User's Manual

LGA Mounting Manual

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1. The LGA Package

1.1 Overview of the LGA Package

The land grid array (LGA) package is a resin molding package in which the external pins have a land structure and are arranged in a matrix on the bottom surface of the package. The LGA package is mounted by reflow. The LGA package is widely used for microcontrollers and other semiconductor devices in consumer equipment.

1.2 LGA Package Structure

The figures below show the external appearance and structure of a Renesas LGA package.

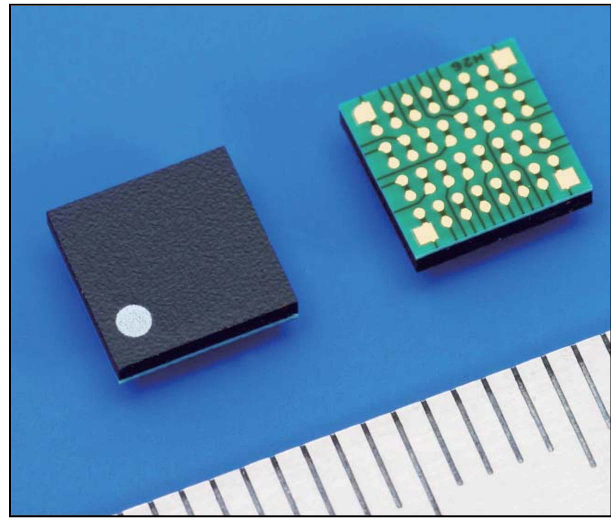


Figure 1.1 LGA Package

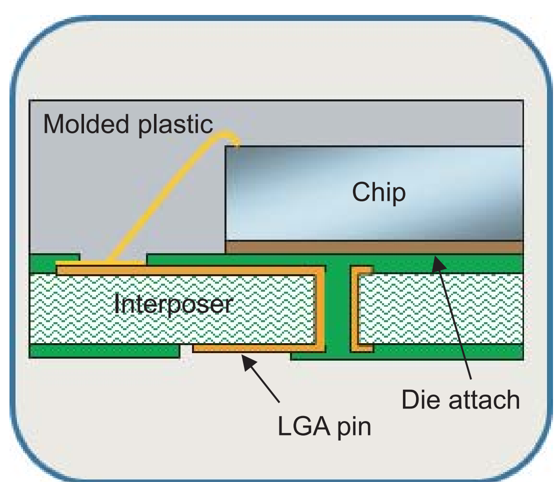


Figure 1.2 LGA Package Cross Section

1.3 LGA Lineup

The table below lists Renesas lineup of miniature, thin-form LGA packages.

Table 1.1 LGA Lineup (Pin counts for different package dimensions)

Terminal Pitch	Body Size (mm)								
	3x3	4x4	5x5	5.5x5.5	6x6	6.5x6.5	7x7	8x8	9x9
0.65 mm			49		64	Δ81	85	113	145
							100		
0.50 mm	25	36	49	100	113		145	177	
		Δ49	64						
			81						

Note: Cells marked with a delta (Δ) indicate which are under planning.

2. Mounting Board Design

2.1 Mounting Pad Structure

There are two types of mounting pad; solder mask defined (SMD), in which the solder resist overlays the mounting pads, nd non solder mask defined (NSMD), in which the solder resist does not overlay the pads. While the NSMD structure is the most common mounting pad structure, users should determine the mounting pad structure based on consideration of the board wiring design.

The LGA land type is the NSMD type, in which the solder resist does not cover any of the land area.

The mounting pad form on the mounting board is made to be the same as that of the LGA itself, and soldering connection geometry with a good vertical balance after reflow soldering can be achieved by **designing with an NSMD structure** in which the solder resist does not cover any of the pad area.

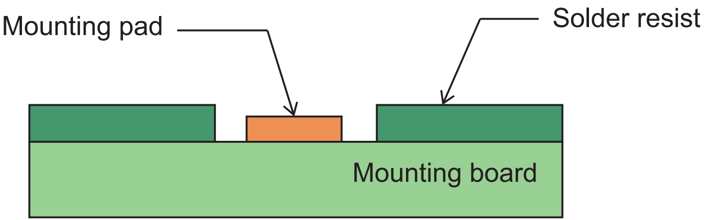


Figure 2.1 Pad Structure (NSMD structure)

2.2 Mounting Pad Design Example

This section presents a mounting pad design example for the mounting board that is matched to the LGA package land size.

Table 2.1 Mounting Pad Design Example

(Unit: mm)

LGA land size	ϕ0.25	ϕ0.30	ϕ0.35
Mounting pad design	ϕ0.25	ϕ0.30	ϕ0.35

Mounting Pad Design Example for LGA Packages with Reinforcement Lands

Some LGA packages have the reinforcement lands which are located in the four corners. Since these reinforcement lands increase the resistance to stress of the solder joint, we recommend designing a mounting pad that matches the reinforcement land specifications if an LGA product that has reinforcement lands at the four corners is used.

