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Renesas Surface Mount Package

User's Manual

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Renesas
Surface Mount Package

User's Manual

RENESAS

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Contents

Section 1 Overview of Mounting Technologies

The electronics industry is facing growing demands for electronic products offering greater multifunctionality, smaller size, and higher mounting densities, and these demands can be expected to accelerate in the future.

In response to these demands, there has been a shift in IC mounting methods from traditional through-hole mounting on a printed wiring board to surface mounting (see Figure 1.1).

The utilization ratio of surface mount devices (SMDs) currently exceeds 50% for both consumer and industrial products, and their importance is increasing as the electronic industry continues to expand.

Surface mount packages are rapidly becoming smaller and thinner in order to improve the mounting density, and it is essential to establish mounting technologies to handle such packages.

This section gives an overview of mounting process related printed wiring board design, materials, equipment, soldering processes, and points requiring attention in the mounting process.

Figure 1.1 shows the lead insertion method and surface mount method. Table 1.1 shows the main surface mount technologies.

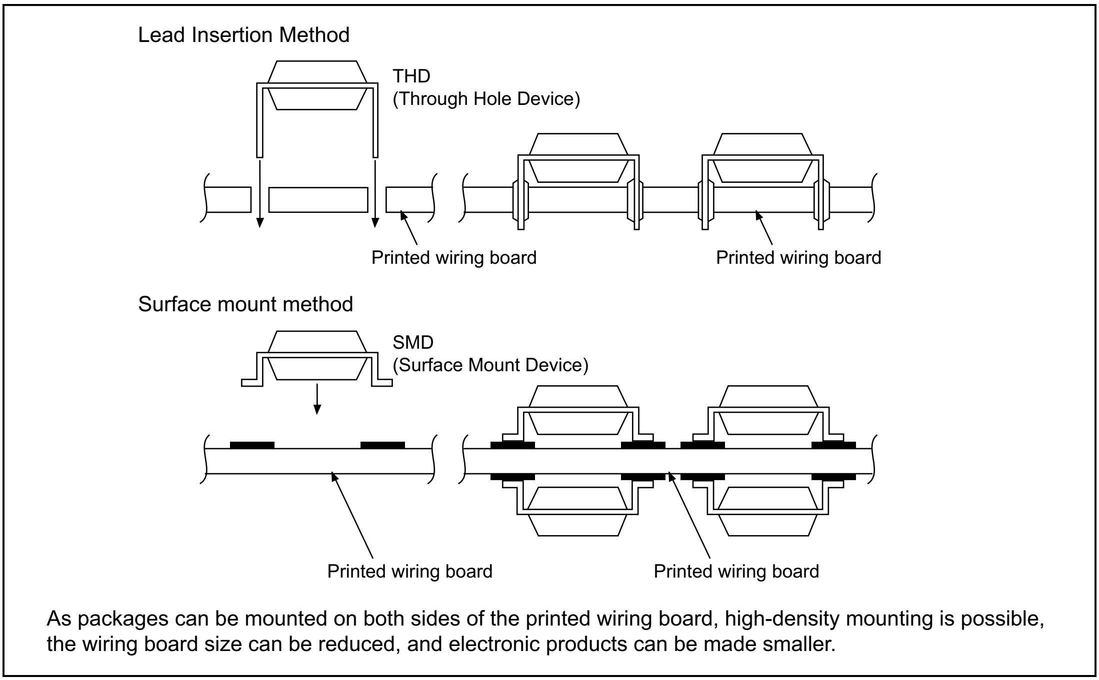


Figure 1.1 Comparison of Mounting Methods

Table 1.1 Surface Mount Technologies

- Surface mount technologies
  - Design
    - PC board design
      - Conductor pattern design (including mounting pad design)
  - Parts & materials
    - Main parts
      - PC board
      - Surface mount ICs (SMDs)
      - Another chip parts
    - Supplies
      - Solder paste, presolder, flux, adhesive, cleaning solvent
  - Equipment
    - Solder printer
    - Component mounter
    - Soldering equipment
    - Cleaning equipment
    - Other equipment (soldering inspection equipment, reworking equipment)
    - Ancillary items (squeegee, metal mask)
  - Mounting processes
    - Solder supply process
    - Component mounting process
    - Soldering process
    - Cleaning process
    - Other (soldering inspection, reworking)

Table 1.2 shows various soldering methods used for surface mounting. The soldering equipment used depends on the soldering method.

Table 1.2 Surface Mount Soldering Methods

- Surface mount soldering methods
  - Flow soldering method — SMD is soldered by dipping after temporary fixing with adhesive
  - Reflow method
    - Presoldering — Reflow soldering is performed by applying adhesive flux following preliminary solder coating
    - Solder printing
      - Laser
      - Pulse heater
      - Optical beam
      - Infrared heating
      - VPS (vapor phase soldering)
      - Air reflow (including N2 reflow)

Details of the mounting process are given in following section 2, Mounting Process.

Section 2 Mounting Process

This section describes the surface mounting process, focusing on surface mount technologies.

Further details can be confirmed with the manufacturers of the respective materials and equipment.

2.1 Mounting Process Sequence

Surface mounting process diagrams are shown below.

While flow and reflow soldering methods are available, the reflow method is normally used for surface mounting, and therefore only the reflow method will be covered here.

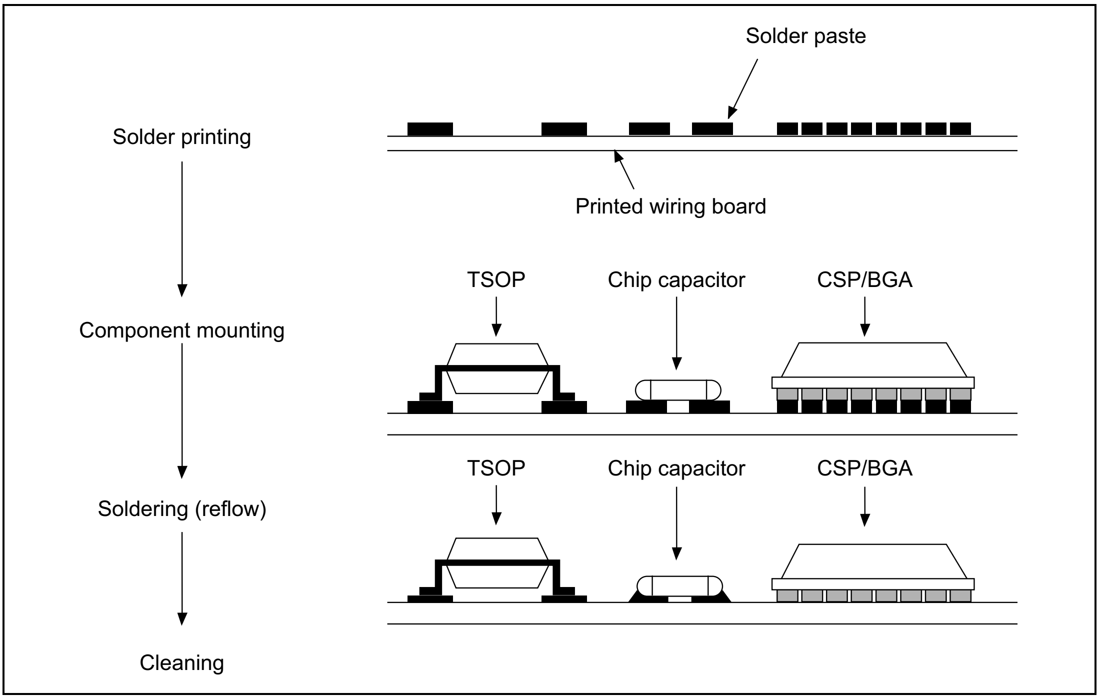


Figure 2.1 Single-Sided Surface Mounting Process Diagram

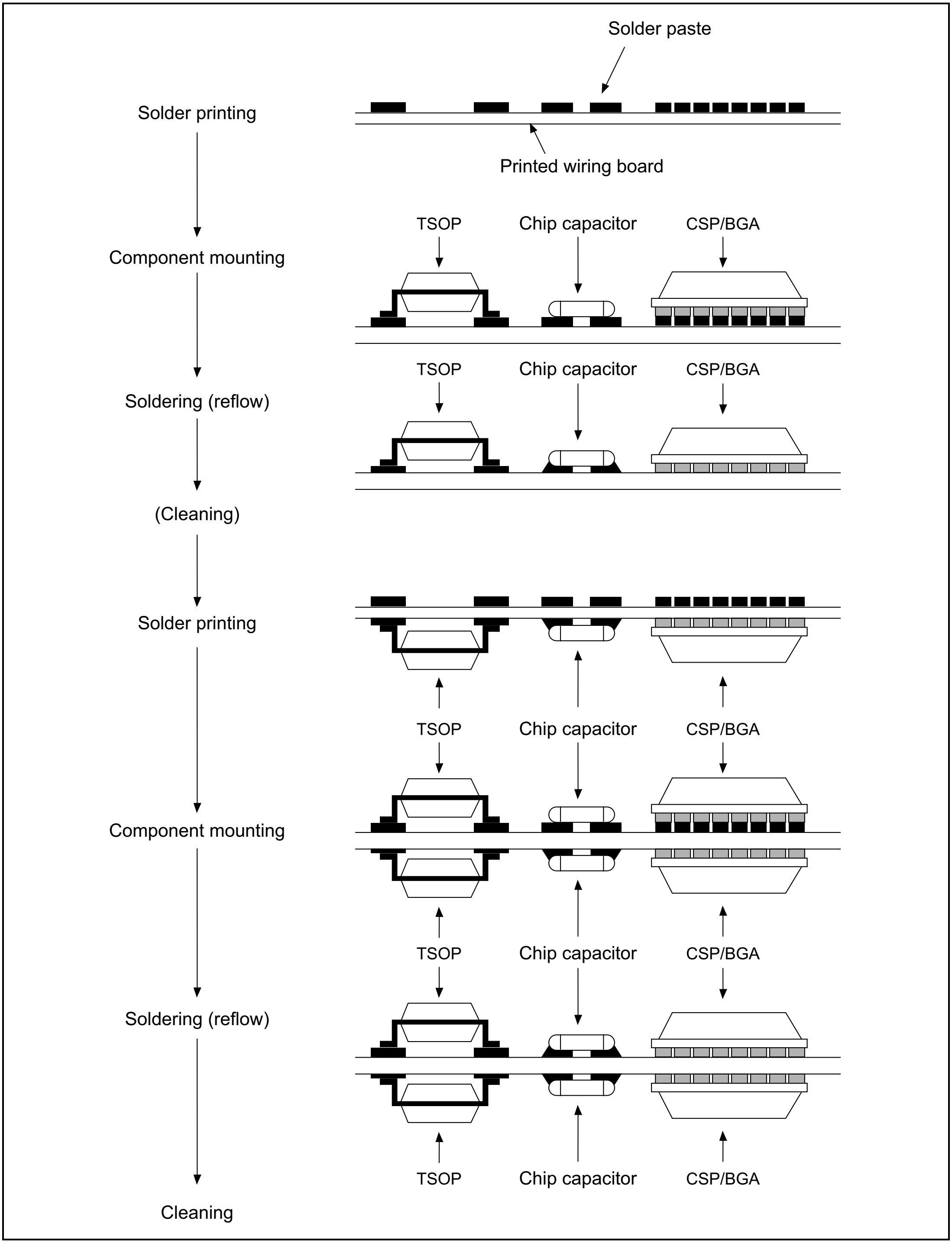


Figure 2.2 Double-Sided Surface Mounting Process Diagram

When carrying out double-sided surface mounting, electronic devices may be bonded to the board with adhesive beforehand to prevent them from falling off during reflow processing of the second surface.

The figures above are general process diagrams for surface mounting. Visual soldering inspection and testing are normally carried out after the processes shown above.

2.2 Printed Wiring Board Design

When mounting surface mount type packages on a board, the design of the mounting pads formed on the board and the choice of board material are important considerations. In particular, the soldering yield may be greatly influenced by the mounting pad design, and the board material may have a significant effect on reliability after soldering.

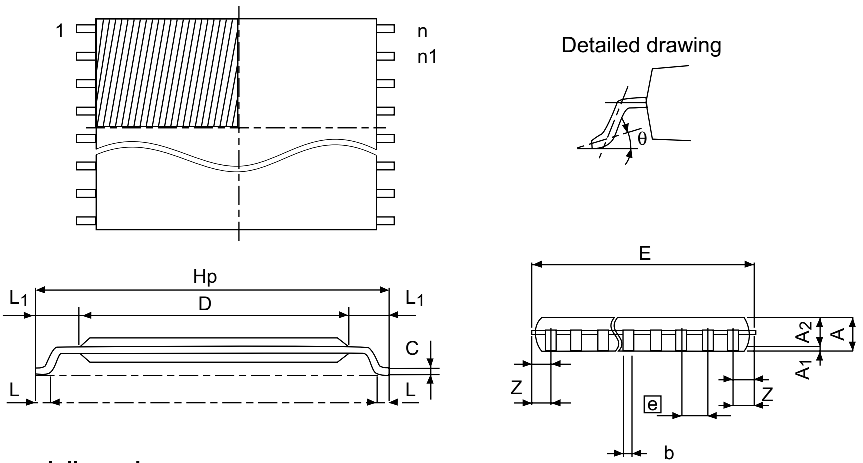
Criteria for mounting pad design and for the selection of the board material are explained below.

2.2.1 Mounting Pad Design

As criteria for mounting pad design, Renesas recommended values are shown in figures 2.3 to 2.12.

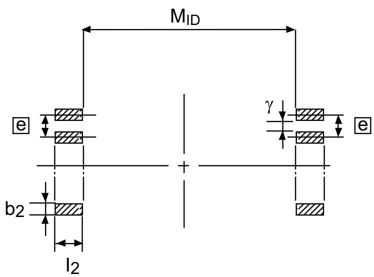
(1) TSOP (Type I) example .... Figure 2.3
(2) TSOP (Type II) example .... Figure 2.4
(3) QFP example .... Figure 2.5
(4) QFP (fine-pitch) example .... Figure 2.6
(5) QFN (P-VQFN) example .... Figure 2.7
(6) CSP/BGA example .... Figure 2.8
(7) Discrete examples (1) to (4) .... Figure 2.9 to Figure 2.12

External views of package



Mounting pad dimensions

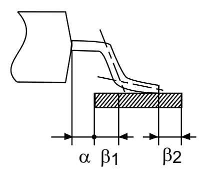
- Mounting pad dimension definitions and recommended values are shown below.



$M_{ID} = D + 2a$

$l_2 \geq L + \beta_1 + \beta_2$

$b \leq b_2 \leq \boxed{e} - \gamma$



- The pad pitch is taken as the linear pin interval (lead pitch) of the package to be mounted.

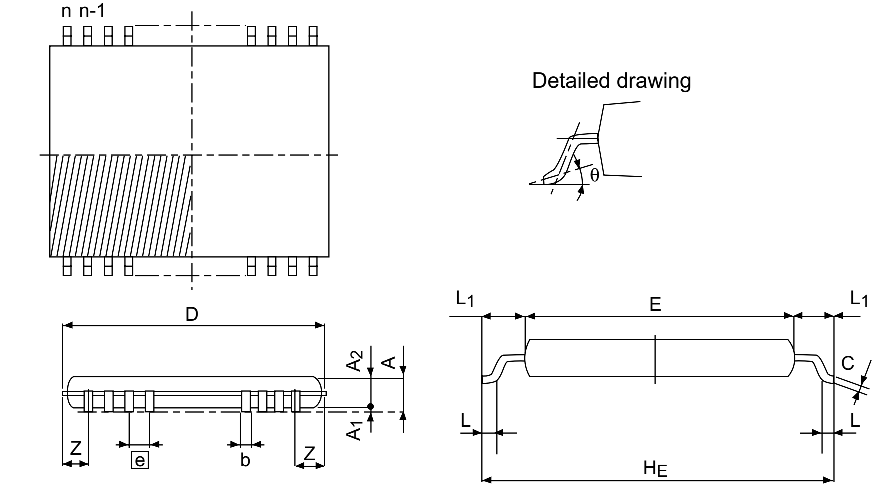
Renesas recommended values

(Unit: mm)

$\boxed{e}$	0.65	0.5	0.4	0.3	Notes
α	0.05 to 0.1	←	←	←	Mounting board cleanability
β_1	0.2 to 0.25	←	←	←	Soldering strength
β_2	0.2 to 0.4	←	←	←	Mask pattern precision and visual inspection of soldering
γ	0.3	0.25	0.2	0.15	Margin for preventing solder bridging

Figure 2.3 TSOP (Type I) Example

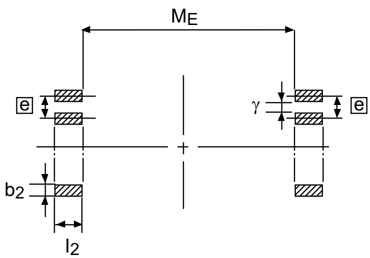
External views of package

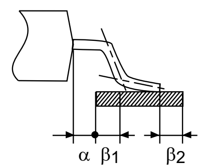


Mounting pad dimensions

- Mounting pad dimension definitions and recommended values are shown below.

