ECO SOLDER®

High-Reliability, High-Preheat Resistance Lead-Free Solder Paste

M705-GRN360-MZ

For Head & Pillow (BGA non-wetting) problem

Senju Metal Industry, Co., Ltd.

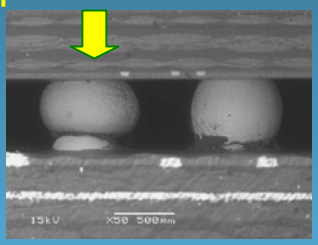
M705-GRN360-MZ

M705-GRN360-MZ is eco-friendly solder paste that provides cream solder with high-temperature preheat resistance while maintaining the high printability of our former paste, GRN360-L60. This new paste mitigates problems involving defective solder fusion between solder balls and paste that have been experienced when BGA/CSP devices are mounted. The use of BGA/CSP devices has recently been expanding, mainly in digital products.

Defective Fusion of BGA Bumps is:

- A phenomenon where molten solder pieces are not fused together due to insufficient wetting. The number of such problems is increasing as Pb-free solder becomes more and more widely used.
- Though there is no metallic reaction, electrical continuity is created in some cases, making it difficult to detect this problem electrically.
- Visual inspection is only effective for checking the periphery of the bumps. A large-scale inspection such as substrate tilting observation by X-ray is required to nondestructively check the internal conditions of the bumps.

An idea for defective bump fusion preventive measures on solder paste side based on diversified fusion mechanism analyses



Potential risk + variation > SMT process margin
→ Defective BGA fusion

Margin UP!

Margin of former solder paste

Flux reduction weakened by thermal and chemical factors

* Though the substrate hardly warps, solder ball surfaces are stained.
* High-density substrates that require high preheat temperature

Paste/bump contact deteriorated by physical factors

* Large size BGA device that tends to warp easily

SMT factors

Reflow temperature, time, and ambience

Printing stability

Heat resistance of solder paste

etc..

GRN360-MZ

Increasing margin on material (solder paste) side

Improving BGA devices is difficult in practice, even if they contain the cause of defective fusion.

M705-GRN360-MZ Performance Table

Item	M705-GRN360-MZ	Test method
Solder powder		
Alloy composition	Ag: 3.0%, Cu:0.5%, Sn: balance	- - -
Melting temperature	217 ~ 220℃	Differential scanning calorimeter (DSC)
Powder shape	Spherical	SEM
Powder particle size	25 ~ 36um	SEM and laser beam method
Flux		
Flux composition *	RO	J-STD-004
Activity *	L0	J-STD-004
Halogen content	0.0% / Flux	Potential difference titration
Surface insulation resistance (after 168 h at 40° C, 90%RH)	1.0E+12 min.	JIS Z 3284
Humidity test under DC voltage (after 1000 h under 45 VDC at 85° C, 85%RH)	1.0E+9 min. No migration detected	JIS Z 3284
Aqueous solution resistance	750Ωm	JIS Z 3197
Copper mirror test	Pass	JIS Z 3197
Fluoride test	Pass	JIS Z 3197
Solder paste		
Viscosity	190 Pa.s	JIS Z 3284
Thixotropy index	0.65	JIS Z 3284
Flux content	12.0%	JIS Z 3197
Heat sagging	0.3 mm max.	JIS Z 3284
Tackiness	1.3N	JIS Z 3284
Tack range	24 h/1.0 N min.	JIS Z 3284
Wet area ratio	77%	JIS Z 3197
Wet effectiveness and dewetting	Rank: 1 - 2	JIS Z 3284
Solder ball	Rank: 1 - 2	JIS Z 3284
Copper plate corrosion test	Pass	JIS Z 3197
Product guarantee period	**6 months**	Unopened cool storage at 0 – 10°C

◆ *Flux composition and activity*

* Numerical values given in the table are not specifications.

The methods of representing these items are specified in ANSI/J-STD-004 (American National Standard). Flux composition "RO" represents rosin base flux. Activity "L0 (Low 0)" means that the flux has a total halogen content of 0.0%. This symbol also means that the flux has passed all reliability tests (copper mirror test, silver chromate test, fluoride test, and copper plate corrosion test) specified in IPC-TM650, and has an insulation resistance of 100 MΩ (1E+0.8Ω) or more in uncleaned condition.

Defective BGA Fusion Prevention Performance of GRN360-MZ

Fusing Performance in BGA/CSP Device Mounting

Test conditions

Test substrate: SENJU POP2
(FR-4, 1.0 mm thick)

Surface treatment: Cu + preflux

Printing aperture/thickness: 280 um/120 umt

BGA device

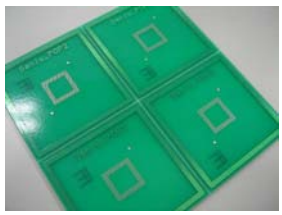
Pitch size: 0.5 mm pitch/353 pins (containing 0.3 mm Sn-Ag-Cu solder balls)

* An easy-to-warp package used for stack mounting

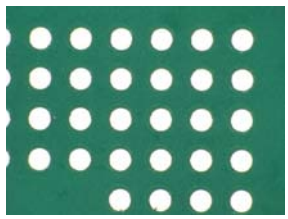
Humidified to intentionally produce defective fusion

