

# *Fujitsu Lead(Pb)-free Package*

*LSI PACKAGING DIV.  
BUSINESS PROMOTION DEPT.*

## *History of Fujitsu Lead-free Package Development Activities*

<b>Lead-free Package Development to Commence</b>	<b>[ April 1998 Completed ]</b>
<b>Customers Application Trend Research</b>	<b>[ Sept 1998 Completed ]</b>
<b>Lead-free BGA Mass Production</b>	<b>[ April 2000 Partially started ]</b>
<b>Lead-free QFP Mass Production</b>	<b>[ Oct 2000 Partially started ]</b>
<b>Target for All LSI Products ultimately Lead-free</b>	<b>[ Dec 2004 ] 100%</b>

## Lead-free Package Definition

### Fujitsu Lead Free Package Specification

Ecologically friendly package with lead being eliminated from its terminal-use material and improved heat resistance.

#### Heat resistance (IR Reflow)

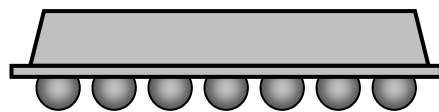
**240°C x 2 Times → 260°C (250°C) x 2 Times**

#### Terminal Material

**BGA = Sn-37Pb (Non Lead-free) → Sn-3.0Ag-0.5Cu (Lead-free)**

**QFP = Sn-10Pb (Non Lead-free) → Sn-2.0Bi (Lead-free)**

BGA package



**Lead-Free  
Solder ball**

Lead frame type package

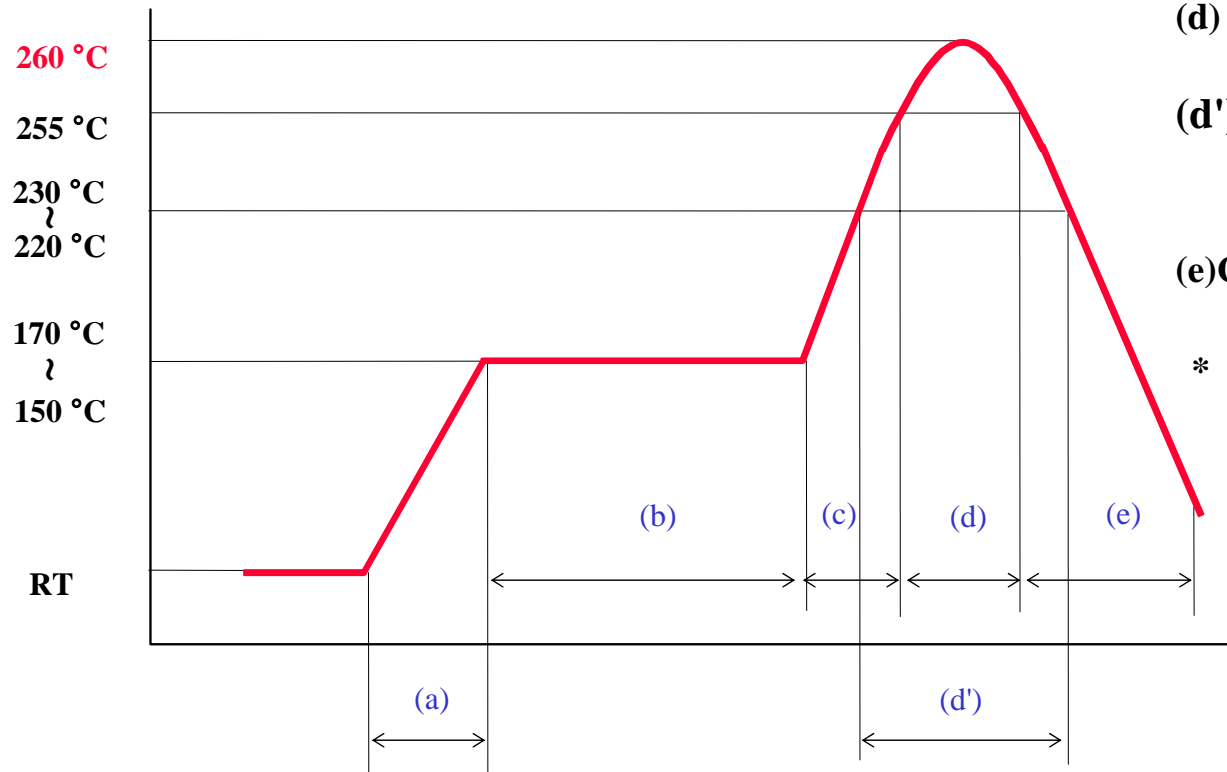


**Lead-Free  
Solder plating**

**Min. 99% Sn 1% Bi  
Typ. 98% Sn 2% Bi  
Max 96% Sn 4% Bi**

## Lead-free Temperature Profile (1)

### H-Rank (Peak temp. 260 °C)

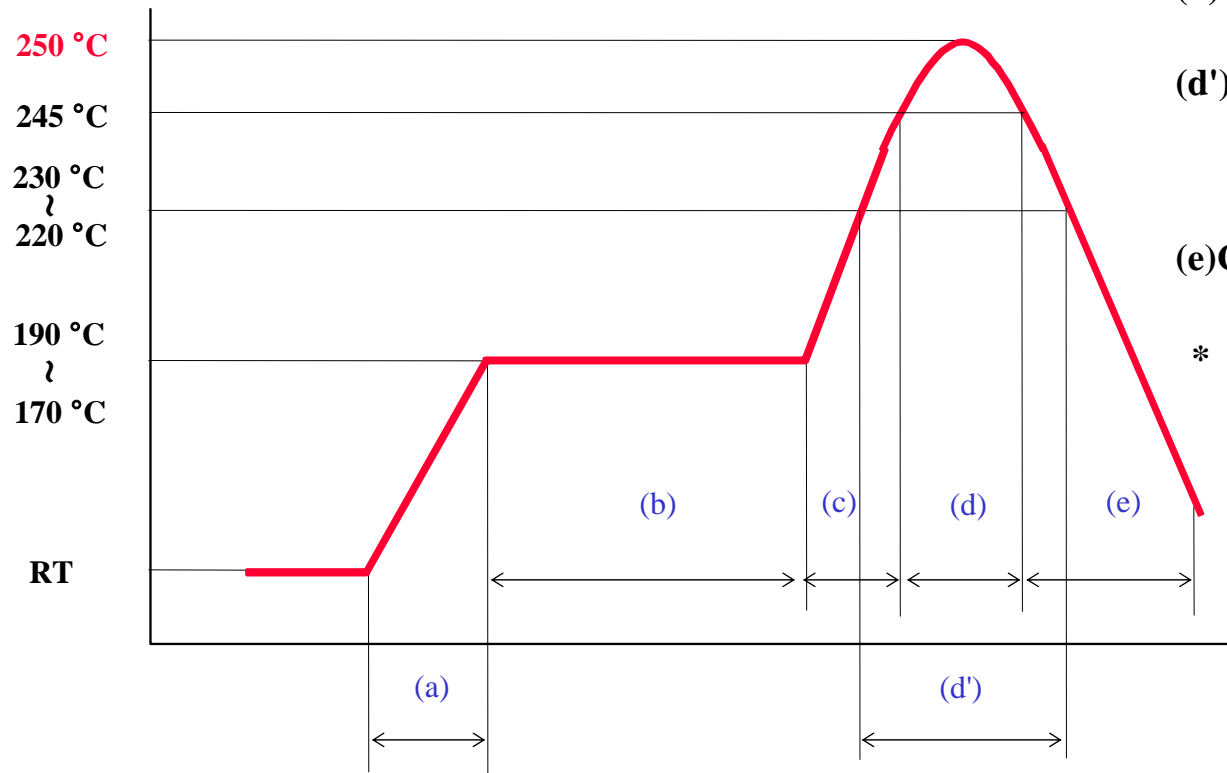


- (a) Temp. inc. gradient : Avg. 1 - 4 °C/sec
- (b) Preliminary heating : Temp. 170 - 190 °C  
60sec ~ 180sec
- (c) Temp. inc. gradient : Avg. 1 - 4 °C/sec
- (d) Actual heating : Temp. 260 °C max.  
255 °C up 10 sec max.
- (d') : Temp. 230°C up 40 sec max. or  
225°C up 60 sec max. or  
220°C up 80 sec max.
- (e) Cooling : Natural Cooling or  
Forced Cooling

\* Package Surface Temp.