$M_E = E + 2\alpha$
$l_2 \geq L + \beta_1 + \beta_2$
$b \leq b_2 \leq \boxed{e} - \gamma$





- The pad pitch is taken as the linear pin interval (lead pitch) of the package to be mounted.

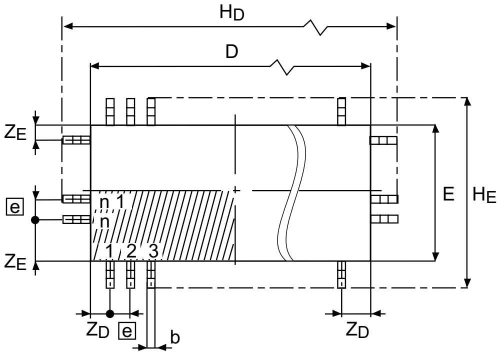
Renesas recommended values

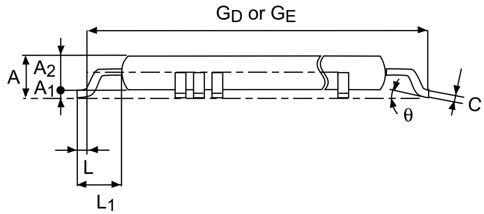
(Unit: mm)

$\boxed{e}$	1.27	1.0	0.8	0.65	Notes
α	0.05 to 0.1	←	←	←	Mounting board cleanability
β_1	0.2 to 0.25	←	←	←	Soldering strength
β_2	0.2 to 0.4	←	←	←	Mask pattern precision and visual inspection of soldering
γ	0.3	←	←	←	Margin for preventing solder bridging

Figure 2.4 TSOP (Type II) Example

External views of package

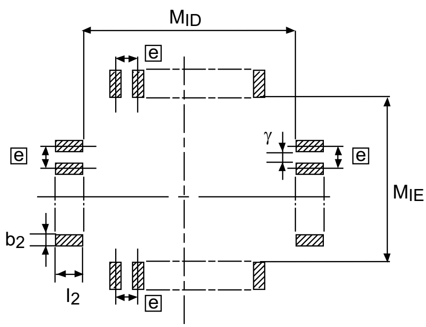


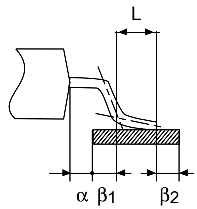


Mounting pad dimensions

- Mounting pad dimension definitions and recommended values are shown below.

$M_{IE} = E + 2\alpha = G_E - 2\beta_1$
$M_{ID} = D + 2\alpha = G_D - 2\beta_1$
$l_2 \geq L + \beta_1 + \beta_2$
$b \leq b_2 \leq \boxed{e} - \gamma$





- The pad pitch is taken as the linear pin interval (lead pitch) of the package to be mounted.

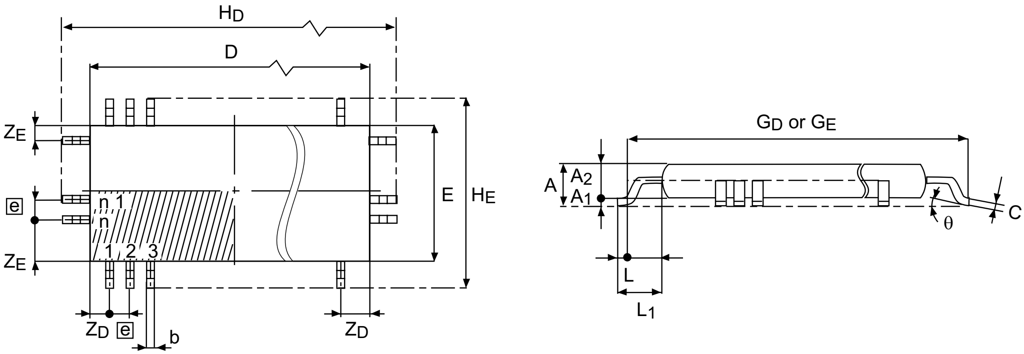
Renesas recommended values

(Unit: mm)

$\boxed{e}$	1.0	0.8	0.65	Notes
α	0.3	←	←	Mounting board cleanability
β_1	0.5	←	←	Soldering strength
β_2	0.2 to 0.4	←	←	Mask pattern precision and visual inspection of soldering
γ	0.3	←	←	Margin for preventing solder bridging

Figure 2.5 QFP Example (Standard, 0.65 mm Pitch or Above)

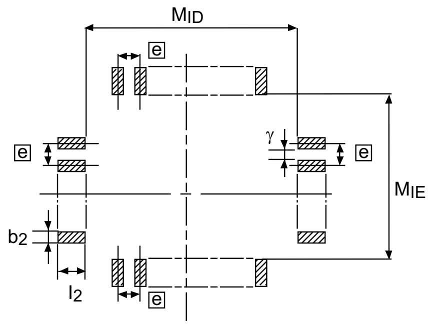
External views of package

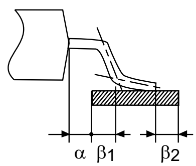


Mounting pad dimensions

- Mounting pad dimension definitions and recommended values are shown below.

$M_{IE} = E + 2\alpha = G_E - 2\beta_1$
$M_{ID} = D + 2\alpha = G_D - 2\beta_2$
$l_2 \geq L + \beta_1 + \beta_2$
$b \leq b_2 \leq \boxed{e} - \gamma$





- The pad pitch is taken as the linear pin interval (lead pitch) of the package to be mounted.

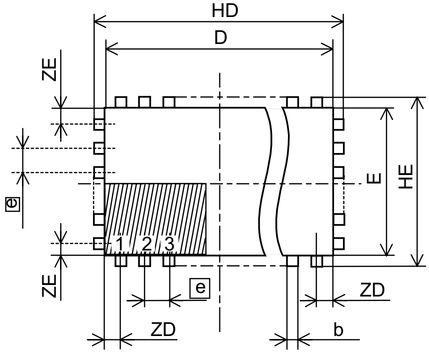
Renesas recommended values

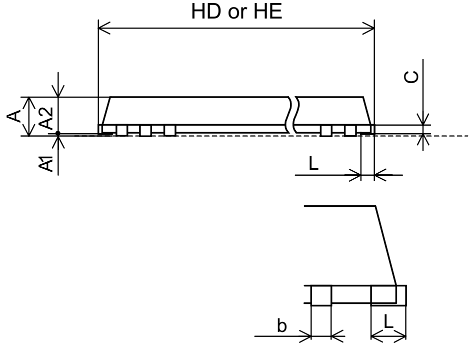
(Unit: mm)

e	0.5	0.4	0.3	Notes
α	0.1 to 0.3	←	←	Mounting board cleanability
β_1	0.2 to 0.4	←	←	Soldering strength
β_2	0.2 to 0.4	←	←	Mask pattern precision and visual inspection of soldering
γ	0.25	0.2	0.15	Margin for preventing solder bridging

Figure 2.6 QFP Example (Fine-Pitch, 0.5 mm Pitch or Less)

External views of package

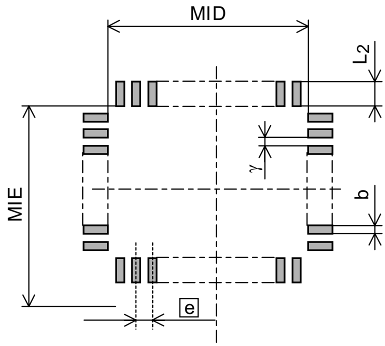




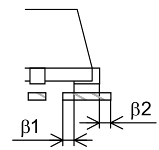
L: Length of flat part of pin
b: Pin width

Mounting pad dimensions

- Mounting pad dimension definitions and recommended values are shown below.



$MIE = HE - 2(L+\beta_1)$
$MID = HD - 2(L+\beta_1)$
$L_2 = L + \beta_1 + \beta_2$ (L2: Mounting pad length)
$b \leq b_2 \leq \boxed{e} - \gamma$ (b2: Mounting pad width)



- The pad pitch is taken as the linear pin interval (lead pitch) of the package to be mounted.

Renesas recommended values

(Unit: mm)

$\boxed{e}$	0.5	Notes
β_1	0.2 to 0.3	Mask pattern precision
β_2	0.2 to 0.3	Mask pattern precision and visual inspection of soldering
γ	0.25	Margin for preventing solder bridging

Reference values based on former EIA standard ED-7404A

Figure 2.7 QFN (P-VQFN) Example

BGA and LGA Mounting Board Mounting Pad Design

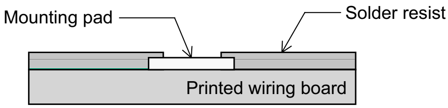
There are two types: an over-resist type in which solder resist is laid over the mounting pad, and a normal type in which solder resist does not touch the mounting pad. Board wiring design should be considered when selecting the type.

By designing the mounting board mounting pad shape with similar dimensions as BGA ball lands and LGA lands, it is possible to obtain a shape with good upper/lower balance after reflow soldering, and help alleviate concentration of thermal stress in a heat cycle.

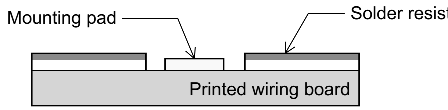
- Recommended values for mounting pad design

Pitch	0.4 m	0.5 mm	0.65 mm	0.8 mm	1.0 mm	1.27 mm
Recommended value ϕ (mm)	0.15 to 0.25 mm	0.2 to 0.3 mm	0.3 to 0.4 mm	0.35 to 0.45 mm	0.45 to 0.55 mm	0.55 to 0.65 mm

Over-resist type (cross-section of structure)



Normal type (cross-section of structure)



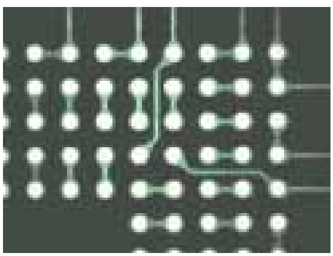


Photo: Over-Resist Type (Example)

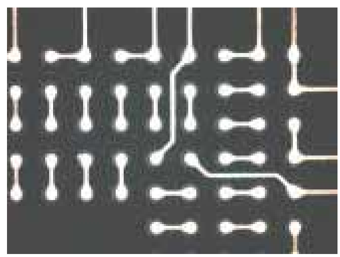


Photo: Normal Type (Example)

Figure 2.8 Examples of BGA and LGA

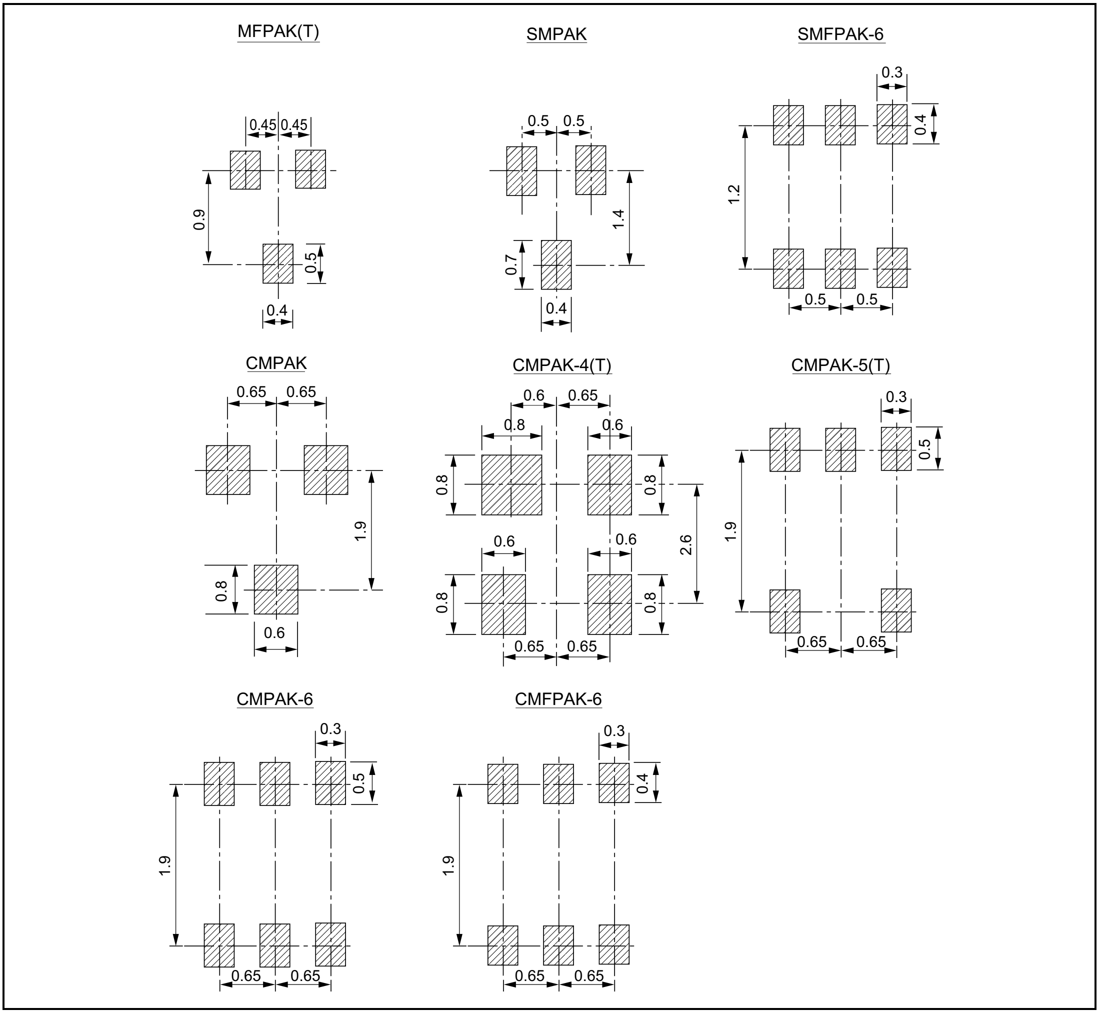


Figure 2.9 Example of Discrete (1)

Note: '(T)' in CMPAK-4(T), CMPAK-5(T), MFPAK(T) indicates transistor packages. However, '(T)' is omitted in each product's document. The mount pad of CMPAK of transistors is the same as the one of diodes.

