Development of the Copper Core Balls Electroplated with the Solder of Sn-Ag-Cu

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Abstract

We developed the copper core ball electroplated with Sn-Ag-Cu of the eutectic composition which used mostly as Pb free solder ball with high reliability. In order to search for the practicality of this developed copper core ball,the evaluation was executed by measuring the initial joint strength of the sample mounted on the substrate and reflowed and by measuring the joint strength of the sample after the high temperature leaving test and the constant temperature and the humidity leaving test. This evaluation was compered with those of the usual other copper core balls electroplated with (Sn,Sn-Ag,Sn-Cu,Sn-Bi) and the Sn-Ag-Cu solder ball.

Keywords : copper core ball electroplated the solder of with Sn-Ag-Cu, UDS(Uniform-Droplet Spray)method j oint strength, BGA(ball-grid array), CSP(chip-scale packaging)

1. Introduction

Recently, the higher density mounting is demanded at the same time as shift to Pb free in the electronic materials. We developed the copper core ball electroplated with the Pb free solder for the correspondence to these demands. The copper core balls are possible to use similar to the solder balls used for BGA and CSP. In addition, these have the following advantages. First, the copper ball as the core part remains like the shape of ball without melting, though the solder on the surface of copper ball was melted at reflowing on the substrate**.** The clearance between the substrate and IC can surely be maintained by this advantage. Secondarily, the excellent electric characteristic and the heat radiation with copper as the core part are reflected in the parts such as BGA and CSP packages.

However, it is a current state that the copper core ball electroplated the solder of with Sn-Ag-Cu [copper core ball (SAC)] has not been developed and the copper core balls electroplated with (Sn , Sn-Ag) are used, though the solder of Sn-Ag-Cu is mainly used as Pb free solder now.
The reason why the copper core ball (SAC) has not been developed is considered that the control of the electroplating bath of ternary alloy system is difficult.

First of all, we developed the copper core ball (SAC) by examining the electroplating of Sn-Ag-Cu on the surface of the copper ball. Afterward, the evaluations of this copper core ball (SAC), the Sn-Ag-Cu solder ball [SAC solder ball] and the usual other copper core balls electroplated with (Sn,Sn-Ag,Sn-Cu,Sn-Bi) were compared.

2. Expermental methods and Results

As the copper ball for electroplating ,the spherical ball of 450 μm in the diameter made by the UDS (Uniform-Droplet Spray) method was used .This is the method of breaking up the melt while imposing regular perturbations on the jet ejected by gas pressure from orifice in the bottom of the crucible. In addition, these droplets are charged as they break up the jet to prevent their merging. [1)]
This copper core ball (SAC) ball was electroplated in the high-speed rotation barrel plating apparatus by using the electroplating bath having the composition as shown in Table 1. DAIN TINSIL SBB-MUⅥ(Sn), DAIN TINSIL AGM-10(Ag) and the organic acid copper(Cu) were selected as the each liquid of electroplating bath of Sn-Ag-Cu. These all were made of Daiwa Fine Chemicals Co., Ltd.

As shown in Table 1, the composition of electroplated layer on the surface of the copper core ball (SAC) was considerably obtained the near eutectic composition of Sn-Ag-Cu from the analysis result of ICP(Atomic Emission Spectrometer).

Table 1. Composition of bath and analysis result of the electroplated layer

Comptision of bath (g/l)		Analysis result of the electroplated layer (%)
Sn	14.4	Bal
Ag	2.0	3.72
Cu	3.0	1.01

After electroplating, the copper core ball (SAC) were washed, rinsed and dried. The cross-section of the copper core ball (SAC) is shown in Fig.1. This copper ball was mounted on the substrate and reflowed at 250℃, in the atmosphere of nitrogen.