## Lead-free Temperature Profile (2)

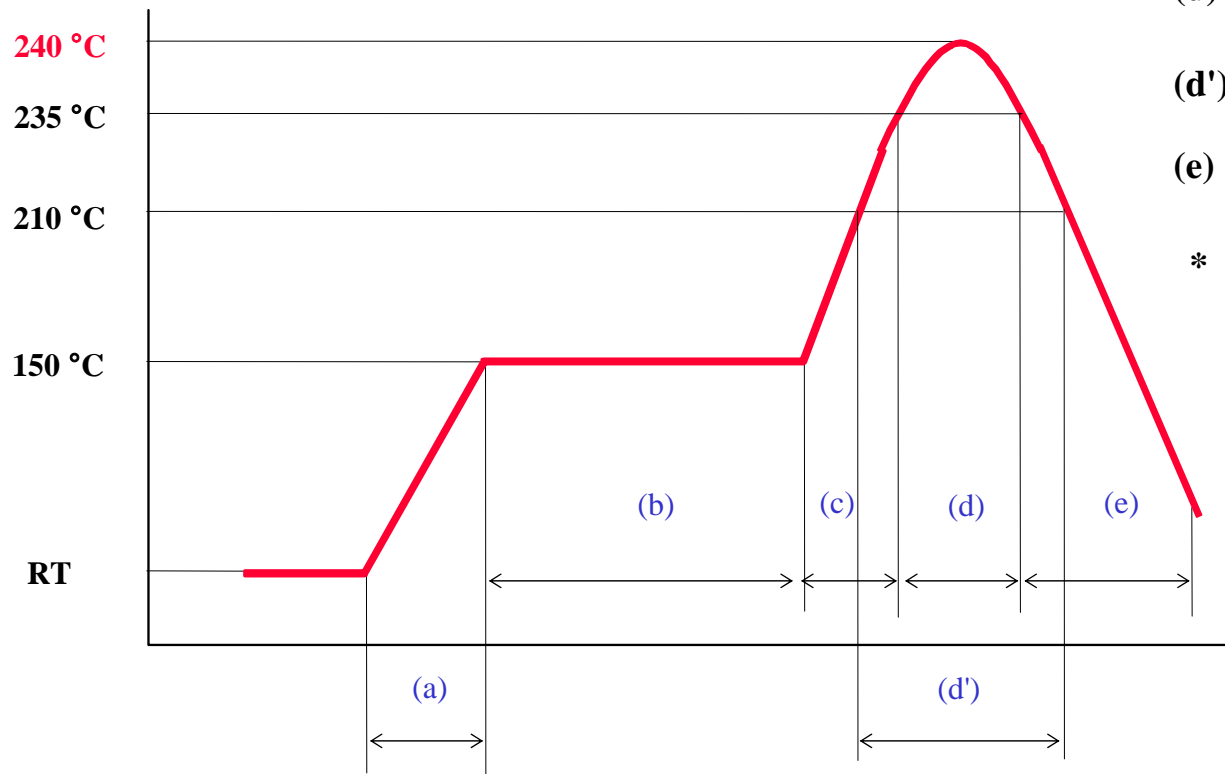
### M-Rank (Peak temp. 250 °C)



- (a) Temp. inc. gradient : Avg. 1 - 4 °C/sec
  - (b) Preliminary heating : Temp. 170 - 190 °C  
60sec ~ 180sec
  - (c) Temp. inc. gradient : Avg. 1 - 4 °C/sec
  - (d) Actual heating : Temp. 250 °C max.  
245 °C up 10 sec max.
  - (d') : Temp. 230 °C up 40 sec max. or  
225 °C up 60 sec max. or  
220 °C up 80 sec max.
  - (e) Cooling : Natural Cooling or  
Forced Cooling
- \* Package Surface Temp.

## Standard Temperature Profile (Reference)

### R-Rank (Peak temp. 240 °C)



- (a) Temp. inc. gradient : Avg. 1 - 4 °C/sec
- (b) Preliminary heating : Temp. 150 - 190 °C  
60sec ~ 120sec
- (c) Temp. inc. gradient : Avg. 1 - 4 °C/sec
- (d) Actual heating : Temp. 240 °C max.  
235 °C up 10 sec max.
- (d') Temp. 210 °C up 40 sec max.
- (e) Cooling : Natural Cooling or  
Forced Cooling
- \* Package Surface Temp.

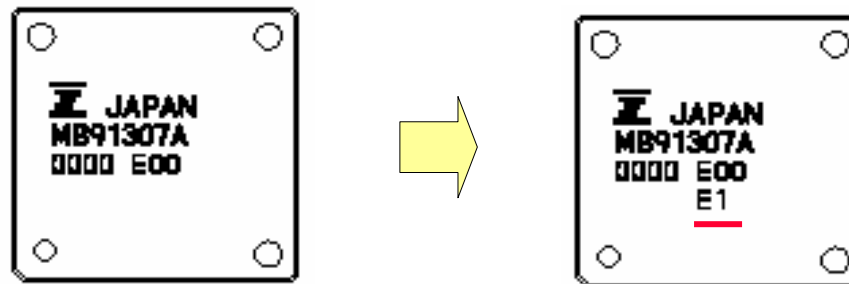
## Discrimination of Lead-free Products

- Part Number : Add “**E1**” to end of full cord

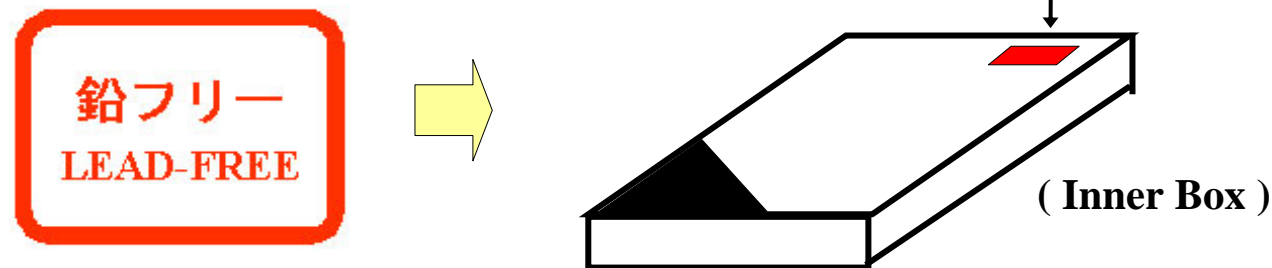
( Ex ) MBM29LV160TE90PBT-JJ     MBM29LV160TE90PBT-JJ**E1**

- Marking : Add “**E1**” to end of marking

\* Correspondence is different in a part of package where the marking space is insufficient.