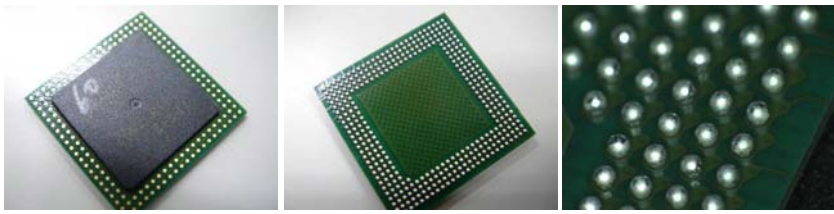
85° C – 85%RH – 12 hr + baking for 3 hr

SENJU POP2



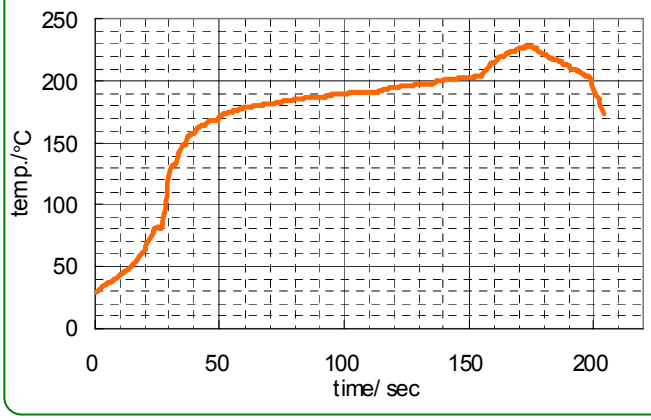
Pattern on PCB side: 0.28 mmϕ





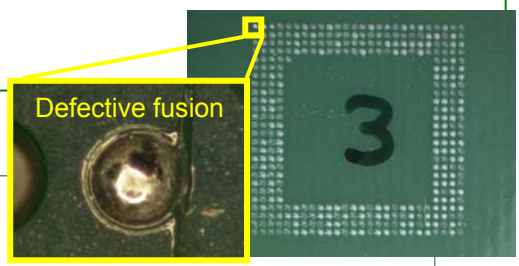
BGA device

Test temperature profile



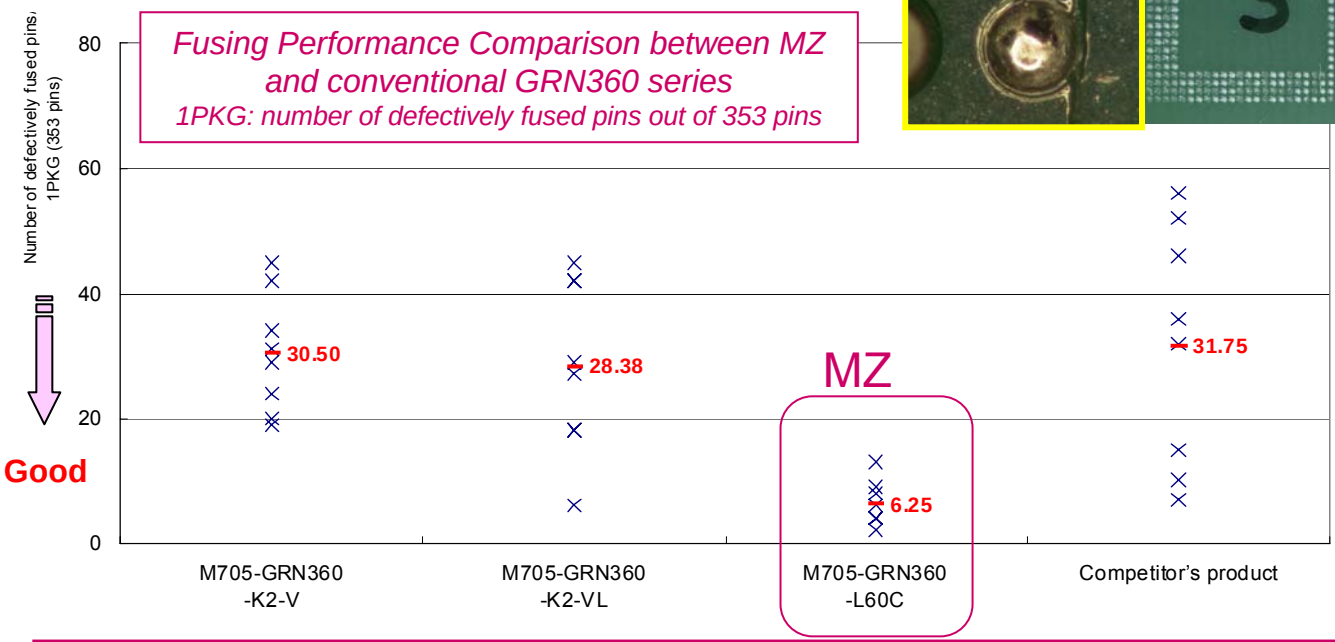
Preheat	Peak temperature	220°C or higher
170-205°C 110sec	**227°C**	**18sec**

* This temperature profile was intentionally deviated from the standard profile to produce defective fusion. Note that this profile is different from that which we recommend for this paste.



Fusing Performance Comparison between MZ and conventional GRN360 series

1PKG: number of defectively fused pins out of 353 pins



In comparison with our conventional products and competitors' products, the GRN360-MZ demonstrates a higher degree of fusion even under such environments detrimental to fusion as PKG warping, abnormal temperature profile, and degraded solder ball surface characteristics, and ensures a stable mounting performance for BGA/CSP devices.

Defective BGA Fusion Control Effect of GRN360-MZ

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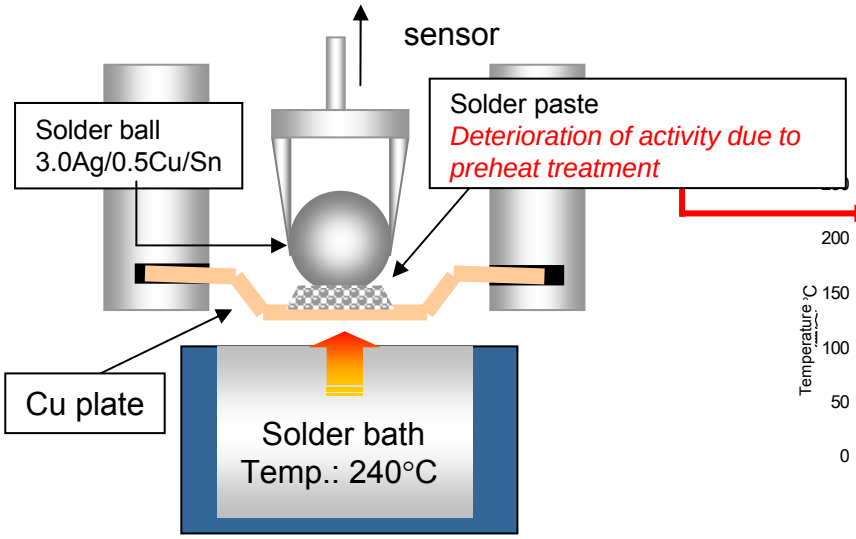
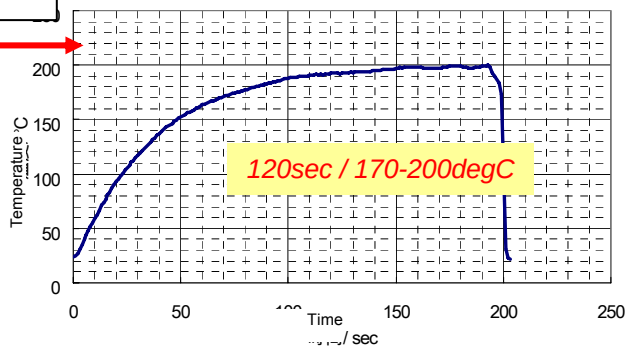
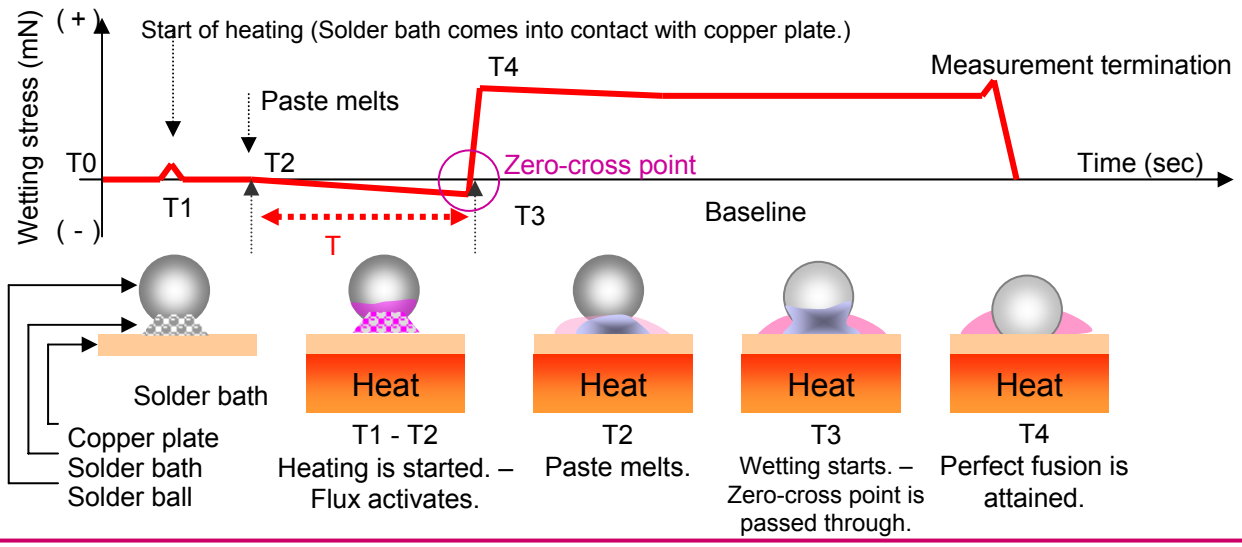
Wettability Evaluation by Wetting Balance Method