Figure 2.2 shows a mounting pad design for a 5x5/64-pin FLGA package.

An SMD structure is used for the reinforcement pads, and an NSMD structure is used for all other pads. While the reinforcement lands on the package have a complex shape, the form of the reinforcement pads on the mounting board is simplified. Also, the aperture size of the metal mask used for solder printing for the reinforcement pads is set to be roughly 80% of the SR aperture area. If an excessive amount of solder is applied to the reinforcement pad areas, a phenomenon in which the package floats up can occur during reflow soldering due to the influence of the melted solder. This can result in insufficient solder connections to the signal pins.

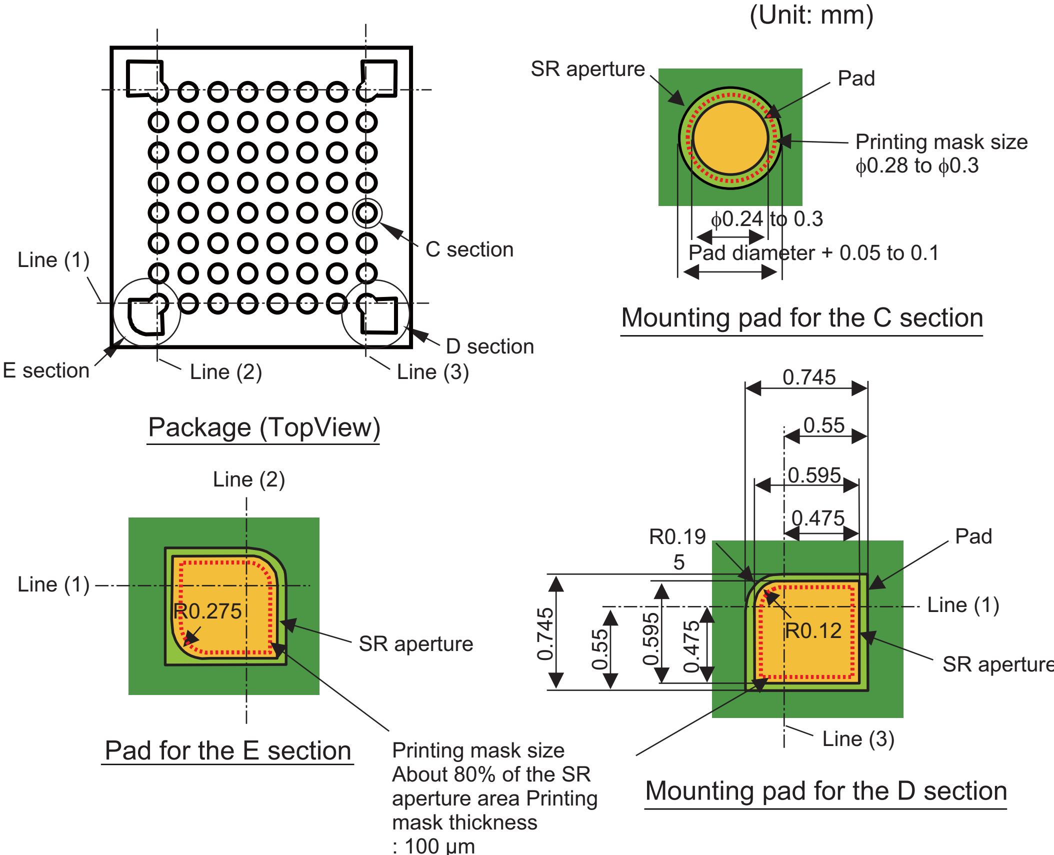


Figure 2.2 Design Example for 0.5 mm pitch 5x5/64-Pin FLGA

3. The Mounting Process

3.1 Details of the LGA Mounting Process

Solder paste (solder cream)	Lead-free solder Printing positional tolerances 0.5 mm pitch LGA: within ±0.10 mm 0.65 mm pitch LGA: within ±0.12 mm	• Recommended design values of stencil — ϕ0.25 mm to ϕ0.35 mm — Thickness: 0.10 mm • Sample solder material — M705-235C-32-11*[1] or equivalent (M705 solder composition: Sn-3Ag-0.5Cu)
Placement	Precision (placement positional tolerance) Placement positional tolerances based on recognition of all lands or outline recognition 0.5 mm pitch LGA: within ±0.10 mm 0.65 mm pitch LGA: within ±0.12 mm	• Placement system with recognition system — KE-760 (Juki Corporation) or equivalent
	Conditions 0.5 mm pitch placement loading: up to 180 g Placement speed: 39.5 mm/second to 275 mm/second Placement push-in depth: 0 to 0.5 mm 0.65 mm pitch placement loading: 60 g to 250 g Placement speed: 39.5 mm/second to 395 mm/second Placement push-in depth: 0 to 2.0 mm	(The same as for earlier BGA products)
Reflow soldering conditions	The reflow thermal conditions specified in the delivery specifications document must be followed.	• Reflow equipment — Air reflow or nitrogen reflow equipment (the same equipment as used for earlier BGA products)

Notes: LGA package products can be mounted with the same conditions as BGA package, and they can also be mounted at the same time when QFP, SOP, and similar package products are mounted.