- Attach lead-free label to mark on aluminum-laminated bag and on inner box



## Heat Resistance Improvement (ongoing)

### Group

GROUP	BGA	QFP/SOP
A:260 °C max	SCSP, FBGA(*1), BCC	SOP, TSOP, TQFP
B:250 °C max	FBGA(*2), PBGA, SMCP	QFP(*1), LQFP
C:240 °C max	FLGA, EBGA, TBGA, SMCP	QFP(*2)

\*1:Small Pin Count  
\*2:Large Pin Count

### Improvement

Item	BGA	QFP/SOP
Material improvement	Substrate material change Die paste change Mold resin change	Die paste change Mold resin change
Structural improvement	-	Die stage structure change Die stage size change

### Result

GROUP	Old PKGs			Improvement PKGs		
	240 °C	250 °C	260 °C	240 °C	250 °C	260 °C
A:260 °C max	OK	OK	OK	OK	OK	OK
B:250 °C max	OK	OK	NG	OK	OK	OK
C:240 °C max	OK	NG	NG	OK	OK	NG



## Evolution of Various Plating Materials

A: Good / B: Modest / C: Poor

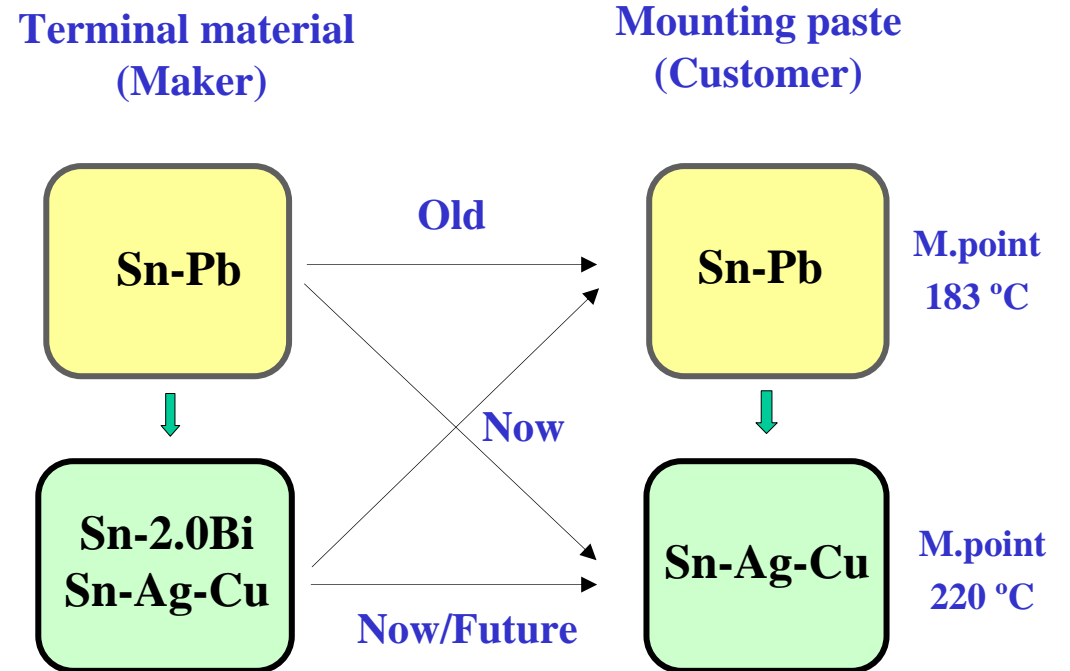
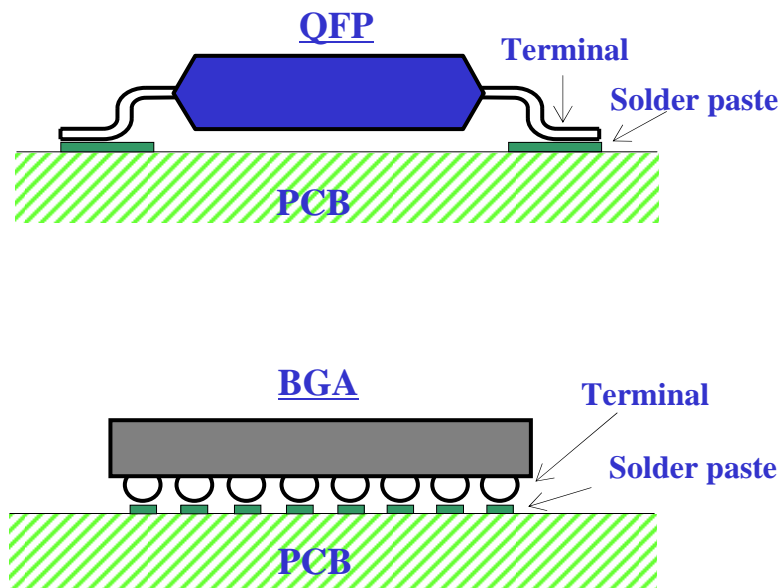
Plating	Non Whisker	Solderability	Peel Strength	Low Cost
Sn-Pb (Now Lead-free)	A	A	A	A
Sn-2.0Bi	B	B	A	B
Sn-Ag	C	C	A	C
Sn-Cu	C	C	A	B
Sn-Zn	C	B	B	C
Sn	C	B	A	A

Notes : 2nd material addition rate → 2 ~ 3 %

## Requirement of Lead-Free Package

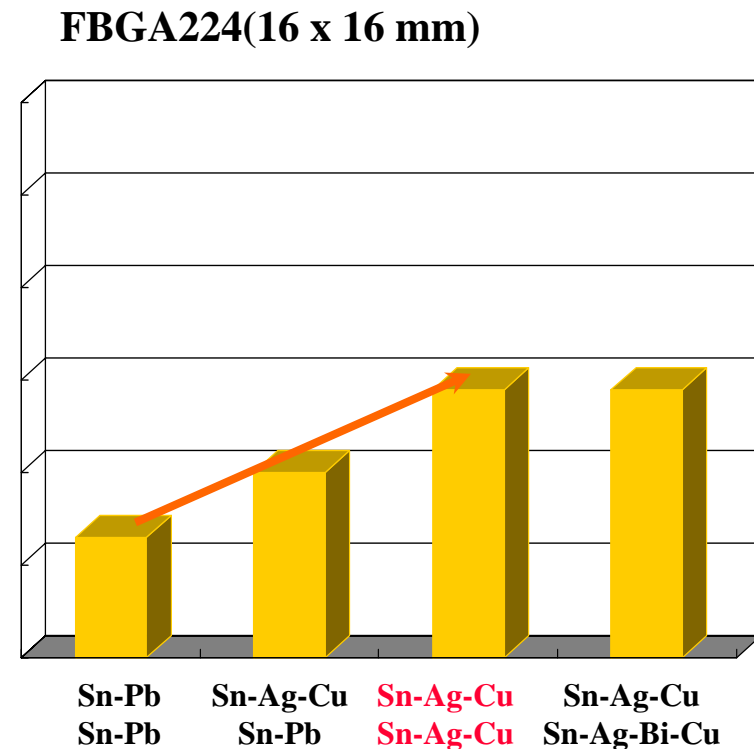
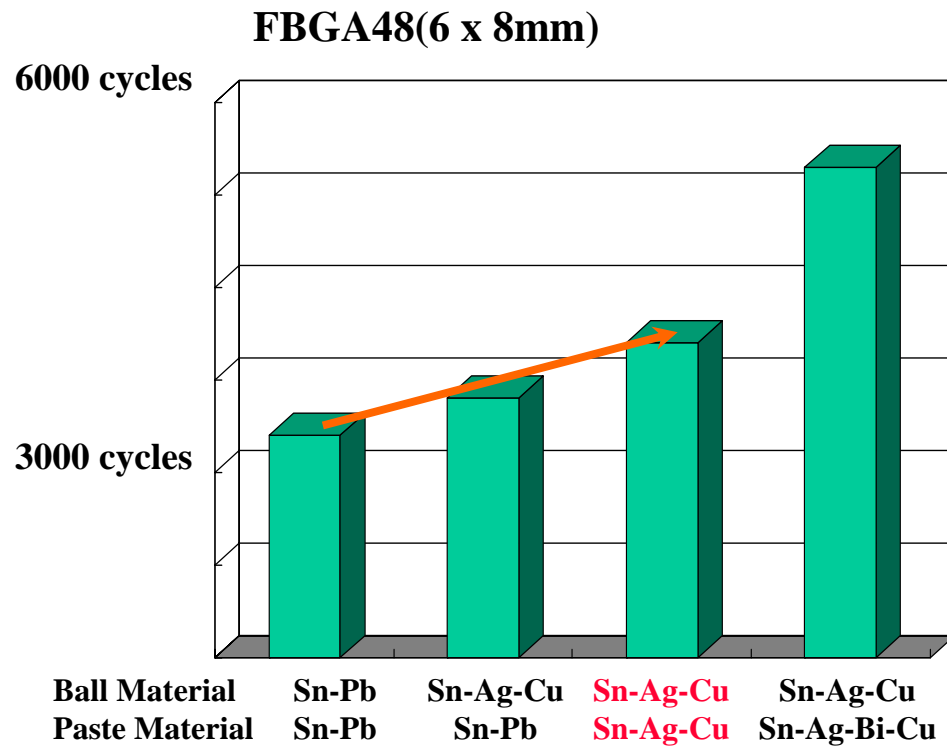
- ★ **Improvement of Package heat resistance**  
(for higher reflow temperature)
- ★ **Verification of Solderability**  
(for convert to Lead-Free of Solder Paste & Terminal material)