Preheat treatment: in thermostatic oven at 200°C for 3 min



Correlation between Meniscus Chart and Bump Fusion



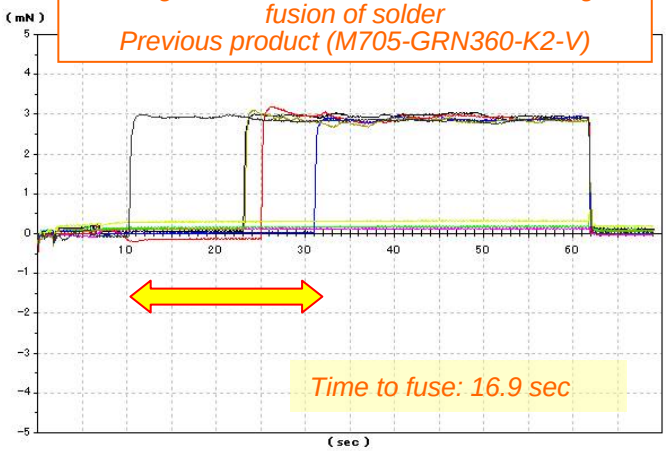
T1 - T2
Heating is started. – Flux activates.

T2
Paste melts.

T3
Wetting starts. – Zero-cross point is passed through.

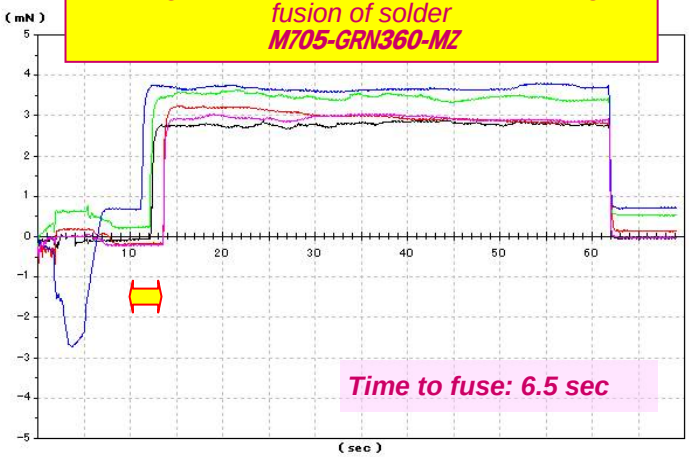
T4
Perfect fusion is attained.

Wetting behavior in the course from melting to fusion of solder
Previous product (M705-GRN360-K2-V)



Time to fuse: 16.9 sec

Wetting behavior in the course from melting to fusion of solder
M705-GRN360-MZ



Time to fuse: 6.5 sec

GRN360-MZ has a function of reducing/cleaning solder ball surfaces even under an excessively stressed condition. This function accelerates the fusion of molten solder pieces, thereby enables stable mounting of BGA/CSP devices.

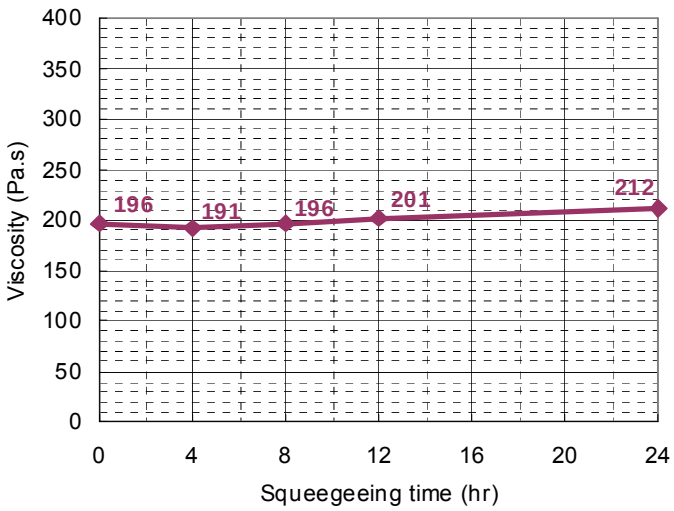
Flowability of GRN360-MZ and its Stability Change with Time

Change (increase) in the viscosity of solder paste causes defective squeegee removal, chipped printing, and other failures in a printing performed under the same conditions.
Due to excellent viscosity stability retention characteristics、GRN360-MZ hardly changes its initial viscosity even in a production where this paste has to be continuously replenished. Solder paste should be used within 48 h after taken out of the cold storage yard.

Viscosity Change during 24 h Continuous Squeegeeing

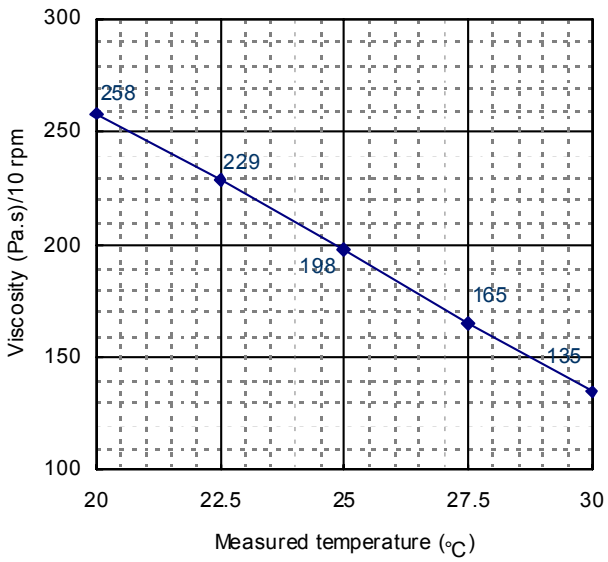
Printing rate: 120 sheets/hr
Printing ambience condition: 20 - 25°C , 20 – 40%RH

Measures revolutions (rpm)	Squeegeeing time				
	SQ0h	SQ4h	SQ8h	SQ12h	SQ24h
10	196	191	196	201	212
3	452	440	450	451	469
4	367	355	368	369	385
5	314	304	309	317	324
10	199	192	197	199	205
20	132	129	134	137	140
30	102	101	105	107	113
10	193	186	194	197	204
Thixotropy index	0.647	0.639	0.632	0.625	0.618

