第 26卷 第 10期
2005年 10月
焊 接 学 报
TRANSACTIONS OF THE CHINA WELDING INSTITUTION
Vol.26 No.10
October 2005

QFP结构微焊点强度的试验

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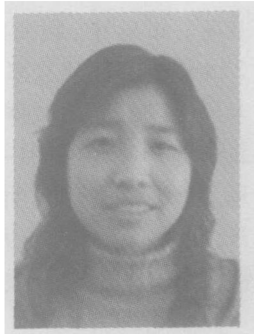
胡永芳

摘 要：采用微焊点强度测试仪(STR－1000型)测试了方形扁平式封装器件(QFP)的抗拉强度，并对不同间距、不同钎料成分的 QFP和 SOP结构焊点进行了比较。研究结果表明，在相同的钎料成分下，焊脚间距越大，所需的抗拉力越大，抗拉强度越高；共晶钎料 QFP焊点的抗拉强度比纯铅的抗拉强度低，QFP焊点的结合强度比钎料自身的抗拉强度高。

关键词：抗拉强度；方形扁平式封装器件(QFP)；共晶钎料
中图分类号：TG454 文献标识码：A 文章编号：0253－360X(2005)10－78－03

0 序 言

随着电子封装的密度越来越高，引脚数多、间距细的器件(如球栅阵列封装 BGA、四边扁平封装器件 QFP(以下均用“QFP”来简称)、芯片级封装 CSP)的使用将成为主流产品[1]，在实际生产中四边扁平封装器件 QFP器件的使用更为普遍。由于 QFP器件的焊点既起到电气连接作用，同时起到机械连接的作用[2]。在正常工作条件下，QFP器件经常处于温度循环负载中，长期的温度循环负载会在引脚处焊点产生周期性的应力应变过程，导致焊点开裂。其开裂机理主要是温度循环过程中 QFP器件基板和 PCB板材料之间的热膨胀系数(CTE)失配、钎料微结构和金属间化合物层厚度的变化，出现不同程度的裂纹(断裂)，从而导致器件失效[3]，所以 QFP器件的可靠性研究十分重要。影响焊点的可靠性的因素较多，但焊点强度是能直接反映其可靠性的指标之一[4]。

通常焊点强度的评价方法，主要使用拉伸试验、三点弯曲试验或四点弯曲试验，以及剪切试验等[5]，但是这些试验都是基于常规的宏观试验(试件)进行的，与焊点直径 0.30～1.00 mm的微焊点强度有较大差距。由于 QFP四边有翼形引脚，引脚间距特别小(一般为 1.00 mm、0.40 mm、0.30 mm等)，必须采用微焊点拉伸试验来评价其强度才能准确地反映其真实性。作者选择日本 RHESCN公司生产的微焊点强度测试仪(STR－1000)来测试 QFP器件的抗拉强度，较为准确、真实地反映了其力学性能特性。

收稿日期：2005－03－30

1 试验设备及工作条件

STR－1000是一台专门针对表面组装元器件(SMD)的微焊点(或引脚)强度试验、印制电路板耐久弯曲试验以及其它多种力学性能测试的试验仪器。它能测试拉力、推力、剥离、剪切等多种强度，配合数据软件具有自动计算、保存、分析的功能。主要由测定部主机、传感器(剪切、抗拉)、剪切用刀具、拉力用针钳、钩针、双眼实体显微镜(LCD)、推力用工具、倾斜工作台、拉力用夹具(熔融 BGA、非熔融 BGA)等部件构成，如图 1所示。它的主要工作原理是，测试时，钩针(或推刀)与受试工件产生的力通过传感器传到 STR－1000的主机内，再通过数据线传输到计算机内的软件中，自动绘制成曲线和输出所需数据。STR－1000测试仪的正常工作条件为工作电压 100 V(50～60 Hz)，温度 15～30 ℃，相对湿度 40%～80%。由于它的测试精度较高，工作场所或工作台应该具有防碰撞、防震动的功能。

