Lead-free Program in Mitsubishi Semiconductor (IC)

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Mitsubishi Electric Corporation Semiconductor Group Manufacturing Technology & Production Management Div.
Assembly Engineering Dept. System LSI Package Technology Sect. Quality Management Dept. Quality & Reliability Engineering Sect.

1) Lead elimination program

a) Mass production of Lead-free products has been started from 2001/4, and it will be increasing during 2002 and 2003.

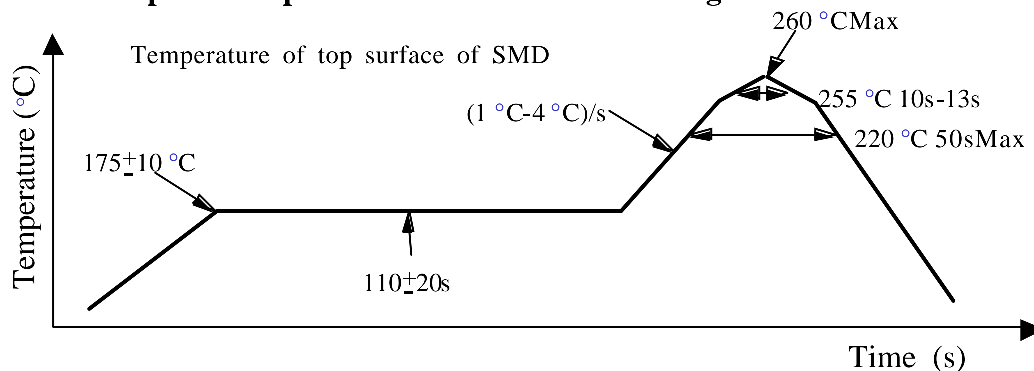
b) Basic evaluations (external inspection , solderability , wetting etc.) and reliability tests (high temperature storage, temperature cycling etc.) of Lead-free lead finish materials have been finished. From these evaluations, we have selected Sn-1.5Cu for the lead finish plating material.
The stability evaluations in mass production line were also carried out and the products in which a final certification was completed are changed to Lead-free lead finish. The Lead-free(Pb-free) lead finish samples are available according to customer requirements.

c) A ball material of FBGA has been fixed to Sn-Ag-Cu. The sample is now available and mass production also started in some products.

d) Moisture sensitivity level (MSL) test profile corresponding to Lead-free soldering was decided as shown in a following section (peak temperature is 260 °C). Using this temperature profile, representative/typical packages were evaluated to obtain an ability of MSL against the peak temperature rise of 20 °C. Some packages show a drop of MSL compared to current MSL against the peak temperature of 240 °C. These packages also need the change of mold compound or frame pattern to keep the same MSL as the current one.

e) We would like to talk over a requirement on MSL with customer individually for each product based on evaluated MSL data.

2) IR reflow temperature profile for Lead-free soldering test



3) Parallel procurement of current product and Lead-free lead finish product

We can not do the parallel production after changing a production line to Lead-free plating.

4) Solder pastes used in our evaluation

We used following three type of solder paste for the evaluation.
Sn-Ag-Cu , Sn-Ag-Cu-Bi , Sn-Zn-Bi

[The mounting evaluation result in a lead free solder plating]

Various evaluations of lead free solder are performed with our company examination condition. The lead free solder plating (Sn-1.5Cu) has enough solderability compared with the conventional article(Sn-10Pb) and it has been confirmed to have the an equivalent level reliability.