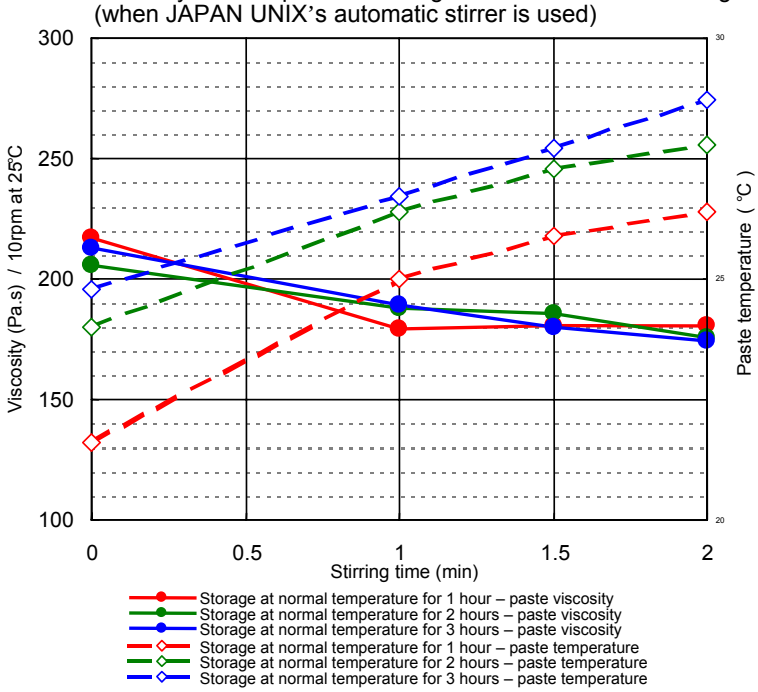


Dependence of Paste Viscosity on Temperature and Attention to Temperature Rise due to Automatic Stirring

Temperature - paste viscosity diagram



Viscosity and temperature changes due to automatic stirring (when JAPAN UNIX's automatic stirrer is used)

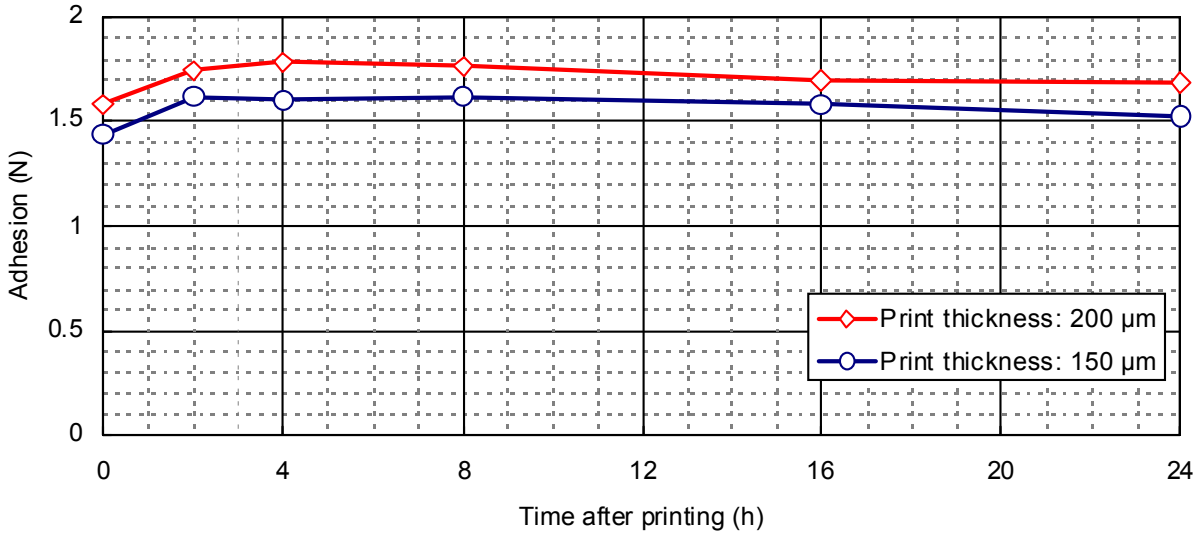


Viscosity of cream solder is highly sensitive to temperature, demonstrating a viscosity change of approx. 10 Pa.s per 1°C of temperature change. Therefore, proper control of the ambient temperature is important to maintain highly reproducible printability.
Note that the use of an automatic stirrer may increase the temperature of the paste and lower its viscosity. When using paste that has been stored at the normal temperature (use environment temperature) for 1 to 2 hours, take the minimum necessary measures to control paste temperature change, i.e. viscosity change, in either case of manual or automatic stirring.

Adhesion Retention and Sagging of GRN360-MZ

Adhesion Change with Time According to Mask Thickness

<Evaluation conditions>
Measuring instrument: tackiness tester made by Rhesca Co.
Pressurization rate: 2.0 mm/s Pressurization time: 0.2 s
Measurement load: 0.49 N Lifting speed: 10 mm/s
Storage ambience: 25°C 50%RH

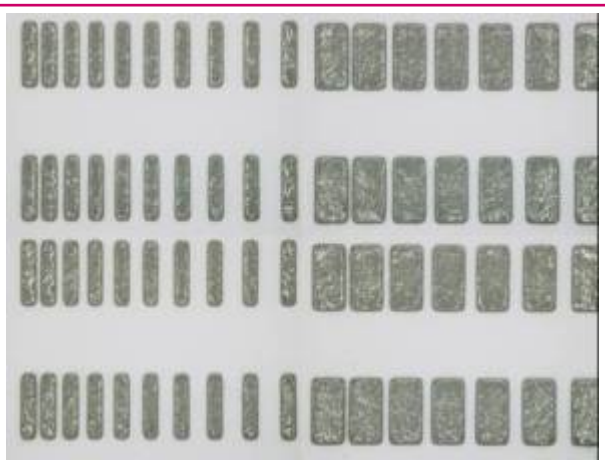
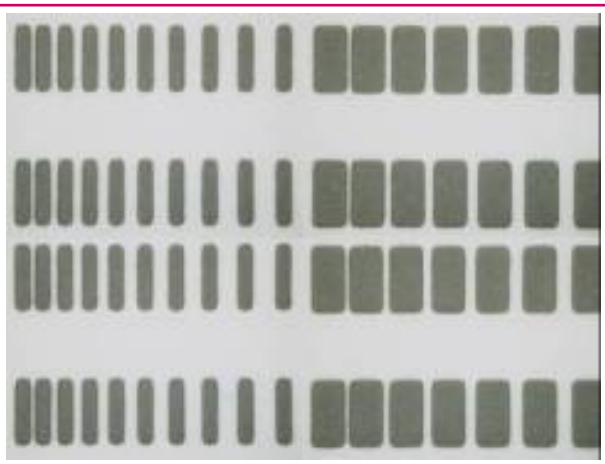


The adhesion and adhesion retention power of solder paste are very important to prevent displacement of parts that have been mounted by a stage (substrate)-shifting type high-speed mounter and to maintain the mountability of parts after line maintenance. Use of paste with poor adhesion and adhesion retention power will result in various mounting failures such as tombstone effect. GRN360-MZ has high levels of initial adhesion and adhesion retention power.