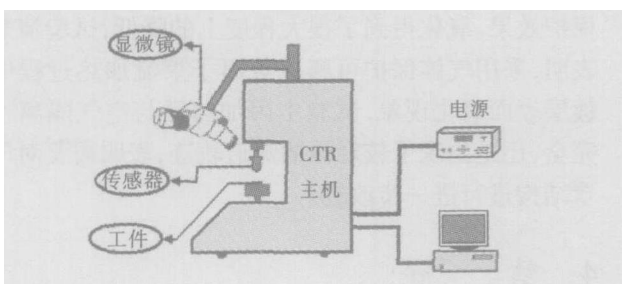

图 1 系统组成
Fig. 1 Schematic of system

将 45°倾斜的工作台安装好,将 QFP组件安装在倾斜的工作台上,选用直径合适的钩针进行测试。设定合适的工作参数,借助双目体视显微镜观察,将钩针置入引脚间距中,然后进行引脚拉伸试验,系统自动输出拉伸曲线。根据以下的公式可计算出抗拉强度为

$$\sigma_b = \frac{F}{A},$$

式中:σ_b为焊点的抗拉强度;F为焊点的抗拉力;A为 QFP的引脚焊接面积,A=引脚宽×结合长度。

QFP、SOP测试方法如图 2所示。图 2a为 QFP的 J形引脚的抗拉强度测试简易图;图 2b为钩针下降并刚进入引脚的操作图;图 2c为钩针继续伸入引脚处并刚好钩住一个引脚的操作图;图 2d为刚拉断引脚时的操作图。试验是通过选择不同成分不同间距的 QFP焊点进行抗拉测试试验,其试验结果如表 1所示。

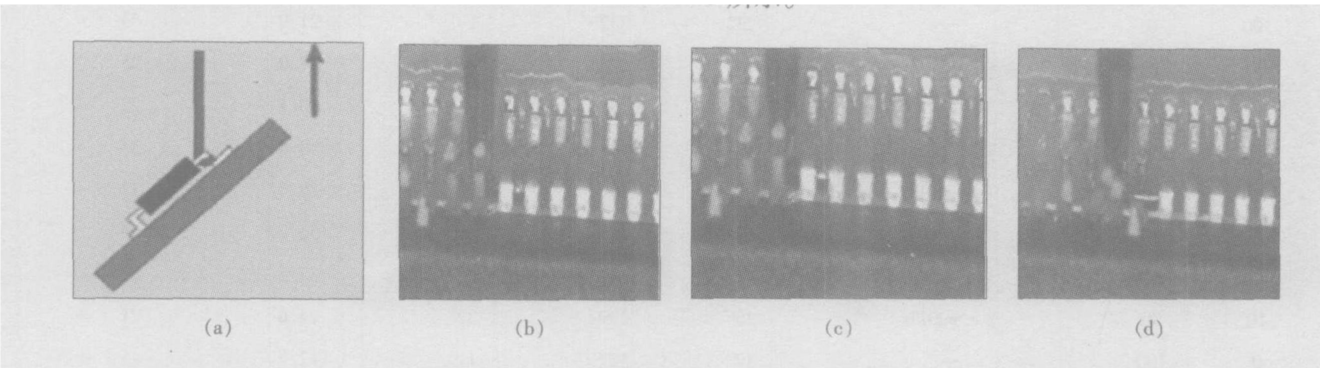

图 2　QFP拉伸试验测试方法

Fig. 2　Tensile test of quad flat pack

表 1　QFP和 SOP的微焊点强度试验结果

Table 1　Experimental results of micro-joints strength of QFP and SOP

测定速度 5 mm/min						
试料	SnPb共晶钎料(Sn63-Pb37)			纯 铅(Pb)		
测定值(gf)	0.5 mm	0.8 mm	1.2 mm	0.5 mm	0.8 mm	1.2 mm
1	1 233.0	2 594.0	2 750.0	1 342.0	2 650.0	3 200.0
2	1 196.0	2 459.0	2 761.0	1 350.0	2 750.0	3 452.0
3	1 168.2	2 531.2	2 821.0	1 451.2	2 950.0	3 109.0
4	1 371.2	2 581.0	2 901.0	1 421.8	2 850.0	3 004.0
5	1 316.0	2 456.0	2 793.2	1 365.0	2 820.0	3 462.0
面积 A/mm²	0.5×0.5	0.8×0.5	1.2×0.3	0.5×0.5	0.8×0.5	1.2×0.3
钎缝 σ_b/MPa 平均值	50.27	63.10	77.92	55.44	70.10	90.1011
钎料 σ_b/MPa	–	11	–	–	41～50	–