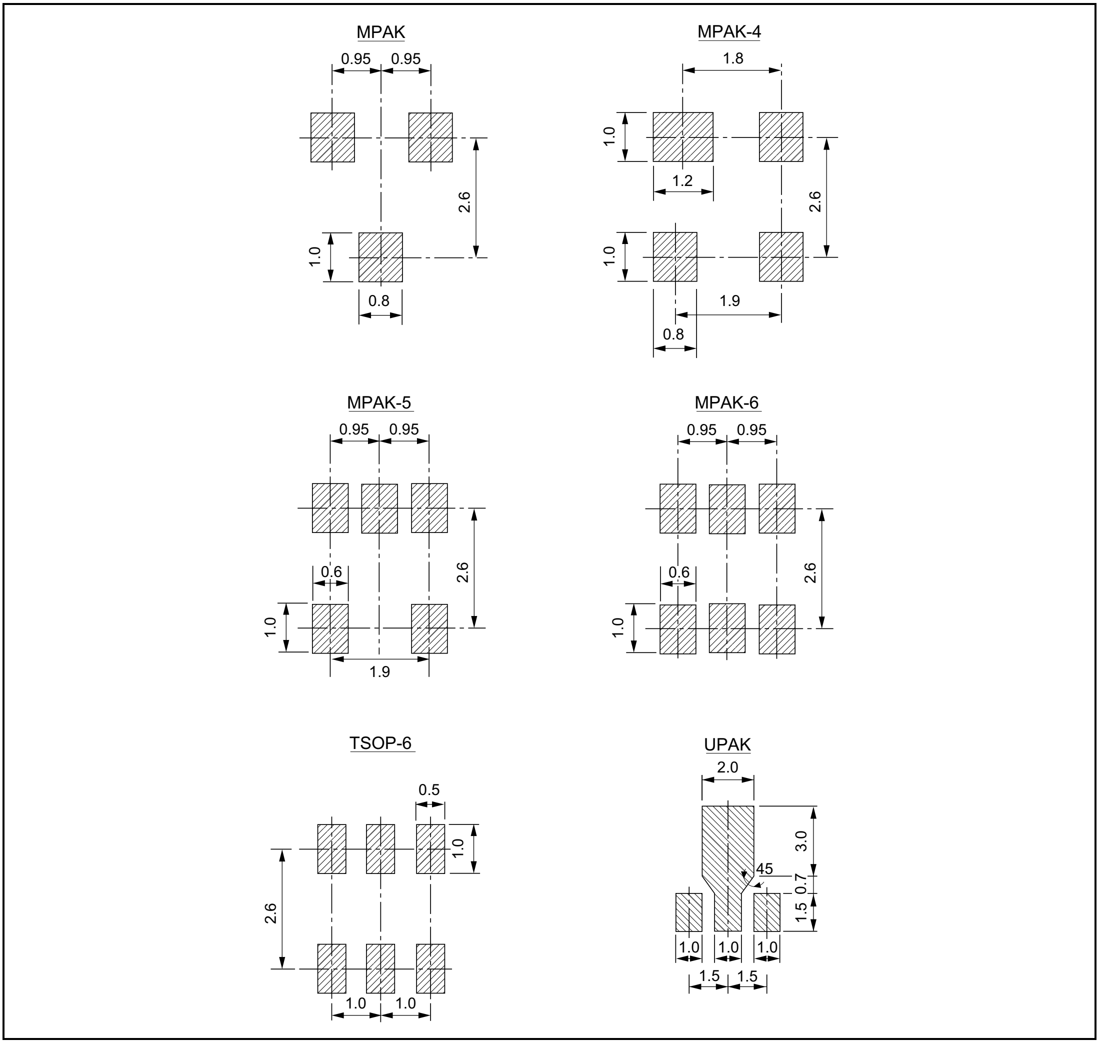


Figure 2.10 Example of Discrete (2)

Note: The mount pad of MPAK, MPAK-5 of transistors is the same as the one of diode.

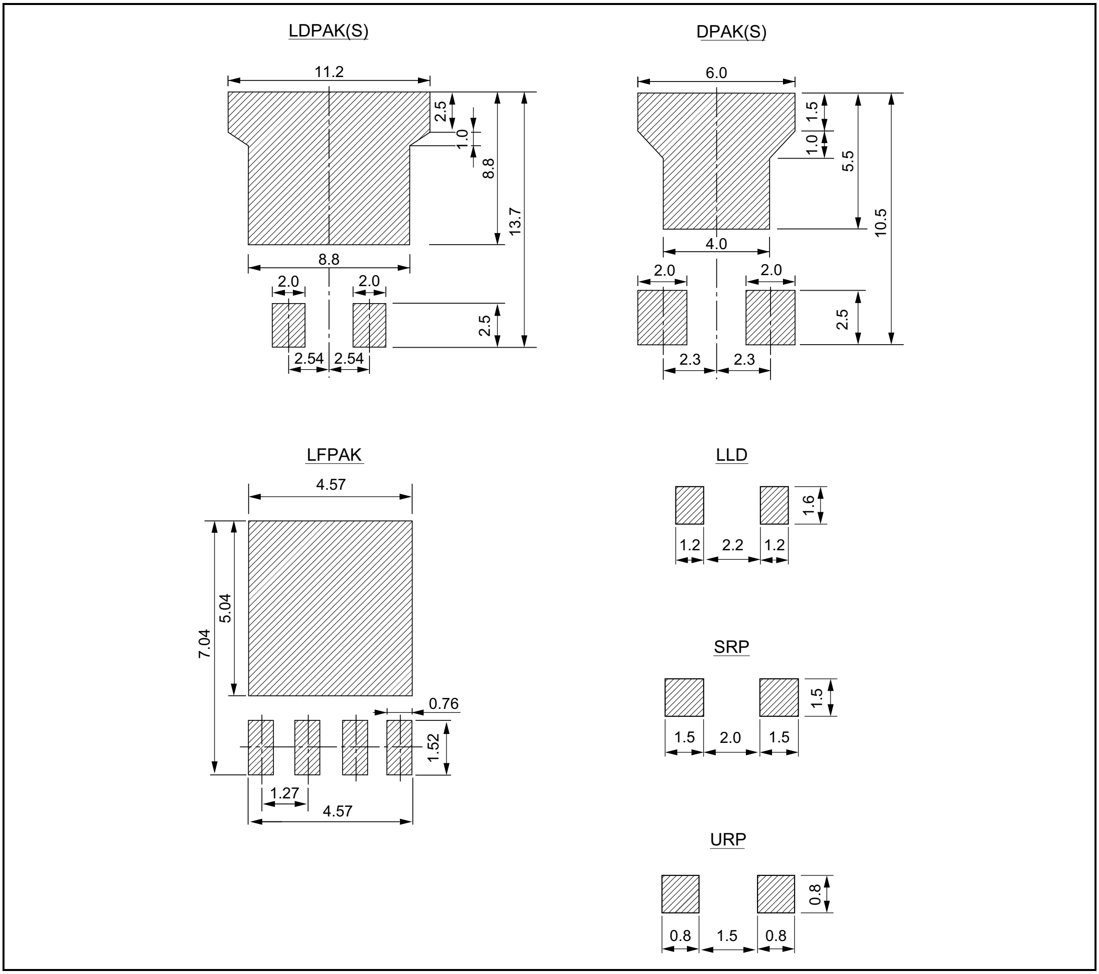


Figure 2.11 Example of Discrete (3)

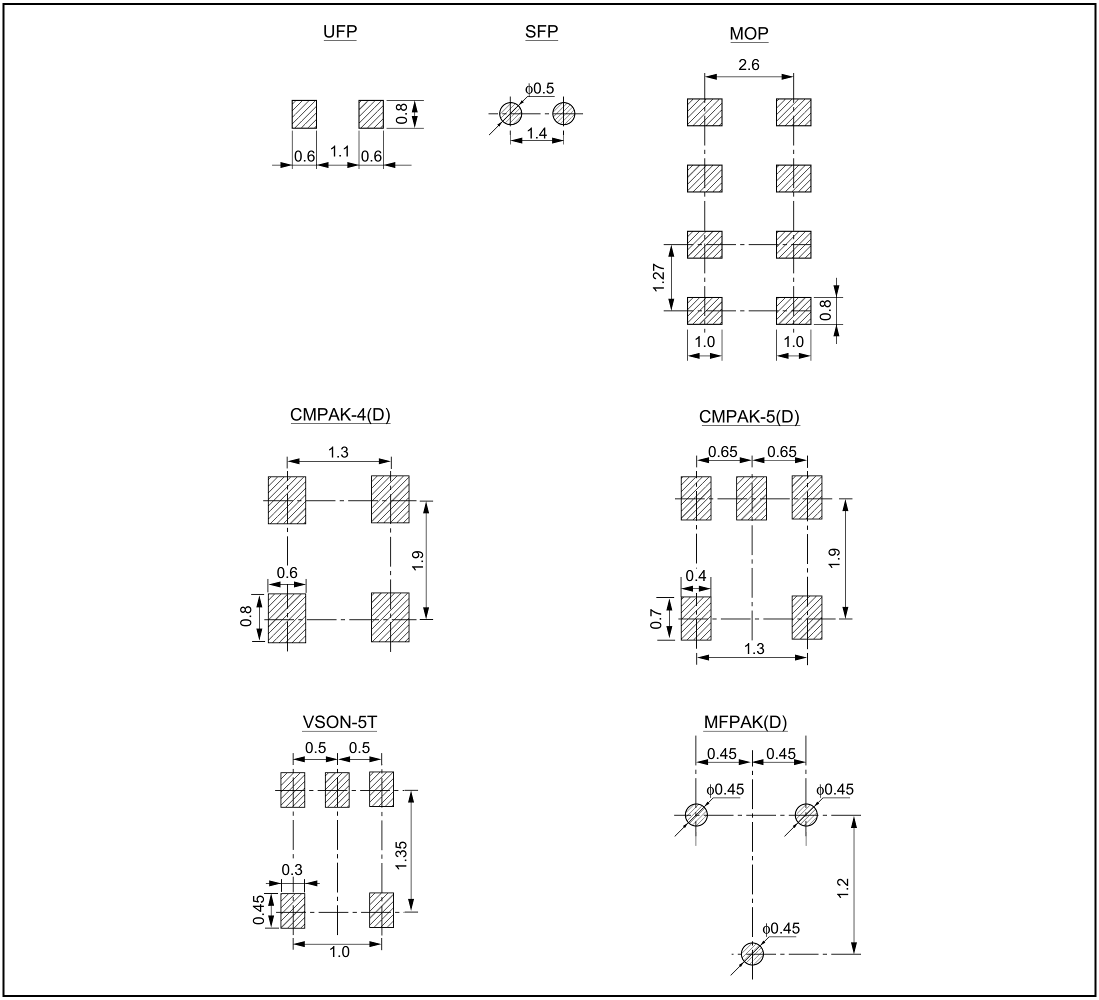


Figure 2.12 Example of Discrete (4)

Note: '(D)' in CMPAK-4(D), CMPAK-5(D), MFPAK(D) indicates diodes packages. However, '(D)' is omitted in each product's document.

2.2.2 Printed Wiring Board Materials

With regard to board materials, in broad terms there are epoxy resin based printed wiring boards and alumina ceramic based thick-film circuit boards (ceramic boards). In the fields of consumer and industrial products, in particular, four kinds of printed wiring board are widely used for different purposes, as shown in Table 2.1.

Table 2.1 Examples of Board Materials

Type		Composition			Features	Uses
		Resin	Base Material	Conductor		
Printed wiring board	Paper phenol (FR-2) board	Phenol	Paper	Copper foil	Low price, mass-producibility	Consumer electronics
	Paper epoxy (FR-3) board	Epoxy	Paper	Copper foil	Intermediate board between paper phenol and glass epoxy	Audio products, VTRs, etc.
	Glass epoxy (FR-4) board	Epoxy	Glass fabric	Copper foil	Excellent electrical characteristics, moisture resistance, dimensional stability	Consumer electronics, industrial electronics
	Glass epoxy (FR-4) board (halogen-free)	Heat-resistant epoxy	Glass fabric	Copper foil	Environment-friendly • Higher coefficient of elasticity than general FR-4 (little warping or flexure) • Higher heat resistance than general FR-4	Consumer electronics, industrial electronics
	Heat-resistant glass epoxy (FR-5 equivalent) board	Heat-resistant epoxy	Glass fabric	Copper foil	High Tg, high reliability, glass polyimide low-cost type	COB (Chip On Board) thin type
Flexible board		Polyimide		Copper foil	Freely bendable	Cameras, calculators, etc.
Ceramic board		Alumina ceramic		Ag-Pd	High heat resistance and thermal conductivity, excellent reliability	Automotive electrical equipment

When designing a board, electrical characteristics, thermal radiation characteristics, and so on must be taken into account in selecting the board material, and consideration of the items on the following page is also recommended.

Environment-friendly halogen-free boards are also beginning to be used.

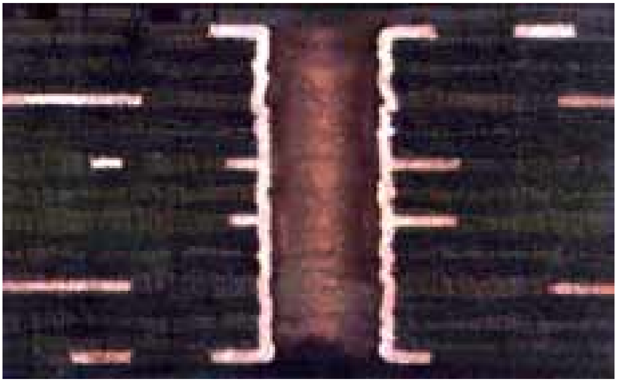


Figure 2.13 Cross Section of Glass Epoxy Board

(1) Preventing Mounting Board Oxidation

In the case of a printed wiring board, the conductive material forming the mounting pads is copper foil, and depending on the storage conditions and soldering temperature, surface oxidation may occur and solderabilty may degrade.

In order to perform highly reliable soldering, consideration should be given to carrying out processing to prevent surface oxidation, as shown in Table 2.2, to avoid solderabilty degradation of the mounting pad surfaces on which devices are mounted.

Table 2.2 Processing to Prevent Mounting Pad Surface Oxidation

Surface Processing	**Solder Leveler Processing**	**Pre-Flux**		**Surface Plating**
Protective Material	**Solder**	**Rosin Flux**	**Water-Soluble Flux**	**Ni/Au**
Advantages	No exposure of copper surfaces	Good solderabilty	Formed only on copper surfaces Good solderabilty	Good heat resistance
Disadvantages	Solder thickness not stable Solderabilty not stable	Adhesion to entire board results in susceptibility to adherence of foreign matter	Solderabilty reduced in case of double-sided surface mounting	Expensive Mounting reliability may deteriorate depending on thickness of gold plating

When mounting fine-pitch ICs such as TSOPs, in particular, pre-flux surface processing is recommended. Various kinds of pre-flux processing are available, and the appropriate type should be selected to suit the application.

When surface processing with solder is necessary for fine-pitch mounting pads, solder plating of uniform thickness is recommended.

When using Ni/Au for surface processing, it is advisable to conduct a thorough evaluation of the effect of the thickness of the plating on the reliability of connecting devices after mounting.

(2) Board Warping

If board warping after reflow is considered a problem, investigation of the following items is recommended.

- Making the conductive material occupancy ratio equal for the upper and lower surfaces of the board
- Studying the layout of mounted devices in double-sided surface mounting, and minimizing the difference in thermal expansion coefficients of the upper and lower surfaces
- Providing a mechanism to prevent warping during reflow (in the cooling phase)
- Executing reflow while forcibly preventing warping by using a jig to hold the printed wiring board securely
- Using a heat-resistant glass epoxy board

As the type and thickness of the board used have an effect on board warping, we recommend that specifications be decided on through close consultation with the board manufacturer.

(3) Reliability of Solder Joints

With regard to the reliability of solder joints, the thermal expansion coefficients of the mounted devices and the board must be considered. For example, when surface-mounting ceramic packages, the use of a ceramic board with virtually the same thermal expansion coefficient is recommended.

Also, when mounting thin packages (such as TSOPs or CSPs), the silicon chip occupancy ratio is high in relation to the package size, and the apparent overall package thermal expansion coefficient is reduced. It is therefore necessary to select a board material that enables the package thermal expansion coefficient to be approached as closely as possible.

For systems requiring high reliability, selection of an FR5 equivalent board, for example, is recommended.

2.3 Solder Supply Process

2.3.1 Solder Paste

(1) Composition

The main constituents of solder paste are solder powder and flux. The proportion of solder powder in solder paste is generally in an approximate range of 80 to 95 wt%, and this proportion affects the viscosity of the paste and the solder thickness after reflow. An overview of solder powder and flux is given below.