Print Sagging and Heat Sagging

<Evaluation conditions>
Print mask thickness: 150 um/JIS Z 3284 Sagging evaluation pattern
Heating condition: 180°C x 120 sec

Sagging of solder paste affects solder ball generation and bridging prevention in narrow-pitch parts mounting. GRN360-MZ hardly sags even when heated, which is very effective for preventing capillary ball generation.

Print sagging/5th sheet in continuous printing	After heating to 180°C for 120 sec
	

Printability of GRN360-MZ

Printed Figure, Transcription Volume Stability, and their Recovery after Brief Suspension of Printing

<Printing conditions>

Printing machine used: SP-28PD
Print mask: SMIC9006
Mask thickness: 120 μm
Squeegee type: metal/60°in angle
Printing speed: 40 mm/sec
Figures to be evaluated: *ϕ0.3 mm dots and 0.4 mm pitch x 0.22 mm wide vertically printed slits*

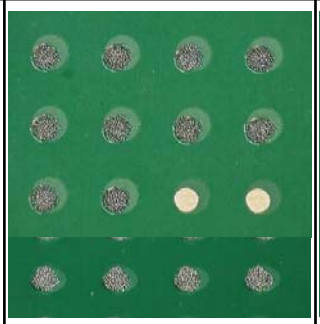
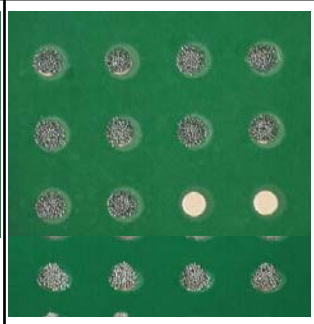
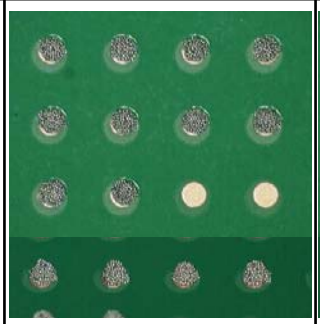
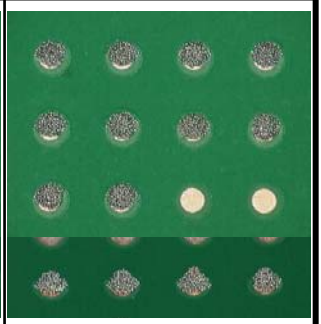
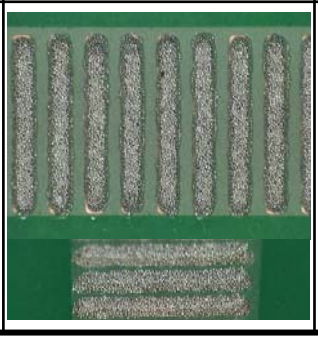
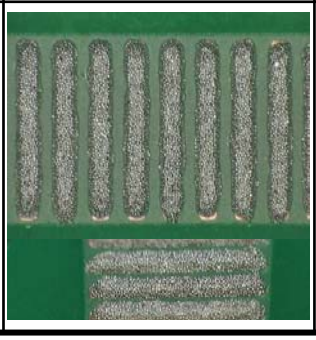
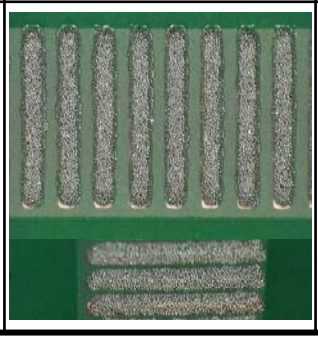
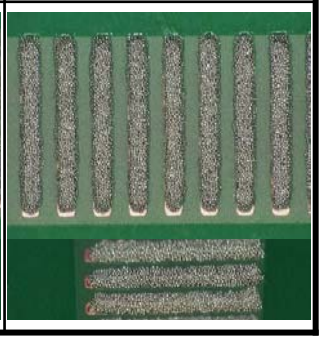
Volume inspection machine: IPV NM-TD10
Clearance: 0 mm
Printing plate lowering speed: 1.5 mm/sec (constant)
Printing plate lowering distance: 2.5 mm
Printing pressure: 0.20 N/mm (blade length: 350 mm)

Printing direction

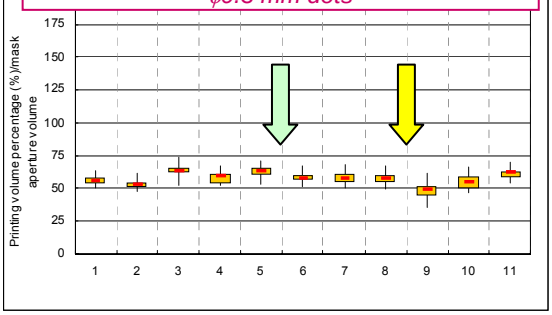
Mask cleaning

Suspension of printing for 1 hr after mask cleaning

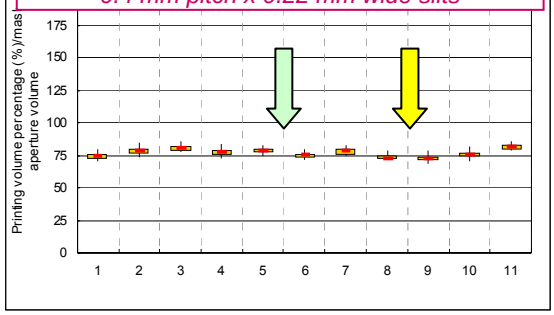
Printing 10 substrates | Printing 5 substrates | Printing 5 substrates

	1st	9th	11th	16th
Φ0.3mm				
0.4mmPitch 0.22mm slit				

Change in Transcription Volume to Mask Aperture Ratio ϕ0.3 mm dots



Change in Transcription Volume to Mask Aperture Ratio 0.4 mm pitch x 0.22 mm wide slits