1. Manufactured by Senju Metal Industry Co., Ltd.

The LGA mounting process is described in detail in the following pages.

3.2 Solder Paste Printing

3.2.1 Solder Paste

The main components of solder paste are solder powder and flux.

(1) Solder Powder

- Solder powder contains a range of solder powder size as shown below, and this range affects the printability of the solder paste.
- The land pitch, as listed in the table below, should be taken into consideration when selecting the solder powder. Note that solder paste with a fine particle size has issues such as the easier formation of capillary balls and degraded wettability. This means that thorough evaluation is required during materials selection.

Source: Senju Metal Industry Co., Ltd.

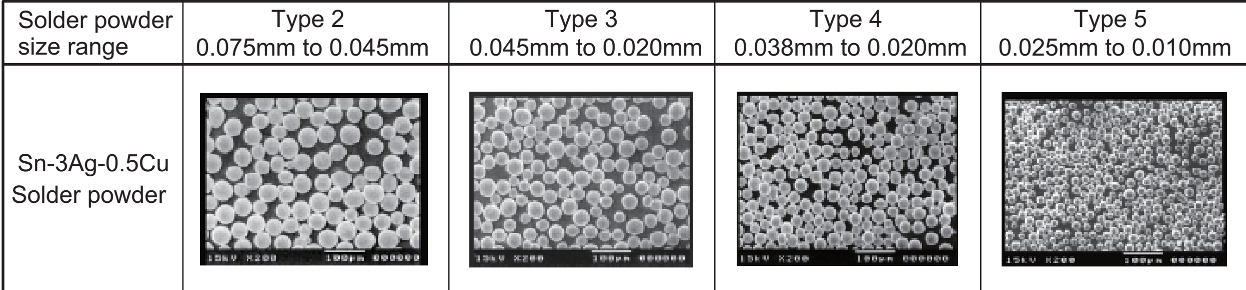


Figure 3.1 Electron Microscope Images of Solder Powder in Solder Paste

Table 3.1 Land Pitch and Ranges of Solder Powder Sizes in Solder Paste

Solder Powder Size Range	Land Pitch (mm)					
	1.27	1.00	0.80	0.65	0.50	0.40
0.075 to 0.045 mm	○	○	○			
0.045 to 0.020 mm			○	○		
0.038 to 0.020 mm				○	○	
0.025 to 0.010 mm					○	○

(2) Flux

- There are three main types of flux: rosin based fluxes, synthetic resin fluxes, and water soluble fluxes.
- There are three types of rosin based fluxes according to their activation level: R (rosin fluxes), RMA (mildly activated fluxes), and RA (activated fluxes). The table below lists the features of these three types.

Table 3.2 Flux Types and Their Characteristics

Flux Type	Characteristic
R type, ROL type (Non-activated Rosin, Rosin Low activity levels)	Non-activated fluxes, Noncorrosive.
RMA type, ROM type (Rosin Mildly Activated, Rosin Moderate activity levels)	Mildly activated fluxes. Noncorrosive. These fluxes have better solderability than the R type fluxes.
RA type, ROH type (Rosin Activated, Rosin High activity levels)	Highly activated fluxes. These fluxes have better solderability than the R and RMA type fluxes. They are, however, strongly corrosive.

(3) Characteristics Required in the Solder Paste

Printing

- Solder powder size: A particle size of less than 1/4 to 1/5 the thickness of the stencil is most commonly selected to assure the release characteristics in solder printing.
- Viscosity is too high, the release characteristics of the solder can be degraded and result in thin pringing. If the viscosity is too low, print blotting and/or print droop may occur. For printing applications, a viscosity of around 200 to 300 Pa•s/25°C is commonly used.

Before and After Reflow

- Before reflow
  - Solder paste should have minimal aged deterioration during manufacturing and good printability.
  - Solder paste should have minimal aged deterioration after printing (it should have a long viscosity retention time and should not cause shape collapse to occur).
  - The flux and the solder powder must not separate.
- After reflow
  - Solder paste should have good solderability and capillary balls must not be formed.
    (Note that no solder powder oxidation occurs and select a solder powder with a narrow particle size distribution. Also, select a flux whose solvents have a low boiling point and select a solder with a high molecular weight rosin and relatively low volume of flux itself.)
  - Flux residues must not affect end product reliability.

Note: The user should select the solder paste according to the application.

3.2.2 Stencil Examples

The table below lists stencil design examples for various land sizes. The aperture dimensions and The thickness must be selected by taking post reflow soldering open connections and solder bridges into account.