(a) Solder powder

Various alloys are used as the metallic constituent of solder powder, especially Sn-Pb and Sn-Pb-Ag types, including eutectic solder (63Sn-37Pb) and silver bearing solder (62Sn-36Pb-2Ag). Recently, also, in consideration of environmental problems, various metallic constituents aimed at the total elimination of lead (mainly Sn-Ag-Cu types) have come into use. These alloys can be categorized according to use and soldering method.

Particle sizes of solder powder span the range shown in Figure 2.14, and have an effect on paste printability and so forth.

When mounting fine-pitch ICs, spherical solder powder is recommended.

A solder powder particle diameter of 50 to 60 µm or less is generally used, but for fine-pitch packages (such as 0.5 mm pitch QFPs and 0.8mm pitch CSPs), a solder powder with a smaller particle diameter of 40 µm or less and narrow particle size distribution gives better results. However, the smaller the particle size of solder powder, the greater is the risk of the occurrence of solder balls due to surface oxidation, and effects on solder wettability. Therefore, great care is necessary in handling solder paste that uses such solder powder.

(b) Flux

Flux, which promotes soldering, has four kinds of constituents – an adhesion-imparting agent, a thixotropic agent, a solvent, and an activator – used for the following purposes.

- Adhesion-imparting resin: Device mountability, metal cleaning, and prevention of reoxidation
- Thixotropic agent: Solder powder/flux separation prevention, sagging prevention
- Activator: Remove the oxide film
- Solvent: Paste formation

There are five kinds of flux according to the activator: R (rosin flux), RMA (weak activation flux), RA (activation flux), A (composite resin strong activation flux), and WS (water-soluble flux).

For SMD, RMA or RA type are recommended.

(2) Required Characteristics

The characteristics required of solder paste are described below.

(a) Before reflow

- Quality remains stable with aging
- Good printability and applicability
- Quality remains stable with aging (long adhesion retention time, no deformation)
- No separation of solder powder from flux
- No hardening of surface after solder paste manufacture
- Little sagging (blotting) after application

(b) After reflow

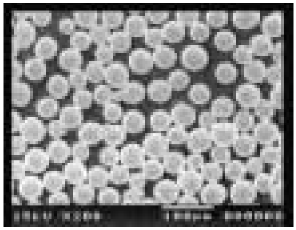
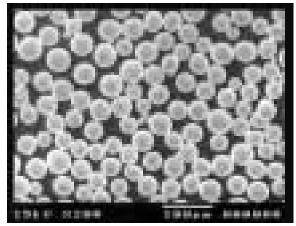
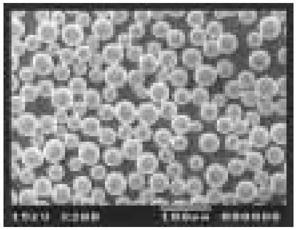
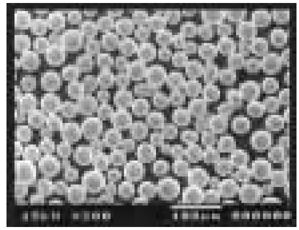
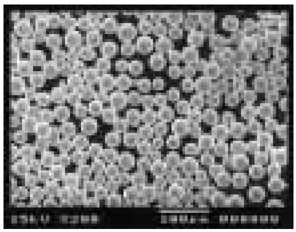
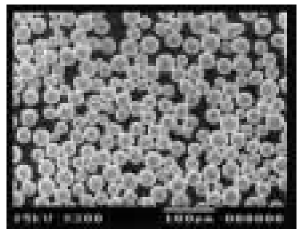
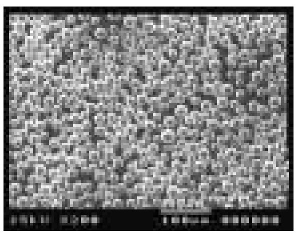
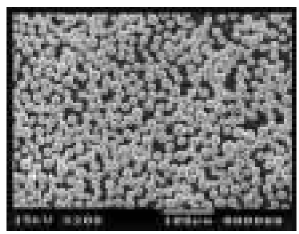
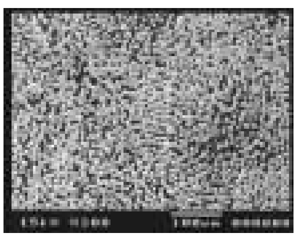
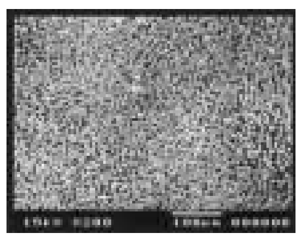
- Good solderabilty
- Minimal occurrence of solder balls
- Maintenance of good cleanability, leaving no flux residue
- Ability to secure reliability even in case of flux residue

From the standpoint of printability, solder bridges, solder balls, cleanability, etc., we recommend that the following points be borne in mind when selecting solder paste.

(c) Printability

- We recommend that a solder paste be selected with a solder powder particle size not exceeding 1/4 to 1/5 the metal mask aperture width.
- If the viscosity is too high, detachability will be poor and streaking will occur, and if too low, blotting and print sagging will occur. Therefore, a figure of around 200,000 to 300,000 CPS/25ºC (measured by Malcolm viscometer) is recommended.

  (Attention must also be paid to thixotropy.)

	Sn-Ag-Cu Solder Powder	Sn-Pb Solder Powder
Powder particle size range 0.053 mm to 0.036 mm		
Powder particle size range 0.045 mm to 0.025 mm		
Powder particle size range 0.036 mm to 0.025 mm		
Powder particle size range 0.025 mm to 0.015 mm		
Powder particle size range 0.015 mm to 0.005 mm		

Source: Senju Metal Industry Co., Ltd.

Figure 2.14 SEM Photographs of Solder Particles for Solder Paste

Solder Powder for Solder Paste [For Reference]

Solder powder particle size ranges and corresponding pitches
(lead types: QFP, SOP, etc.)

Solder powder particle size range	Lead pitch (mm)					
	1.27	1.00	0.80	0.65	0.50	0.40
0.053 mm to 0.036 mm	○	○	○			
0.045 mm to 0.025 mm			○	○	○	
0.036 mm to 0.025 mm				○	○	○
0.025 mm to 0.015 mm						○
0.015 mm to 0.005 mm						

Source: Senju Metal Industry Co., Ltd.

Solder powder particle size ranges and corresponding pitches
(bump and land types: BGA, LGA, etc.)

Solder powder particle size range	Bump/land type (mm)					
	1.27	1.00	0.80	0.65	0.50	0.40
0.053 mm to 0.036 mm	○	○	○			
0.045 mm to 0.025 mm			○	○		
0.036 mm to 0.025 mm				○	○	
0.025 mm to 0.015 mm					○	○
0.015 mm to 0.005 mm						

Source: Senju Metal Industry Co., Ltd.

(d) Solder bridges and solder balls

- We recommend that attention be paid to solder powder oxidation, and solder paste with a narrow particle size distribution be selected.
- We recommend that solder paste with a low boiling point of solvent in the flux be selected, and solder paste with a high rosin molecular weight and small actual flux content be selected.

(e) Cleanability

- As a reduction in solubility with respect to the oxidized cleaning agent is a probable cause of cleaning residue, selection of a solder paste that uses rosin with good stability with respect to oxidation is recommended.

2.3.2 Solder Supply Process

(1) Solder Paste Printing Process

There are two solder paste supply methods: dispensing and printing (screen mask or metal mask). From the standpoint of productivity, etc., the printing method is generally more widely used, and therefore only the printing method will be described here.

(a) Printing precision

Image recognition capability is recommended for solder printing equipment for fine-pitch packages (such as QFPs with a pitch of 0.5 mm or less). The printing precision of printing equipment with image recognition capability is currently ±0.25 to 0.05 mm.

(b) Print shape (solder)

Factors affecting the print shape include the type of metal mask, printed wiring board mounting pad surface shape and surface processing, printer conditions, and solder paste. A brief description of metal mask types and printer conditions, which are particularly influential factors, is given below.

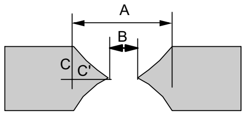
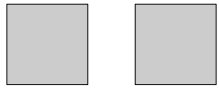
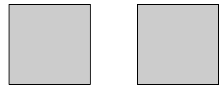
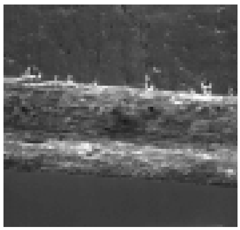
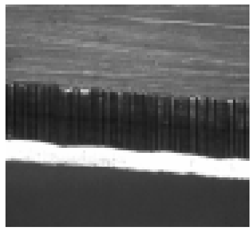
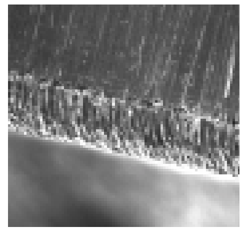
1. Types of metal mask

   With increasingly fine IC lead pitches, the narrowing of metal mask apertures means that the cross-sectional shape of mask aperture areas greatly affects the quality of the print shape.

   A metal mask created by means of conventional etching processing is curved in the direction of thickness, so that during printing, solder paste remains in the curved portion, and as the number of items printed increases, metal mask aperture areas become clogged with solder paste residue, with the result that streaking occurs during printing, or solder paste gets onto the rear surface of the metal mask (the surface on the printed wiring board side), causing blotting during printing.

   To improve this situation, metal masks with high etching precision, and metal masks using new manufacturing methods, have come onto the market. The table below shows a comparison of the etching method, and the new additive method and laser method.

Table 2.3 Comparison of Metal Mask Manufacturing Methods

Manufacturing method	Etching	Additive	Laser
Material	Stainless steel, copper, phosphor bronze	Nickel	Stainless steel
Cross-sectional shape	 A-B Film correction value 50 to 60% C = C' **Note:** Etching precision differs according to manufacturer		
Cross-sectional photograph			

When fine-pattern printing is being considered, use of an additive type or laser type metal mask is recommended.

2. Printer conditions

   The following five items affect printability.

   (1) Squeegee

   A squeegee is an elastic rubber blade, polyurethane rubber or the like being widely used. The hardness of the rubber is an important condition for performing good printing, and a hardness of 60 to 90 degrees is suitable.

   The cross-sectional shape of the front edge of an above-described resin squeegee may be of three kinds — flat, rectangular, or sword-shaped — according to the kind of printing for which it is used.

   Recently, too, metal squeegees offering excellent abrasion-resistance and stability of solder supply have come onto the market. During printing, it is desirable to reduce the pressure of the front edge of the squeegee and print at low speed, in which case the solder paste exhibits a phenomenon called “rolling.”

(2) Print gap (distance between printed wiring board and metal mask)

If the print gap is too small, blotting will occur, and if too large, variation of print shape, shattering of solder during separation, or the like, will occur. It is therefore necessary to make an appropriate gap setting.

Recently, contact printing technology has been coming into use in which the above-mentioned gap is made 0 mm, but use of this contact printing requires printing equipment provided with low printing pressure and high-speed separation control functions.

(3) Printing pressure

Actual printing pressure is generally around 5 to 10 g/cm^2, but this value denotes the pressure of the front edge of the squeegee, and requires careful consideration as it greatly affects compression of the front edge of the squeegee.

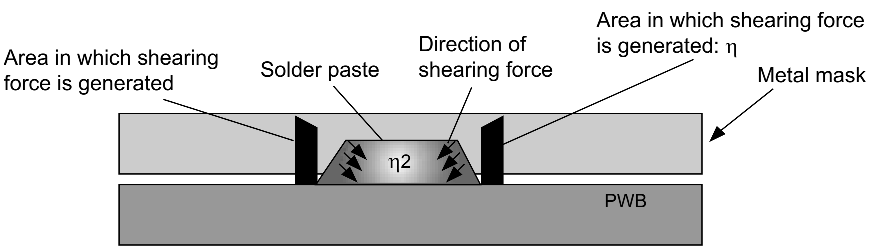
Recently, printing equipment provided with a floating squeegee mechanism for implementing printing at low and uniform printing pressure has appeared on the market.

(4) Squeegee speed

During printing, a squeegee speed of 5 to 50 mm/sec is used. It is necessary to slow down the speed as much as possible and use a speed setting at which solder paste rolling occurs.

(5) Separation speed

By controlling the separation speed, it is possible to minimize the shearing force generated between the mask and solder paste during separation after printing, and improve solder paste separability. The necessity of using the above-described technology can be expected to increase in the future to handle finer-pitch ICs.



(2) Solder Paste Supply Quantity

(a) Solder paste supply quantity for gull-wing leads

The quantity of solder paste to be supplied is found by first calculating the necessary quantity of solder using the simple method below, taking account of the optimal soldering shape after reflow, and then calculating the necessary quantity of solder paste.

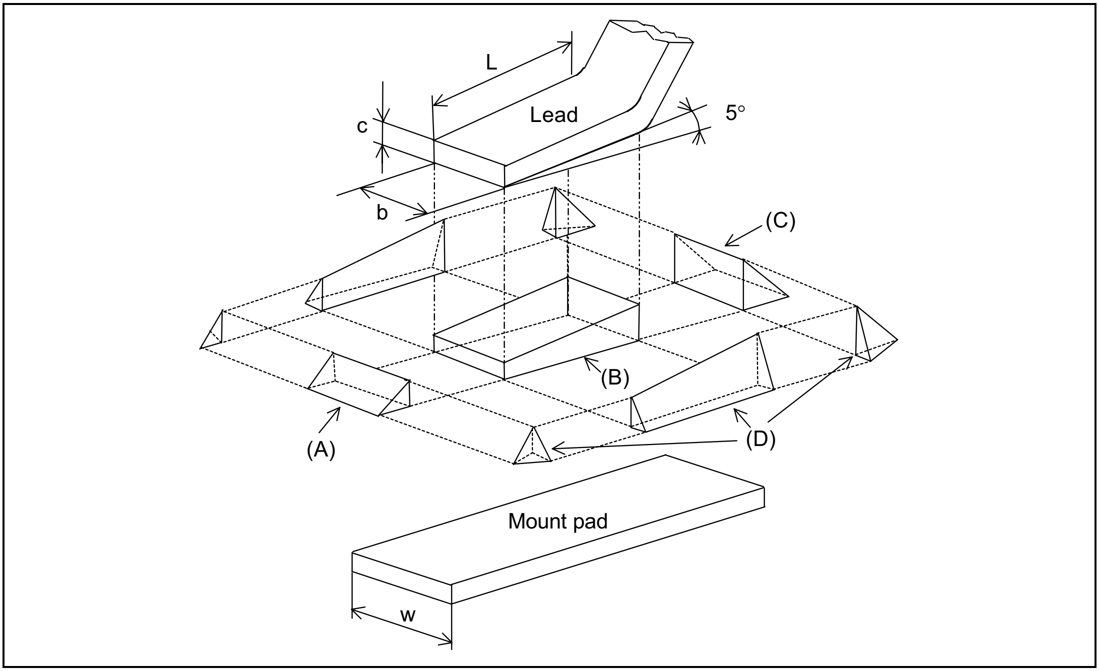


Figure 2.15 Exploded Block Diagram of Soldering Area

The optimal quantity of solder is found by calculating the volume of solder of each block in the exploded block diagram of the soldering area shown in Figure 2.15.

A to D: Solder quantities of each block
Optimal quantity of solder = A + B + C + 2D

Next, the necessary quantity of solder paste is found from the following equation.

$$\text{Necessary quantity of solder paste } (A \times t) = \text{optimal quantity of solder} \times (\omega 1/\rho 1 + \omega 2/\rho 2) / (\omega 1/\rho 1)$$

where: A = Metal mask aperture area
t = Solder paste print thickness
$\omega 1$ = Solder weight percentage in solder paste
$\rho 1$ = Specific gravity of solder
$\omega 2$ = Flux weight percentage in solder paste
$\rho 2$ = Specific gravity of flux

The aperture dimensions of the metal mask for solder paste printing, and the thickness of the metal, must be investigated based on the result of the above calculation of the necessary quantity of solder paste.

(b) Solder paste supply quantity for CSP/BGA (0.75 mm pitch or more)

We recommend that the quantity of solder paste to be supplied be set paying particular attention to the following items.