Evaluation item	An evaluation sample, material (choosed from the followings for each evaluation item)
1. Solderability 2. Lead free package mountability 3. Junction intensity 4. Whisker generating investigation	(1)Composition of solder paste Melting point (solid/liquid) / Reflow peak temperature [1)] Sn-Ag-Cu 216/220 °C 230+/-3 °C Sn-Ag-Cu-Bi 208/217 °C 230+/-3 °C Sn-Zn-Bi 187/197 °C 220+/-3 °C Sn-Pb 183/183 °C 220+/-3 °C (2) Evaluation frame quality of the material Alloy 42 Cu-Ally (3) Terminal plating composition Sn-1.5Cu Sn-10Pb (the conventional article) (4) Mounting board FR-4 (board thickness:1.2mm) (5) Evaluation package 52 pin TSOP type (0.8mm pitch) package 100 pin QFP (0.5mm pitch)package

1)Solder paste

2-1. Solderability

(1) Pre-treatment

(a) High Temperature 150 °C,16h

(b) PCT 105 °C 100%,4h

(2) Examination method

(a) Wetting balance method (according to MIL-STD-883E method 2022.2)

Soldering bath temperature is 230 °C (Sn-Pb) and 250 °C (Sn-Ag-Cu).

After dipping the specimen into flux, it's immersed in the soldering bath and later removed. The solder meniscus force is measured by the meniscograph apparatus.

(b) Solder dipping method (according to EIAJ ED-4701/303)

Soldering bath temperature is 230 °C (Sn-Pb) and 250 °C (Sn-Ag-Cu). Immersion rate is 25mm/s. Duration is 5s.

After dipping the specimen into flux, it's immersed in the soldering bath and later removed. Visual inspection is carried out by the optical microscopy. (magnification : x40 times)

(3)Criteria

(a) Wetting balance method

Zero cross time (the recorded wetting balance curve crosses the zero balance point) shall be within 3sec.

(b) Solder dipping method

95% or more of the specimen shall be covered with solder and the condition shall be smooth.

The specimen shall not have any concentration of pinholes, voids or other defects at one place, and these defects shall not be accounted for more than 5% of the overall surface.

The specimen shall not have any peeling of solder.

(4)Conclusion

Zero Cross Time is less than three seconds. The solderability is good. Evaluation result is shown Table 1.

Table 1. Solderability evaluation result

(a) Pretreatment conditions 150 °C 16h preservation

Package	Lead pitch	Frame	Terminal plating	Solder paste	Evaluated result				Conclusion
					Wetting balance method			Solder dipping method	
					Max(sec)	Min(sec)	Ave(sec)		
100P6Q	0.5mm	Cu	Sn-1.5Cu	Sn-Ag-Cu	0.4	0.2	0.28	Satisfactory	Sufficient solderability
100P6D	0.5mm	Fe			0.3	0.2	0.28	Satisfactory	Sufficient solderability
100P6Q	0.5mm	Cu		63%Sn-37%Pb	0.4	0.2	0.26	Satisfactory	Sufficient solderability
64P4B	1.778mm	Fe			0.6	0.4	0.50	Satisfactory	Sufficient solderability

(b) Pretreatment conditions 105 °C 100% 4h preservation

Package	Lead pitch	Frame	Terminal plating	Solder paste	Evaluated result				Conclusion
					Wetting balance method			Solder dipping method	
					Max(sec)	Min(sec)	Ave(sec)		
100P6S	0.65mm	Fe	Sn-1.5Cu	Sn-Ag-Cu	0.4	0.3	0.36	Satisfactory	Sufficient solderability
100P6Q	0.5mm	Cu		Sn-Ag-Cu	0.8	0.4	0.56	Satisfactory	Sufficient solderability

2-2. Lead free package mountability

(1) Examination method

All terminals of the mounted device on the PCB with various evaluation pastes are observed with the optical microscope and the scanning electron microscope (SEM).

(2) Criteria

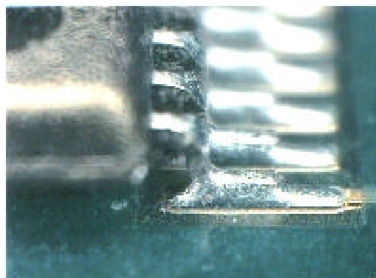
The fillet on the lead must exist.

