Fujitsu Lead-free Package

Semiconductor Group
LSI Packaging Division

History of Fujitsu Lead-free Package Development Activities

Lead-free Package Development to Commence	[April 1998 Completed]
Customers Application Trend Research	[Sept 1998 Completed]
Lead-free BGA Mass Production	[April 2000 Partially started]
Lead-free QFP Mass Production	[Oct 2000 Partially started]
Target For All LSI Products ultimately lead-free	[Dec 2002]

Lead-free Package Definition

Fujitsu Lead Free Package Specification

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

Heat Resistivity

260ºC (250ºC) x 2 Reflows

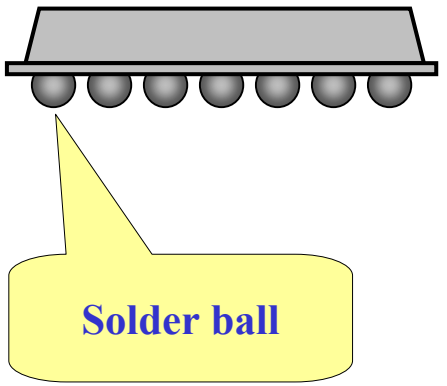
Terminal Material

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

When compared with non lead-free:

1. A bit dull in color; less lustrous
2. Similar wettability
3. Similar on-board reliability
4. Similar solder combination mounting

BGA



Lead-free Package Definition

Fujitsu Lead Free Package Specification

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

Heat Resistivity

260 ºC (250ºC)x 2 Reflows

Terminal Material

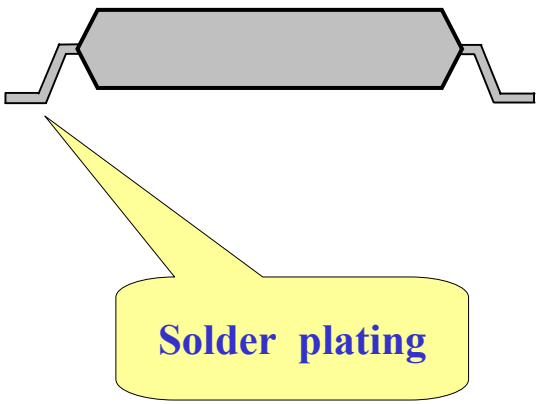
QFP = Sn-10Pb (Non lead-free) → Sn-2.0Bi (Lead-free)

⇩

When compared with non lead-free:

1. A bit dull in color; less lustrous
2. Similar wettability
3. Similar on-board reliability
4. Similar solder combination mounting

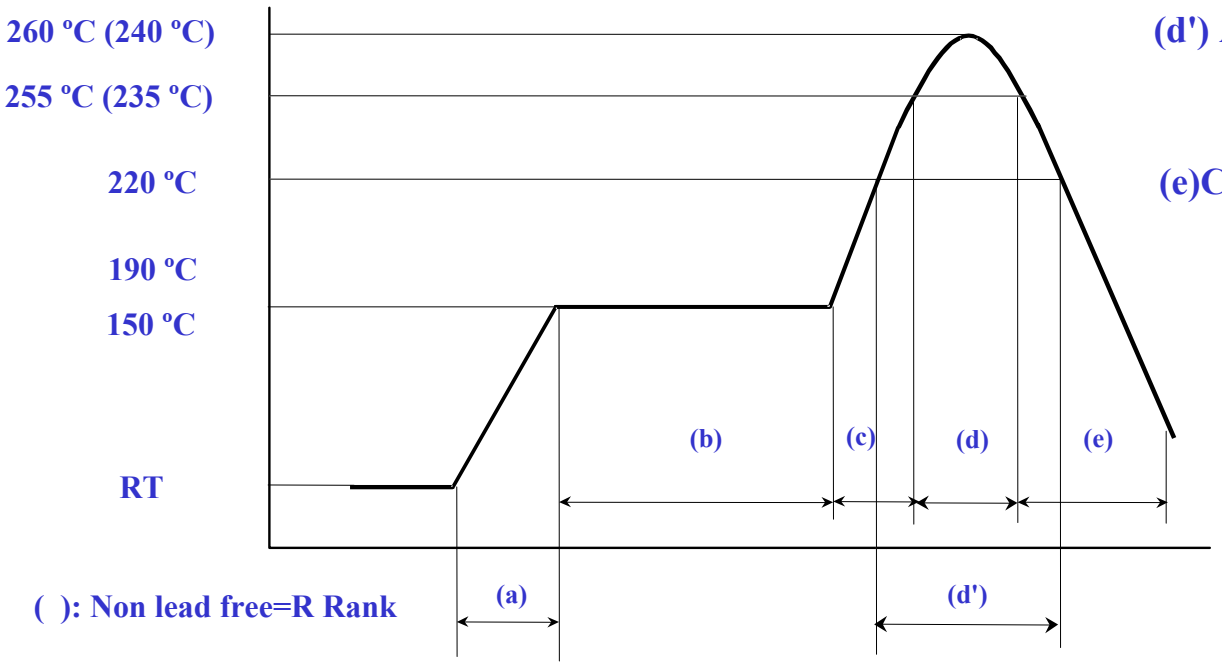
QFP



Lead-free Temperature Profile

* Package Surface Temp.

H Rank



( ): Non lead free=R Rank

(a) Temp. inc. gradient : Av. 1~4ºC/sec

(b) Preliminary heating : 150~190ºC,120~180sec

(c)Temp. inc. gradient : Av. 1~4ºC/sec

(d) Peak Temp : 260ºC max.
255ºCup 10 sec max.

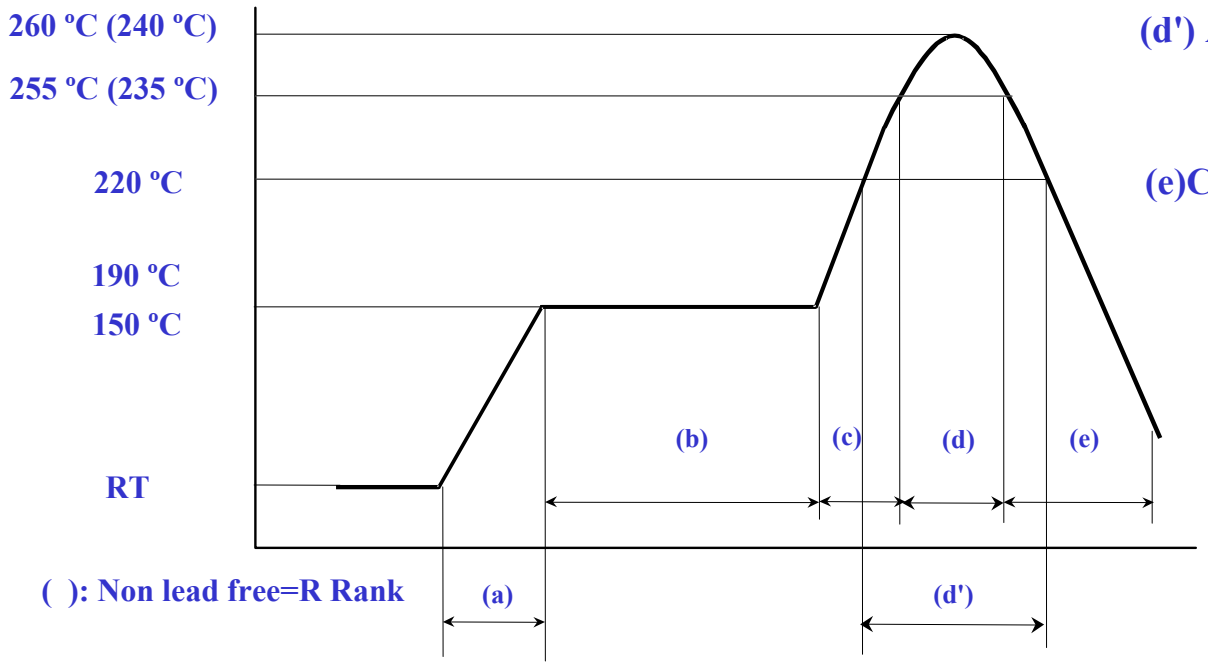
(d') Actual heating : 230ºCup 40 sec max.
: 225ºC up 60sec max.
: 220ºC up 80sec max.

(e)Cooling : Natural Cooling or Forced Cooling

Lead-free Temperature Profile

* Package Surface Temp.

M Rank



( ): Non lead free=R Rank

(a) Temp. inc. gradient : Av. 1~ 4ºC/sec

(b) Preliminary heating : 150~190ºC,120~180sec

(c)Temp. inc. gradient : Av. 1~ 4ºC/sec

(d) Peak Temp : 250ºC max.
245ºCup 10 sec max.

