

The Activator Optimization of Low-temperature SnBi Lead-free Solder Paste

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Abstract. The optimization of activator used in SnBi lead-free solder paste were carried out by welding experiments with the spreadability and the spot morphology as the main comment indexes. And the properties of the composite activator which was mixed by two activator possessing good performances were studied. The results indicated that the pastes with succinic acid and salicylic acid for as single activator have low wettability, the surface is easily oxidized; When (succinic acid : salicylic acid) is 2:3, the solder paste has good weldability and the spreadabilities are 83%. The appearance of spots is regular, plump, beamy and less surface oxide.

Introduction

Lead-free solder paste is the key to the electronic product surface assembly welding materials, the development of its support of the flux has become an urgent task in the field of electronic assembly surface [1]. Flux at home and abroad is composed by the activator, solvents, film former, surfactant, anti oxidant and corrosion inhibitor ect [2]. Activator is used to remove the pad and the solder surface oxides in the brazing temperature, so as to improve the wettability between solder and pad, and prevent oxidation during reflow soldering before solder joints were formed [3]. Activator is choiced by three main ways that include the experiment of heating quality analysis, the combination of different organic acids and the combination of organic acid and organic amine [4]. It is that good performance of organic activator was optimized by the experiment of heating quality analysis, then properties of single activator and compound activator were studied.

Experimental And Materials

The Preparation of Flux

The weighed 33% rosin, 10% activator (succinic acid, salicylic acid), solvents (tetrahydrofurfuryl alcohol, isopropanol, ethanol, diethylene glycol monobutyl ether), regulator triethanolamine, 0.6% inhibitor BTA, 2% surfactant sodium lauryl diethylene glycol ether, 0.4% hydroquinone antioxidants were leted into beaker with certain ratio. The beaker was covered with fresh-keeping film, which was heated and stirred on constant temperature magnetic stirrer, and cooled to room temperature formed the flux finally.

The Paster of Flux

Accurately weigh Sn42Bi58 alloy powder and flux according to the ratio of 8 : 1, which pour into 50mL beaker and stir 5min with a glass rod, so that the solder powder and flux are fully mixed evenly and then standing 3min, solder paste was made.

Flux Performance Testing

1) The Stability of The Flux

Under room temperature, the flux is a transparent light yellow viscous liquid with a certain viscosity. The flux is stirred for several minutes, so that it is fully mixing. Then taked 50 ml sample into the 100 ml tube, which is covered tightly and leted in the cooler cooling to (5 + 2) °C keeping 60 min, and then observe under this temperature flux that have obvious stratification or crystal

precipitation phenomenon. Open the tube cover, the sample is puted in without air circulation oven, under $(45 \pm 2) ^\circ\text{C}$ keeping 60 min. Then the flux is no delamination was observed at this temperature . Thus, the flux has good stability.

2) Determination of Non-volatile Materials[5]

Non-volatile Materials refer to the content of the solid residue flux at a certain temperature. Accurately weighed the 6g flux (m_1), which was dropped into a volume of 25 ml in the melting pot and heated in boiling water bath so that most of its solvent was evaporated. Puted the flux in $(110 \pm 2) ^\circ\text{C}$ ventilation oven and dried within 4 h, which taked out and placed in a drying oven for cooling to room temperature, which dried and weighed repeatedly until the error is kept within ± 0.05 g as a constant, this specimen quality is m_2 .

Were done in both samples , the average value of flux is non-volatile matter content value .

Mamely: $W = m_2/m_1 \times 100\%$

Type: m_1 is the initial mass of the sample ; m_2 is constant when the quality of the sample after drying

3) Non-viscosity Test[5]

Flux is coated on the the copper (50mmx50mmx0.5mm) , where chalk ash were spreaded on and wiped with gauze. It is indicated that the non-viscosity of flux is eligible if the copper has no traces of gauze.

Spreadability of Paste Test[6]

The copper test piece was cut 30mmx30mmx0.5mm flat , with a # 500 sand paper to remove the oxide film , which is polished with a polishing paste, and then cleaned with ethanol and dried in oven.

The copper piece was placed in a temperature of $(150 \pm 2) ^\circ\text{C}$ in the oven oxidation of 1h, all specimens should be placed on the same level of the oven .Taked proper solder paste with a glass rod on the copper, which puted on scale to photo, and placed 250°C high temperature box type resistance furnace. After holding 5min, it was taked out cooling to room temperature in the air and put on scale pictures.

The photos were upload to computer, which clipped with Microsoft office Word, and then imported AutoCAD in orde to determinate spreading area utilizing query function of AutoCAD. Finally, spreadability of flux was calculated.

Results And Discussion

Physical Properties of Flux

It shows that the impact of single activator and compound activator on the properties of flux from Tab.1

As can be seen from Tab.1, the flux was prepared by single activator or compound activator, which has weak corrosion, qualified non-viscosity and non-volatile materials that can satisfy GB/T15829-1995 "soft soldering using fiber material " requirements, wherein the fraction of non- volatile matter content is not more than 15% [7] .