The lead on the land must be wetted more than 80% in area.

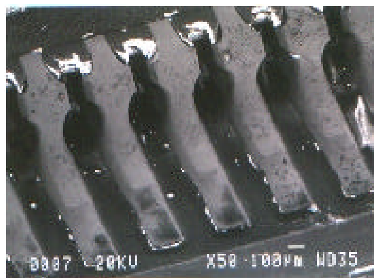
The lead edge (no plating place) is not included in the judgment.

(3) Conclusion

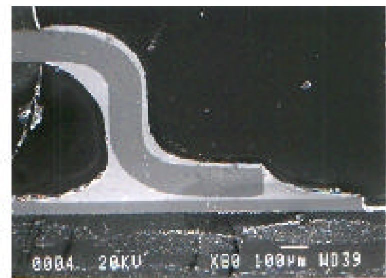
A judgment standard is satisfied. Solder wettability around the lead is good. Formation of the fillet for the lead free solder plating isn't different from the conventional article. A paradigm case, the mounted aspect and the cross section of mounted lead jointed with Sn-Ag-Cu paste are shown in Figure 1.



Mounting aspect
(Optical microscope image)



Mounting aspect
(SEM image)



Cross section of mounted lead
(SEM image)

Fig. 1 Appearance image (the optical microscope, SEM) and cross-sectional image (SEM) after mounting

2-3. Junction intensity

(1) Examination method

A temperature cycle examination (-40 °C to 125 °C) is carried out for mounted device on the PCB with various evaluation pastes in table3. Tension strength of terminals is performed on our company examination condition shown in Fig. 2 on each measurement point.

(2) Conclusion

Change by temperature cycle examination of tension strength of the lead free solder plating (Sn-1.5Cu) is equivalent to the case of the conventional article(Sn-10Pb).(Figs. 3 and 4)

Table3. Examination conditions of various paste and terminal plating.

Composition of solder paste \ Leadframe / plating	Alloy 42		Cu-Ally	
	Sn-1.5Cu	Sn-10Pb	Sn-1.5Cu	Sn-10Pb
Sn-Ag-Cu	○ (1)	—	○ (1)	—
Sn-Ag-Cu-Bi	○ (2)	—	○ (2)	—
Sn-Zn-Bi	○ (3)	—	○ (3)	—
Sn-Pb	○ (4)	○ (5)	○ (4)	○ (5)

○:Estimated the combinations.