Table 3.3 Stencil Design Examples

Unit: mm

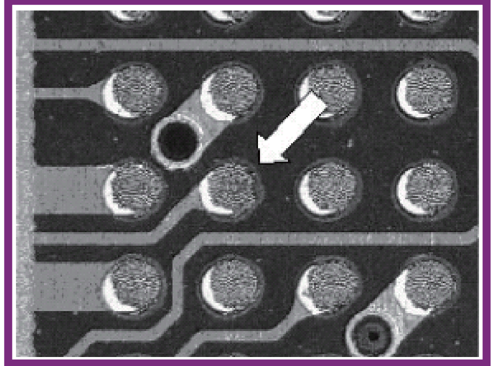
LGA land size		ϕ0.25	ϕ0.30	ϕ0.35
Mounting pad design		ϕ0.25	ϕ0.30	ϕ0.35
Stencil	Aperture diameter	ϕ0.25	ϕ0.30	ϕ0.35
	Thickness	0.1	0.1	0.1

3.2.3 Inspection Following Solder Printing

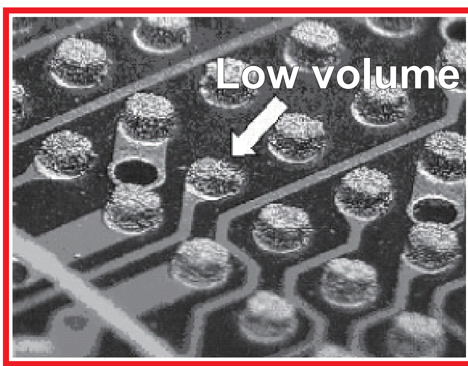
The amount of solder paste has a large effect on the connection quality. In some cases, only using a 2D inspection for the paste volume inspection will be inadequate for evaluating the post-printing print quality. We therefore recommend the adoption of 3D inspection, especially when manufacturing high-reliability equipment.

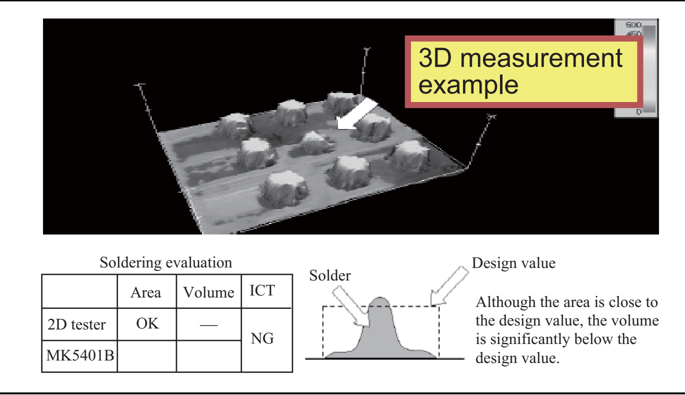
We recommend that you consider the examples of 3D inspection equipment introduced below and examine the inspection equipment.

Inspection photograph taken from directly above



Inspection photograph taken from oblique side





	Area	Volume	ICT
2D tester	OK	—	NG
MK5401B			

Source: Electronics Mounting Technology
Author: Takuo Kajima, Anritsu

Figure 3.2 3D Inspection Unit Example

3.3 Mounting (placement)

3.3.1 Image Recognition

When mounting devices using image recognition of lands, mounting equipment that includes land recognition software is required. The adequate recognition ability to differentiate between signal lands (pins) and reinforcement lands, which have a different shape and size, is necessary when performing land recognition of LGA packages that have reinforcement lands.

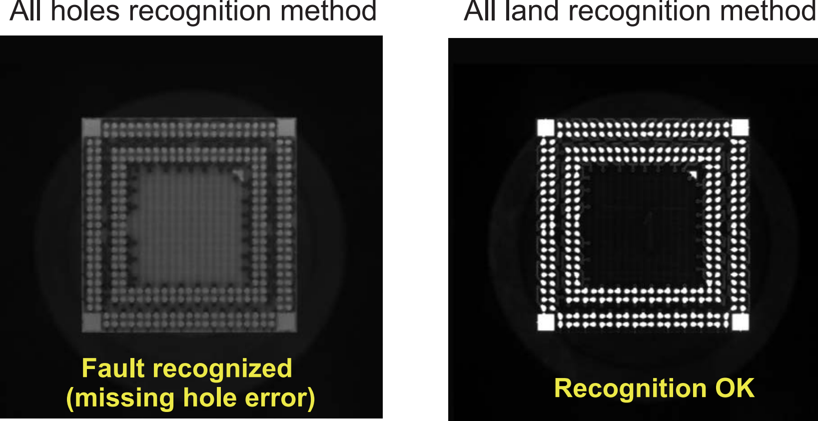


Figure 3.3 Image Recognition Result for LGA with Reinforcement Land Recognition Function

3.3.2 Placement Nozzle

Although LGA package devices have a resin molding structure, we still recommend using a suction collet that has a built-in spring to reduce the impact load applied to devices during mounting.