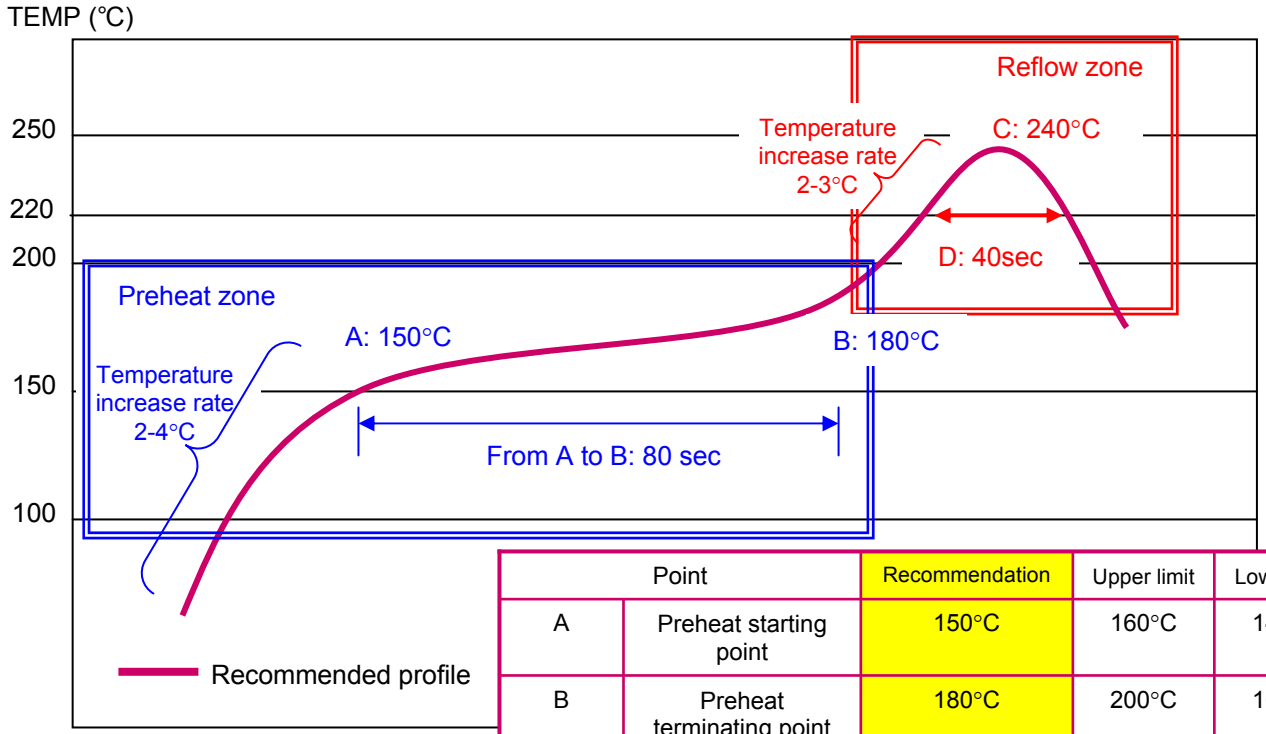


Cleaning

Printing suspension for 1 hr after cleaning

GRN360-MZ enables continuous printing without deteriorating the distinctness of printed figures, thereby minimizing blurred printing and sagged printing. This solder paste also maintains almost the same level of print transcription volume percentage as the initial percentage even after a brief suspension of printing, demonstrating that it has a high level of reproducible printability.

Recommended Temperature Profile for GRN360-MZ and Precautions in Profile Adjustment



Reflow oven used for verification
SAI-838 (air reflow oven)
SNR-825 (nitrogen reflow oven)

Point		Recommendation	Upper limit	Lower limit
A	Preheat starting point	150°C	160°C	140°C
B	Preheat terminating point	180°C	200°C	160°C
From A to B	Preheating time	80sec	100sec	60sec
C	Peak temperature	240°C	255°C	230°C
D	Temperature holding time at 220°C or higher	40sec	60sec	30sec

Precautions in temperature profile design

It is ideal to design a temperature profile so that all parts are treated according to the recommended profile. If ΔT of the substrate requires temperature conditions different from the above recommendation, adjust the temperature profile within the allowable range of the work while paying attention to the following:

Preheat

• Excessive preheat treatment (due to higher treatment temperature and/or longer treatment time);
Reoxidation of the solder powder and subsequent consumption and/or deterioration of activity of the flux will result, leading to defective melting of the solder, defective fusion of the BGA/CSP devices, or other defective mounting.
• Insufficient preheat treatment (due to lower treatment temperature and/or shorter treatment time);
Remaining solvent in the flux may cause scattering of solder/flux and/or void generation in the reflow zone.

Peak temperature

• Excessive main heating (due to higher peak temperature and/or longer solder melting time);
Scattering of solder/flux accompanied by void discharge, generation/growth of voids in the area near the bottom electrode, deterioration in thermal fatigue resistance of soldered joints, and deterioration in external appearance of joints after reflow (deterioration in residue cracking resistance) will be caused.
• Insufficient main heating (due to lower peak temperature and/or shorter solder melting time);
Insufficient main heating will cause poor wetting of electrodes of the parts (defective fusion in the case of BGA/CSP devices). Attention must also be paid to temperature drop in continuous mounting. Main heating with a sufficient margin is required.

Temperature increase rate

• Excessively high temperature increase rate
An excessively high temperature increase rate will affect the sagging characteristics of the solder paste, resulting in solder ball and/or side ball generation. Also pay attention to the scattering of the flux and tombstone effect.
• Excessively low temperature increase rate
Paste is exposed to a thermal stress even when it is heated up to the peak temperature. An excessively low temperature increase rate may exert thermal stress on paste at a high-temperature range (200 - 220°C). Pay attention to the deterioration of reflow characteristics discussed above.

* Solderability differs depending on the specifications of the reflow oven, as well as the type of substrate and parts used for surface-mounting. In very small apertures requiring a small amount of paste and structures that allows flux to flow out easily, in particular, solder may melt abnormally even in the preheat range shown in the figure above. For these apertures and structures, be sure to carry out a solderability evaluation test before using this paste.

Reflow Characteristics of GRN360-MZ

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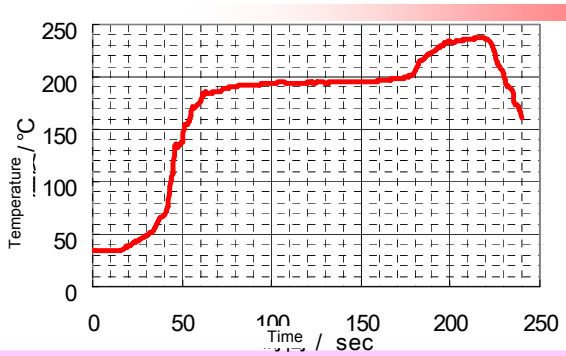
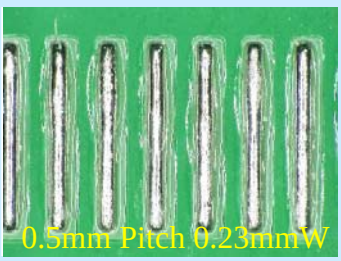
Air reflow characteristics for narrow slits, very small apertures, and flat lands
Test mask thickness: 100 um

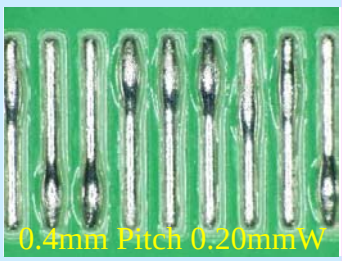
Preheat		Peak	
Temperature	Time	Temperature	220°C or more
186-202°C	**116sec**	**238°C**	**38sec**

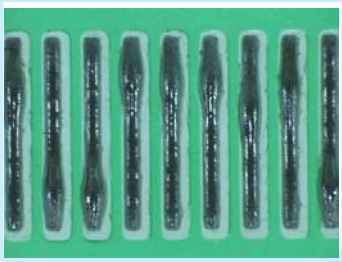
** The numerical values given in the above table are not for the recommended temperature profile. They were given for heat resistance evaluation test only.*