1. Solder paste print thickness

   We recommend that the minimum solder paste print thickness setting be made as shown below, taking account of the flatness of the IC package.

   Minimum solder paste print thickness = IC package flatness + 0 to 30 μm

2. Solder paste print diameter

   We recommend that the following items be into consideration when setting the solder paste print diameter.

   - Allow a distance of at least 0.3 mm between metal mask apertures to prevent solder bridging.
   - Set the solder paste print diameter to at least the minimum solder paste print thickness stipulated in item 1 to prevent a solder open state.

(3) Typical Package Mounting Evaluation Data

The results of carrying out mountability evaluation for typical packages with solder paste print thickness and print diameter as parameters are shown below.

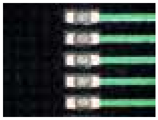
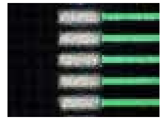
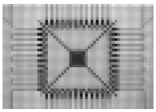
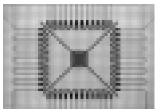
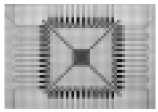
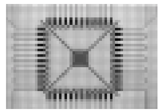
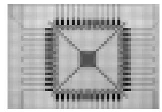
Solder Paste Supply Quantity vs Mountability (P-VQFN)

- Evaluation samples

Package	: 48-pin P-VQFN (0.5 mm pitch)
Package leads	: 0.20 × 0.35 mm
Mounting pads	: 0.25 × 0.75 mm
Solder paste	: 3.0Ag/0.5Cu/Sn

- Mounting conditions

Mounting load	: 300g/ic
Mounting depression amount	: 0.2 mm
Reflow temperature	: 250°C±5°C (Air reflow)

	Metal mask aperture dimensions (mask thickness: 0.10 mm)				
	0.20 mm × 0.20 mm	0.25 mm × 0.35 mm	0.25 mm × 0.55 mm	0.25 mm × 0.75 mm	0.25 mm × 0.95 mm
Solder print appearance					
X-ray observation after reflow					
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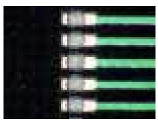
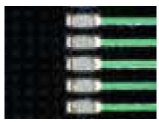
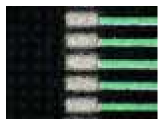
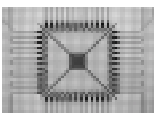
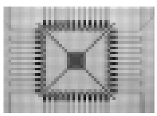
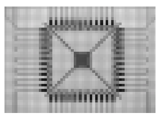
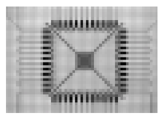
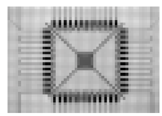
	Bridging occurrence rate: 0/10	Bridging occurrence rate: 0/10	Bridging occurrence rate: 0/10	Bridging occurrence rate: 0/100	Bridging occurrence rate: 0/10
	0.30 mm × 0.30 mm	0.30 mm × 0.35 mm	0.30 mm × 0.55 mm	0.30 mm × 0.75 mm	0.30 mm × 0.95 mm
Solder print appearance					
X-ray observation after reflow					
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	Bridging occurrence rate: 0/10	Bridging occurrence rate: 0/10	Bridging occurrence rate: 0/10	Bridging occurrence rate: 0/10	Bridging occurrence rate: 0/10

Solder Paste Supply Quantity vs Mountability (240-Pin FBGA)

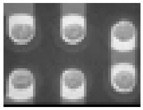
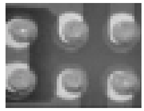
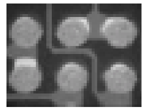
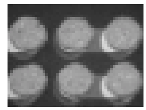
- Evaluation samples

Package	: 240-pin FBGA (0.8 mm pitch)
Package shape	: 15 mm□
Balls	: φ0.45 mm
Mounting pads	: φ0.40 mm
Solder paste	: 3.0Ag/0.5Cu/Sn

- Mounting conditions

Mounting load	: 300g/ic
Mounting depression amount	: 0.2 mm
Reflow temperature	: 240°C±5°C (Air reflow)

- Evaluation results

	Metal thickness	Metal mask aperture dimensions φ0.3 mm	φ0.4 mm	φ0.5 mm	φ0.6 mm (0.55 mm*1)
Mounting board mounting pads (φ0.40 mm)	0.05 mm				
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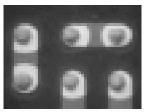
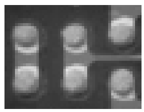
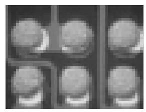
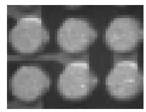
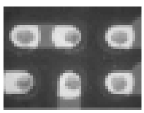
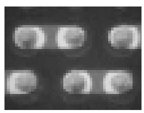
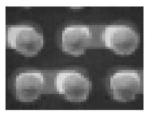
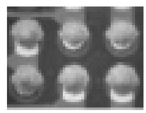
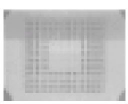
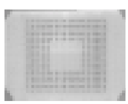
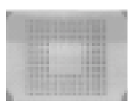
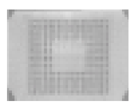
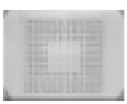
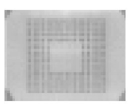
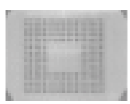
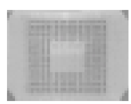
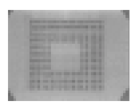
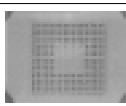
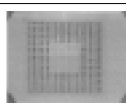
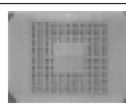
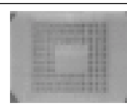
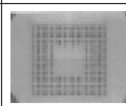
	0.15 mm				
		Open state occurrence rate: 0/10	Open state occurrence rate: 0/10	Open state occurrence rate: 0/10	Open state occurrence rate: 0/10
		Bridging occurrence rate: 0/10	Bridging occurrence rate: 0/10	Bridging occurrence rate: 0/10	Bridging occurrence rate: 4/10
	0.25 mm*2				
		Open state occurrence rate: 0/10	Open state occurrence rate: 0/10	Open state occurrence rate: 0/10	Open state occurrence rate: 0/10
		Bridging occurrence rate: 0/10	Bridging occurrence rate: 0/10	Bridging occurrence rate: 0/10	Bridging occurrence rate: 6/10

*1: Mask thickness: 0.25 mm, aperture diameter: 0.55 mm
*2: As mask thickness is great, paste removability is poor, and less than ideal supply quantity

- X-ray analysis photographs

Aperture dimensions / Metal thickness	φ0.3 mm	φ0.4 mm	φ0.5 mm	φ0.6 mm (0.55 mm*3)	
	No bridging	No bridging	No bridging	No bridging	Bridging
0.05 mm					
0.15 mm					
0.25 mm					

*3: Mask thickness: 0.25 mm, aperture diameter: 0.55 mm

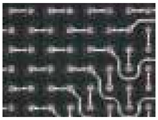
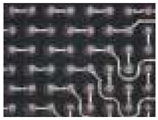
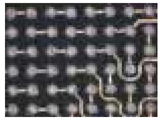
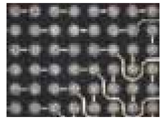
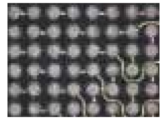
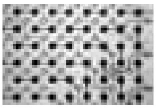
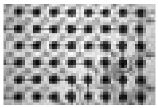
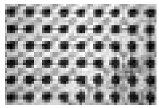
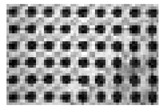
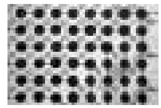
Solder Paste Supply Quantity vs Mountability (0.65 mm Pitch LGA)

- Evaluation samples

Package	: 336-pin P-LFLGA (0.65 mm pitch)
Package leads	: ϕ0.35 mm
Mounting pads	: ϕ0.35 mm (Cu + heat-resistant pre-flux)
Solder paste	: 3.0Ag/0.5Cu/Sn

- Mounting conditions

Mounting load	: 180g/ic
Mounting depression amount	: 0.2 mm
Reflow temperature	: 250°C±5°C (Air reflow)

	Metal mask aperture dimensions (mask thickness: 0.10 mm)				
	ϕ0.25 mm	ϕ0.30 mm	ϕ0.35 mm	ϕ0.40 mm	ϕ0.45 mm
Solder print appearance					
X-ray observation after reflow					
	Open state occurrence rate: 2/10	Open state occurrence rate: 0/10	Open state occurrence rate: 0/10	Open state occurrence rate: 0/100	Open state occurrence rate: 0/10
	Bridging occurrence rate: 0/10	Bridging occurrence rate: 0/10	Bridging occurrence rate: 0/10	Bridging occurrence rate: 0/100	Bridging occurrence rate: 0/10

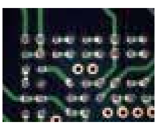
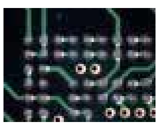
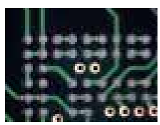
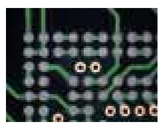
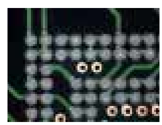
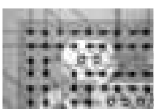
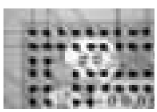
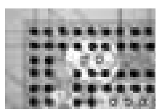
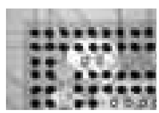
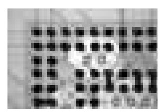
Solder Paste Supply Quantity vs Mountability (0.50 mm Pitch LGA)

- Evaluation samples

Package	: 304-pin P-LFLGA (0.50 mm pitch)
Package leads	: ϕ0.30 mm
Mounting pads	: ϕ0.30 mm (Cu + heat-resistant pre-flux)
Solder paste	: 3.0Ag/0.5Cu/Sn

- Mounting conditions

Mounting load	: 180g/ic
Mounting depression amount	: 0.2 mm
Reflow temperature	: 250°C±5°C (Air reflow)

	Metal mask aperture dimensions (mask thickness: 0.10 mm)				
	ϕ0.20 mm	ϕ0.25 mm	ϕ0.30 mm	ϕ0.35 mm	ϕ0.40 mm
Solder print appearance					
X-ray observation after reflow					
	Open state occurrence rate: 6/8	Open state occurrence rate: 0/8	Open state occurrence rate: 0/8	Open state occurrence rate: 0/8	Open state occurrence rate: 0/8
	Bridging occurrence rate: 0/8	Bridging occurrence rate: 0/8	Bridging occurrence rate: 0/8	Bridging occurrence rate: 0/8	Bridging occurrence rate: 3/8

2.4 Device Mounting Process

2.4.1 Mounter

An important point in the device mounting process is the mounting precision of the mounted devices. In device mounting, it is necessary to confirm position deviation due to the effects of self-alignment of devices, and secure a mounting precision within that range.

With small lead pitches of 0.5 mm or less, in particular, high-precision mounter is necessary.

Table 2.4 shows the features of different types of mounter.

Table 2.4 Features of Different Types of Device Mounting Equipment

Item \ Type	High-Speed Type	Multifunction Type	
Mounting cycle	Chip devices: 0.1 to 0.15 sec	Chip devices	0.3 to 0.6 sec
		QFP, etc.	0.9 to 4.0 sec
Mounting precision	Chip devices: ±0.1 to 0.15 mm	Chip devices	±0.05 to 0.15 mm
		QFP, etc.	±0.05 to 0.10 mm
Device mode	Tape only	Tray, Tape, Tube	
Mounting precision	Mechanical centering, image recognition	Chip devices	Image recognition
		QFP, etc.	Image recognition

The following five factors should be considered when selecting mounter.

- Price in relation to performance (mounting precision, mounting speed)
- Suitability for short-run, multiple-device production
- Basic performance (positioning, repetition precision, resolution)
- Connection to preceding and succeeding equipment (electrical, mechanical)
- Manufacturer's service system

When mounting fine-pitch (0.5 mm or less) IC packages such as TSOPs and QFPs, or IC packages with external ball such as CSPs and BGAs, in particular, we recommend that the following three points be carefully considered when selecting mounter.

- Printed wiring board pattern recognition and IC package recognition (in the case of CSP/BGA, external ball recognition)
- Device mounting precision of ±0.1 mm or less (±0.05 mm or less for a pitch of 0.4 mm or less)
- Ability to control Z-axis (device thickness direction) during device mounting

There are now a large number of mounter manufacturers, offering functions that differ to a certain degree. With regard to the image recognition method for recognizing devices, in particular, there is a trend away from a read area split recognition method toward a total-read batch recognition method in order to shorten the recognition time.

As selection of the mounter is crucial to the device mounting process, as indicated above, thorough exchange of information with the equipment manufacturer is recommended.

2.4.2 Self-Alignment Effect

The phenomenon whereby, even if the precision of alignment between printed wiring board mounting pads and the leads of the package to be mounted is poor, and misalignment occurs, normal positioning is restored automatically during reflow, is known as a "self-alignment effect." The self-alignment force of each device for mounting can be found from the equation below, and by comparing this self-alignment force with the deadweight of the device, it is possible to estimate whether a self-alignment effect can be obtained.

Self-alignment force: $\gamma \times L \times n$

γ: Solder surface tension
L: Length of contact between package lead and solder (perimeter)
n: Number of package lead pins

Solder surface tension reference values: Sn/37Pb: 481mN/m
Sn/3.0Ag/0.5Cu: 558mN/m

Results of self-alignment effect evaluation for typical Renesas packages are given below for reference.

Self-Alignment (TSOP) (I)

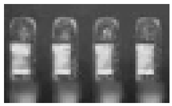
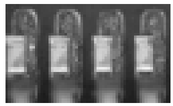
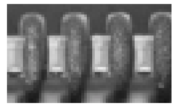
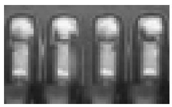
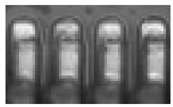
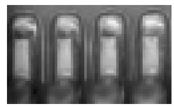
- Evaluation samples

Package	: 52-pin TSOP (0.4 mm pitch)
Package dimensions	: 10.49 mm × 10.99 mm
Package leads	: 0.50 mm × 0.15 mm
Mounting pads	: 0.90 mm × 0.20 mm (Cu + heat-resistant pre-flux)
Metal mask	: 0.90 mm × 0.20 mm × 0.13 mm (additive)
Solder paste	: 63Sn-Pb, 3.0Ag-0.5Cu-Sn
Lead plating	: 1.5Cu-Sn

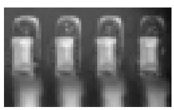
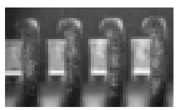
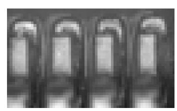
- Mounting conditions

Mounting load	: 300g/ic
Mounting depression amount	: 0.2 mm
Reflow temperature	: 220°C±5°C (Sn/Pb: Air reflow)
	240°C±5°C (Ag/Cu/Sn: Air reflow)

- Sample observation results before and after reflow (3.0Ag-0.5Cu-Sn paste)

	Lead protrusion in mounting: 1/3 lead width	Lead protrusion in mounting: 1/2 lead width	Lead protrusion in mounting: 2/3 lead width
Before reflow			
After reflow			
Solderabilty result	0/20	0/20	0/20

- Sample observation results before and after reflow (63Sn-Pb paste)

	Lead protrusion in mounting: 1/3 lead width	Lead protrusion in mounting: 1/2 lead width	Lead protrusion in mounting: 2/3 lead width
Before reflow			
After reflow			
Solderabilty result	0/20	0/20	0/20

Self-Alignment (TSOP) (II)

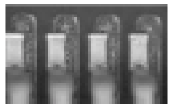
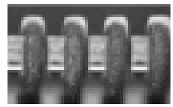
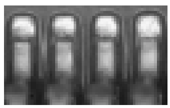
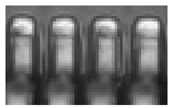
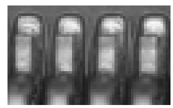
- Evaluation samples