### Solder Combination



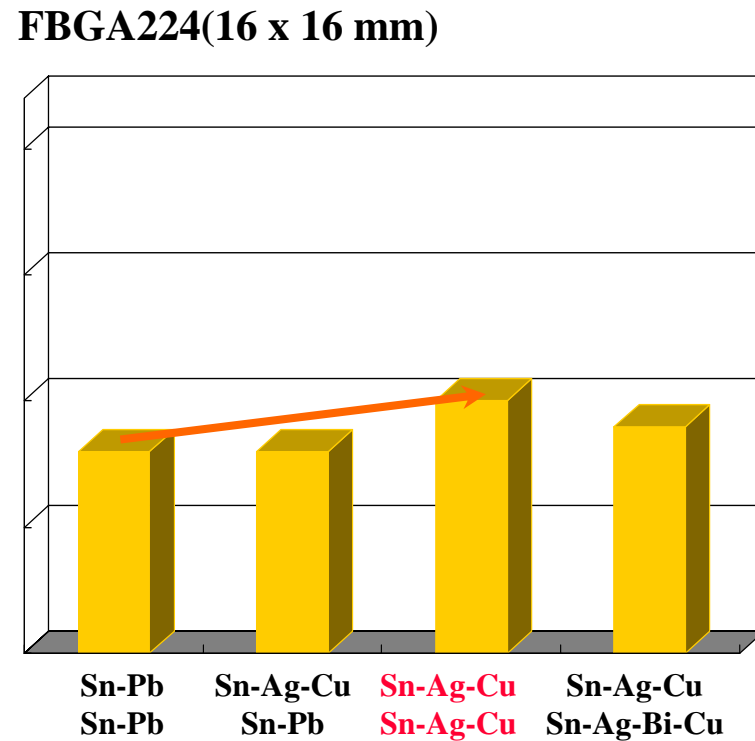
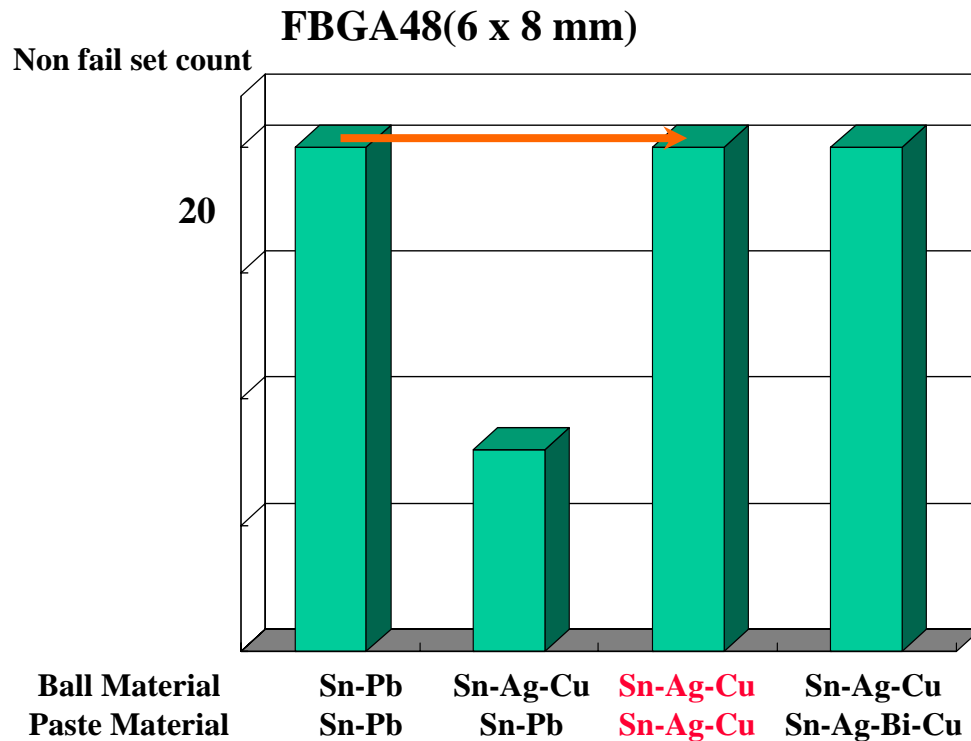
## Solder Combination Evaluation (Temperature Cycle Test)

- (1) Package : FBGA48(6 x 8 mm, 0.8mm pitch)/ FBGA224(16 x 16 mm, 0.8mm pitch) [n=8]
- (2) Test condition : -25°C ~ RT ~ 125°C
- (3) PCB : FR-4 (110 x 110 x 0.8mmt)



## Solder Combination Evaluation (Drop Test)

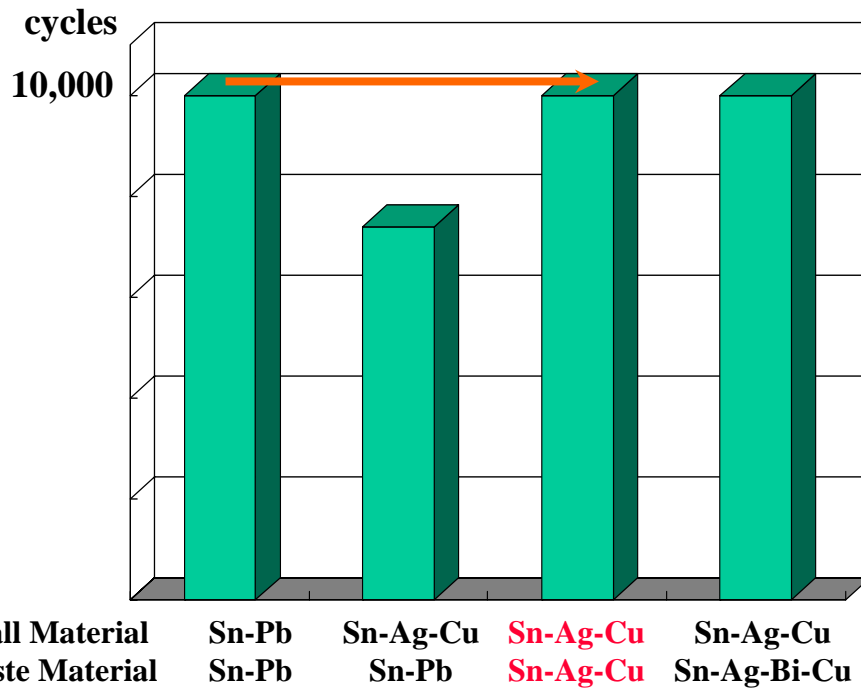
- (1) Package : FBGA48(6 x 8 mm, 0.8mm pitch)/ FBGA224(16 x 16 mm, 0.8mm pitch) [n=8]
- (2) Test condition : 1.5m height, 1set - 6-directions
- (3) Sample : Mobile phone unit (Weight 150g)