(d') Actual heating : 230ºCup 40 sec max.
: 225ºC up 60sec max.
: 220ºCup 80sec max.

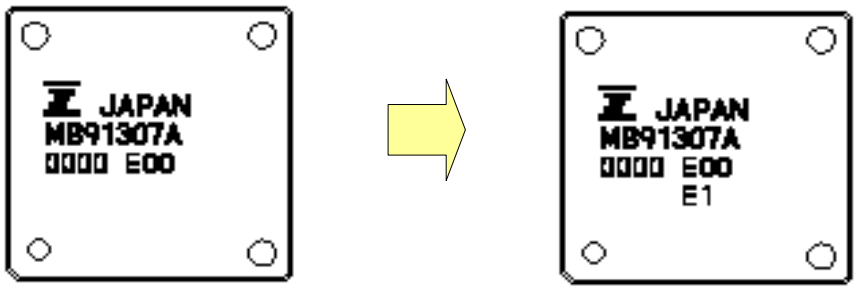
(e)Cooling : Natural Cooling or
Forced Cooling

Discrimination of Lead-free Products

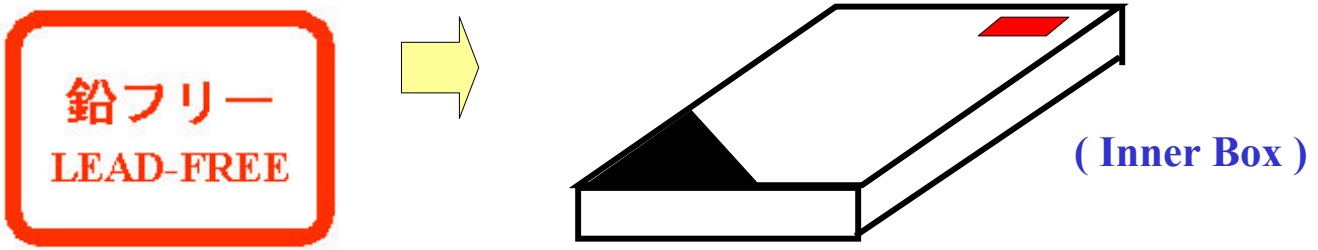
- Part Number : **Add E1 at the end**

  (Ex) MBLM29LV160TE90PBT-JJ ⇒ MB29LV160TE90PBT-JJE1

- Marking : **Add "E1" at the end**



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



(Inner Box)

Pb-Free Plan & Status

Package		CY2001	CY2002	CY2003
QFP/SOP	QFP LQFP TQFP SSOP TSOP	Mass-Production		
BGA	PBGA		Mass-Production	
	FBGA		Mass-Production	
	TAB-BGA		Eval. / MP April ～	
	EBGA		Eval. / MP June ～	
	FCBGA		Eval. / MP June ～	
LGA	FLGA		Mass-Production	
BCC	BCC		Mass-Production	
WLP	Super CSP		Eval. / MP April ～	

2002.Dec.
100%

Thermal Performance Grouping

Grouping (Non Lead-free)

Group	BGA	QFP / SOP
A:260Cmax	SCSP Small-FBGA PBGA BCC	SOP TSOP TQFP
B:250Cmax	Large-FBGA SMCP	QFP LQFP
C:240Cmax	FLGA EBGA TBGA SMCP*	HQFP

Method

Item	BGA	QFP / SOP
Package Material	・Substrate Material ・Die Paste Material ・Encapsulation Resin	・Die Paste Material ・Encapsulation Resin
Package Structure	———	・Die stage Structure ・Die stage Dimension

Result (Lead-free)

Group	Non Lead-free			Lead-free		
	240C	250C	260C	240C	250C	260C
A:260Cmax	○	○	○	○	○	○
B:250Cmax	○	○	×	○	○	○
C:240Cmax	○	×	×	○	○	×

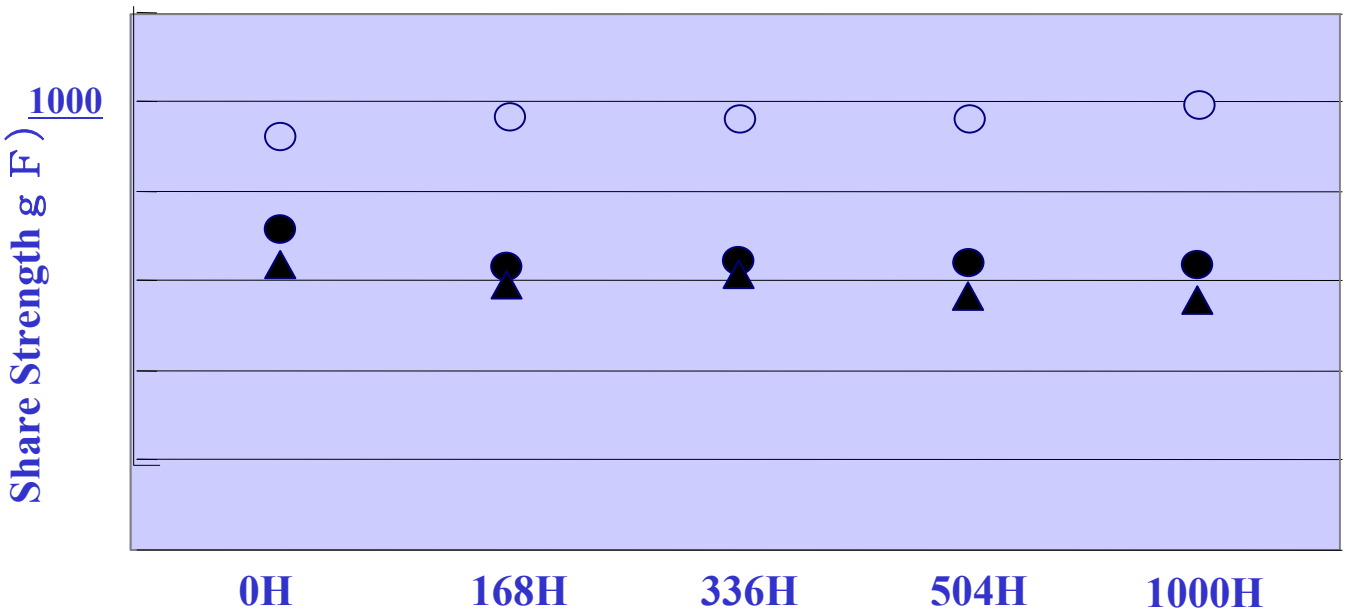
Evaluation Summary (Sn-Bi)

	Heat Resistivity	Moisture Resistivity	Wettability
TSOP	260°C	A	A
SOP	260 ~ 280°C	A	A
TQFP	260°C	A	A
LQFP	250 ~ 260°C	A	A
QFP	250 ~ 260°C	A	A

BGA Ball Evaluaion

Composition	Advantage	Disadvantage
Sn-Ag-Cu	Better Mounting Reliability than Sn-Pb/Sn-Pb	High Melting Point (220°C)
Sn-Ag-Bi-Cu	Lower Melting point than Sn-Ag-Cu	Lower Mounting Reliability by Bi content increase

Ball share Strength



Package : FBGA224(0.8mmP)