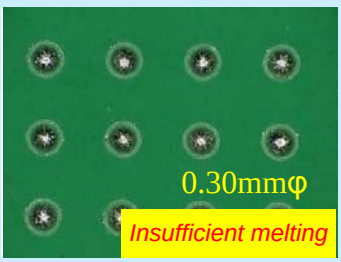


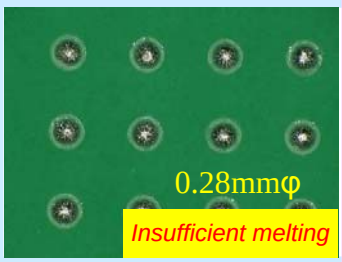
M705-GRN360-L60

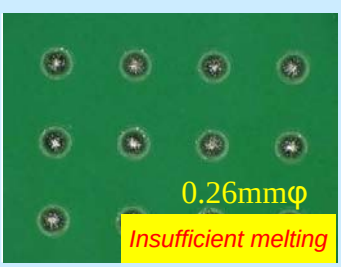


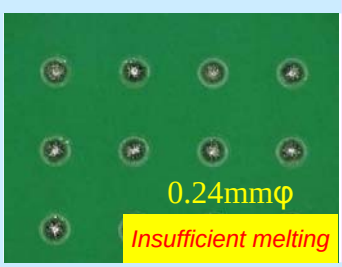


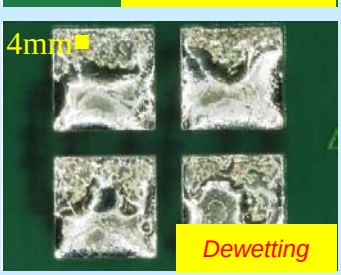


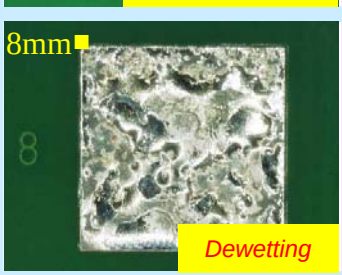




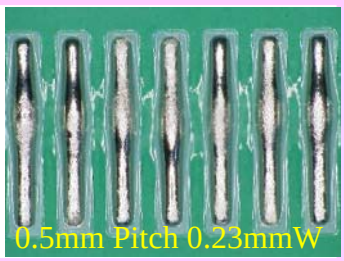


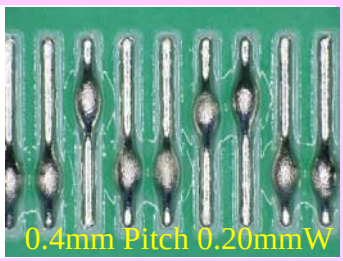


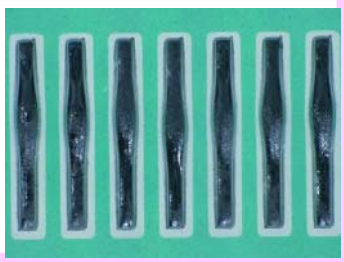


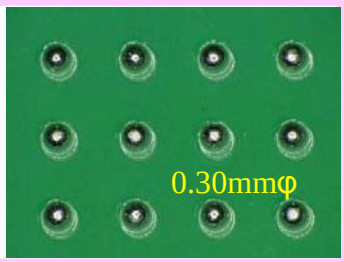


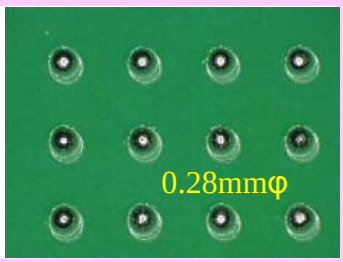
M705-GRN360-MZ

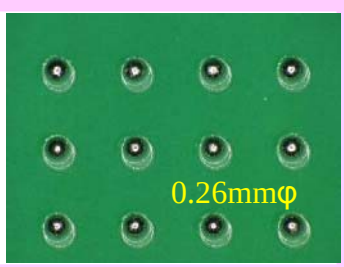


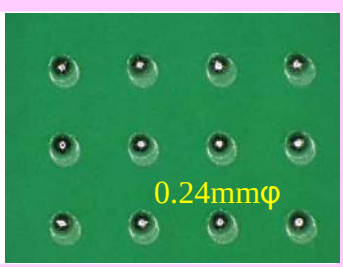


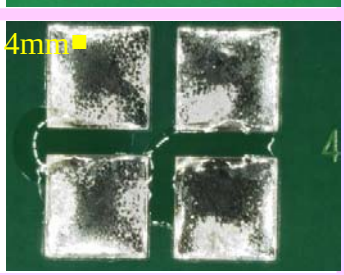








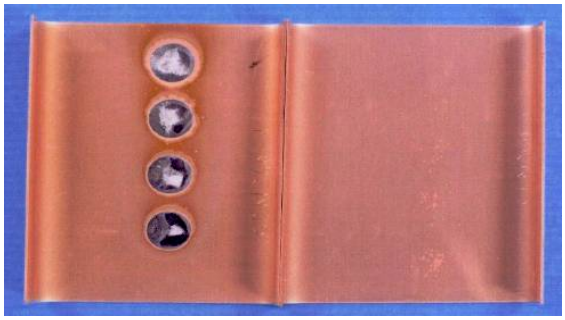




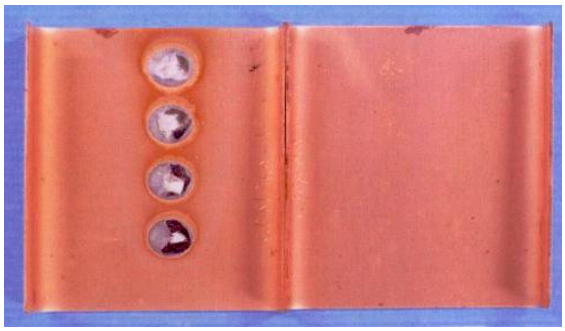
When stressed excessively in a preheat process, our previous solder paste, GRN360-L60, often deteriorated the melting characteristics of very small dots and uniform wetting in flat lands. GRN360-MZ, which has improved heat resistance over the previous paste, ensures high solderability even after being subjected to a long, high-temperature preheat treatment. GRN360-MZ also demonstrates the same levels of control performances for solder ball generation between slits, residue scattering, and cracking as those of the previous paste.