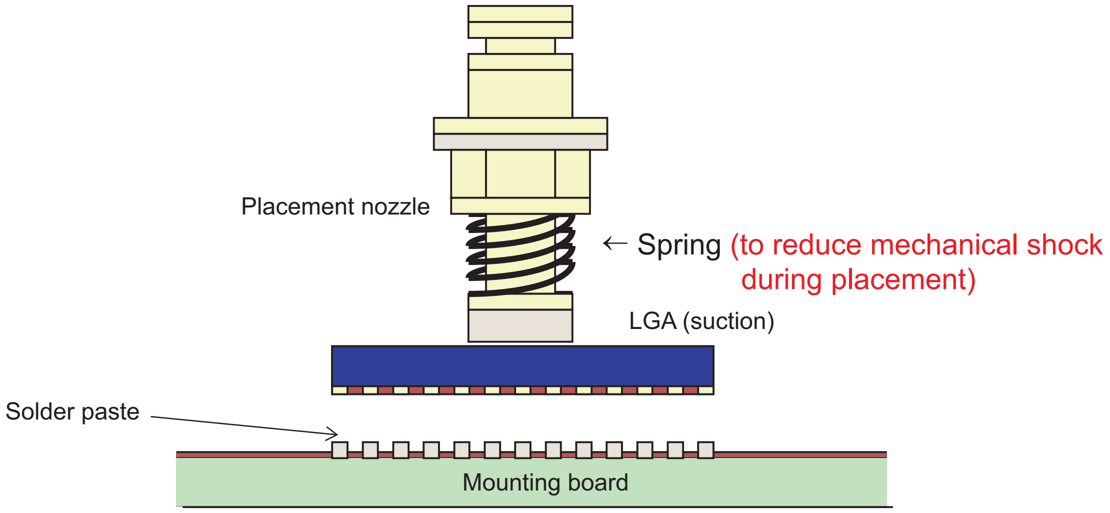


Figure 3.4 Placement Nozzle Example

The optimal placement condition must be determined, following issues into consideration: the push-in amount which can cause solder paste squashing, positional displacement, and the placement positional tolerance determined according to the LGA package self-alignment and other issues.

3.3.3 Placement Positional Error Tolerances

This section presents an example of results of self alignment evaluation for 0.5 mm pitch LGA packages.

We set the solder printing positional error and LGA placement positional error as reverse direction respectively, evaluate and examine the tolerance.

Mounting Conditions

1. Solder paste: M705-235C-32-11 (Sn-3Ag-0.5Cu)
2. Stencil: ϕ0.30 mm × 0.10 mm
3. Reflow condition: 150°C to 180°C, main heating at 250°C air reflow