Ball Diameter. : ϕ0.5mm

Aging : 125°C Storage

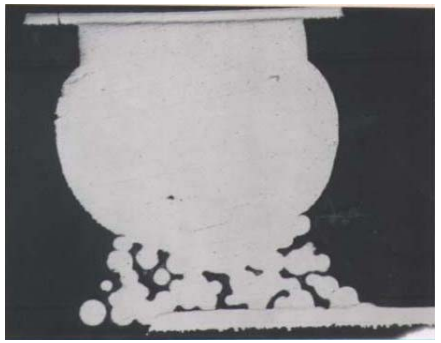
● ・・・Sn-Ag-Cu

○ ・・・Sn-Ag-Bi-Cu

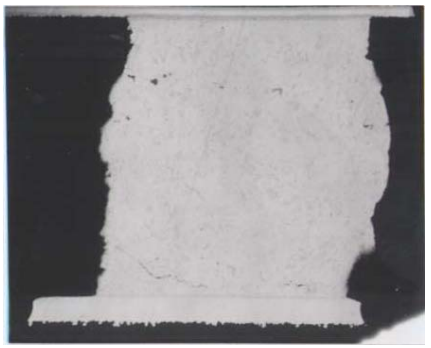
▲ ・・・Sn-Pb

Reflow Peak Temperature& Solder-joint

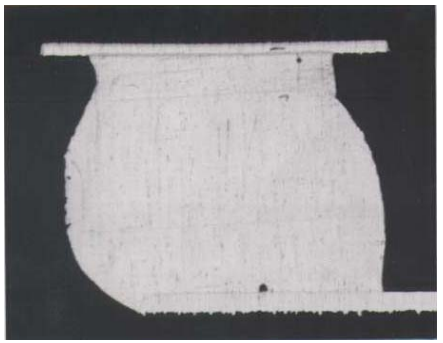
*** Jointable at 230ºC**



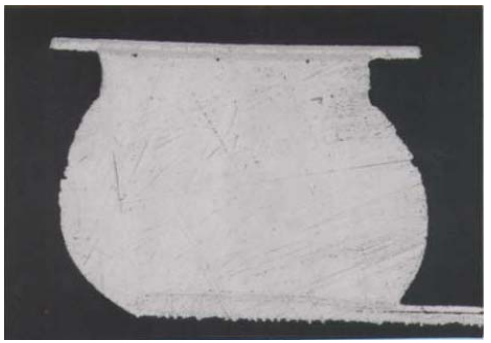
Peak Temperature
210ºC typical



Peak Temperature
220ºC typical



Peak Temperature
230ºC typical



Peak Temperature
220ºC typical

【Condition】

Ball material : Sn-3.5Ag-0.75Cu

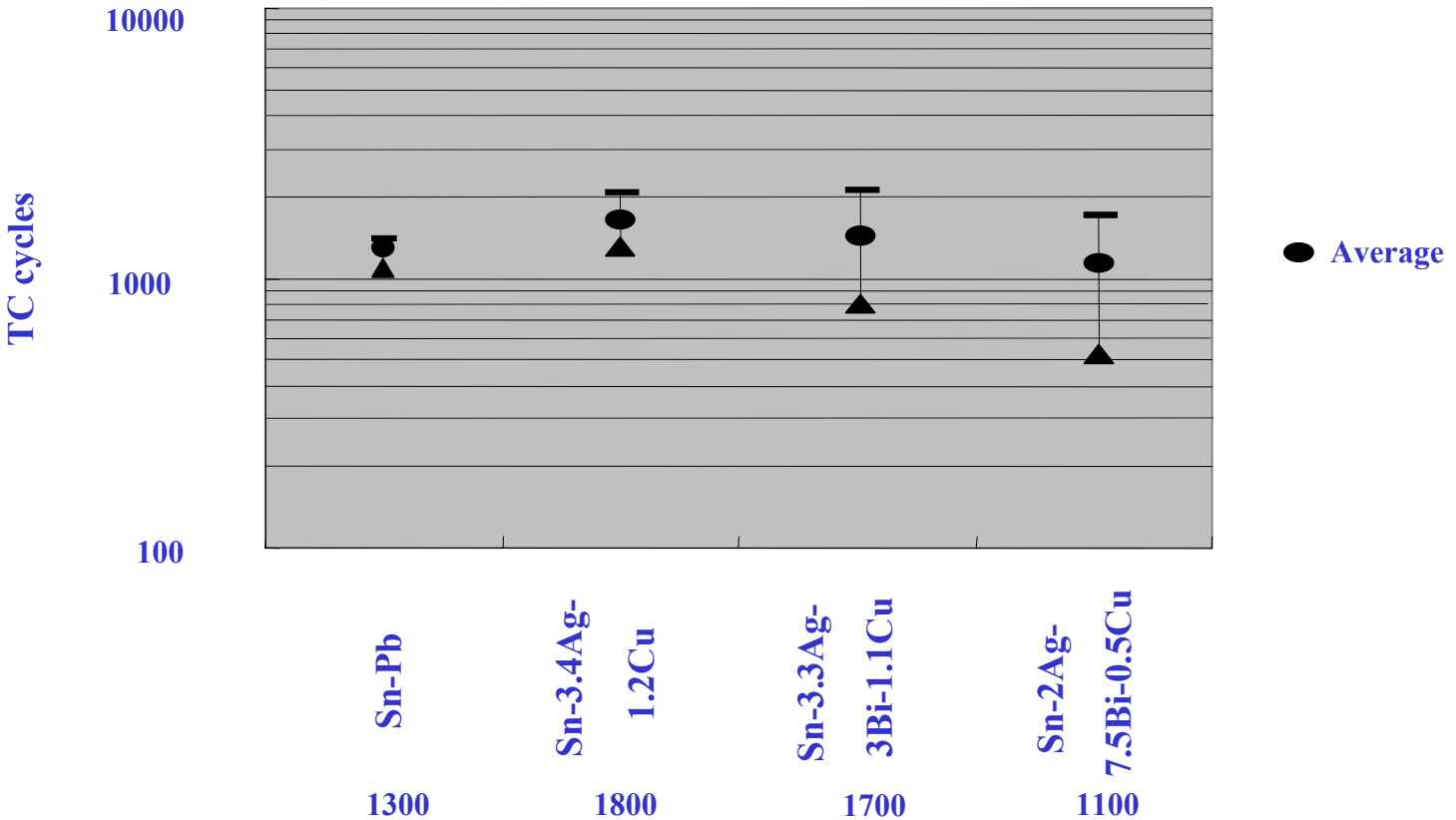
Paste material : Sn-3.5Ag-0.75Cu

Reflow method : IR/Hot air

Peak Temp : Joint Temp

On-Board Thermal Cycle

Sample : FBGA224(0,8mm pitch) Ball Diameter: ϕ 0,5mm
Substrate : 110mmX110mmX0.8mm t ,4-layers , Land Diameter: ϕ 0.3mm(NSMD)
Test Condition : -25ºC (9min)~RT(1min)~125ºC (9min)



Plating Material Evaluation

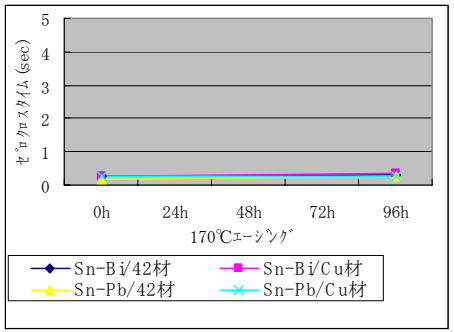
Note : Each Metallic Additives Ratio is 2~3%

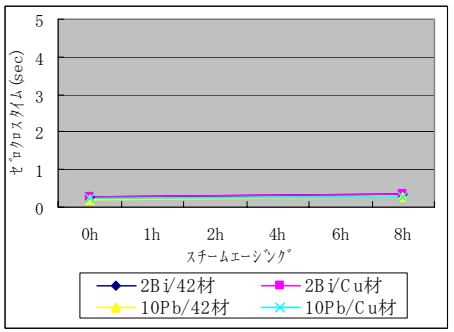
Plating Material	Whisker	Wettability	Joint strength	Cost
		◎	◎	
Sn－Bi	○	○	◎	○
Sn－Ag	△	△	◎	△ *
Sn－Cu	△ *	△	◎	○
Sn－Zn	△ *	○ *	○	△
Sn	△	△	◎	◎
Test Condition	50℃Aging	Meniscograph (Zero-Crosstime)	Peel Strength (Thermal Cycle)	Material Cost
Legend	◎ : Reference ○ : Not Observed △ : Observed	◎ : Reference ○ : Moderate Long △ : Long	◎ : Reference ○ : Weak	◎ : Reference ○ : Moderate Expensive △ : Expensive

Zero-Cross Time

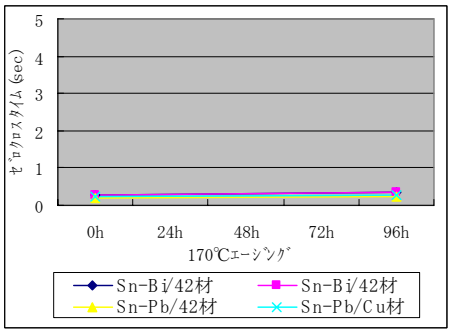
Sample Size : 3.30xo.46xo.25t Dipping Speed :10mm/sec Dipping Depth : 1mm

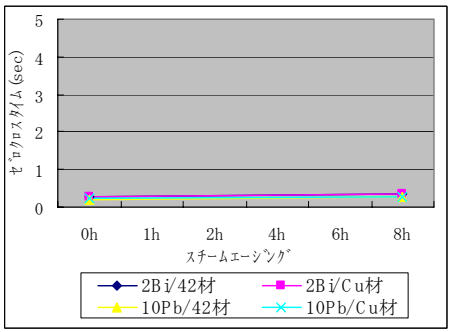
Test Condition-1
Solder : Sn-Ag-Bi-Cu
Solder Temperature : 230°C
Flux : RA type