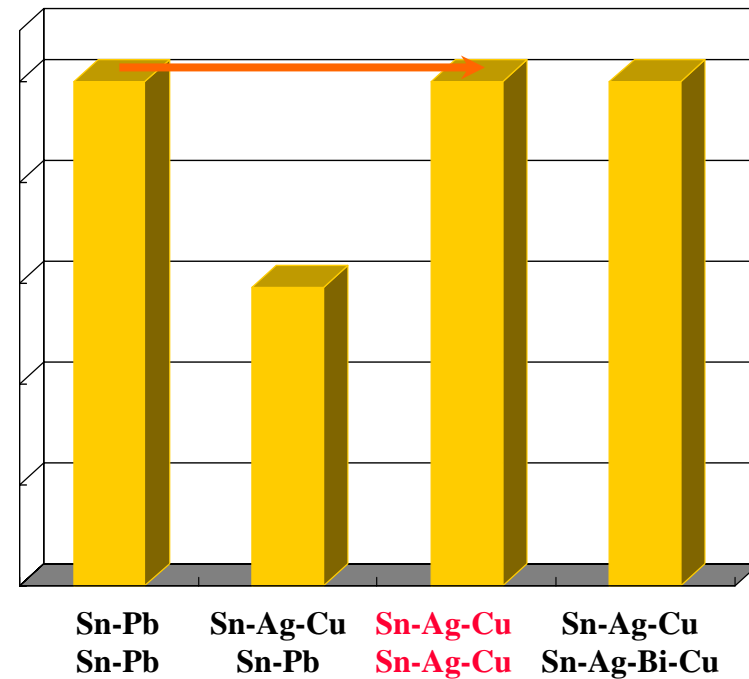
## Solder Combination Evaluation (Bending Cycle Test)

- (1) Package : FBGA48(6 x 8 mm, 0.8mm pitch) / FBGA224(16 x 16 mm, 0.8mm pitch) [n=8]
- (2) Test condition : Span 90 mm, Bend 3.0mm
- (3) PCB : FR-4 (110 x 110 x 0.8mmt)

