Technical Information 2017

Halogen-Free (No Halogen)

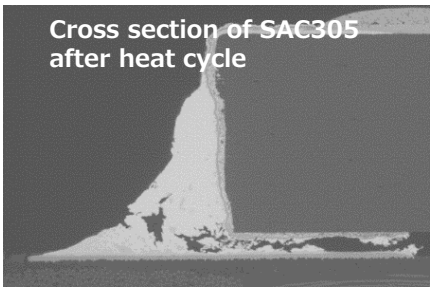
PS48BR-600-LSP

Highly Durable Lead-free Solder Paste

- **High Durability (-40 ⇔ +150℃ 3,000 cycles)**
- **Fine-pitch printing (0.5mmP BGA applicable)**
- **Prevent residue crack (Engine direct mounting [-40⇔+125℃] applicable)**
- **High Electrical reliability (No whisker occurrence due to zero halogen)**

Is lack of durability of lead-free solder paste a concern?

- Exposed to harsher environment
- Increased number of fragile components
- With high density components, difficulty to supply sufficient solder paste



Develop new solder paste to solve these problems

HARIMA

Harima Chemicals, Inc.

PS48BR-600-LSP Sn-3.2Ag-0.5Cu-4.0Bi-3.5Sb-Ni-Co

HARIMA

Highly Durable Lead-free Solder Paste

Thermal fatigue characteristics of solder joint（-40⇔+150℃ cycle）

■ **Develop solder alloy for much harsher environment（Product# : Alloy 48）**

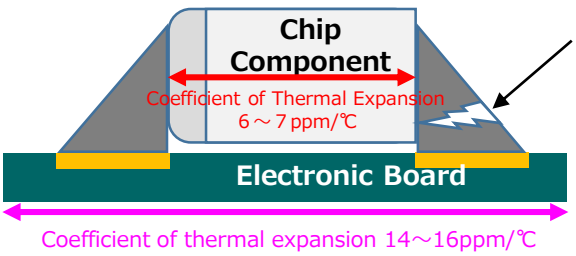
- More control devices are mounted in harsher environment, such as engine room
- Higher environmental performance is required from soldering material
- Develop solder alloy that can pass 40⇔+150℃thermal cycle

【Installation environment and thermal cycle conditions】

Installation Environment	Thermal cycle condition
Engine room	-40℃ ⇔ +125℃
Engine direct mounting	↓
Electromechanical Integration	**-40℃ ⇔ +150℃**

Maintain joint reliability with larger sized fragile chip component

Joint cross-section for chip component

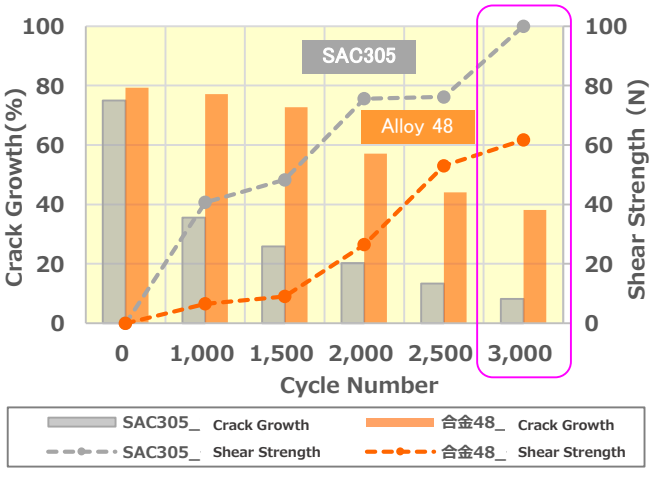


Due to repeated change in Coefficient of Thermal Expansion (CTE), **solder cracks**

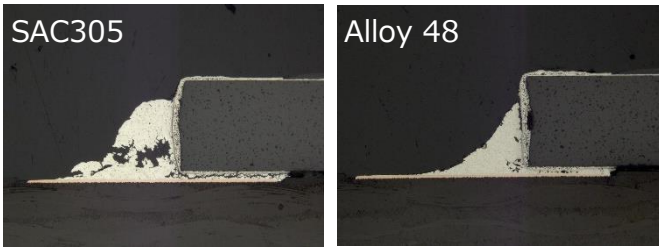
Misalignment of board and component due to solder stress
= CTE difference x test temperature difference x component size