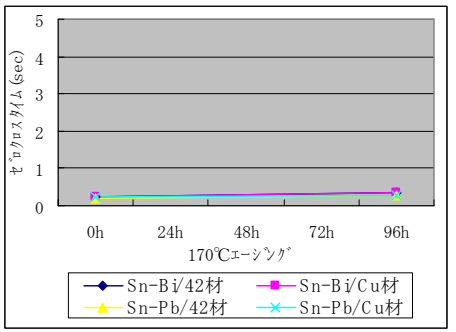


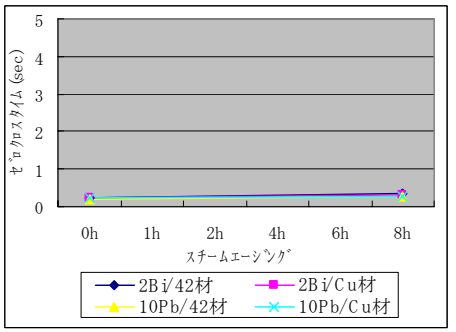
Test Condition-2
Solder : Sn-Ag--Cu
Solder Temperature : 230°C
Flux : RA type





Test Condition-3
Solder : Sn-Pb(Reference)
Solder Temperature : 220°C
Flux : RA type

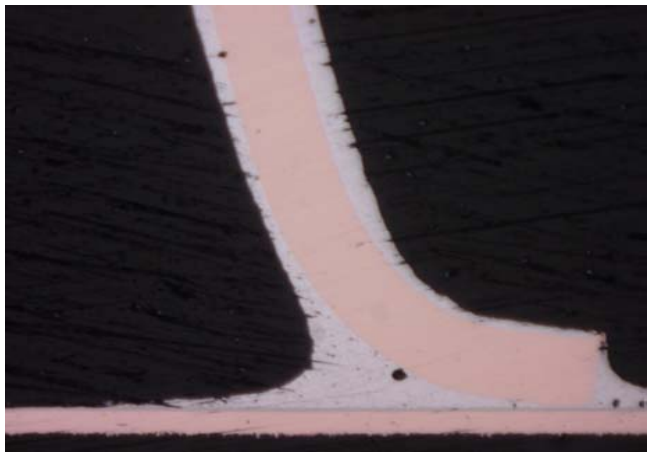




Crosssection of Connection(Sn-Bi Plating)

Package : QFP208(0.5mm pitch)

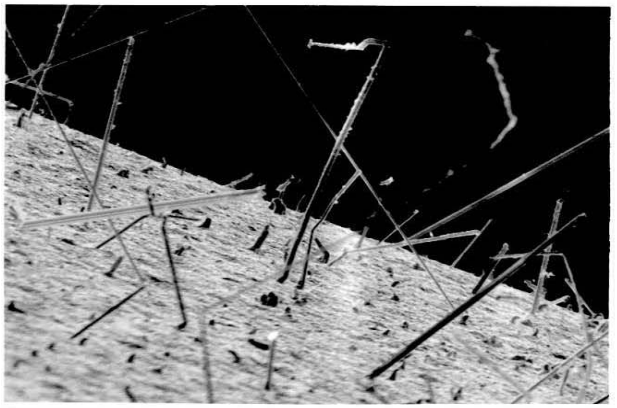
A) Paste : Eutectic Solder Lead Frame : 42-Alloy Reflow Temperature :230ºC



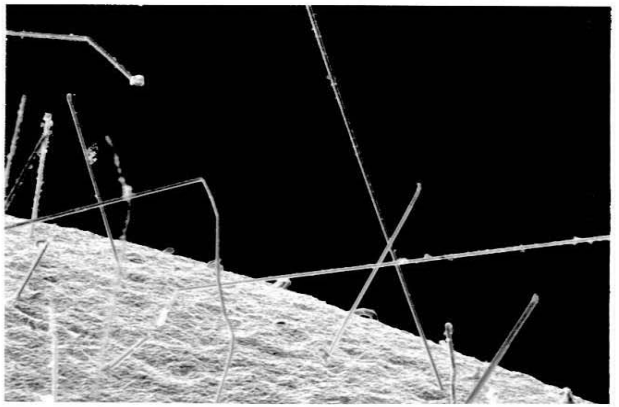
B) Paste : Sn-Ag-Cu Lead Frame : 42-Alloy Reflow Temperature :240ºC

Example of Lead-free Whisker

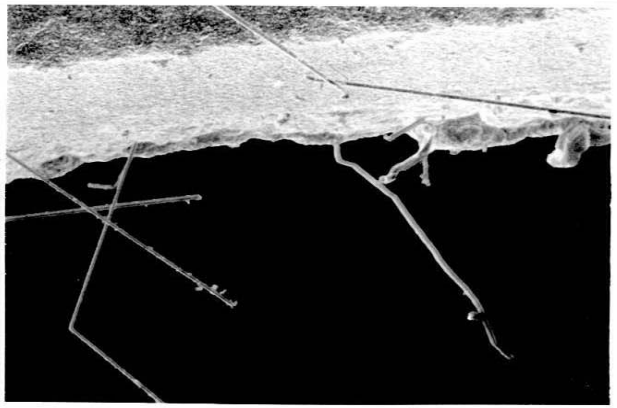
Sample A : Sn-Cu (42Alloy)



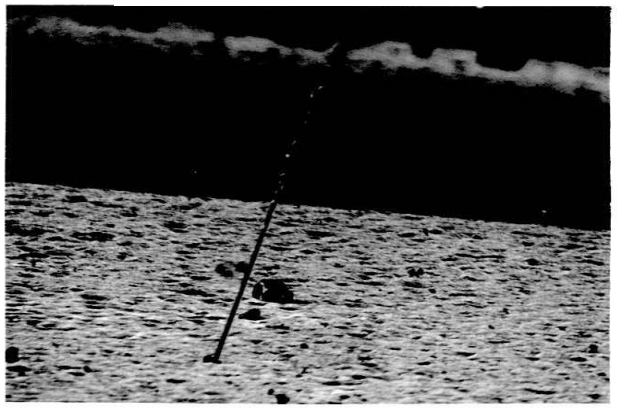
Sample A : Sn-Cu (42Alloy)



Sample A: Sn-Cu (42Alloy)