Package	: 52-pin TSOP (0.4 mm pitch)
Package dimensions	: 10.49 mm × 10.99 mm
Package leads	: 0.50 mm × 0.15 mm
Mounting pads	: 0.90 mm × 0.20 mm(Cu + heat-resistant pre-flux)
Metal mask	: 0.90 mm × 0.20 mm × 0.13 mm (additive)
Solder paste	: 63Sn-Pb, 3.0Ag-0.5Cu-Sn
Lead plating	: 10Pb-Sn

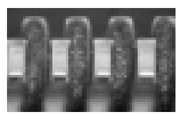
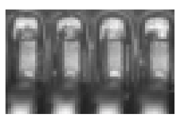
- Mounting conditions

Mounting load	: 300g/ic
Mounting depression amount	: 0.2 mm
Reflow temperature	: 220°C±5°C (Sn/Pb:Air reflow)
	240°C±5°C (Ag/Cu/Sn:Air reflow)

- Sample observation results before and after reflow (3.0Ag-0.5Cu-Sn paste)

	Lead protrusion in mounting: 1/3 lead width	Lead protrusion in mounting: 1/2 lead width	Lead protrusion in mounting: 2/3 lead width
Before reflow			
After reflow			
Solderabilty result	0/20	0/20	0/20

- Sample observation results before and after reflow (63Sn-Pb paste)

	Lead protrusion in mounting: 1/3 lead width	Lead protrusion in mounting: 1/2 lead width	Lead protrusion in mounting: 2/3 lead width
Before reflow			
After reflow			
Solderabilty result	0/20	0/20	0/20

Self-Alignment (P-VQFN)

- Evaluation samples

Package	: 48-pin P-VQFN (0.5 mm pitch)
Package leads	: 0.20 mm × 0.35 mm
Mounting pads	: 0.25 mm × 0.75 mm (Cu + heat-resistant pre-flux)
Metal mask	: 0.25 mm × 0.75 mm × 0.10 mm (additive)
Solder paste	: 3.0Ag-0.5Cu-Sn

- Mounting conditions

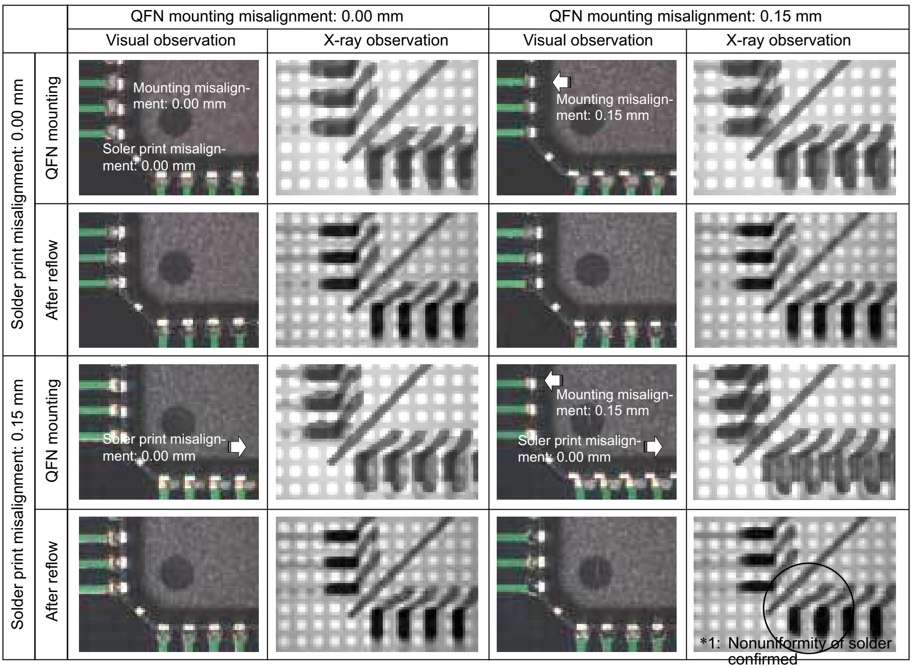
Mounting load	: 300g/ic
Mounting depression amount	: 0.2 mm
Reflow temperature	: 250°C±5°C (Sn/Pb: Air reflow)

- Evaluation results

Solder print misalignment (+x)	QFN mounting misalignment (-x)									
	0.00 mm		0.05 mm		0.08 mm		0.12 mm		0.15 mm	
	Appear-ance	X-ray	Appear-ance	X-ray	Appear-ance	X-ray	Appear-ance	X-ray	Appear-ance	X-ray
0.00 mm	0/3	0/3	0/3	0/3	0/3	0/3	0/3	0/3	0/3	0/3
0.05 mm	0/3	0/3	0/3	0/3	0/3	0/3	0/3	0/3	0/3	0/3
0.10 mm	0/3	0/3	0/3	0/3	0/3	0/3	0/3	0/3	0/3	0/3
0.15 mm	0/3	0/3	0/3	0/3	0/3	0/3	0/3	1/3*1	0/3	3/3*1

*1: Nonuniformity of solder confirmed

- Evaluation result photographs (examples)



P-VQFN packages have exceptionally good self-alignment, but if there is marked solder print or mounting misalignment, the quantity of solder may not be uniform even if self-alignment can be confirmed visually.

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Self-Alignment (FBGA)

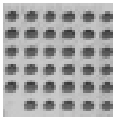
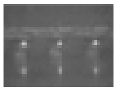
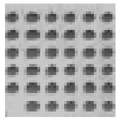
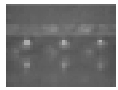
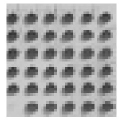
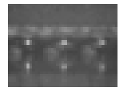
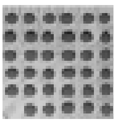
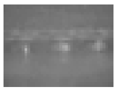
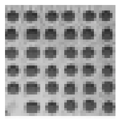
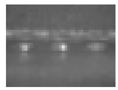
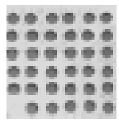
- Evaluation samples

Package	: 240-pin FBGA (0.8 mm pitch)
Package dimensions	: 15 mm □
Balls	: ϕ0.45 mm
Mounting pads	: ϕ0.40 mm (Cu + heat-resistant pre-flux)
Metal mask	: ϕ0.40 mm × 0.10 mm (additive)
Solder paste	: 63Sn-Pb, 3.0Ag-0.5Cu-Sn
Solder balls	: 63Sn-Pb, 3.0Ag-0.5Cu-Sn

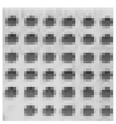
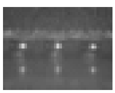
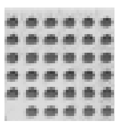
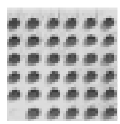
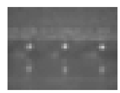
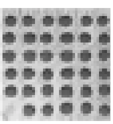
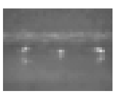
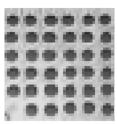
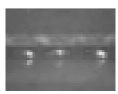
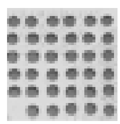
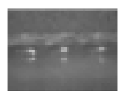
- Mounting conditions

Mounting load	: 300g/ic
Mounting depression amount	: 0.2 mm
Reflow temperature	: 220°C±5°C (Sn/Pb:Air Reflow)
	240°C±5°C (Ag/Cu/Sn: Air reflow)

- Sample observation results before and after reflow (3.0Ag-0.5Cu-Sn paste, balls)

	Ball misalignment in mounting: 0.1 mm		Ball misalignment in mounting: 0.2 mm		Ball misalignment in mounting: 0.3 mm	
Before reflow						
After reflow						
Result	0/20		0/20		0/20	

- Sample observation results before and after reflow (63Sn-Pb paste, balls)

	Ball misalignment in mounting: 0.1 mm		Ball misalignment in mounting: 0.2 mm		Ball misalignment in mounting: 0.3 mm	
Before reflow						
After reflow						
Result	0/20		0/20		0/20	

Self-Alignment (0.65 mm Pitch LGA)

- Evaluation samples

Package	: 336-pin P-LFLGA (0.65 mm pitch)
Package pads	: ϕ0.35 mm
Mounting pads	: ϕ0.35 mm (Cu + heat-resistant pre-flux)
Metal mask	: ϕ0.35 mm × 0.10 mm (additive)
Solder paste	: 3.0Ag-0.5Cu-Sn

- Mounting conditions

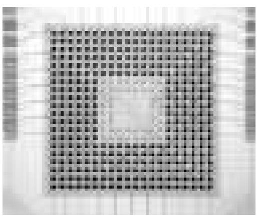
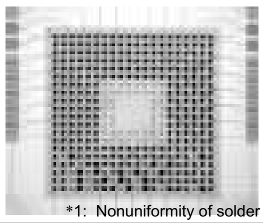
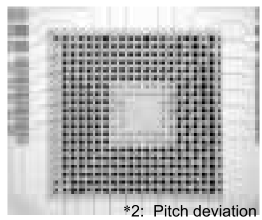
Mounting load	: 180g/ic
Mounting depression amount	: 0.2 mm
Reflow temperature	: 250°C±5°C (Air reflow)

- Evaluation results

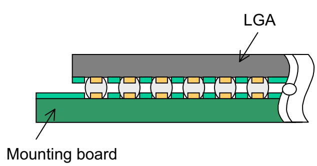
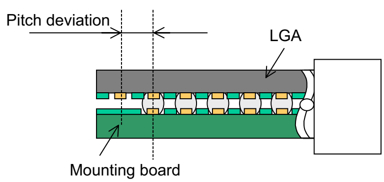
Solder print misalignment (+x)	LGA mounting misalignment (-x)									
	0.00 mm		0.05 mm		0.10 mm		0.15 mm		0.20 mm	
	Appear-ance	X-ray	Appear-ance	X-ray	Appear-ance	X-ray	Appear-ance	X-ray	Appear-ance	X-ray
0.05 mm	0/3	0/3	0/3	0/3	0/3	0/3	0/3	0/3	0/3	0/3
0.10 mm	0/3	0/3	0/3	0/3	0/3	0/3	0/3	0/3	1/3 *1	1/3 *1
0.15 mm	0/3	0/3	0/3	0/3	0/3	0/3	0/3	0/3	2/3 *2	2/3 *2

*1: Nonuniformity of solder
*2: Pitch deviation

- Evaluation result photographs (examples)

	LGA mounting misalignment: 0.20 mm		
	Solder print misalignment: 0.05 mm	Solder print misalignment: 0.10 mm	Solder print misalignment: 0.15 mm
X-ray photo after reflow		 *1: Nonuniformity of solder	 *2: Pitch deviation

- Cross-sectional images of LGA pitch deviation

Cross-sectional images	• Normal mounting 	• Mounting with pitch deviation 

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Self-Alignment (0.50 mm Pitch LGA)

- Evaluation samples

Package	: 304-pin P-LFLGA (0.50 mm pitch)
Package pads	: ϕ0.30 mm
Mounting pads	: ϕ0.30 mm (Cu + heat-resistant pre-flux)
Metal mask	: ϕ0.30 mm × 0.10 mm (additive)
Solder paste	: 3.0Ag-0.5Cu-Sn

- Mounting conditions

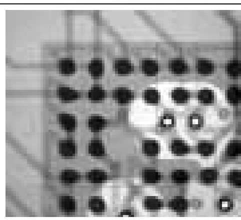
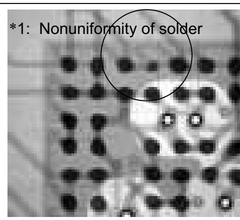
Mounting load	: 180g/ic
Mounting depression amount	: 0.2 mm
Reflow temperature	: 250°C±5°C (Air reflow)

- Evaluation results

Solder print misalignment (+x)	LGA mounting misalignment (-x)					
	0.05 mm		0.10 mm		0.15 mm	
	Appear-ance	X-ray	Appear-ance	X-ray	Appear-ance	X-ray
0.05 mm	0/3	0/3	0/3	0/3	0/3	0/3
0.10 mm	0/3	0/3	0/3	0/3	0/3	2/3*1
0.15 mm	0/3	0/3	0/3	2/3*1	0/3	3/3*1

*1: Nonuniformity of solder

- Evaluation result photographs (examples)

	LGA mounting misalignment: 0.15 mm	
	Solder print misalignment: 0.05 mm	Solder print misalignment: 0.10 mm
X-ray photo after reflow		

2.5 Soldering Process

There are two kinds of surface mount soldering methods: flow and reflow. The description here will focus on reflow, which is most commonly used for surface mounting.

Table 2.5 Examples of Reflow Methods

Heating Method	Method	Advantages	Disadvantages
Full heating	• Infrared reflow • Belt reflow • VPS • Air reflow (N2 reflow)	Suitable for mass production Peripheral devices can be soldered simultaneously	Package is subjected to thermal stress Board is susceptible to warping
Partial heating	• Laser • Pulse heater • Light beam	No heating effect on package Retrofitting possible	Not suitable for mass production (long cycle)

As shown above, reflow methods allowing full heating are well suited to mass production. When a package susceptible to thermal stress is used, retrofitting by means of a partial heating method is recommended.

2.5.1 Soldering Equipment (Full Heating Method)

Four typical full heating methods are shown in Table 2.6.

Table 2.6 Comparison of Full Heating Methods

Method	Advantages	Disadvantages
Infrared reflow • Far infrared • Near infrared	• Simple construction • Low cost	• Difficult to directly heat parts in shadow • In near infrared case, difference in degree of heating due to color selectivity
VPS (Vapor Phase Soldering)	• Uniform heating is possible • Temperature control system not necessary	• High equipment cost • High running costs
Air reflow • Hot air only • Combined with infrared heating	• Easy to directly heat parts in shadow and close-packed parts • Uniform heating is possible	• Soldering defects due to copper foil oxidation • Displacement of devices due to air velocity • Board vibration due to air velocity
N2 reflow • Hot air only • Combined with infrared heating	• Easy to directly heat parts in shadow and close-packed parts • Uniform heating is possible	• High running costs • Displacement of devices due to air velocity • Board vibration due to air velocity

Figure 2.16 shows the heat transfer paths in each full heating method.

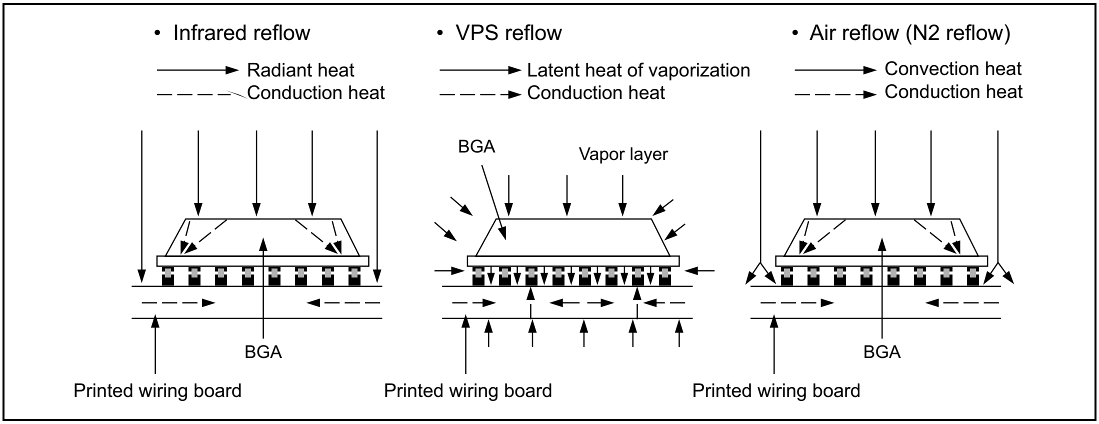
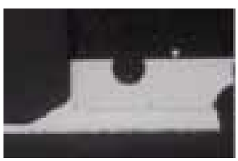
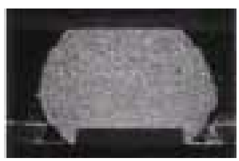
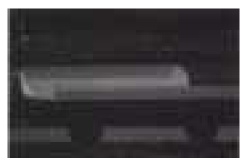


Figure 2.16 Heat Transfer Paths of Full Heating Methods

As can be seen from the heat transfer paths, with infrared reflow a soldering area in the shadow of the package body cannot be heated directly, and therefore the use of VPS or air reflow (N2 reflow) equipment is recommended when performing soldering at the bottom of the package, as in the case of CSP/BGA packages.