→ As component gets bigger, it is easier to break on the joint

3216R Crack growth rate and max. shear strength



Joint cross section（after 3,000 cycle）



Complete rupture　　No rupture

Control the progress of crack, and even after 3,000 cycles maintains 3 times strengths than SAC305

PS48BR-600-LSP Sn-3.2Ag-0.5Cu-4.0Bi-3.5Sb-Ni-Co

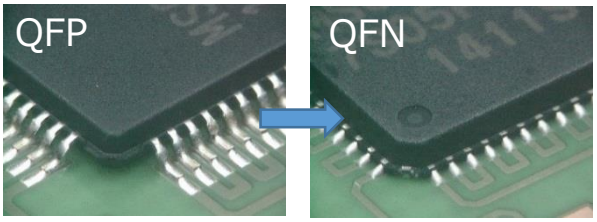
Highly Durable Lead-free Solder Paste

Thermal Fatigue Characteristics of Solder Joint(-40⇔+150℃)

■ Particularly effective for low joint reliability component

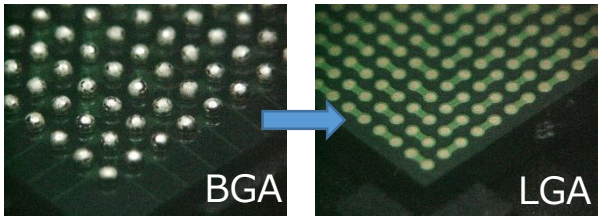
IC Appearance

ICs are larger than Chips, therefore, stress applied on IC solder joint is stronger



Absorb stress with leads　Stress concentrated on joint

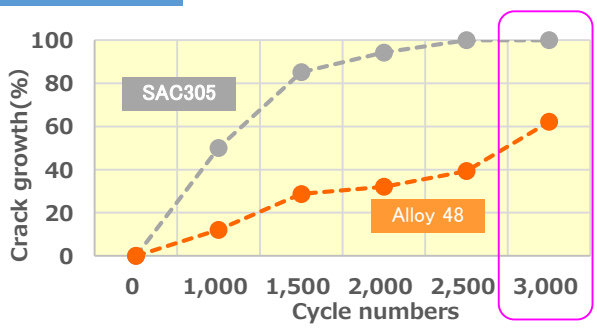
Easy to break - Fragile



With ball　No ball, less solder at joint

Easy to break - Fragile

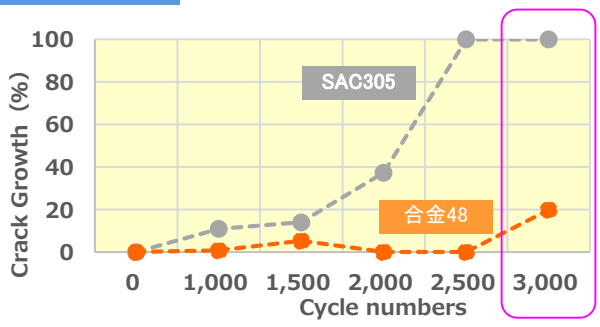
0.5mmP QFN Crack growth ratio



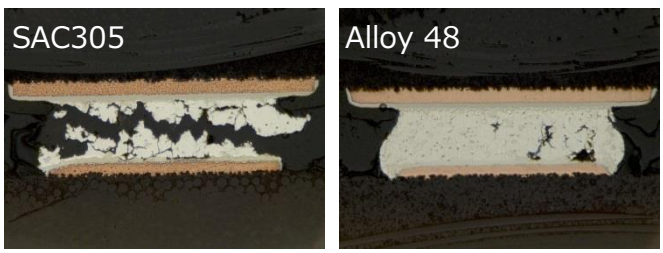
Joint cross section (after 3,000 cycle/ end lead)

Completely ruptured　No rupture

0.5mmP LGA Crack Growth Ratio



Joint cross section (after 3,000 cycle/ end lead)



Completely ruptured　No rupture

Control the progress of crack, no solder joint rupture even after 3,000 cycles

PS48BR-600-LSP Sn-3.2Ag-0.5Cu-4.0Bi-3.5Sb-Ni-Co

Highly Durable Lead-free Solder Paste

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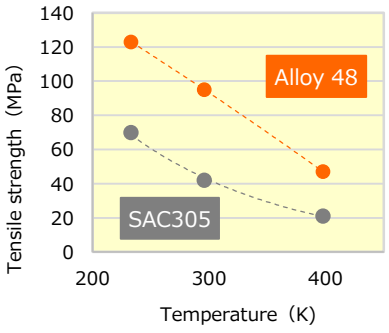
Solder Alloy Characteristics