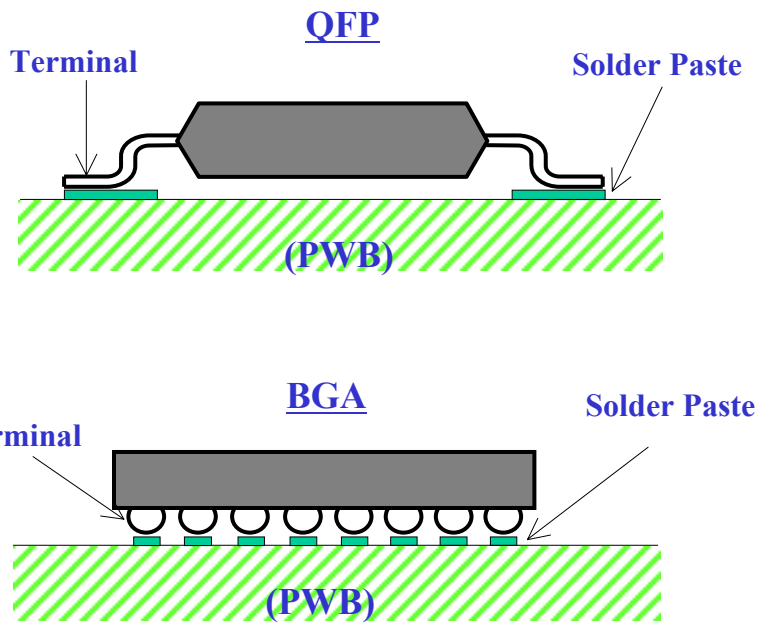


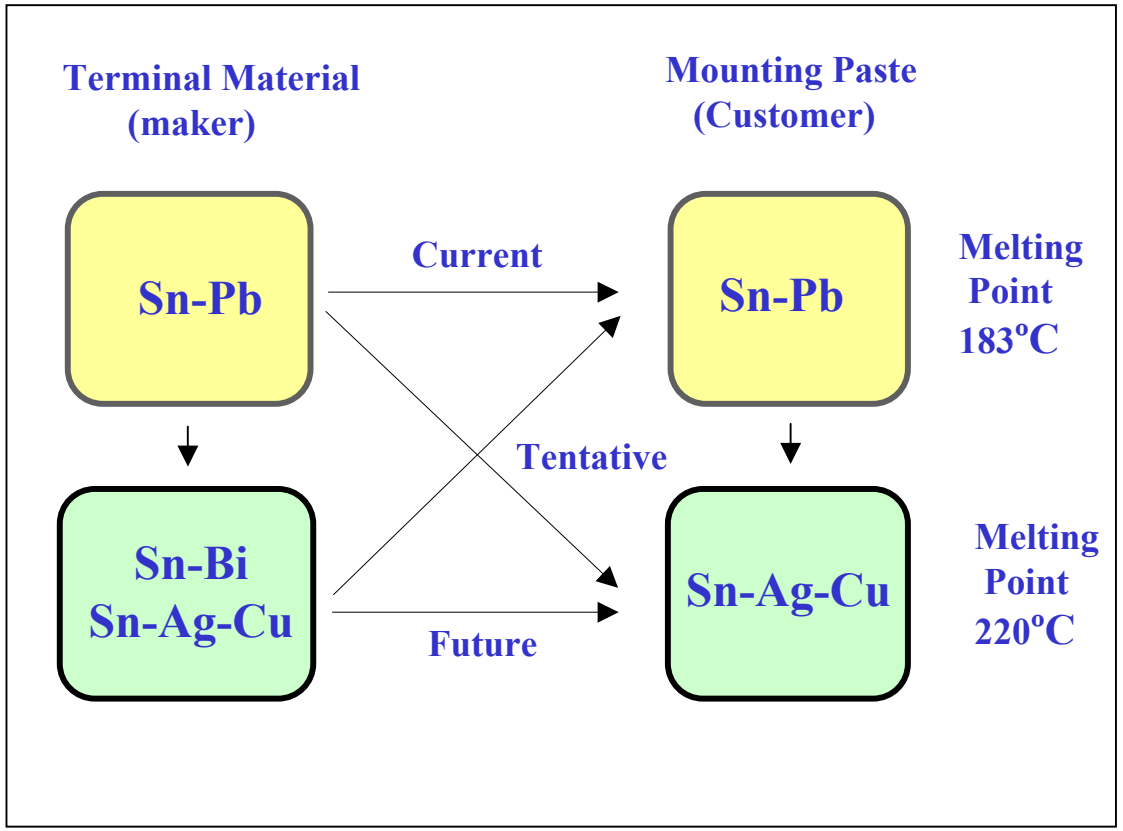
Sample B: Sn-Ag (42Alloy)



Target of Mountability

- ★ Improvement of Package Heat Resistivity
- ★ Quality Assurerance of Soldering Mountability

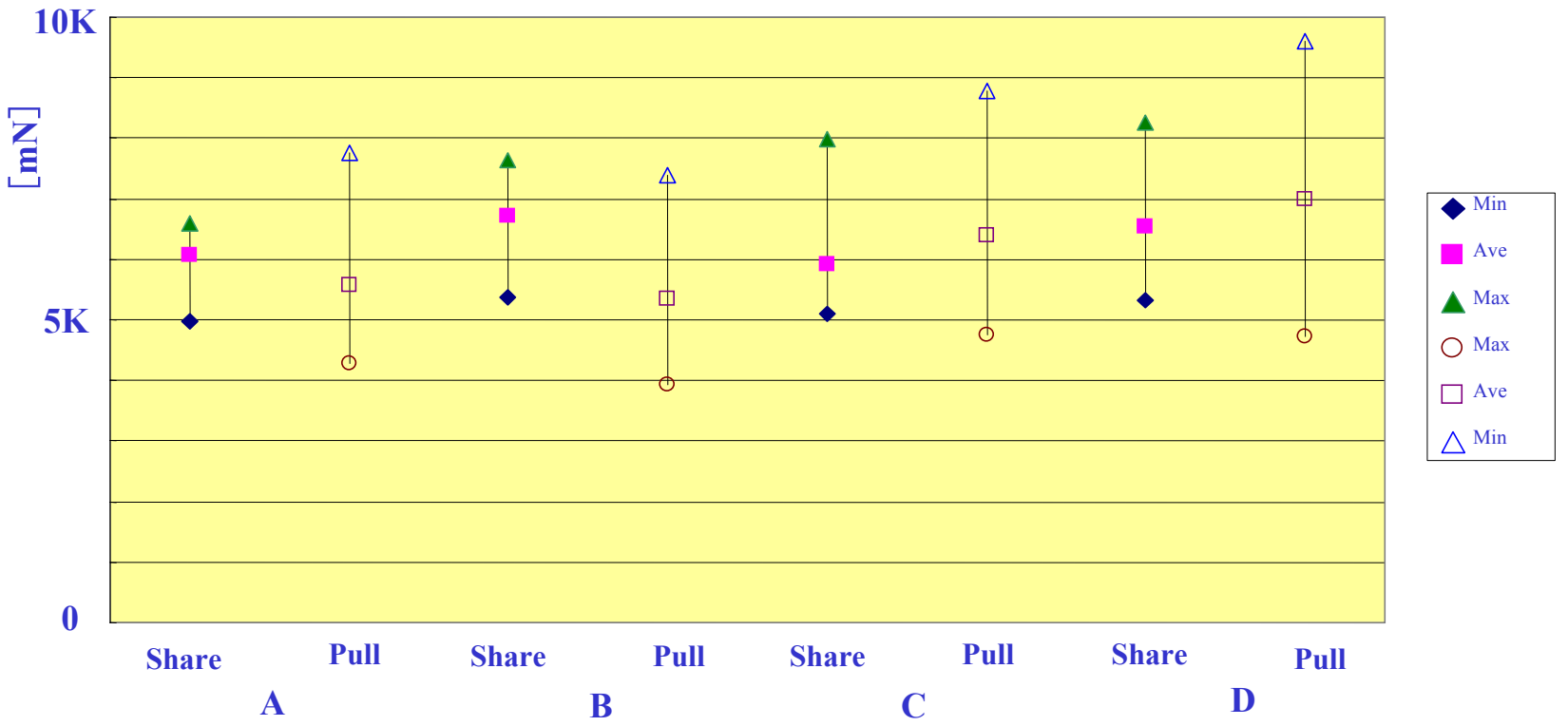




Ball Adhesive Strength

Package : FBGA224(16mmx16mm)
Solder Ball Diameter : ϕ0.45mm

A : Eutectic Ball ＋ Eutectic Paste
B : Sn-Ag-Cu Ball ＋ Eutectic Paste
C : Sn-Ag-Cu Ball ＋ Sn-Ag-Cu Paste
D : Sn-Ag-Cu Ball + Sn-Ag-Bi-Cu Paste



(Damage Mode)
Share : A~D=Normal(Solder Part sliced)
Pull : A=Normal(Solder torn) B,C,D=Interface Delamination

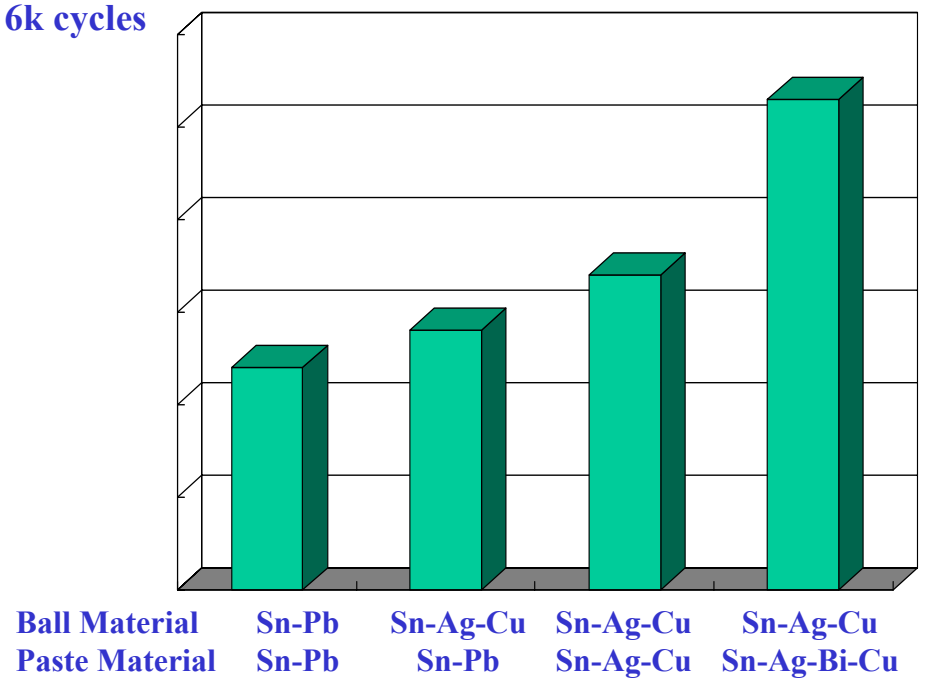
Solder Combination Evaluation(Thermal Cycle)

Board : FR-4,110mm x 110mm x 0.8mmt
Package : FBGA (6 x 8 mm)/ FBGA (16 x 16 mm)