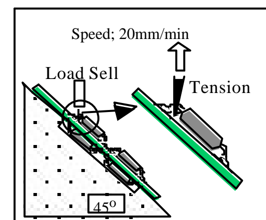


Figure 2. Tension Strength of Terminals

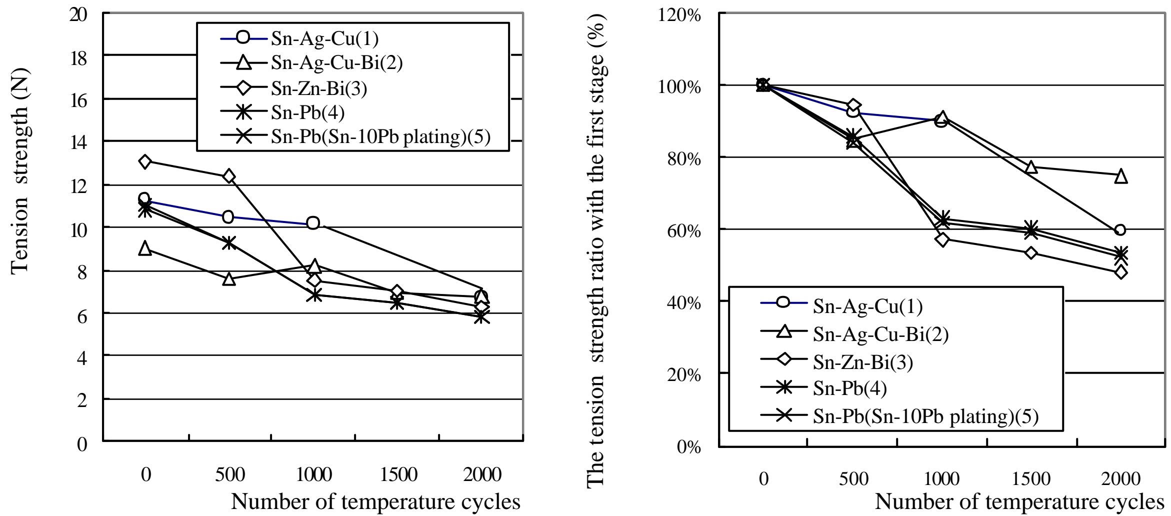


Figure3. The solder joint reliability (alloy 42 Frame)

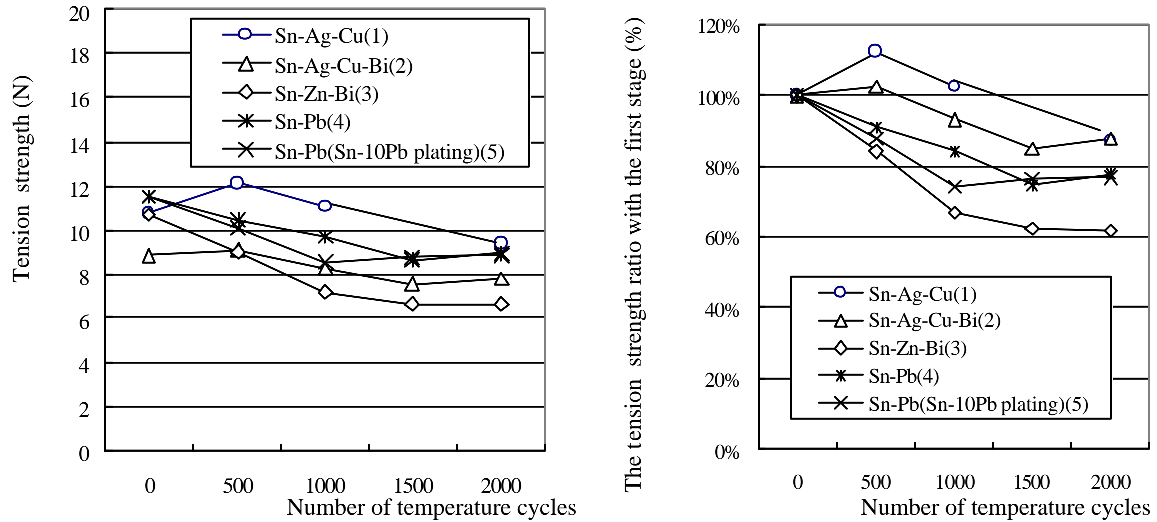


Figure 4. The solder joint reliability (Cu Frame)

2-4. Whisker generating investigation

(1) Pre-treatment

The thermal stress should not be given.

(2) Examination method

a) The storage at 25 °C 60%

b) Temperature humidity storage(85 °C 65%)

The lead free solder plating after an examination is observed with the optical microscope (magnification : x40 times). As the case may be difficult to judge of whisker generating, it is observed with SEM (magnification in the range of 1000 times or more).

(3) Criteria

The whisker shall not occur.

(4) Conclusion

The whisker has not occurred. Evaluation result is shown in Table 3.

Table3. The observational result at several times(Sn-1.5Cu plating).

environment condition	Leadframe	storage time(h)						
		0	240	480	960	1200	1440	1920
25deg.C60%	Cu-Ally	○	○	○	○	○	○	○
	Alloy 42	○	○	○	○	○	○	○
85deg.C65%	Cu-Ally	○	○	○	○	○	○	○
	Alloy 42	○	○	○	○	○	○	○

○: no-whisker
×: appeared whisker