Solder Alloy characteristics Enhanced strength, 2 times more than SAC305

	Alloy 48	SAC305
Metal composition	Sn-3.2Ag-0.5Cu-4.0Bi-3.5Sb-Ni+Co	Sn-3.0Ag-0.5Cu
Melting point	223℃	219℃
Tensile strength	**95MPa**	**42MPa**
0.2% proof stress	65MPa	32MPa
Elongation	20.4%	33.7%
Young's modules	51Gpa	52Gpa
Coefficient of thermal expansion (CTE) ※25℃～100℃	21.1ppm	24.2ppm

Solder Alloy Strength

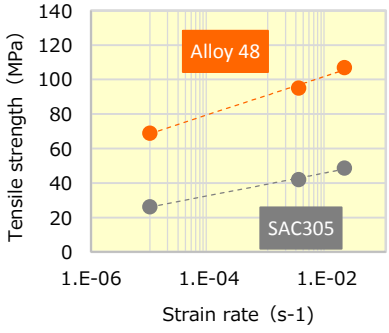
Temperature/Tensile strength



Maintains higher strength at 125℃(398K) than SAC305 at room temperature

Superior durability at high temperature

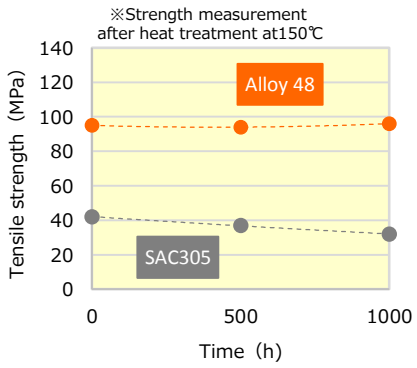
Strain rate/Tensile strength



Regardless of strain rate, higher strength than SAC305 (high strength even at low strain rate)

Not prone to Creep deformation

Tensile strength after high temperature exposure



Even in heat treatment at 150℃/1,000h, almost no deterioration of strength is observed

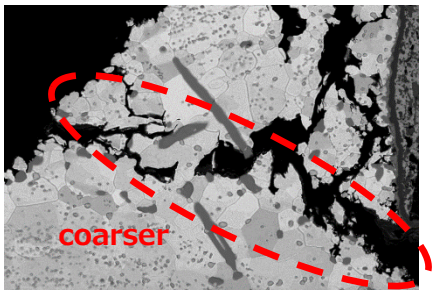
Strong resistance to thermal degradation

Highly Durable Lead-free Solder Paste

Improved Durability Mechanism

■ Fracture mechanism of SAC305

After thermal cycle – Fillet Cross Section



Due to different CTE of board and component, repeated stress is applied to solder joint
↓
Solder inter metallic compound becomes coarser
↓
Crack formation
↓
Crack propagates, and grows, leads to fracture

■ Mechanism to improve durability

3 Mechanism to strengthen solder joint

Dispersion strengthening — Strengthen solder by forming hard intermetallic compound

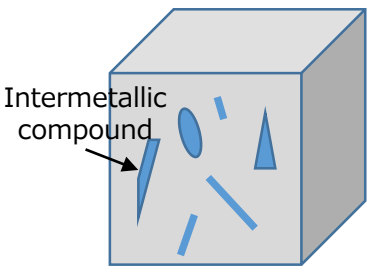
Solid-solution strengthening — Strengthen solder by solid solution in Sn matrix

Crystal gain refinement strengthening — Strengthen solder by refining structure

Dispersion strengthening

Ag Sb Cu

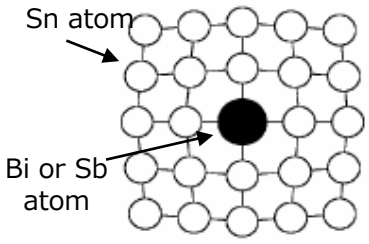
Ag_3Sn SnSb Cu_6Sn_5



Hard intermetallic compound acts as a crack arrester(stops the progress of crack growth)