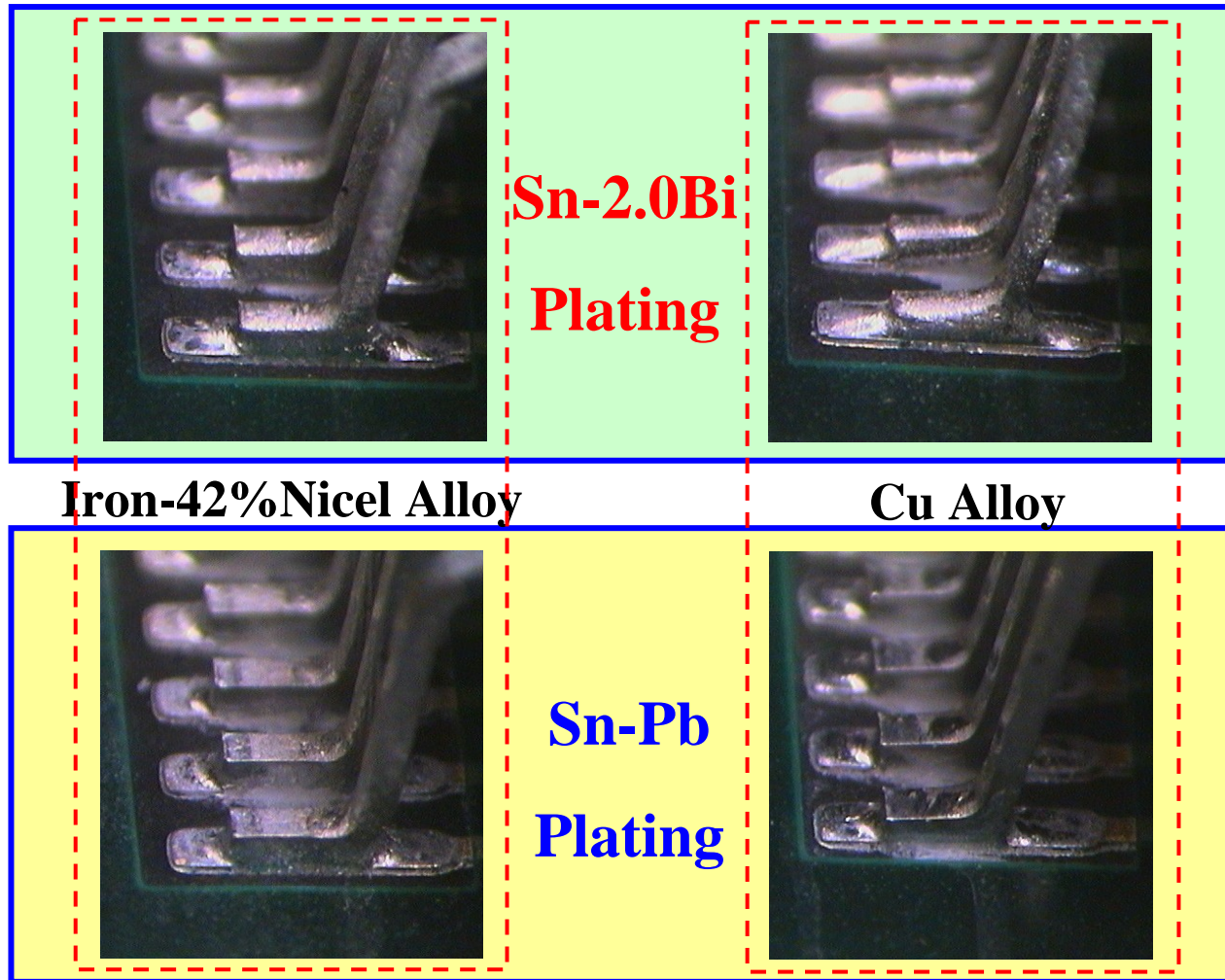
**FBGA48(6 x 8mm)**



**FBGA224(16 x 16 mm)**

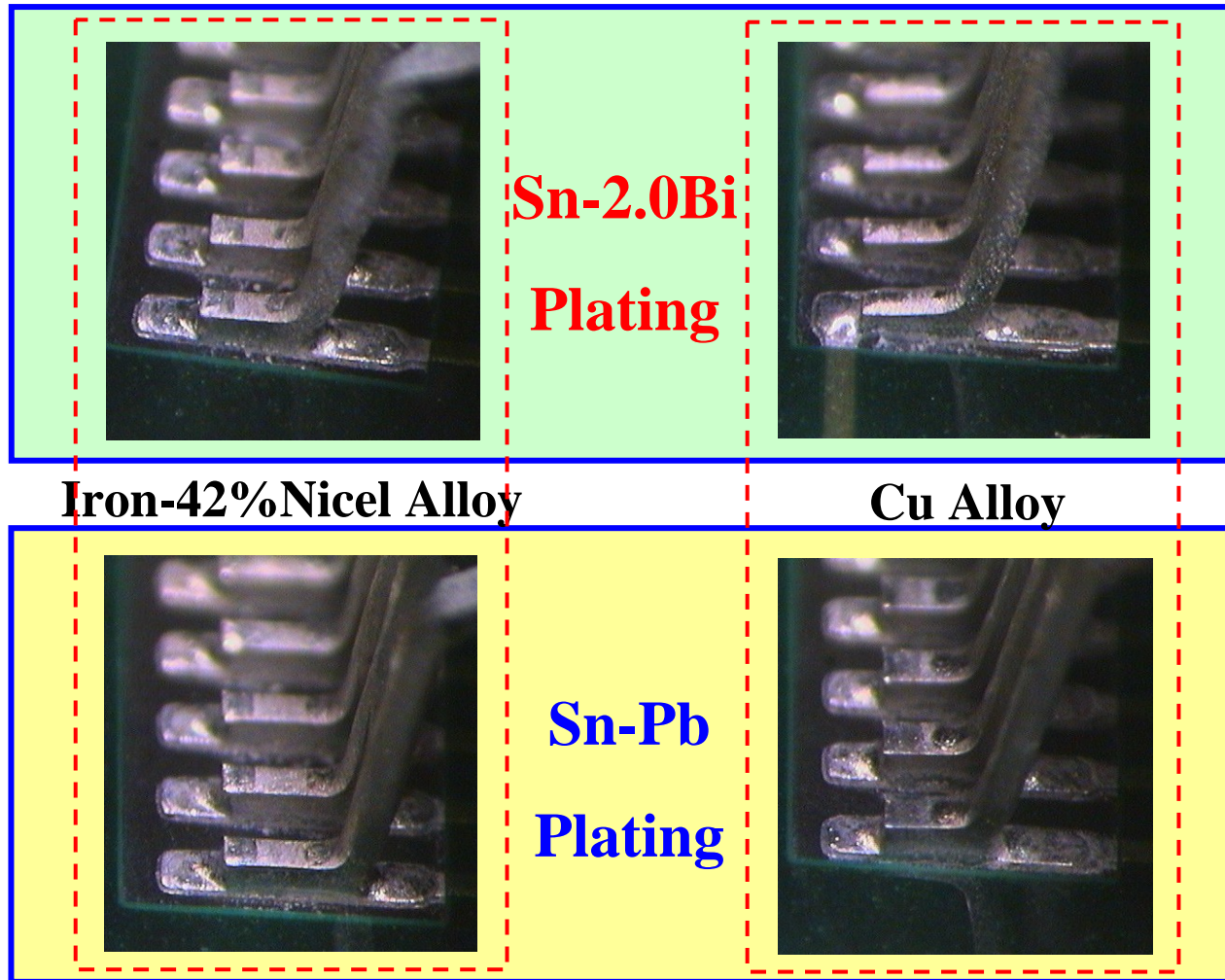


## State of solder joint (Solderability of Sn-Pb Solder Paste)



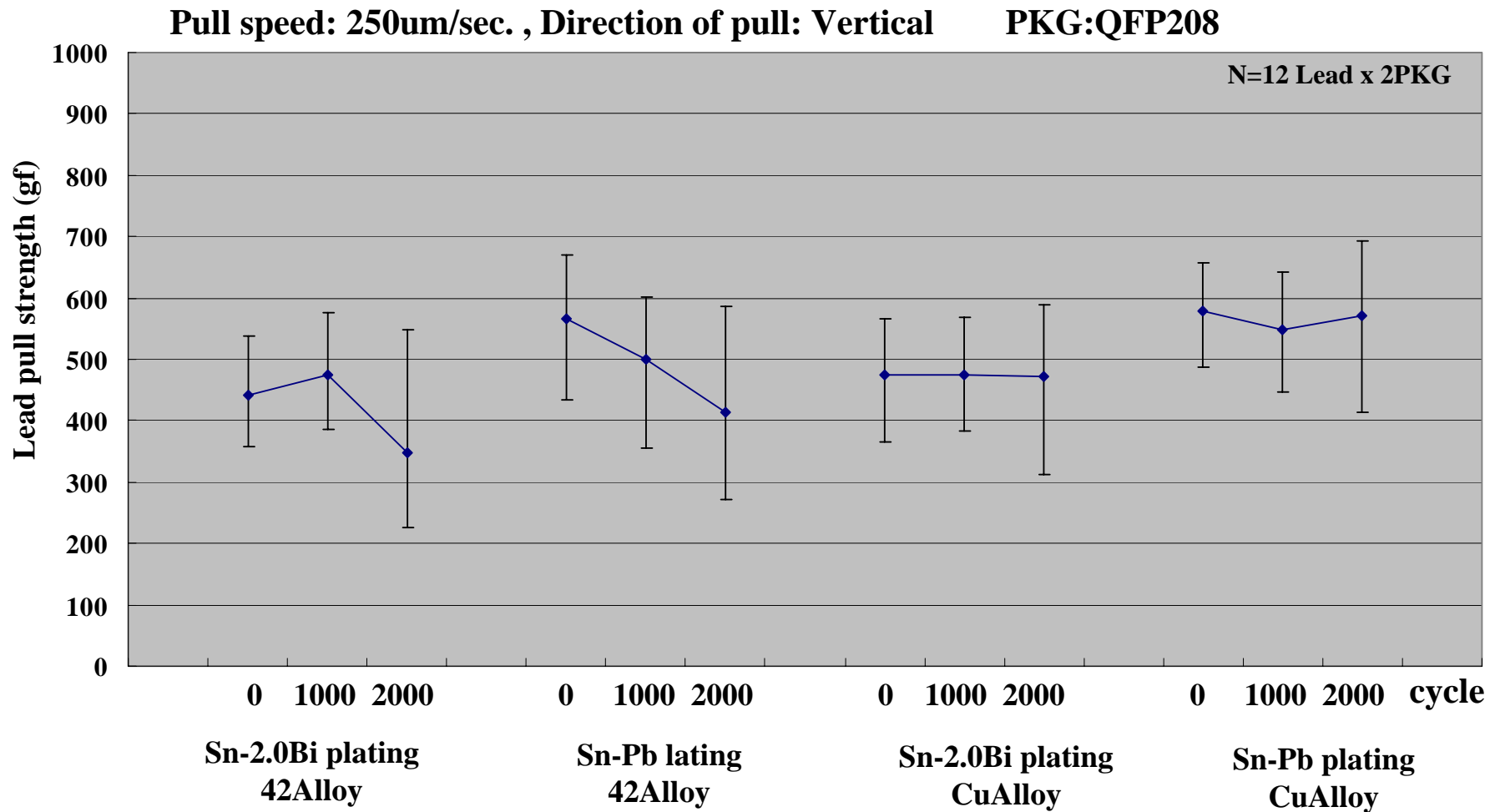
Reflow condition:  
Peak temp. 220 °C

## State of solder joint (Solderability Sn-Ag-Cu Solder Paste)



Reflow condition:  
Peak temp. 240 °C

## Lead pull strength after TC Test (Sn-Ag-Cu Paste)



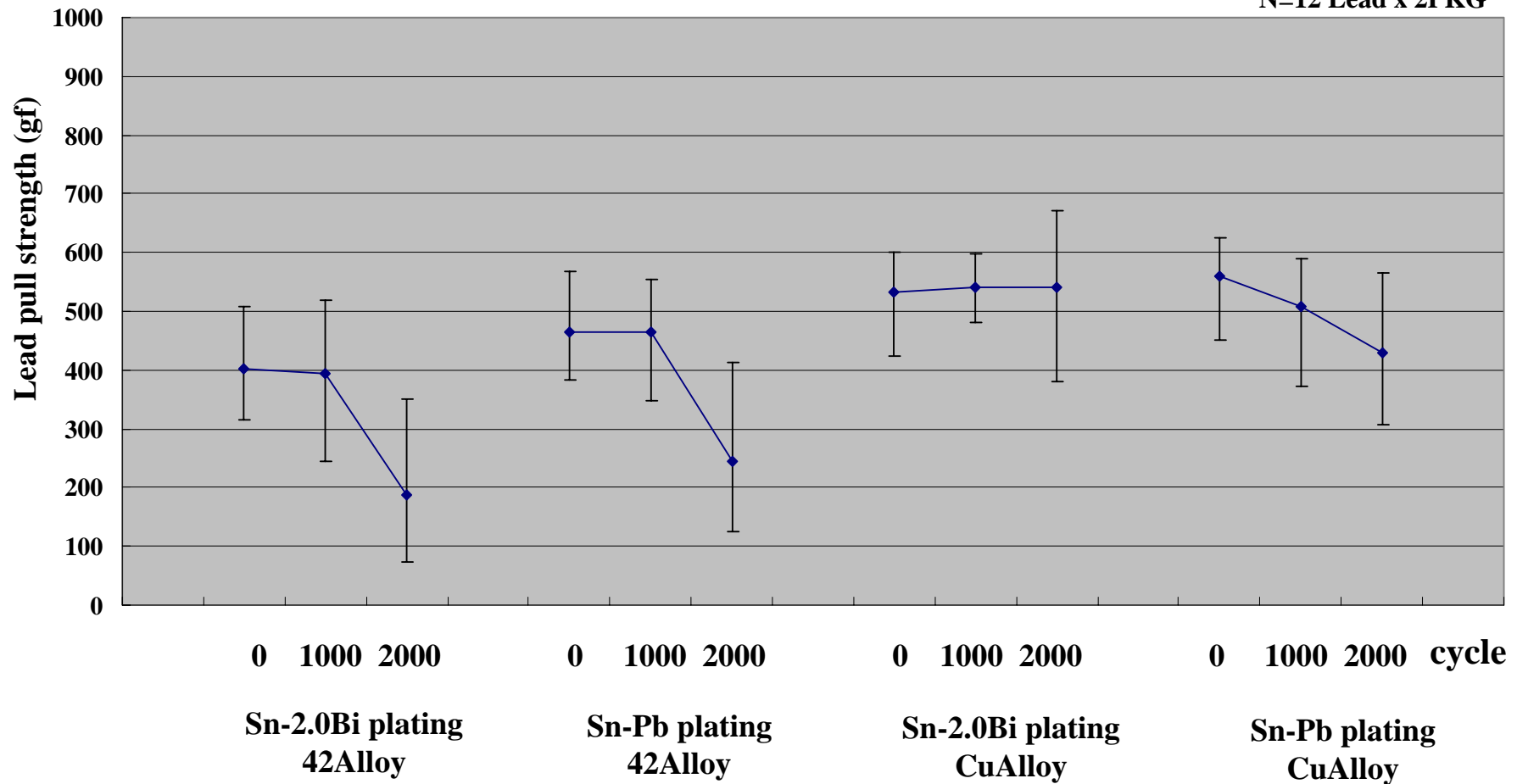


## Lead pull strength after TC Test(Sn-Pb Paste)

**Pull speed: 250um/sec. , Direction of pull: Vertical**

**PKG:QFP208**

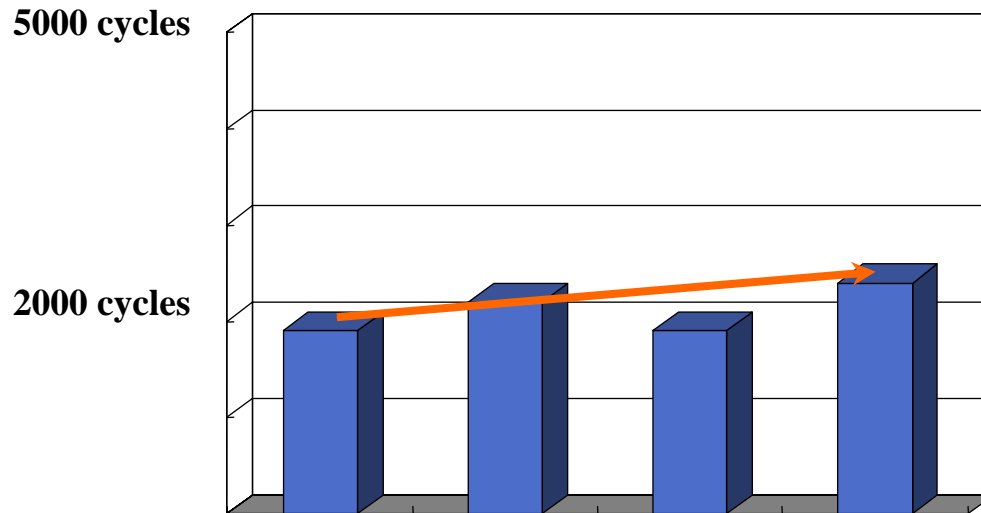
