructure and fracture morphology of the joint was analyzed. The creep strength of 625 ℃ for 17 958 h is 70 MPa, which can deduce that the sustained strength after 10^5 h is 46.5 MPa and the FATT is -13 ℃. It is proved that the properties of TIG+MIG welding joint at high temperature is determined by the change of microstructure. Furthermore, $M_{23}C_6$ plays an important role.

Key words: T91 steel; FATT; microstructure; sustained strength

Investigation for SnAgCu/Cu and SnAgCu/Au/Ni/Cu surface mounted soldered joints stored at high temperature XUE Song-bai[1], WANG Xu-yan[1], YU Sheng-lin[2] (1. College of Materials Science & Technology, Nanjing University of Aeronautics & Astronautics, Nanjing 210016, China; 2. The 14th Research Institute, China Electronics Technology Group Corporation, Nanjing 210013, China). p62-64

Abstract: Shear strength and fracture photograms of SnAgCu/Cu and SnAgCu/Au/Ni/Cu surface mounted soldered joints stored at high temperature were investigated. Results indicate that the shear strength of SnAgCu/Cu and SnAgCu/Au/Ni/Cu soldered joints decrease with high temperature storage time increasing, and the shear strength of SnAgCu/Cu soldered joint is larger than that of SnAgCu/Au/Ni/Cu soldered joint. Analysis for fracture photograms of SnAgCu/Cu and SnAgCu/Au/Ni/Cu soldered joints indicates that most of the fractures of SnAgCu/Cu and SnAgCu/Au/Ni/Cu soldered joints occurred in the metallic layer of surface mounted components' ends and minority fractures occurred in the solder/pad interface or in the solder.

Key words: shear strength; Sn-Ag-Cu solder; soldered joint; storage at high temperature

Simulation of the temperature field and flow field in full penetration laser welding DU Han-bin[1], HU Lun-jf[2], WANG Dong-cuan[1], SUN Cheng-zhi[1] (1. Automotive Engineering Academy of Shanghai Automotive Industry Co. (Group), Shanghai 200437, China; 2. School of Materials Sci. & Eng., Huazhong University of Science and Technology, Wuhan 430074, China). p65-68, 100

Abstract: A three dimensional mathematical model for the temperature field and flow field in full penetration laser welding of titanium alloy was presented. In this model, the heat source comprises a plane heat source on the top surface and a cylindrical heat source along the z direction, which takes into account the plasma effect and the keyhole absorption. The mushy region is introduced to provide a simple method to dispose of the pressure and velocity boundary conditions. Calculated results from the models are found to agree with the experimental results for the geometry profile of weld. The metal flow is the main cause for forming the typical "hourglass" cross section profile.

Key words: laser welding; temperature field; flow field; mathematical simulation

Influence of cerium on microstructure of Sn-Ag-Cu lead-free solder CHEN Yan[1], XUE Song-bai[2], LV Xiao-chun[1], LIAO Yong-ping[1] (1. Harbin Welding Institute, Harbin 150080, China; 2. Nanjing University of Aeronautics and Astronautics, Nanjing 210016, China). p69-72

Abstract: The microstructures of Sn-3.8Ag-0.7Cu lead-free solder with different contents of cerium were studied. The studied results showed that the microstructures can be refined and the intermetallic compounds can be suppressed because of addition of small amounts of cerium into the lead-free solder. When cerium is 0.03wt%, the microstructure of the solder is fine and distributed uniformly, and which possess the best mechanical properties of soldered joints and better wettability. When cerium is over 0.03wt%, the black cerium-rich phase appears and increases with the content of cerium. The microstructure analyses and theoretical calculation indicated that the black cerium-rich phase is a compound of Sn and Ce.

Key words: cerium; lead-free solder; microstructure

Tansient liquid phase bonding tungsten to copper alloy SHEN Yi-fu[1], LIU Shi-fu[1], LI Jun-wei[2], XU Jie[1] (1. College of Materials Science and Technology, Nanjing University of Aeronautics and Astronautics, Jiangsu Nanjing 210016, China; 2. XiaMen Honglu Corporation, Fujian Xiamen 361021, China). p73-76