Solid solution strengthening

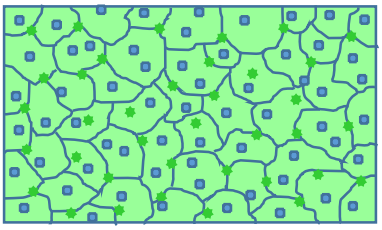
Bi Sb



Control of movement by applying strain to Sn atom

Crystal refinement

Ni Co



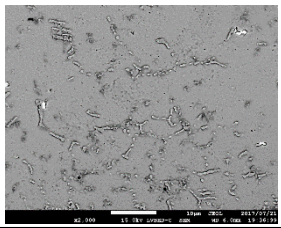
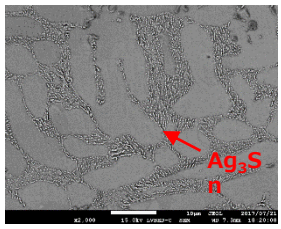
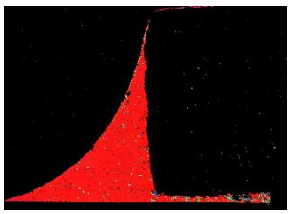
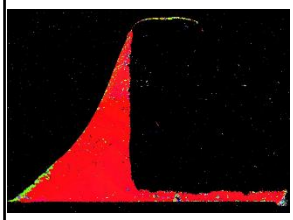
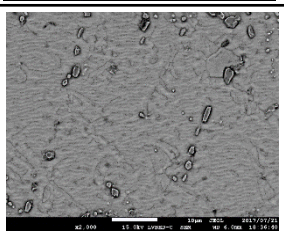
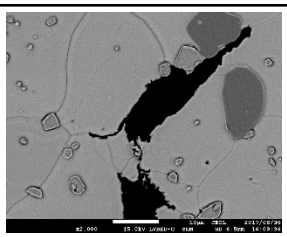
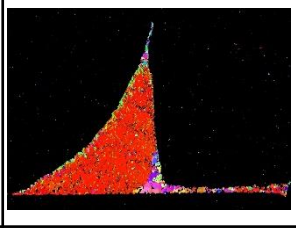
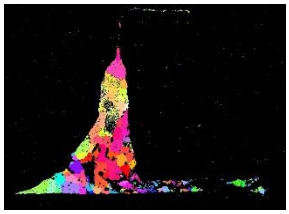
By becoming crystal nucleus, it prevents structure coarsening and crack growth

PS48BR-600-LSP Sn-3.2Ag-0.5Cu-4.0Bi-3.5Sb-Ni-Co

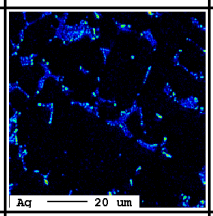
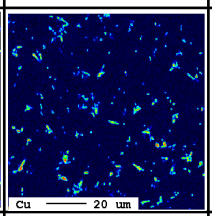
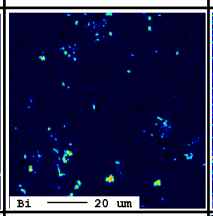
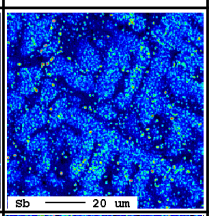
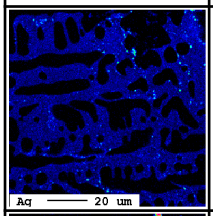
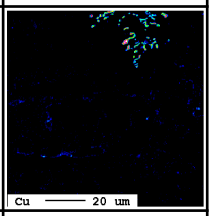
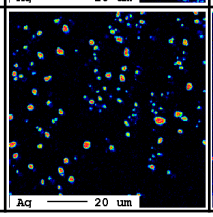
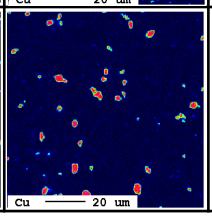
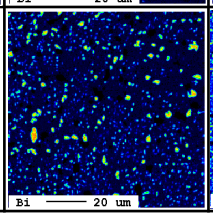
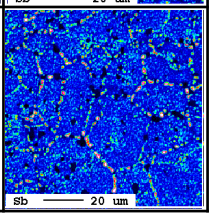
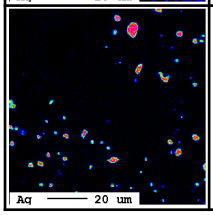
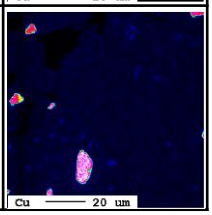
Highly Durable Lead-free Solder Paste