Reliability Test of M705-GRN360-MZ

Copper plate corrosion test
M705-GRN360-MZ
Each test condition: complying with JIS Z 3197

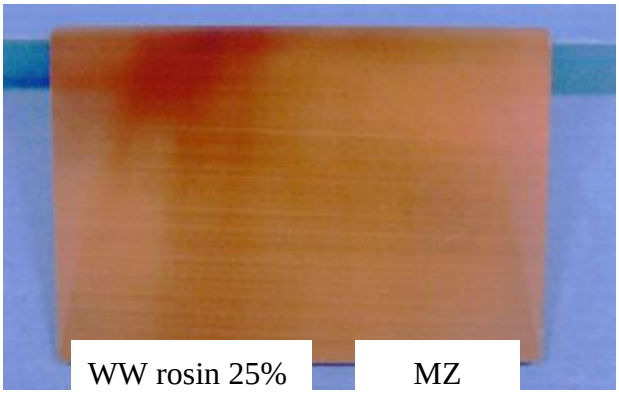


Before humidification

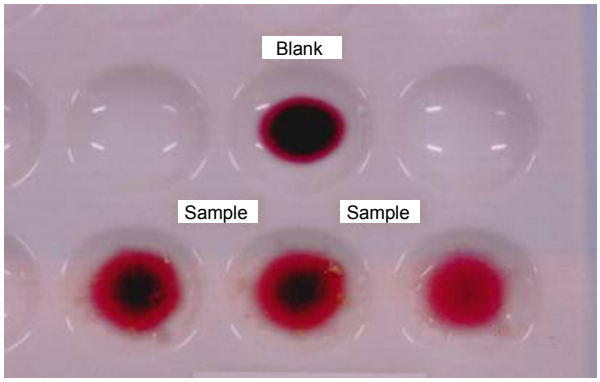


After humidification

Copper mirror test
M705-GRN360-MZ
Each test condition: complying with JIS Z 3197



Fluoride test
M705-GRN360-MZ
Each test condition: complying with JIS Z 3197

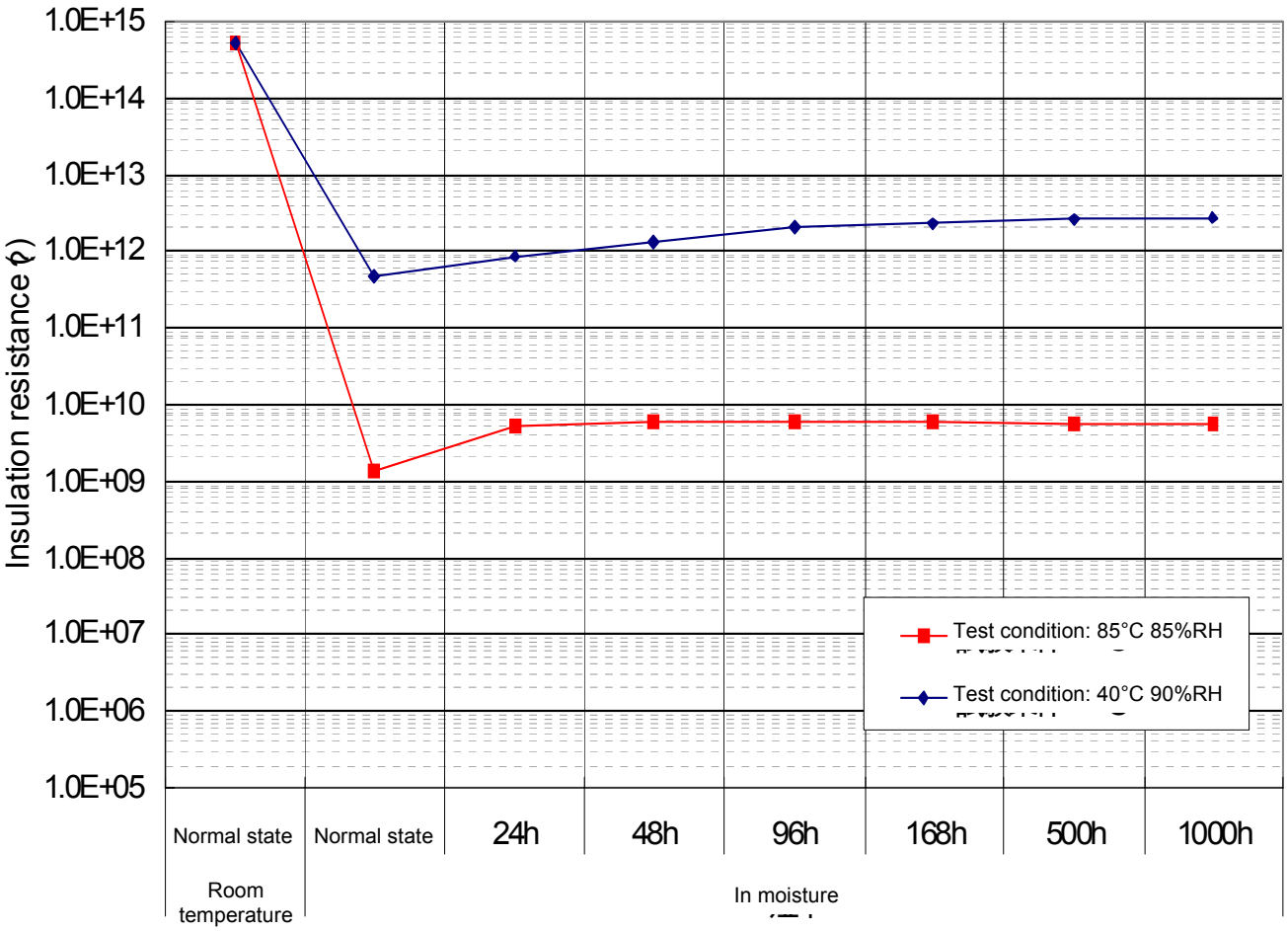


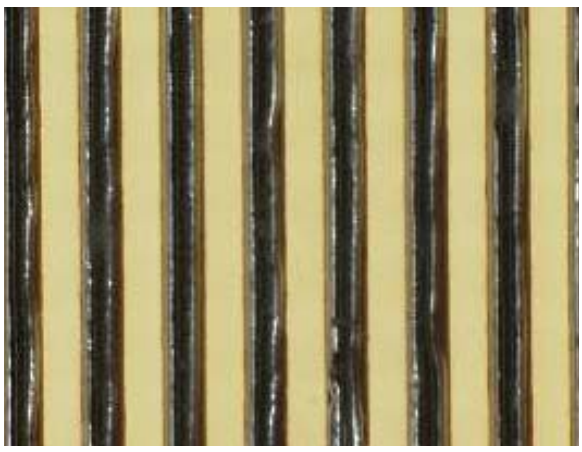
Silver chromate paper test
M705-GRN360-MZ
Each test condition: complying with JIS Z 3197

Reliability Test of M705-GRN360-MZ

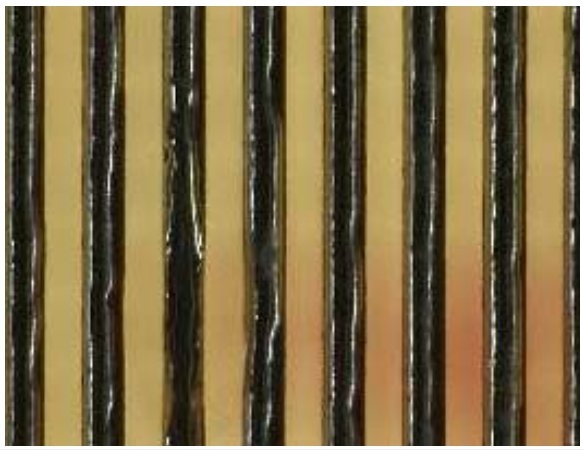
Migration test/M705-GRN360-MZ

Ambient conditions: 40°C 90%RH and 85°C 85%RH (two conditions)
Applied voltage: 45 V Measures voltage: 100 V (measured inside oven)





Before test



After 1000 hours at 85°C 85%RH
No migration was detected.