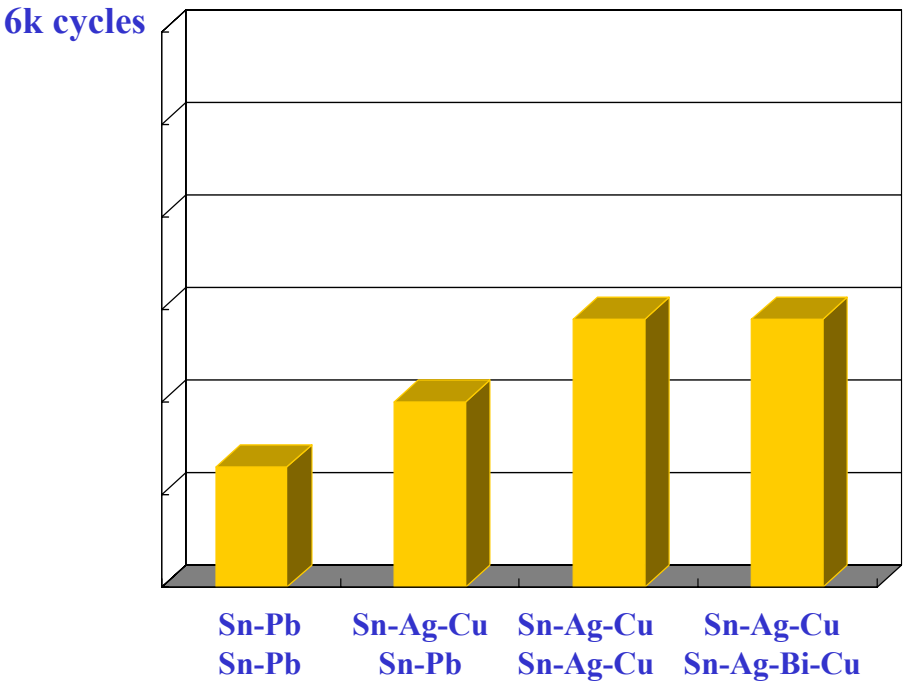
TC condition : -25ºC ～ RT ～ 125ºC

Non fail cycles

FBGA (6 x 8mm)

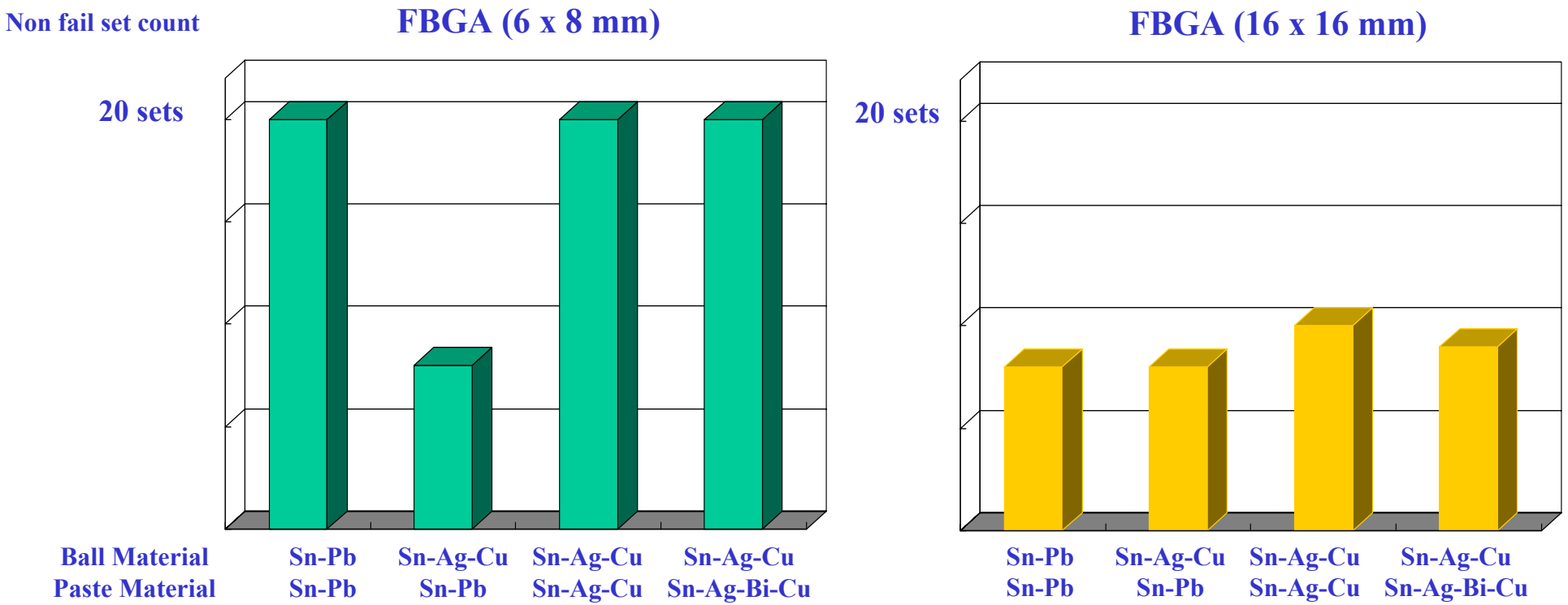


FBGA (16 x 16 mm)



Solder Combination Evaluation(Drop Test)

Sample : Mobile Phone Board (weight : 150g)
Package : FBGA (6 x 8 mm)/ FBGA (16 x 16 mm)
Condition : 1.5m height, 1set - 6-directions

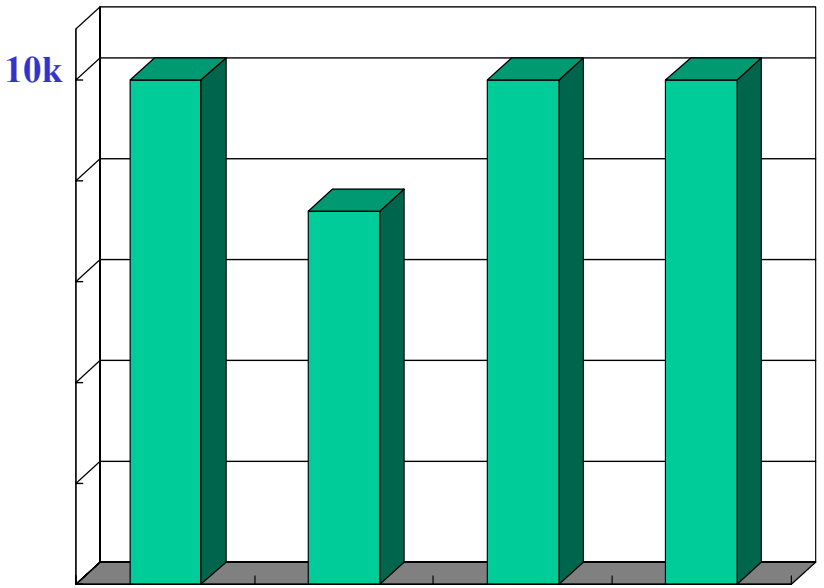


Solder Combination Evaluation (Bending Cycle Test)

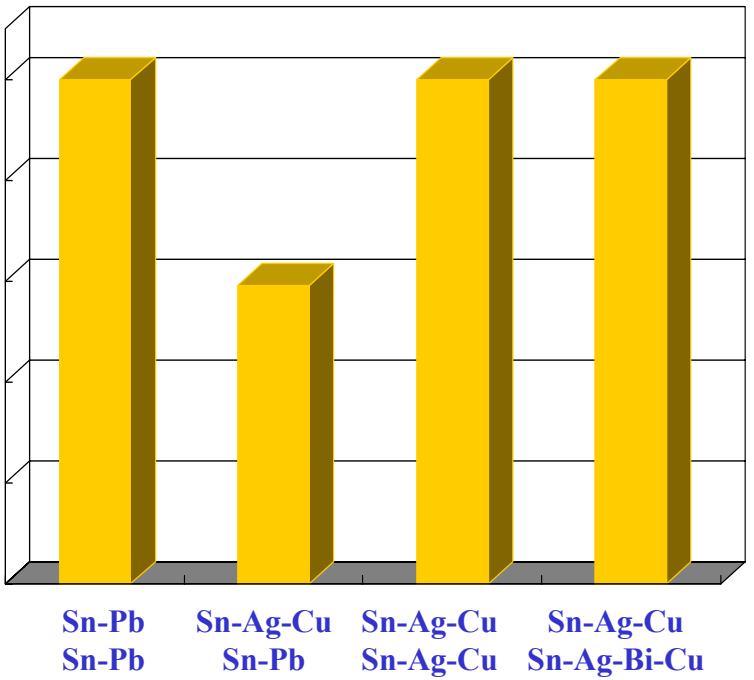
Sample : Mobile Phone Board (weight : 150g)
Package : FBGA (6 x 8 mm) / FBGA (16 x 16 mm)
Condition : Span 90 mm, Bend 3.0mm

Non fail cycles

FBGA (6 x 8mm)