**N=12 Lead x 2PKG**



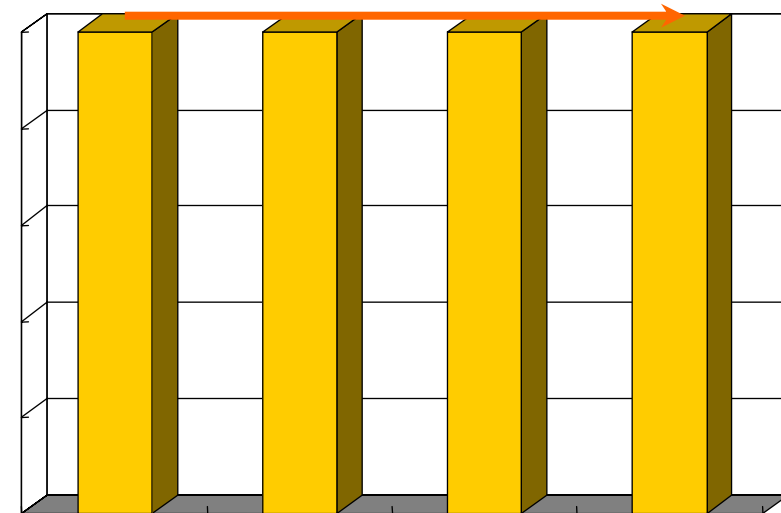
## Solder Combination Evaluation (Temperature Cycle Test)

- (1) Package : QFP208 (28 x 28 mm, 0.5mm pitch) [n=8]
- (2) Test condition : -25°C ~ RT ~ 125°C
- (3) PCB : FR-4 (110 x 110 x 0.8mm)

Iron-42%NiCe Alloy



Cu Alloy



Plating Material : Sn-Pb Sn-Pb Sn-2.0Bi **Sn-2.0Bi**  
 Paste Material : Eutectic Sn-Ag-Cu Eutectic **Sn-Ag-Cu**

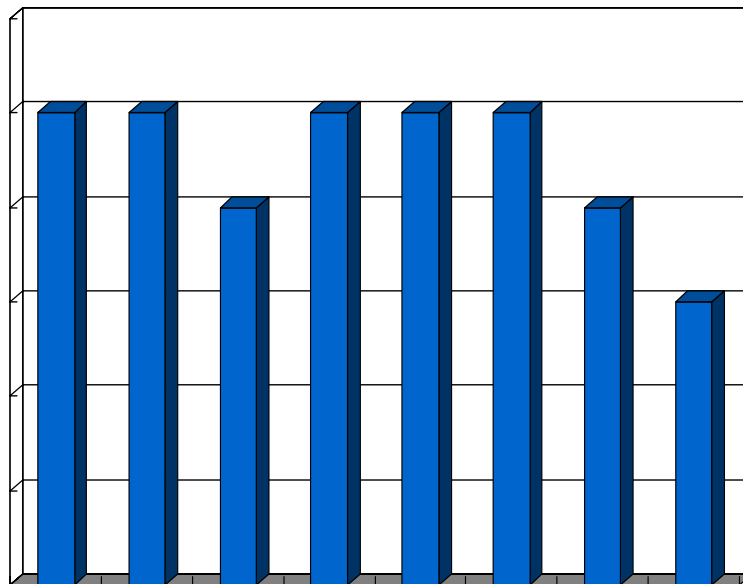
Sn-Pb Sn-Pb Sn-2.0Bi **Sn-2.0Bi**  
 Eutectic Sn-Ag-Cu Eutectic **Sn-Ag-Cu**