Tab.1 The testing results of physical properties of flux

number	mass ratio of activator succinic acid: salicylic acid	stability	corrosion	non-viscosity	non-volatile materials/%
a	1:0	non delaminating	less	qualified	5.5
b	0:1	non delaminating	less	qualified	5.2
c	2:1	non delaminating	less	qualified	4.9
d	3:7	non delaminating	less	qualified	4.6
e	4:1	non delaminating	less	qualified	5.3
f	2:3	non delaminating	less	qualified	4.7







The Influence of Activator Ratio on The Welding Performance of Solder Paste

As can be seen from Tab.2, Solder paste were with single activator, which has poor wettability, low spreadability and many residue;while solder paste prepared with compound activator has good wettability, of which spreadability can reach 83% ,and bright spot and regular morphology.

It is because that single activator difficult to play activity in the whole welding process, whole different boiling point of compound activator can make the flux with different activation temperature gradient; low-temperature activator has activity in welding at low temperature, which can induce and stimulate high-temperature activator, so that the activator in the welding of the whole temperature range has active [8].

However , the greater ratio of succinic acid , the more the residue around the solder joints in complex formulation ; It caused the solder joint with defects and increased non-volatile materials of flux. Comprehensive consideration, the most suitable ratio of succinic acid and salicylic acid is 2:3 or 3:7.

Tab.2 Morphology of solder joint prepared with different proportion of Activator

activator	A	B	C	D	E	F
Morphology of solder joint						
Spreadability /%	68.2	76.3	72.6	81.4	79.7	82.7

The Microscopic Influence of Activator Ratio on Interface Layer of Solder joint

It can be shown from Fig.1 that activator ratio has great influence on the reaction layer of solder joints .Perpared Solder is with a, b, f group formula, of which diffusion layer of solder joint was flat and smooth, no obvious hole and crack defects, but spreadability of a, b, f group is poorer; Solder perpared with c、 d、 e group formula, of which diffusion layer of solder joint is not flat and there are cracks, holes.

It can be seen from Fig.1 and Tab.3 that the interface layer between the brazing solder and the Cu layer of the substrate is 3, A interface of the substrate layer is a Cu layer, a high atomic concentration of Cu ; B layer is closed to the copper substrate ,where solder and Cu substrate have been reaction in the process of welding, Sn and Cu atomic are interdiffused so as to generate IMC.It has been studied that the IMC is Cu₃Sn[9].C layer is fiber material layer, where Cu substrate metal is dissolved to fiber;It shows that the element diffuse fully and the fiber material spread well on the surface of Cu substrate during welding process.

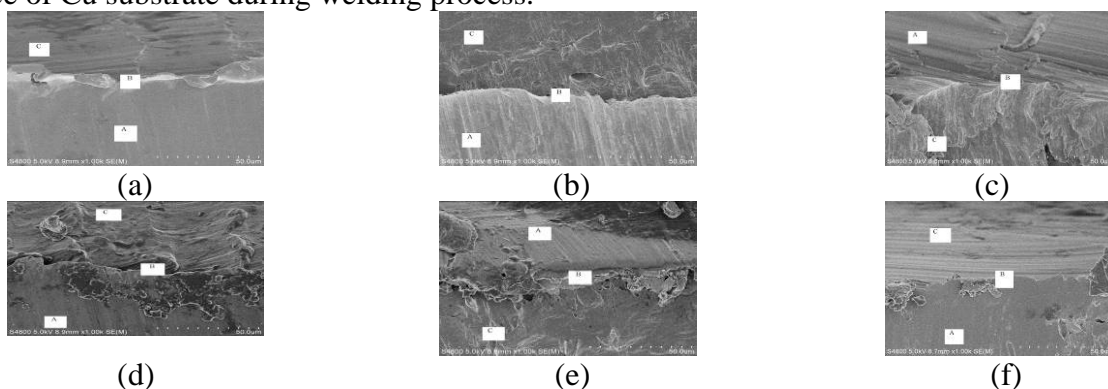


Fig.1 SEM photos of solder joint prepared by different ratio of activator

Tab.3 The energy spectrum analysis of solder joint cross section

element	A		B		C	
	wt/%	at/%	wt/%	at/%	wt/%	at/%
Cu	100	100	60.43	74.02	19.65	17.25
Bi	0	0	31.98	6.43	59.64	63.31
Sn	0	0	7.59	19.55	20.71	19.44

Therefore, when succinic acid :salicylic acid=2:3 in activator,Sn42Bi58 solder has best spreadability and weldability on Cu substrate.

Conclusion

(1) When the rosin, solvents, corrosion inhibitors, surface active agent are added quantitatively in self-flux, performance of solder prepared with compound activator is superior to single activator. The solder paste has good spreadabilities, full solder joint and few non-volatile materials.

(2) When the mass ratio of compound activator of succinic acid and salicylic acid is 2:3, solder joint of welding is smooth and good welding quality; Spreadability of prepared SnBi solder paste can reach 83% on the copper plate.

(3) Showed from the cross section morphology of solder joint, which solder alloy and the substrate occur reaction-diffusion and generate IMC layer resultly.

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