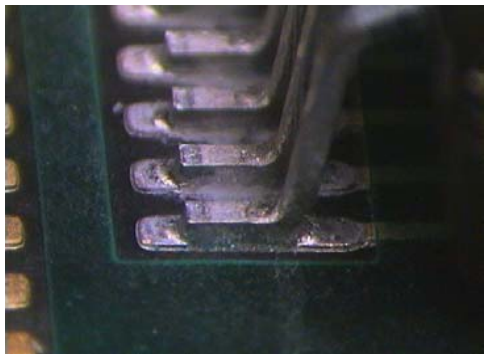
FBGA (16 x 16 mm)



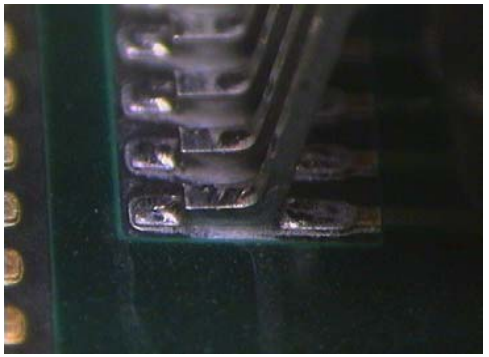
Solder Combination Evaluation(Connection View)

Package : QFP208(0.5mm pitch)

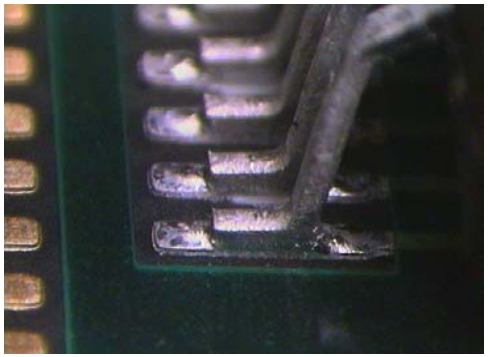
A) Plating : Sn-Pb
Paste : Eutectic Solder
LF : 42-Alloy



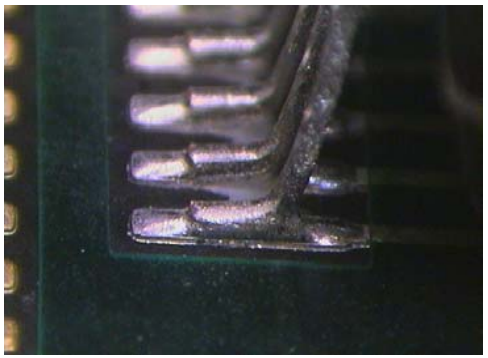
B) Plating : Sn-Pb
Paste : Eutectic Solder
LF : Cu-Alloy



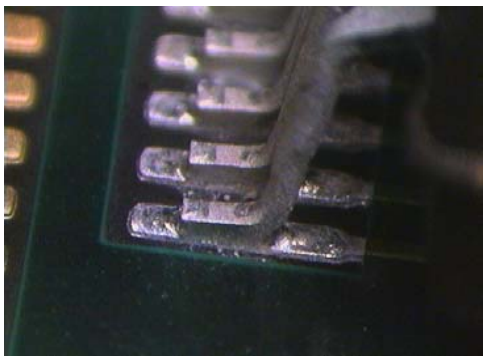
C) Plating : Sn-Bi
Paste : Eutectic Solder
LF : 42-Alloy



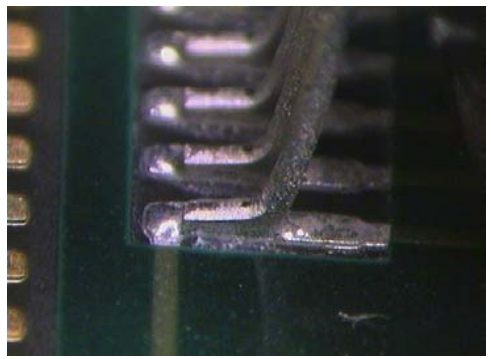
D) Plating : Sn-Bi
Paste : Eutectic Solder
LF : Cu-Alloy



E) Plating : Sn-Bi
Paste : Sn-Ag-Cu
LF : 42-Alloy

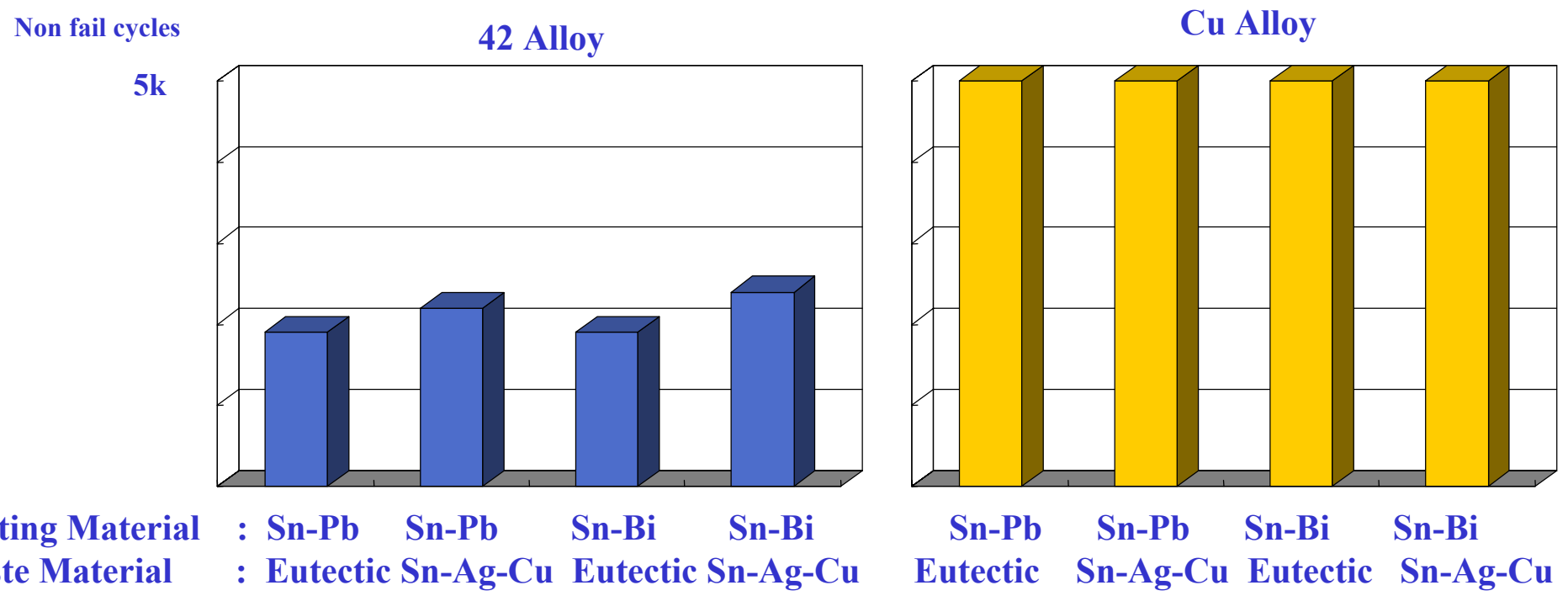


F) Plating : Sn-Bi
Paste :Sn-Ag-Cu
LF : Cu-Alloy



Solder Combination Evaluation(Thermal Cycle)

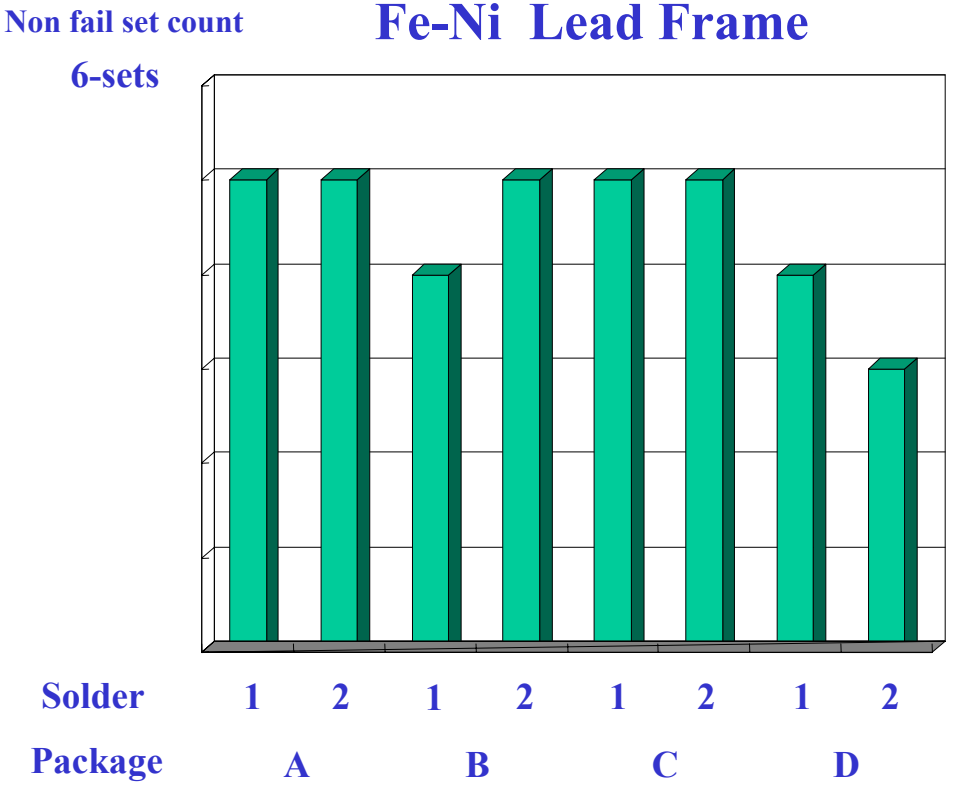
Board : FR-4,110mm x 110mm x 0.8mmt
Package : QFP208 (0.5mm pitch)
TC condition : -25°C ~ RT ~ 125°C