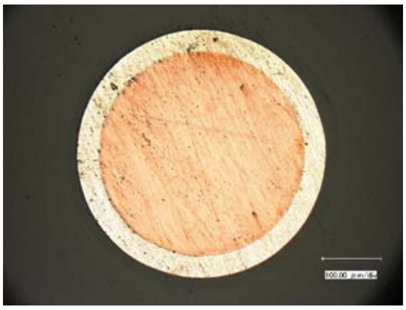
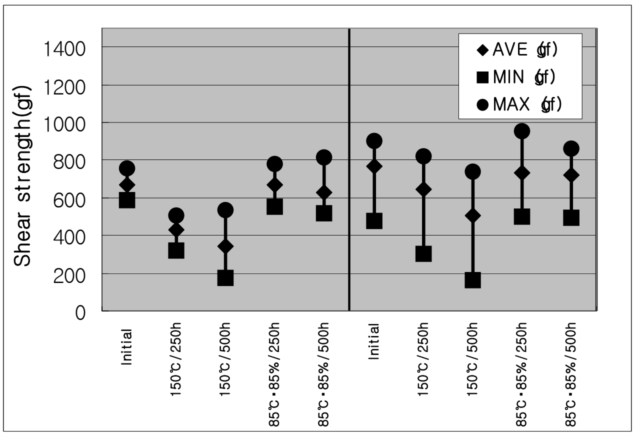


Fig. 1. Cross-section of the copper core ball (SAC)

As the reliability evaluation, the initial joint strength of the reflowed samples were measured by the shear strength, and then the joint strengths of this samples were measured after the high temperature leaving test and after the constant temperature and humidity leaving test .The former test was done at 150℃ and the latter test at 85℃ in 85%. The leaving time of the each tests was 250h and 500h. And for comparison, these same evaluation of the usual other copper core balls (Sn, Sn-Ag, Sn-Cu, Sn-Bi) and the SAC solder ball were carried out. And the cross-section of these joint interfaces was analyzed by EPMA.



Copper core ball (SAC)   SAC solder ball

Fig. 2. Initial shear strength and shear strength after leaving tests of copper core ball (SAC) and S AC solder ball.

The initial shear strength and the shear strength after each leaving tests of copper core ball (SAC) and SAC solder ball are shown in Fig 2. And the average shear strengths of the other copper core balls in addition the above two kinds of the balls are shown in Table 2.

Table 2. Average shear strength of the various balls

kind of Cu core and solder ball	Initial	High Temp. (150℃)		Const Temp/Humi. (85℃/85%)	
		After 250h	After 500h	After 250h	After 500h
Cu core(SnAgCu)	670	429	341	668	629
Sn-Ag-Cu solder	769	643	504	734	719
Cu core(Sn)	692	469	313	708	701
Cu core(SnAg)	676	370	362	634	637
Cu core(SnCu)	740	335	299	693	672
Cu core(SnBi)	848	-	-	778	754

(Unit:gf)

3. Summary

1) The electroplating bath which was able to electroplate the layer having the near eutectic composition of Sn-Ag-Cu on the surface of copper ball which made by UDS method was found.
2) The initial joint strength of the copper core ball (SAC) is a little inferior to that of the SAC solder ball. But, the strength scatter of the former ball was smaller than that of the latter ball.
3) After each leaving test of the above two kinds of balls, the decrease of the joint strengths confirmed. But the strength scatter of the copper core ball (SAC) was smaller than that of the SAC solder ball.
4) On the balls of all type, the strengths after the high temperature leaving test decreased more than the strengths after the constant temperature and humidity test.
5) In the comparison with the copper core ball (SAC) and the copper core balls (Sn,Sn-Ag,Sn-Cu),the chenge of the strength after the each leaving tests showed the similar tendency.
6) By the EPMA mapping image, the intermetallic compound precipitation of Ag-Sn was cofirmed in Sn-Ag-Cu matrix of the copper core ball (SAC) and the growth of the intermetallic compound layer of Cu-Sn was confirmed on the interface of the copper core and the solder, after both leaving tests.

4. Reference

1. S.Imae,H.Lu,M.Nisida,O.Kajita,T.Ando,J.H.Chun: Proceedings of 2000 P/M World Congress p.390(2000).