Change of Structure

■ Cross-sectional structure

	Cross-section observation		EBSD（※Crystal orientation analysis）	
	Alloy 48	SAC305	Alloy 48	SAC305
Initial				
-40⇔+150℃ 3,000 cycles				
	No significant change in inter metallic compound after heat cycle	Collapse of Ag_3Sn network after heat cycle ⇩ Crack formation	Even after thermal cycle, crystal orientation is uniform ⇩ Low structural change after repeated stress	After thermal cycle, crystal orientation is not uniform ⇩ Due to repeated stress, structure becomes coarser

■ Element image

	Alloy 48				SAC305	
	Ag	Cu	Bi	Sb	Ag	Cu
Initial						
-40⇔+150℃ 3,000 cycles						

There is no significant bias of elements after thermal cycling

PS48BR-600-LSP Sn-3.2Ag-0.5Cu-4.0Bi-3.5Sb-Ni-Co

Highly Durable Lead-free Solder Paste

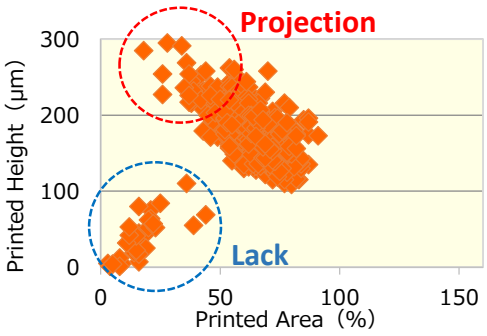
Solder Paste Characteristics

■ Fine pitch printing – capability to mount 0.5 mm P BGA

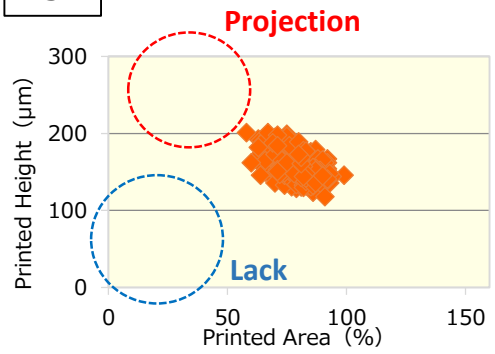
By formulating high water repellant synthetic resin, friction at metal mask opening can be reduced.

【Φ0.25mm opening／Printability】 **※150μm mask used**

Conventional



LSP



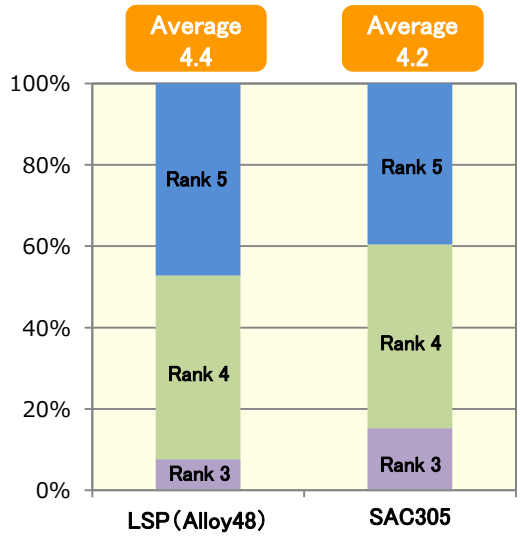
Printed shape (LSP)

Excellent printing realized – no missing solder or horn

■ Stable wetting characteristics

Same or bettering wetting than current SAC 305, even with the addition of Bi/Sb

【 Wettability at Lead Edge 】

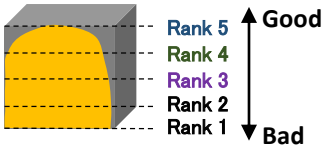


Evaluation component

0.5mmP QFP (208 pin)