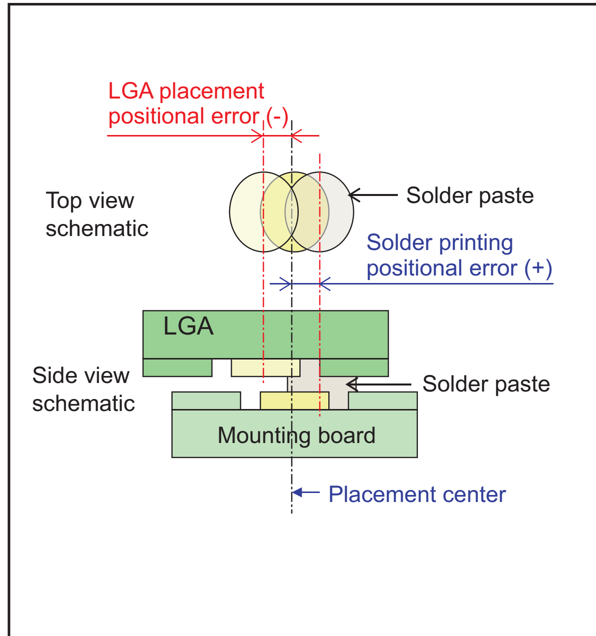


Figure 3.5 Placement Positional Error Evaluation

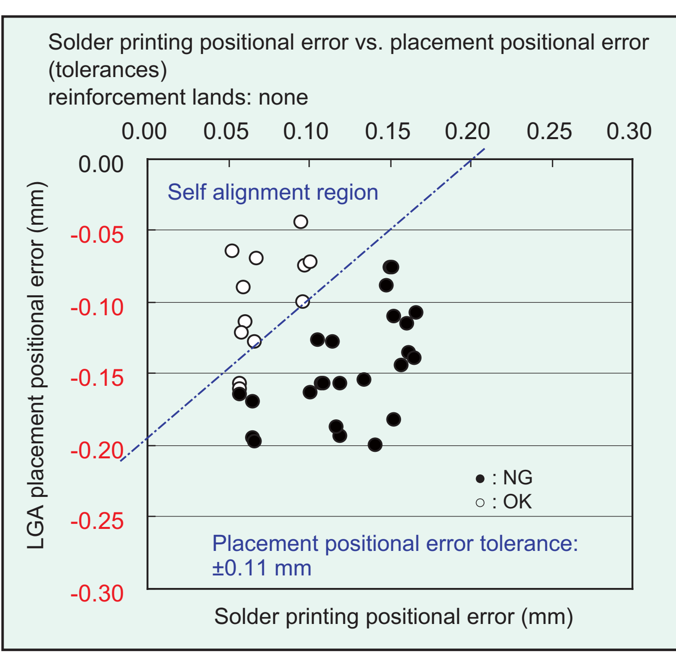


Figure 3.6 Placement Positional Error Evaluation Results

As a result of this evaluation, the 0.5 mm pitch LGA package placement positional error tolerances were found to be as follows.

- Solder paste printing positional error: ±0.10 mm
- LGA package placement positional error: ±0.10 mm

4. The Reflow Process

The reflow temperature profile must be determined based on the ability of the mounted devices to withstand heat and their solderability.

4.1 Package Heat Resistance

To prevent adsorption of moisture after the moisture-proof packing has been opened, within the limits of the storage condition after the opening moisture-proof packing, perform the reflow soldering operation under the following conditions.

If time longer than the limits has elapsed, the semiconductor devices must be baked under the baking conditions shown.

Table 4.1 Component Heat Tolerance

Heat tolerance temperature: for 260°C

Maximum reflow temperature (package surface temperature)	Under 260°C
Time at temperatures over 255°C	Under 30 seconds
Time at temperatures over 217°C	60 to 150 seconds
Time at the preheat temperature of 150°C to 200°C	60 to 120 seconds

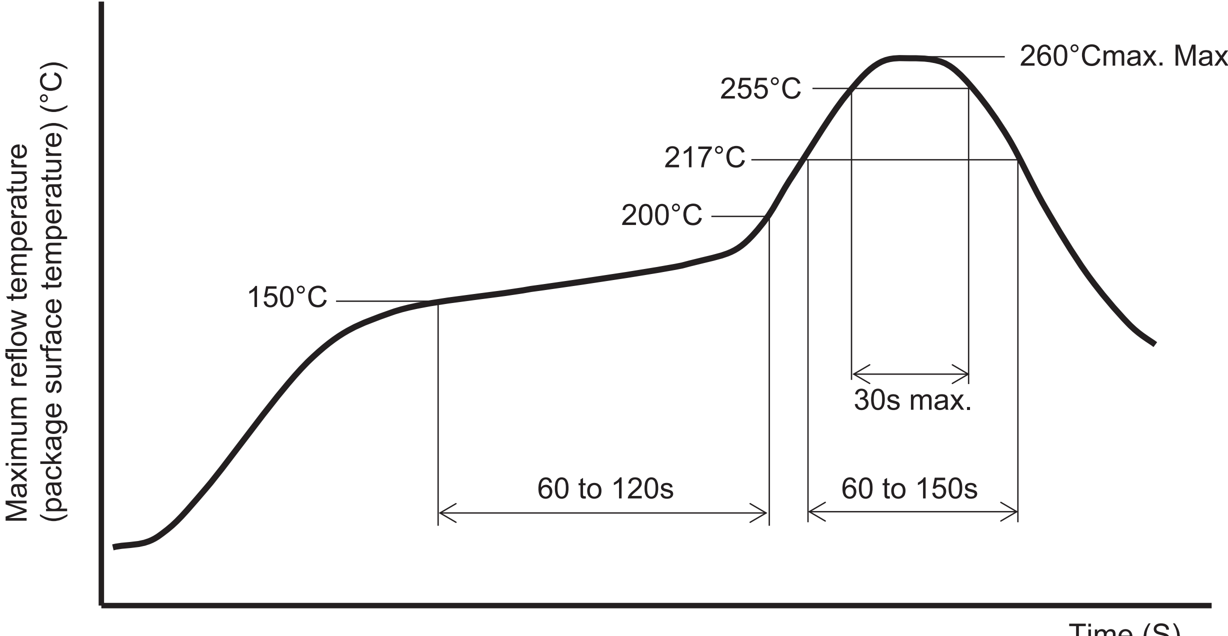


Figure 4.1 Reflow Heat Resistance Temperature Profile

- Investigate means to assure that the heating slope is 1 to 3°C/second.
- Set the cooling slope based on issues such as circuit board warping.

4.1.1 Storage Conditions After Opening Moisture-Proof Packing

Table 4.2 Storage Conditions

Item	Conditions	Remarks
Temperature	5°C to 30°C	
Humidity	Under 70%RH	
Time*	168 hours	Note: The time from opening the moisture-proof packing until the last reflow soldering has been completed

4.1.2 Baking Conditions

If the stipulated time after opening the moisture-proof packing has elapsed, the corresponding semiconductor products should be baked. Use 10 hours at 125°C as an initial guideline.