The use of VPS or air reflow (N2 reflow) equipment, which keeps the package surface temperature down, is also recommended for thin packages such as TSOPs and CSPs to minimize thermal stress.

Cross-sectional photographs of Sn3.0Ag-0.5Cu solder after mounting are shown below for typical packages for reference.

100-Pin QFP	28-Pin QFN	261-Pin BGA	64-Pin LGA
0.5 mm Pitch	**0.5 mm Pitch**	**0.65 mm Pitch**	**0.65 mm Pitch**
			

2.5.2 Soldering Process

The soldering process with a full heating method is described below.

A necessary condition for the soldering process is that the devices to be mounted and the printed wiring board are connected both electrically and mechanically. To fulfill this condition, the temperature profile conditions described below must be met. A temperature profile indicates temperature changes over time shown by a printed wiring board with devices mounted inside the soldering equipment.

(1) Approach to Setting Temperature Profile

The following two points must be satisfied when setting the temperature profile.

- Temperature setting necessary for soldering
- Temperature setting for guaranteeing device reliability

The actual condition setting items of a temperature profile that meets the above conditions are as follows.

- Peak temperature
- Solder melting time (time during which the product is kept at or above the solder melting point)
- Preheating time and temperature
- Temperature ramping

We recommend the use of reflow equipment that allows the zones shown in Figure 2.17 to be totally separated and temperature settings to be made for each.

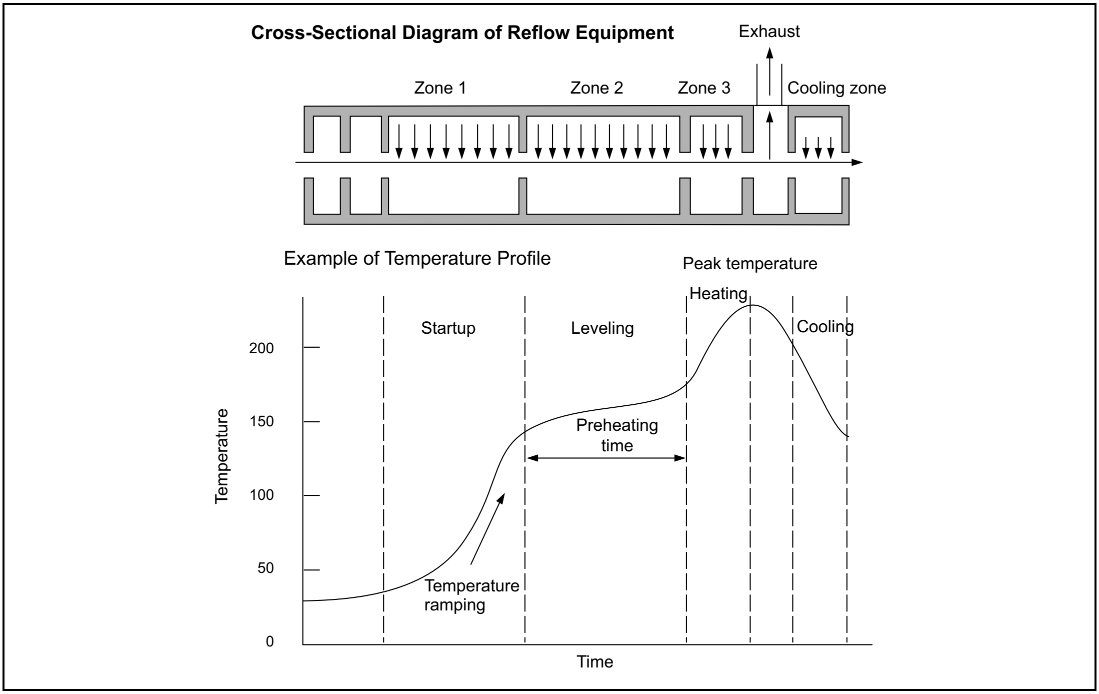


Figure 2.17 Relationship between Reflow Equipment and Temperature Profile

(2) Temperature Profile Conditions

The four points necessary for a temperature profile are described here.

(a) Peak temperature

In order to set the optimal peak temperature, the following two points should be noted when carrying out equipment temperature setting.

The temperature of areas to be soldered (underside of IC leads or mounting pads) must be higher than the solder paste melting point.

(A peak temperature 20 to 40ºC higher than the solder melting point is recommended.)

Note: For eutectic solder (Sn: 63%, Pb: 37%), the temperature is 200 to 220ºC.

The surface temperature of the devices to be mounted must be less than the thermal durability temperature of those devices.

(b) Solder melting time

Solder paste contains solder powder, and a certain solder melting time is necessary for the solder powder to melt and spread onto the devices electrodes and the printed wiring board mounting pads. However, in the case of devices that have Ag-Pd electrodes, if the solder melting time is too long, there may be a “silver scavenging” phenomenon in the Ag-Pd electrodes (in which the Ag from the material being soldered diffuses into the solder), reducing the strength of the solder joint. Thorough soldering evaluation is therefore recommended before setting the solder melting time.

Also, when using devices or a printed wiring board with a large thermal capacity, the rate of cooling will be slower, and therefore the use of reflow equipment provided with a cooling mechanism is recommended.

(c) Preheating time

Soldering defects that may arise in the soldering process include wicking, in which solder is drawn up onto the IC leads, and the Manhattan phenomenon that can be seen in small chip devices.

A probable cause of these defects is lack of temperature uniformity during reflow.

With high-density mounting boards, in particular, since many devices are mounted on the same board, the rate of temperature increase varies according to the size of the individual devices. Preheating is necessary in order to minimize such temperature differences.

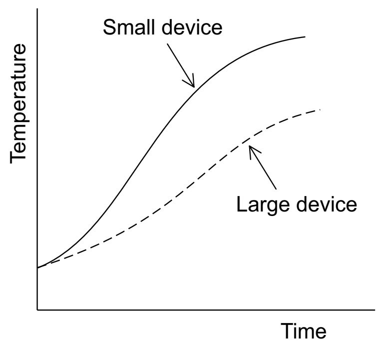


Figure 2.18 Example of Temperature Rise for Different Devices

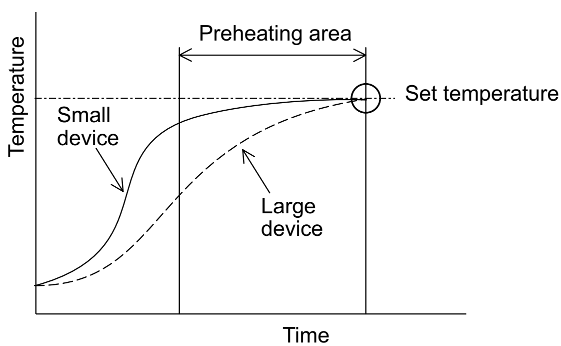


Figure 2.19 Example of Temperature Leveling by Preheating

We recommend that the reflow equipment temperatures and conveyor speed be adjusted so that temperature variations of the printed wiring board and various devices are minimized within the preheating time in the temperature profile described in 2.5.2 (1).

Inadequate preheating conditions are also a likely cause of solder ball formation and poor wetting during soldering.

To remedy the above defects, we recommend that the following points be noted as reflow preheating conditions.

- Setting a preheating temperature and time that allow full volatilization of volatile constituents in the solder paste
- Setting a preheating temperature and time necessary for raising the activity of the activator in the flux

(d) Temperature ramping

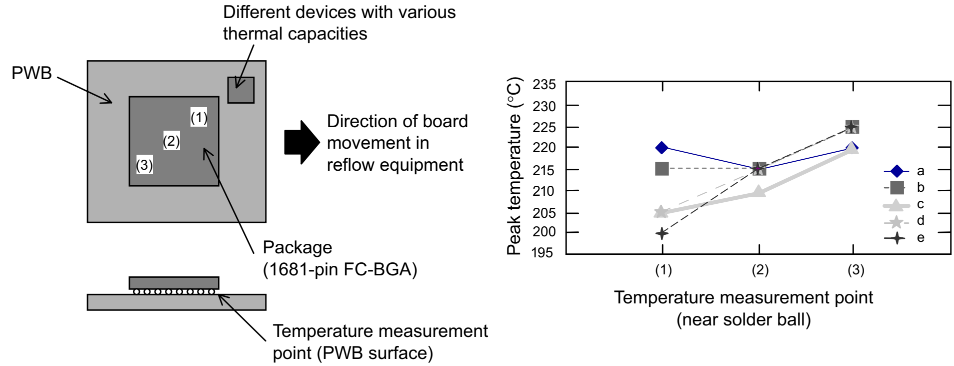
Depending on the package, there may be a risk of cracking if the temperature ramping (i.e. the rate at which the temperature is increased or decreased) is too large. With current reflow soldering equipment, an increase in temperature of 1 to 4°C/second is recommended.

A fast cooling rate is also recommended in order to improve the luster of the solder surface.

(3) BGA Package Reflow

With CSP/BGA and similar packages in which solder is present at the bottom of the package, temperature variations inside the package during reflow are a concern, but temperature variations can be kept in check by providing as long a preheating time as possible in the reflow temperature profile.

Results are shown below of evaluation of the effect on FC-BGA package internal temperature variations and solderabilty when devices with various thermal capacities are mounted in close proximity to an FC-BGA package.



Reflow Conditions	Solder Ball peak Temperature Variation (ºC)	Soldering Defect Mode		
		Open state	Bridging	Other
a	5	0/5	0/5	0/5
b	10	0/5	0/5	0/5
c	15	0/5	0/5	0/5
d	20	0/5	0/5	0/5
e	25	0/5	0/5	1/5*1

*1: Void created inside solder ball

It was confirmed from the above evaluation results that, when devices with various thermal capacities are mounted in the vicinity of an FC-BGA package, soldering defects occur when there is a temperature variation inside the FC-BGA package of 20ºC or more. Allowing a margin for temperature variation inside the mounting board, we recommend that temperature variation inside the package should not be allowed to exceed 10ºC.

2.5.3 Soldering Methods for Various Surface Mount Packages

Table 2.7 shows the appropriate soldering methods to be used for the various types of surface mount packages. Select the soldering method based on factors such as mass production capability, thermal damage to devices, etc.

Table 2.7 Soldering Methods for Various Surface Mount Packages

Mounting Conditions		SOP SSOP HSOP QFP LQFP HQFP HLQFP	TQFP HTQFP	TSOP	TSSOP VSSOP P-VSON HSOI G-QFP SIP*3	QFJ SOJ	G-QFJ	HTSSOP*4 HQFP*4 HLQFP*4 HTQFP*4 QFN P-VQFN BGA LFBGA HBGA HFBGA TFBGA	MFPAK SMPAK CMFPAK SMFPAK TSOP-6 LDPAK(S)	LFPAK	RP8P*4	SFP	Other Discrete Packages
Partial heating methods	Soldering iron/ Laser	○	○	○	○	○	○	×	○	○	×	×	○
	Pulse heater	○	○	○	○	×	×	×	○	×	×	○	○
	Hot air	○	○	○	○	○	○	○	○	×	○	○	○
Full heating methods	Infrared reflow/ Air reflow	○	○	○	○	○	○	○	○	○	○	○	○
	Vapor phase reflow	○	○	○	○	○	○	○	○	○	○	○	○
	Flow soldering*5	○*1	○*1,2	○*2	○	×	○	×	×	×	×	○	○

O: Soldering is possible using this method on the conditions recommended by Renesas Technology Corp.
×: Soldering cannot be performed using this method. (Please avoid using this method.)

*1: Varies depending on the product. Contact your sales representative for more details.
*2: For some products, the maximum solder bath temperature is 235°C and the maximum time passing through the solder bath is 5 seconds.
*3: Only the SP-23TD may be surface mounted.
*4: Heat spreader exposed type and die pad exposed type.
*5: With fine-pitch packages, there is the potential for solder bridges, etc. Use this method only after the soldering conditions have been confirmed.

2.6 Cleaning Process

Various kinds of solvents have traditionally been used in flux cleaning after devices have been mounted on a printed wiring board, but in consideration of the issue of environmental contamination, there are growing demands for the selective use of cleaning materials, or omission of the cleaning process.

(1) Necessity or Otherwise of Cleaning

The following points should be considered in determining whether or not there is a need for flux cleaning after device mounting on a printed wiring board.

- Anti-corrosive properties, insulation resistance, migration, etc., of the flux to be used
- Necessary product reliability level
- Environment in which the product will be used
- Required appearance level
- Visual inspection capability
- Whether or not an in-circuit test is necessary

(2) Concerning Flux Cleaning

If cleaning is determined to be necessary based on the above considerations, four items – the flux, cleaning solution, cleaning method, and cleaning equipment – should be considered in deciding on the cleaning process.

Information relating to these four items is summarized in Table 2.8.

Table 2.8 Examples of Cleaning Process Selection

Flux	Cleaning Solution	Cleaning Method Selection		Cleaning Equipment Selection
Rosin flux	Petroleum-based solvent	Immersion cleaning	Use/non-use of ultrasonic cleaning	In-line type or batch type
	Terpene-based solvent	Spray cleaning (including rinse cleaning)		
	Demineralized water based solvent	Spray cleaning (including rinse cleaning) or immersion cleaning		
Water-soluble flux	Water	Spray cleaning or immersion cleaning		
	Water + neutralizer	Spray cleaning or immersion cleaning (including neutralizer cleaning)		

The above four items and the method of making a decision on cleaning are described below.

2.6.1 Selecting the Flux

There are broadly two kinds of soldering flux: rosin flux and water-soluble flux.

Rosin flux is the most widely used kind at present, and flux residue is nonhygroscopic and non-corrosive under normal conditions, allowing "no-cleaning" processing to be used. A considerable amount of halogen or similar chlorine constituting the main activator in the flux remains after soldering, and therefore problems in the event of inadequate cleaning must be thoroughly investigated.

Water-soluble flux is a comparatively new material, but the following characteristics have caused it to become quite widely used in the United States and elsewhere.

- It enables a cleaner appearance to be obtained than with rosin flux.
- It offers good solderabilty.
- The cleaning solution used (water) is harmless to humans and cheap.

However, in contrast to the various merits of water-soluble flux, residue is highly corrosive, making complete cleaning necessary, and cleanliness requires thorough checking for confirmation.

2.6.2 Selecting the Cleaning Solution

The cleaning solution must be selected in accordance with the characteristics of the flux residue. Generally, the following cleaning solutions are used for the different kinds of flux.

When using rosin flux:

- Terpene-based solvent: A fluid that has components extracted from orange peels (cleaning required)
- Petroleum-based solvent: Petroleum-based solvent or a compound fluid made from a petroleum-based solvent and a surface activator
- Demineralized water based solvent: A water-rinsable cleaning solution comprising a hydrocarbon-based solvent with a surface activator added
- Alcohol-based solvent: Isopropyl alcohol (IPA), ethanol, methanol, etc.
- Alkali-based solvent: A compound fluid made from an organic alkali and a surface activator

When using water-soluble flux:

- Water
- Water with an alkali neutralizer

(1) Rosin Flux Cleaning Solutions

The following points must be considered when selecting a rosin flux cleaning solution.

- Ability to dissolve ionic residue
- Ability to dissolve non-ionic residue
  - — KB value (kauri-butanol value)
  - — Boiling point
  - — Compatibility with resin (resin used for devices and printed wiring board)
- Stability, safety
- Waste water processing (in the case of a terpene solvent, alkali rosin cleaner, etc.)

(2) Water-Soluble Flux Cleaning Solutions

We recommend the use of soft water or deionozed water for water-soluble flux cleaning.

Hard water cannot be recommended as it contains large quantities of calcium, magnesium, and iron ions, which form insoluble salts in the water, causing scale that coats the heating element inside the cleaning tank and clogs the spray nozzles.

With water cleaning, a neutralizer may be used as an additive, but since this contains a surface activator, we recommend discussing the effects of the surface activator with the manufacturer.