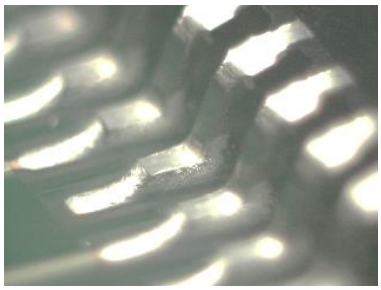
Oxidation at 85℃85%RH ×24h

Judgement



※Rank
Solder wetting height at lead edge

QFP lead tip (LSP)



Stable wetting even at lead end where it is difficult to achieve good wetting

PS48BR-600-LSP Sn-3.2Ag-0.5Cu-4.0Bi-3.5Sb-Ni-Co

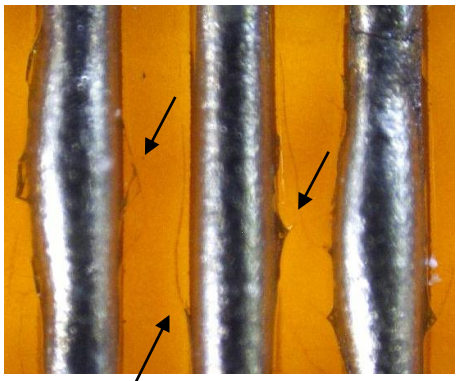
Highly Durable Lead-free Solder Paste

Solder Paste Characteristics

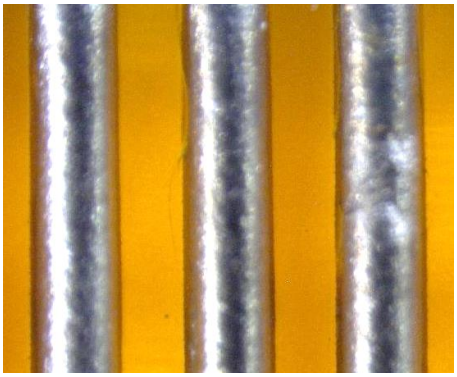
Adding flexible resin prevents residue cracks

Flexible resin prevents residue cracks even after thermal cycle test

【Flexible resin not used】



【Flexible resin used】

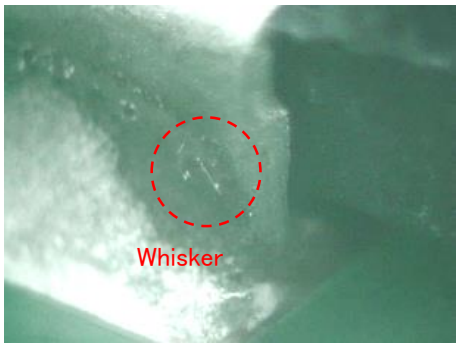


No Crack
Prevent moisture penetration,
and maintain high electrical reliability

Perfect halogen free, as a result no whisker generation

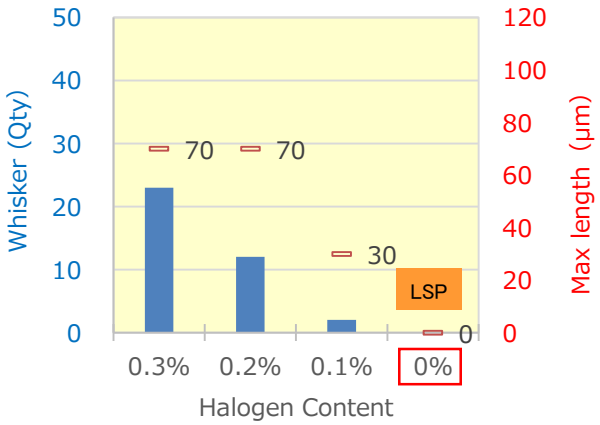
Halogen based activator, which helps generate and grow whisker, is not used – 100% halogen free flux.

【Whisker Generation】



Due to high density component mounting space between components are getting narrower, and whisker generation may cause short circuit.