The total baking time must not exceed 96 hours if devices are baked repeatedly.

Furthermore, if the 30% RH spot on the indicator card is pink when the moisture-proof packing is opened, the products should be baked before mounting.

Note: The bake time is stipulated individually for each products. See the delivery specifications document for details.

4.2 Solderability

- Reflow temperature

  It is important to set the temperature profile which is lower than the guaranteed heat tolerance temperature for the mounted components. It is also important to set the temperature at the solder joint so as to exceed the lower limit temperature which solder paste maker recommends.

  If this temperature range is exceeded, solder shorting or device reliability degradation may occur, and if this temperature range is not reached, end product quality may be reduced by failure to melt the solder or insufficient solder joint strength.
- Atmosphere

  We recommend solder mounting in a nitrogen (N2) atmosphere, which provides improved solder wettability.

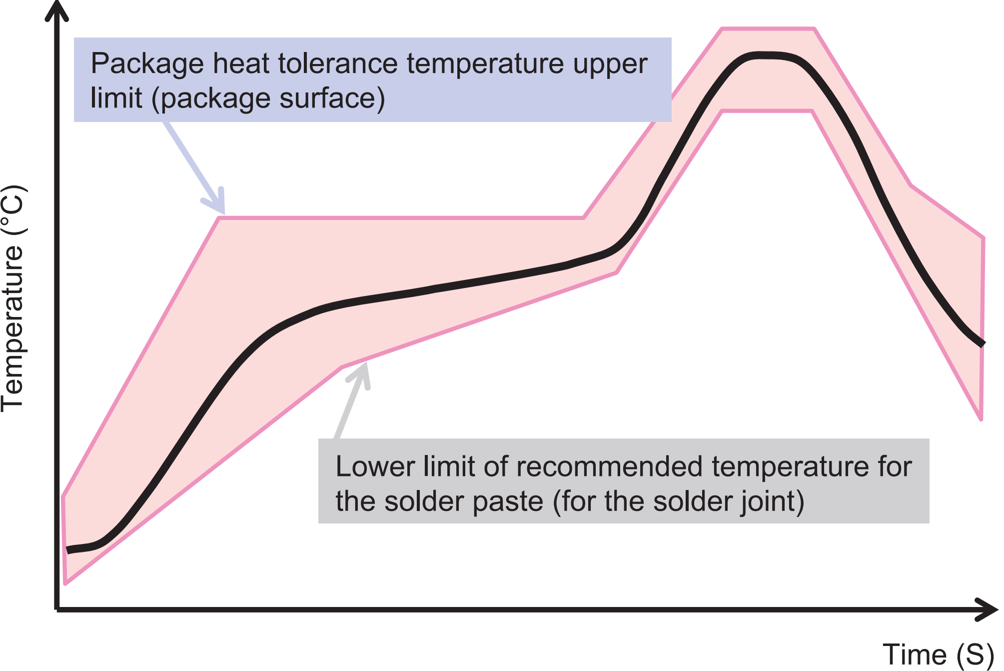


Figure 4.2 Soldering Profile

4.3 Post Reflow Soldered Area Inspection

Since the soldered section of the LGA package is the bottom surface of the package, the soldering cannot be inspected by ordinary visual inspection. X-ray based inspection methods can therefore be effective. This section presents examples of X-ray inspection of soldered sections.

Open circuits and solder shorts that could not be seen with visual inspection can be verified with X-ray inspection.

We recommend that the inspection results for each quality item be provided as feedback for the process management conditions, such as the printing mask design, printing positional error allowable range, and mounting position allowable range.

Table 4.3 Mounting Conditions

Package Type	Placement Force*[1]	Placement Push-In	Reflow Temperature
LFLGA336-14x14-0.65 LFLGA304-13x13-0.5	180g/ic	0.20 mm	250°C (Air Reflow)

Note: 1. The placement force indicates the placement nozzle spring force.

Table 4.4 Mounting Results

Metal mask thickness: 100 µm

	Metal mask aperture					
	ϕ0.20 mm	ϕ0.25 mm	ϕ0.30 mm	ϕ0.35 mm	ϕ0.40 mm	ϕ0.45 mm
LFLGA336-14x14-0.65	—	2/10*[1]	0/10	0/10	0/10	0/10
LFLGA304-13x13-0.5	6/8*[1]	0/8	0/8	0/8	3/8*[2]	—

Notes: 1. Solder open
2. Solder short

		LFLGA336-14x14-0.65 (0.65 mm pitch)		LFLGA304-13x13-0.5 (0.5 mm pitch)	
Stencil Apertures		ϕ0.25 mm	ϕ0.45 mm	ϕ0.20 mm	ϕ0.40 mm
Solder printing positional error: 0.15 mm	Solder printing				
	After reflow X-ray image	Solder open ? (verified by pulling away)		Solder open ? (verified by pulling away)	Solder short

Figure 4.3 X-Ray Inspection Examples

For the 0.65 mm pitch LGA package, neither opens nor shorts were found with metal mask apertures of ϕ0.30 to ϕ0.45 mm. For the 0.5 mm pitch LGA package, neither opens nor shorts were found with metal mask apertures of ϕ0.25 to ϕ0.35 mm.