2　试验结果分析

表 1表明,同一成分不同间距的 QFP焊点的抗拉强度有明显区别。从表 1中还可以看出,QFP/SOP焊点间距越大,破坏焊点所需的拉力也越大,焊点抗拉强度越高。其原因是由于间距越大,QFP/SOP的引脚直径(焊点直径)也变大,与基板的接触面积也越大,钎料与基板和元器件端头的相互作用也越大,所需的拉力就越大,抗拉强度也越高。通过 Sn-Pb共晶钎料(Sn63-Pb37)和纯铅(铅作为钎料)与 QFP引脚及基板的结合强度比较,可知 Sn-Pb共晶钎料的结合强度比纯铅的结合强度低。

有研究表明[6],各种成分的 Sn-Pb钎料(不含其它元素,如锑,铋等)的抗拉强度等力学性能均不太高,如表 2所示,但是微焊点强度明显高于常规宏观试验(试件)的抗拉强度(见表 1)。

表 2的数据可以通过绘制成曲线来进一步分析成分与强度的关系,如图 3所示。在图 3中可以清晰地看出,纯锡或者纯铅的抗拉强度比任何锡铅合金的钎料的强度都低[7]。比较表 1、2的抗拉强度数据,可以很明显地看出实测的微焊点强度比锡铅合金钎料的强度高。研究结果表明,由于微焊点强度测试仪测定的焊点强度更加准确、真实地反映了微焊点的力学性能特性,因此对于钎料与基板和元器

件端头的结合强度(微焊点强度)显著高于钎料自身强度的现象,值得深入地研究。对这一问题的深入研究,将对 QFP /SOP焊点可靠性的研究提供一个先进的研究手段和更为合理的研究方法。

表 2 锡铅钎料的物理性能和力学性能

Table 2 Physical and mechanical properties of tin-lead alloys

钎料成分 (质量分数, %)		国产钎料牌号	熔点 T /℃		抗拉强度 σ_b /MPa	抗剪强度 τ /MPa	伸长率 δ(%)
Sn	Pb	GB /T 3131 - 2001	固相线	液相线			
100	0	-	232	232	19	21.9	43
90	10	S -Sn90Pb	183	220	43	27.0	25
80	20	-	183	208	45	50.1	22
62	38	S -Sn63Pb	183	183	41	43.4	34
50	50	S -Sn50Pb	183	209	36	35.4	32
40	60	S -Sn40Pb	183	235	32	36.7	63
33	67	-	183	250	32	33.5	66
10	90	S - Sn10Pb	265	299	32	24.6	21
0	100	-	327	327	11	12.7	45

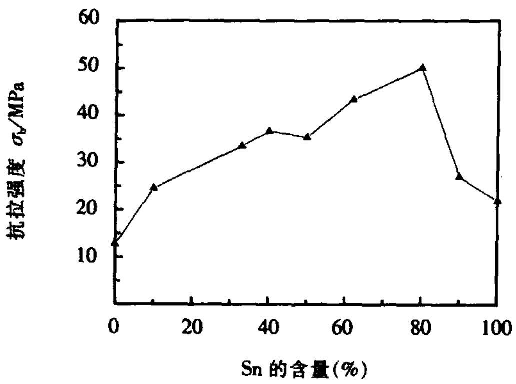

图 3 锡铅合金的抗拉强度

Fig. 3 Tensile strengths of tin-lead alloys

3 结 论

(1) 用锡铅合金作钎料的 QFP焊点抗拉强度比用铅的焊点抗拉强度小;不同间距的 QFP焊点抗拉强度也不一样, QFP引脚间距越大,其抗拉强度也越大。

(2) 比较 QFP的抗拉强度和锡铅钎料的抗拉强度数据, QFP引脚的结合强度大于锡铅合金钎料自身的抗拉强度。

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Abstract: One technological problem about the weak combination of interface between Cr plating layer and substrate which was strengthened by plasma had been put forward according to the application state of under serious ablation and erosion by hot chemical airflow. The technology using distransfer plasma to heat the steel workpiece with Cr plating layer at high speed was used to strengthen interface bonding between Cr plating layer and substrate. The principle of strengthening with plasma was introduced in this paper and the process experiment of strengthening with plasma arc was carried out. The experimental results measurement and analysis show that the metallurgical bonding has occurred between Cr plating layer and substrate and the strengthening of interface bonding between Cr plating layer and substrate is improved remarkably.