【Halogen content vs Whisker】



Control whisker generation
by using halogen free flux

PS48BR-600-LSP Sn-3.2Ag-0.5Cu-4.0Bi-3.5Sb-Ni-Co

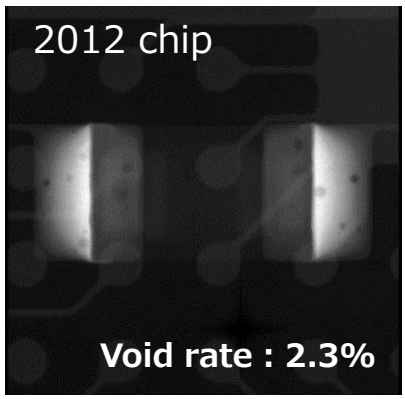
Highly Durable Lead-free Solder Paste

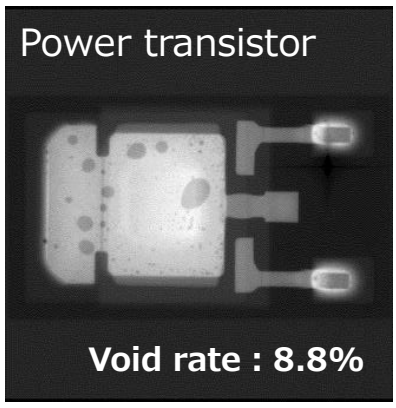
Solder Paste Characteristics

Low void generation

Less void generation by Flux optimization

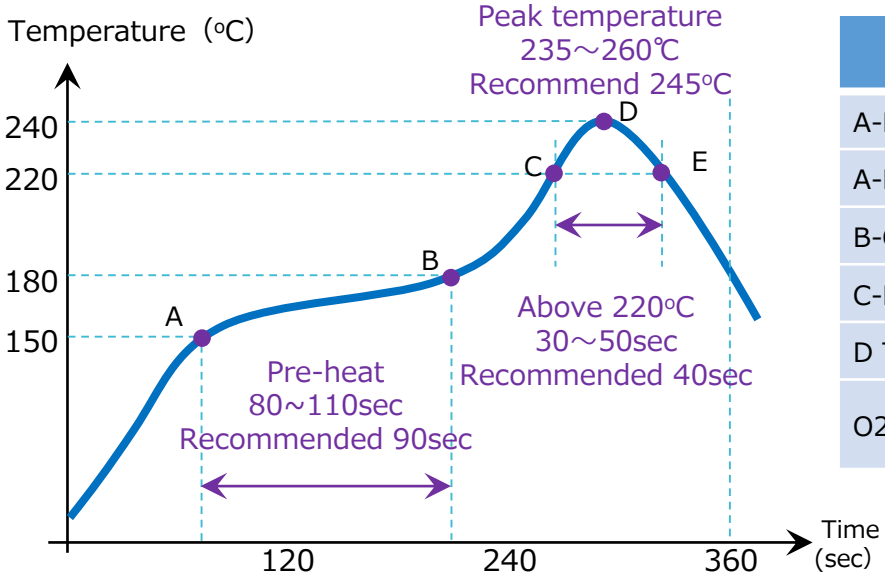
【Surface Mounted component／X-ray image】





There is significant reduction of void generation
even in the component where gas escaping is difficult

Reflow profile recommendation



Item	Recommended Condition
A-B Temperature	150-180℃
A-B Time	80-110 sec
B-C temperature speed	Below 2℃/sec
C-E Time	30-50 sec
D Temperature	235-260℃
O2 Concentration	Below 1,500ppm

PS48BR-600-LSP Sn-3.2Ag-0.5Cu-4.0Bi-3.5Sb-Ni-Co

Highly Durable Lead-free Solder Paste

Other characteristics

Item	Representative value	Test method
Product name	PS48BR-600-LSP	-
Alloy composition	Sn-3.2Ag-0.5Cu-4.0Bi-3.5Sb-Ni-Co	-
Powder size	20-38μm（Type4）	JIS Z 3284
Solidus temperature	205℃	JIS Z 3198
Liquidus temperature	223℃	
Halide content	0.0%	JIS Z 3197
Flux content	10.0%	JIS Z 3197
Corrosivity (Copper plate)	No corrosiveness	JIS Z 3197
Surface insulation resistance	More than $1x10^{9}\Omega$ from initial	JIS Z 3197
Migration	No short between 100um gap electrode	
Viscosity	230Pa･s	JIS Z 3284
Thixotropic index	0.48	
Printing slump	No bridges in 0.2mm gaps	JIS Z 3284
Hot slump	No bridges in 0.3 mm gaps	
Tackiness	1.0N or more（after 24 hours had elapsed）	JIS Z 3284
Wetting effect	Wetting class 2	JIS Z 3284
Solder ball	Rank 3 (Initial and 24 hours after)	JIS Z 3284