5. Reliability Evaluation Data

5.1 Impact Resistance

This section presents the evaluation results of impact resistance for LGA which is mounted on the board. The evaluation is impact bending test which is stipulated in JEITA ED-4702B, and high speed deformation is applied to the board.

This result showed that even LGA packages without reinforcement lands are resistant to ordinary impacts (1500 με).

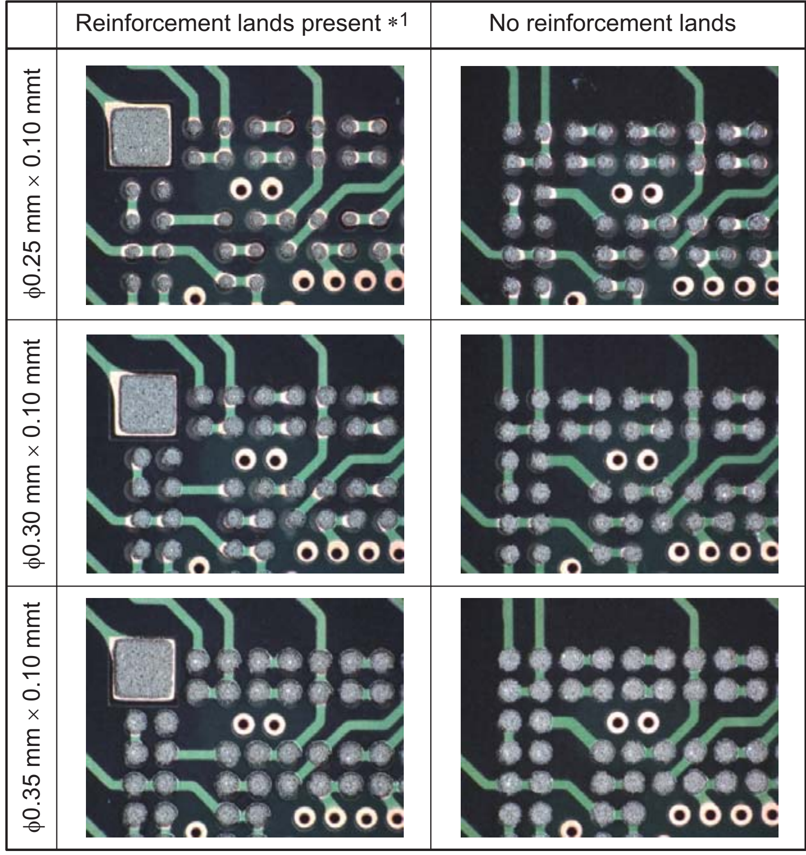
This result also showed that LGA packages with reinforcement lands have relatively better resistance to impacts, and that the use of LGA packages with reinforcement lands is preferable for equipment that requires increased impact resistance.

Table 5.1 Impact Bending Test Results

Solder paste: M705-235C-32-11 (Sn-3Ag-0.5Cu)
Reflow conditions: Preheating at 150°C to 180°C for 90 seconds + main heating at 250°C

Reinforcement Lands	Solder Mask	Mounting Board Deformation		
		2000 με	3000 με	5000 με
Present	ϕ0.25 mm	○	○	●
	ϕ0.30 mm	○	○	●
	ϕ0.35 mm	○	○	●
None	ϕ0.25 mm	○	●	●
	ϕ0.30 mm	○	●	●
	ϕ0.35 mm	○	●	●

○: Pass ●: Open



Note: 1. Reinforcement land solder mask: 0.9 mm square × 0.10 mm thickness

Figure 5.1 Impact Bending Test Inspection Result and Test Method

5.2 Temperature Cycle Test Results

This section presents an example of temperature cycle test results for LGA package types mounted with a lead-free solder paste (SAC305: Sn-3Ag-0.5Cu).

Although single-sided mounting provided superior results, fully adequate temperature cycle characteristics were achieved even by double sided mounting that assumes the use of high-density mounting equipment.

Table 5.2 Temperature Cycle Test Results Comparison

		Sample 1	Sample 2	Sample 3
Size		5 × 5 mm	5 × 5 mm	5 × 5 mm
Land pitch		0.5 mm	0.5 mm	0.65 mm
Reinforcement lands	Present	○		
	None		○	○
Mounting type	Single sided	○		
	Double sided		○	○
Solder paste		SAC305	SAC305	SAC305
Mounting board		FR4/4 layers	FR4/4 layers	FR4/4 layers
Test conditions		−40°C to 125°C	−25°C to 125°C	−25°C to 125°C
1%TTF		3086 cyc	1870 cyc	2111 cyc

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LGA Mounting Manual

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