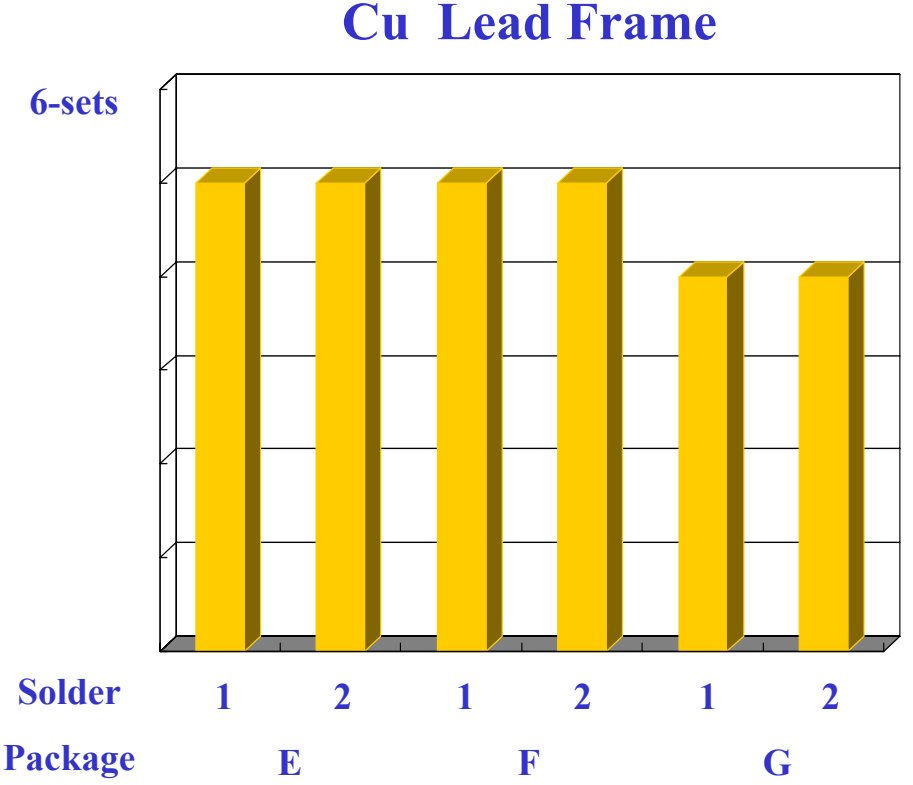
Solder Combination Evaluation(Drop Test)

Sample : Box-shaped(Weight : 150g)
Package : A=TSOP-86 B=LQFP-100 C=TQFP-120 D=QFP-208
E=CSOP-48 F=LQFP-120 G=LQFP-256
Solder Combination : 1=Sn-Bi plating/Sn-Pb paste 2=Sn-Bi plating/Sn-Bi-Cu paste
Test Condition : Height=1.5m 1set=Landing on 4different surfaces

Fe-Ni Lead Frame



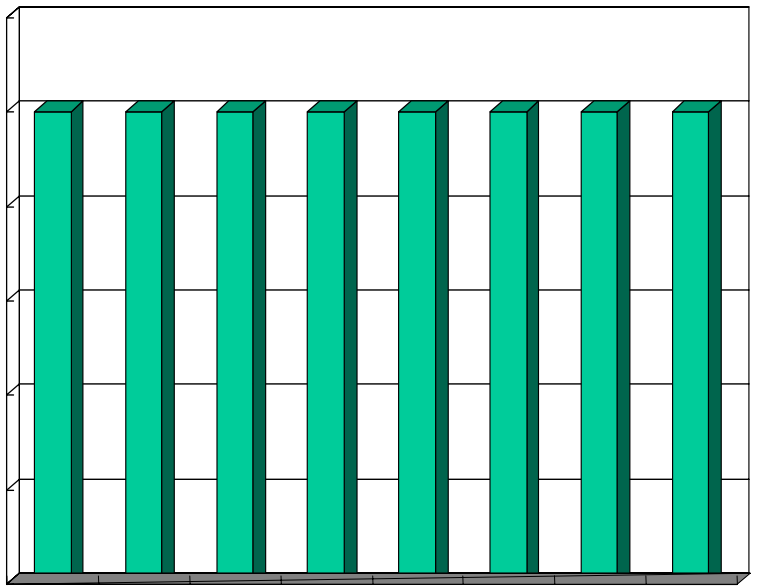
Cu Lead Frame



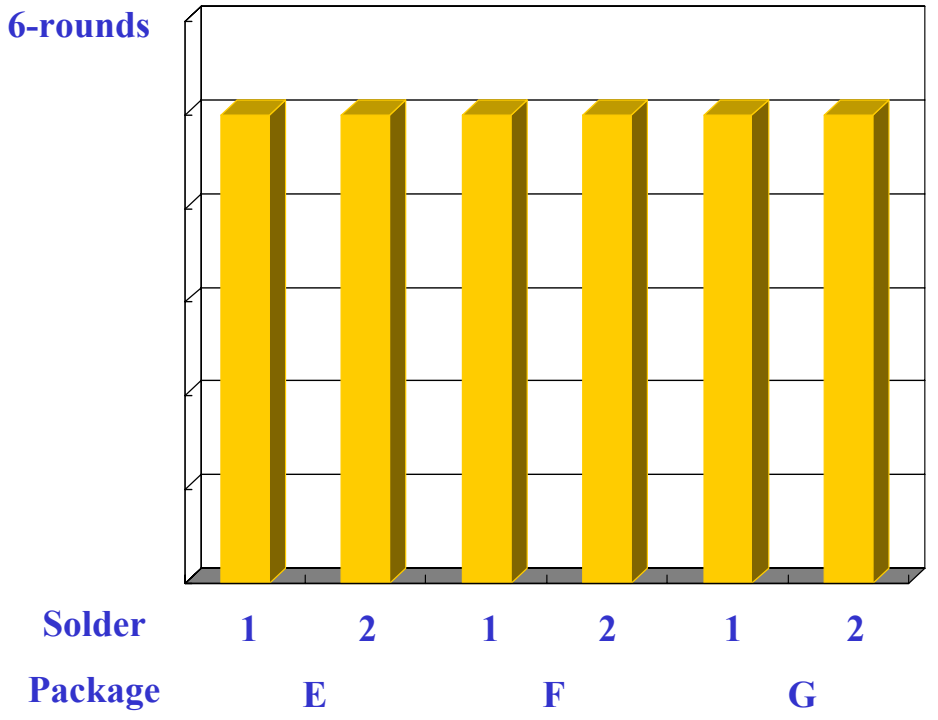
Solder Combination Evaluation(Drop Test)

Sample : Box-shaped(Weight : 150g)
Package : A=TSOP-86 B=LQFP-100 C=TQFP-120 D=QFP-208
E=CSOP-48 F=LQFP-120 G=LQFP-256
Solder Conbination : 1=Sn-Bi plating/Sn-Pb paste 2=Sn-Bi plating/Sn-Bi-Cu paste
Test Condition : 20G,10~2000Hz(1cycle=4minutes) x,y,z girection(1 round)

Fe-Ni Lead Frame



Cu Lead Frame



Conclusion of Fujitsu Lead-free Package

1. Heat resistivity = 260ºC (250ºC)x 2 Reflows
2. Terminal materials
   BGA = Sn-Ag-Cu (Ball)
   QFP = Sn-Bi (Plating)
3. Discrimination of products by:
   Parts number, marking, Lead-Free Sticker
4. Solder combinations work just as well with non lead-free version
5. Completed by Dec 2002 (Target)