## Mounted QFP Drop Test

- ★ Sample: Simplicity case (Weight 150g)
- ★ PKG: A: TSOP-86, B: LQFP-100, C: TQFP-120, D: QFP-208  
E: CSOP48, F:LQFP-120, G: LQFP-256
- ★ Condition : Height 1.5m, 1 Set = 4 Sides  
Solder Combination: 1=Sn-2.0Bi Plating/Sn-Pb Paste 2=Sn-2.0Bi Plating/Sn-Ag-Cu Paste

Fe-Ni Lead-frame

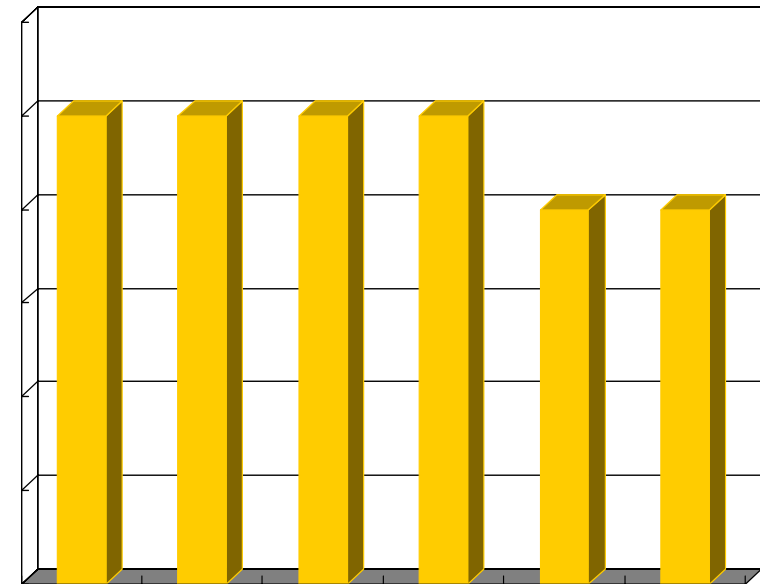
6-Set



Combination 1 2 1 2 1 2 1 2  
PKG A A B B C C D D

Cu Lead-frame

6-Set



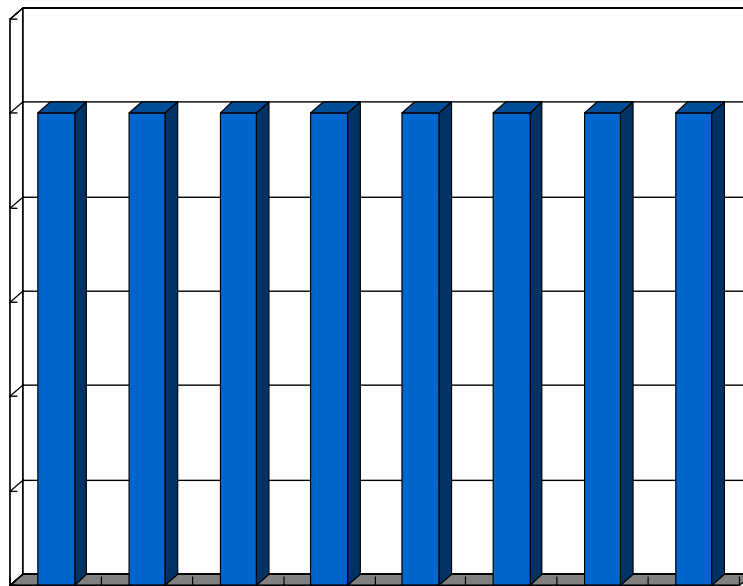
Combination 1 2 1 2 1 2  
PKG E E F F G G

## Mounted QFP Vibration Test

- ★ Sample : PWB(110x110x0.8)
- ★ PKG : A: TSOP-86 B: LQFP-100 C: TQFP-120 D: QFP-208  
E: CSOP48 F: LQFP-120 G: LQFP-256
- ★ Condition: 20G, 10-2000Hz (round trip 4min) x, y, z (1round)  
Combination: 1=Sn-2.0Bi Plating/Sn-Pb Paste 2=Sn-2.0Bi Plating/Sn-Ag-Cu Paste

Fe-Ni Lead frame

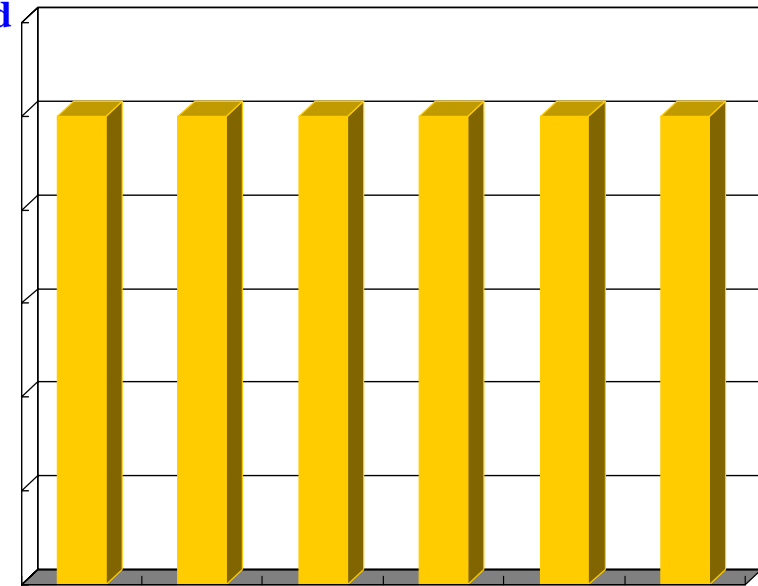
6-round



Combination	1	2	1	2	1	2	1	2
PKG	A	A	B	B	C	C	D	D

Cu Lead frame

6-round



Combination	1	2	1	2	1	2
PKG	E	E	F	F	G	G

## Lead-Free Package Development

PKG		2002	2003	2004
QFP/SOP	QFP			
	LQFP	On mass production		
	TQFP			
	SSOP			
	TSOP			
BGA	PBGA	On mass production		
	FBGA	On mass production		
	TAB-BGA	Developing	O. M. P.	
	EBGA	Developing	O. M. P.	
	FCBGA	Developing *1		
LGA	FLGA	On mass production		
BCC	BCC	On mass production		
WLP	Super CSP	Developing	O. M. P.	

Developing \*1 : Response upon request of customer

## Conclusion of Fujitsu Lead-free Package

### 1. Heat resistance

**H-Rank :260 °C x 2 Reflows**

**M-Rank :250 °C x 2 Reflows**

### 2. Terminal materials

**BGA = Sn-3.0Ag-0.5Cu (Solder Ball)**

**QFP = Sn-2.0Bi (Plating)**

**Min. 99% Sn 1% Bi**

**Typ. 98% Sn 2% Bi**

**Max 96% Sn 4% Bi**

### 3. Discrimination of products by:

**Parts number-"E1", Marking, Label of lead-free**

### 4. Second-Level-Packaging Reliability

**Fujitsu recommend Sn-3.0Ag-0.5Cu solder paste. (for Lead-Free Devices)**

**Usage of SnPb solder paste is also possible. (for Lead-Free Devices)**

### 5. Mass production

**Fujitsu have begun commercial production of Lead Free products since Q2.2000.**

**All products will be changed Lead(Pb)-Free by end of 2004.**

**FUJITSU**

**THE POSSIBILITIES ARE INFINITE**