Key words: plasma beam; plating layer; interface strengthening; metallurgical bonding

Study on strength of soldered micro joints of QFP devices HU Yong-fang[1], XUE Song-bai[1], YU Sheng-lin[2] (1. College of Materials Science & Technology, Nanjing University of Aeronautics & Astronautics, Nanjing 210016, China; 2. 14th Research Insitute, China Eletronics Technology Group Corporation, Nanjing 210013, China). p78 – 80

Abstract: Tensile strength of the quad flat pack (QFP) devices were determined by STR-1000 Joint Strength Tester and compared with the joints soldered with different pitches and different solder compositions QFP and SOP (small outline package). The results indicate that for the same solder compositions, the wider the pitch is, the larger the pulling force is, i. e. the higher the tensile strength is. The tensile strength of soldered joints of QFP with pure lead is higher than that of eutectic solder and as well and as higher than that of eutectic solder itself.

Key words: tensile strength; quad flat pack (QFP); eutectic solder

Reliability of CBGA soldered joint under thermal cycling XUE Song-bai[1], HU Yong-fang[1], YU Sheng-lin[2] (1. College of Materials Science & Technology, Nanjing University of Aeronautics & Astronautics, Nanjing 210016, China; 2. The 14th Research Insitute, China Eletronics Technology Group Corporation, Nanjing 210013, China). p81 – 83

Abstract: Thermal fatigue life of ceramic ball grid array (CBGA) devices under thermal cycling conditions was presented in −55 ℃ ~ 125 ℃. Failure mechanism of the soldered joints including the germinating position and expanding direction of the cracks were observed and analyzed by optical microscopy. Results show that the crack in soldered joints germinats in the borderline all around the outmost solder balls. With the increasing of thermal cycling times, the cracks expand from the borderline of outmost solder balls to the ball center along the interfaces. It is found that the germination and expanding of the micro-cracks are caused by highly concentrated stress and strain as well as interaction between thermal cycling and creep.

Key words: thermal fatigue life; BGA; crack; thermal cycling

Low cycle fatigue property of TA5 titanium alloy welded joint YAN Keng, ZHANG Pei-lei, JIANG Cheng-yu (Province Key Lab of Advaued Welding Technology, Jiangsu University of Science and Technology, Zhenjiang Jiangsu 212003, China). p84 – 86

Abstract: The low cycle fatigue property of TA5 Titanium alloy welded joint with different reinforcement was investigated. The result shows that the increasing of weld reinforcement decreases the low cycle fatigue life of welded joint when the TA5 titanium alloy welded joint is working in the strain value is less than 0.35%. When the strain value is higher than 0.35%, the rule is not obvious. In high stress strain condition, the low cycle fatigue life of TA5 Titanium alloy welded joint is under the circulatory hardening, and in low stress strain condition, its circulatory hardening property is not obvious. The expression of the circulatory stress strain of welded joint and the low cycle fatigue life of its smooth sampling were shown.

Key word: titanium alloys; welded joint; low cycle fatigue

Microstructures and properties of 7A52 aluminum alloy welded joint by twin wire welding YU Jin, WANG Ke-hong, XU Yue-lan, LIU Yong (Department of Materials and engineering, Nanjing University of Science and Technology, Nanjing, 210094, China). p87 – 89

Abstract: 7A52 aluminum alloy was welded by using 5A56 filler with twin wire gas shielded arc welding. The mechanical properties and microstructure of welded joint were studied. The results show that the weldability of 7A52 aluminum alloy is good. The weld zone is the weakest in welded joint due to effects of chemical components of filler and crystallization process. Therefore twin wire gas shielded arc welding of medium and thick 7A52 aluminum plate can obtain excellent welded joint.

Key words: 7A52 aluminum alloy; twin wire gas shielded arc welding; welded joint; microstructure

Effect of diode laser parameters on tensile strength of QFP micro-joints YAO Li-hua, XUE Song-bai, WANG Peng, LIU Lin (College of Materials Science and Technology, Nanjing University of Aeronautics and Astronautics, Nanjing 210016, China). p90 – 92

Abstract: Soldering technology for quad flat pack devices (QFP) were studied by means of 90W diode-laser soldering system and the mechanical properties of micro-joints of QFP were compared with different laser power. Results indicate that diode-laser soldering can obviously improve both the tensile strength of the joints with Sn-Ag-Cu solder and the strength of the joints with Sn-Pb solder. The diode laser output power directly influences the tensile strength of the micro-joints of QFP with the same solders. These results will provide a good method for improving the