2.6.3 Selecting the Cleaning Method and Cleaning Equipment

(1) Cleaning with an Organic Solvent Based Cleaning Solution

There are three main cleaning methods:

- Vapor cleaning
- Immersion cleaning (including ultrasonic cleaning)
- Spray cleaning

Cleaning is generally carried with a combination of vapor cleaning methods.

Points to be noted when using an organic solvent based cleaning solution are listed below.

1. Product damage during ultrasonic cleaning

   When using ultrasonic waves in immersion cleaning, the possibility of damage to the mounted devices must be checked beforehand. (Exposure to ultrasonic waves should be avoided in the case of hermetically sealed devices, such as ceramic package devices, because of the risk of wire breakage.)

Also insure that the printed wiring board and mounted devices do not come into direct contact with the ultrasonic resonator.

2. Water quality and waste water processing in rinsing

   When performing cleaning using a terpene-based or demineralized water based cleaning solution, it is necessary to carry out a detailed investigation of the water quality during washing and the waste water quality in order to introduce water cleaning as a post-cleaning process (rinsing).

3. Safety precautions when using an inflammable solvent

   Because of flammability concerns, explosion prevention safety measures in the cleaning equipment must be thoroughly investigated when using an alcohol- or terpene-based solvent, demineralized water based solvent, petroleum-based solvent, etc.

(2) Cleaning with Water

When cleaning with water, cleaning is generally carried out by means of spraying, followed by water removal and drying.

When implementing water cleaning (including spray cleaning), it is necessary to thoroughly investigate cleaning conditions such as the nozzle pressure and nozzle angle, the drying method, and the drying conditions.

In addition, all local or national regulations pertaining to waste water processing must be observed.

2.6.4 Evaluation Methods

(1) Evaluating the Effects of Cleaning

The following methods can be used to evaluate the effects of cleaning.

- Visual evaluation
- Contact angle and wetting index
- Contamination extraction concentration measurement
- Optical method
- Molecular spectroscopy

(2) Determination of “No-Cleaning” Processing

The important point when implementing “no-cleaning” processing is consideration of the flux to be used, and the following evaluation processes must be carried out.

- Corrosion test
  (Copper mirror test, etc.)
- Reactivity test
  (Silver chromate paper test, etc.)
- Insulation resistance test
  (High-temperature, high-humidity test, etc.)
- Aqueous solution resistance measurement
- Mechanical tests
  (Reliability test as actual product)
  (Reliability test of individual devices)

The criteria for the above items will vary according to the reliability level and specifications required for the product. Thorough investigation is recommended before setting the criteria.

2.7 Inspection Process

As electronic products become smaller and lighter, the electronic devices used in such products are also becoming smaller, with finer processes and higher mounting densities. It has thus become extremely difficult to continue the visual inspections previously carried out after soldering. From the standpoint of reducing the assembly costs of electronic products, also, automation of appearance inspections after soldering is becoming increasingly common.

This section outlines the items for inspection when post-soldering appearance inspection equipment is installed.

(1) Appearance Inspection Equipment

Post-soldering appearance inspection equipment currently on the market is summarized in Table 2.9.

Table 2.9 Appearance Inspection Equipment

Inspection Method	Details of Inspection Method
Optical	• Integrated laser/sensor rotational scanning • Color highlighting • Laser plus multiple cameras • Laser scanning
X-ray	• Conversion of X-ray transparent image to 3-dimensional contour data • Conversion of X-ray slice image to 3-dimensional contour data

Thorough investigation of the following items is recommended when appearance inspection equipment is to be installed.

- Clarification of soldering appearance inspection criteria applied to the actual product
- Setting of inspection items to be used by automatic equipment

Note: Depending on the appearance inspection equipment, there are limits to the items that can be inspected, and therefore the application range must be clarified when deciding on the equipment specifications.

- Inspection precision and reproducibility
- Operability of appearance inspection equipment

Note: Ease of inspection criteria setting (programming), machine switchover time, etc., must be confirmed.

- Equipment inspection cycle and price
- Ease of maintenance

X-ray inspection equipment is recommended if it is necessary to inspect the soldering condition of electronic devices that have soldering areas at the bottom of the IC package, as in the case of CSP and BGA packages.

2.7.1 Appearance Inspection Equipment

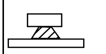
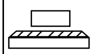
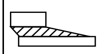
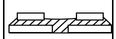
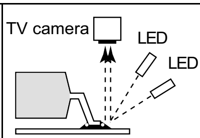
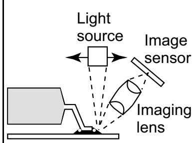
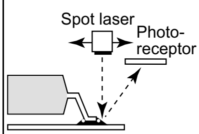
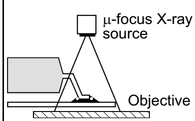
As the soldering connection pitch becomes finer and solder joints are reduced in size, the amount of solder per joint and the area of joint both become smaller, and thus the inspections in each process through the completion of soldering are ever more important. While in the past visual inspections have been the primary means by which these inspections have been performed, recently a variety of automated inspection equipment has been developed and has appeared on the market.

At present the inspection equipment is primarily soldering appearance inspection equipment and solder paste post-printing appearance inspection equipment.

(1) Soldering Appearance Inspection Equipment

While in the past the primary objective of inspections and tests was to determine whether or not the soldering appearance is acceptable, recent equipment is also able to inspect the device mounting state at the same time.

Table 2.10 Overview of Appearance Inspection Equipment

Method/Principle		Defects						
		Soldering Appearance				Device Mounting State		
		Insufficient Solder	Open Lead	Misaligned Lead Bridge	Bridge	Missing Device	Misaligned Device	Incorrect Mounting Orientation
								
Multi-angular illumination		○	○	○	○	○	○	× to ○
Light cut-off		○ to △	○	○	○	○	○	× to △
Laser scanning		○	○	○	○	○	○	× to △
X-ray		○	○	○	○	○	△	×

○ : Evaluation possible

△ : Evaluation conditionally possible

× : Evaluation not possible

In fine-pitch lead packages, the coplanarity, which has an especially large impact on quality, has been standardized at 0.1 mm. Efforts are being made to improve technologies in the pursuit of better lead coplanarity.

(2) Inspection Equipment for Appearance of Solder Paste After Printing

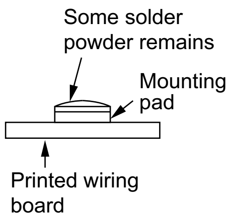
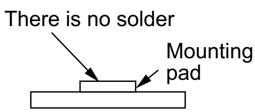
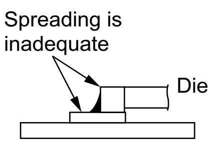
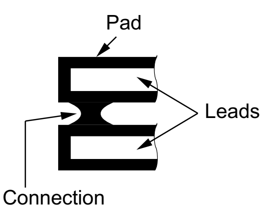
The objective of these systems is to prevent in advance the occurrence of soldering defects (such as inadequate solder, bridging, etc.) by inspecting the shape of the fine-pitch lead solder paste patterns (i.e. the volume, shifted patterns, the height of the paste, bridging, slump, unevenness, etc.) after the minute patterns are printed.

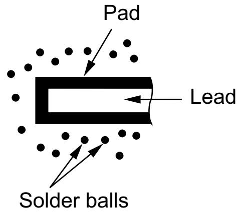
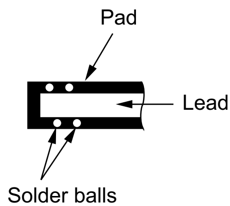
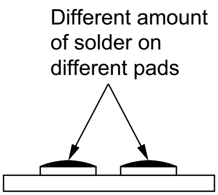
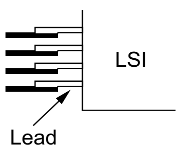
At present, one of two systems is used, either the multi-angular illumination method or the laser scanning method.

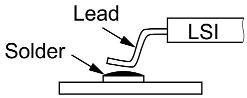
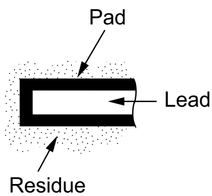
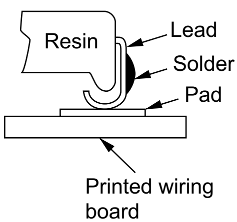
2.7.2 Items Subject to Appearance Inspection

Inspections of the solder joints check for the defects shown in Table 2.15. Both causes and countermeasures for the various defects are listed in this table. This material should be used for reference when improving the various processes.

Table 2.11 Reflow Soldering Defects: Troubleshooting Guide

Type of Defect	Description	Causes	Countermeasures
Inadequate reflow  	Solder powder remains, and either the solder paste has not been subjected to reflow at all or, even though most of the solder paste has been melted in the reflow process, there are still places where soldering has not been performed and solder powder is found on the surface of the solder that has been melted.	• Inadequate heating (temperature, time) • Solder paste degradation (aging) • Excessive preheating (temperature and time between beginning heating and melting the solder)	• Re-evaluate the heating equipment and method. • Store the solder paste in a refrigerator. • Do not use hardened portions of solder paste, such as surface areas.
No solder  	There is no solder where soldering should have been performed.	• Solder paste cannot be printed. • Solder paste printability is poor. • Printing conditions are not suited to the solder paste properties.	• Select solder paste with good printability. • Re-evaluate the printing parameters (including the printing mask thickness and the printing mask size).
Inadequate spreading  	The solder does not spread sufficiently to cover the mounting pad or lead.	• The solder paste printing area is smaller than the pad. • The pad, lead, or paste solderability is poor. • The amount of solder paste used in the printing is inadequate.	• Increase the printing area. • Switch to pads, leads, or solder paste with better solderability. • Plate the pads and leads with solder. • Print a thicker solder layer.
Bridging  	The gap between adjacent pads was filled with solder when the reflow process was performed.	• Too much solder paste has been printed, and thus connection has already been made between adjacent pads by the time of the preheating process. • Solder paste has been printed bridging several pads.	• Reduce the amount of solder (both the printed area and the thickness). • Change the printing method.

Type of Defect	Description	Causes	Countermeasures
Solder balls  	Solder balls are found around the pads or around the device.	• The solder paste has melted in places other than the pad. Possible causes are: — Solder paste print misalignment, or print blotting — Slump of solder paste due to heating — Solder paste capillary effect between the device and board	• Align the printing position. • Print an area slightly smaller than the pads. • Switch to a solder paste that is less likely to slump.
 	Solder balls are found on the surface of solder which has been subjected to a reflow process.	• Inadequate heating (temperature, time) • Solder paste degradation (aging) • Solder paste degradation due to excessive preheating	• Re-evaluate the heating equipment and method. • Store the solder paste in a refrigerator. • Switch to a solder paste that does not degrade as much over time.
Uneven amount of solder  	The amount of solder on the mounting pads is not uniform.	• There is a lack of uniformity in the solder paste during printing, and the amount of solder paste printed is thus non-uniform. • The solder paste printability is poor. • The printing parameters are not set correctly.	• Switch to a solder paste with better printability. • Re-examine the printing parameters.
Shifting of position  	Device is soldered in a misaligned position.	• Devices have been placed in misaligned positions. • Devices have shifted their positions due to vibration during transport. — Inadequate adhesive strength of solder paste — Inadequate force applied to the devices during placement • Shifted due to the flux during reflow — Too much flux in the solder paste	• Place devices so that they are not shifted. • Minimize vibration during transport. • Switch to a solder paste with greater adhesive strength. • Reduce the flux content.

Type of Defect	Description	Causes	Countermeasures
Open lead 	The solder paste is reflowed cleanly, and initially appears to have made a good connection; however, the solder is not attached to the lead.	• A small shift in the position of the device • The flux in the solder paste has caused the device to float. • Bending of leads in QFPs, SOPs, etc. • The amount of solder paste printed is not uniform. • Heating is uneven, and thus there is non-uniformity of the solder melting time.	• Print so that there is no shifting. • Reduce the flux content. • Use LSIs with minimal lead bending. • Re-examine the printing parameters. • Increase the thickness of the print layer. • Re-examine the heating conditions.
Cleaning defect 	Despite the fact that the board has been cleaned, there is flux residue or white powder residue.	• The flux residue is resistant to cleaning. • The cleaning solution is not appropriate. • The cleaning method is not appropriate. • The cleaning solution did not saturate the residue. • There is a long time delay between the reflow process and the cleaning process.	• Use a solder paste that has good cleaning properties. • Re-examine the cleaning solution and cleaning method. • Perform cleaning as soon as possible after the reflow process.
Wicking 	There is no solder between an SOJ or QFJ (PLCC) lead and pad because the molten solder has been sucked up.	• In the VPS method, this occurs when heating is carried out too rapidly.	• Insure adequate preheating in the VPS method. • Perform soldering in a far infrared reflow furnace.

2.8 Reworking Process

Reworking of defective places with a soldering iron has traditionally been used as the reworking method for soldering defects in mounted devices, but some current electronic devices (IC packages such as CSPs and BGAs) cannot be reworked using a soldering iron.

A reworking method for such devices is illustrated in Figure 2.20.

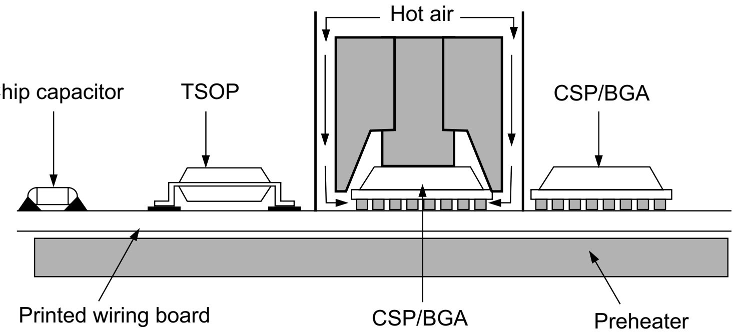


Figure 2.20 Soldering Area Reworking Method for CSP and BGA Packages

Attention should be paid to the following points when using this reworking method.

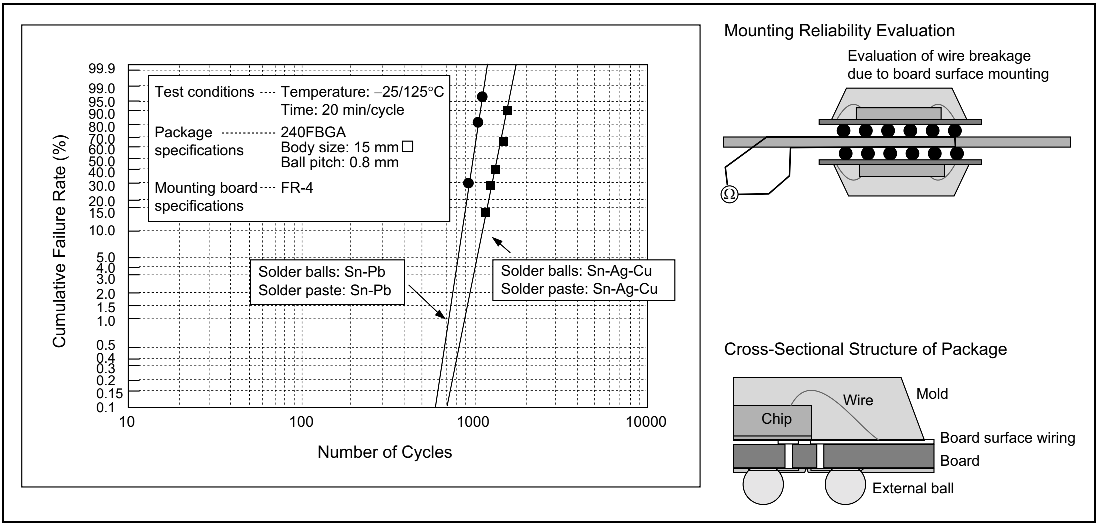
- Thermal effects on nearby devices should be minimized.
- Soldering area reworking conditions vary according to the printed wiring board used (board thickness, lamination, etc.) and the thermal capacity of the mounted devices, and therefore reworking conditions must be set in accordance with the actual product (mounted devices).
- The device manufacturer must be consulted concerning the reuse of mounted devices after soldering reworking.

Note: Renesas Technology Corp. cannot guarantee quality in the case of reuse of reworked CSP or BGA devices.

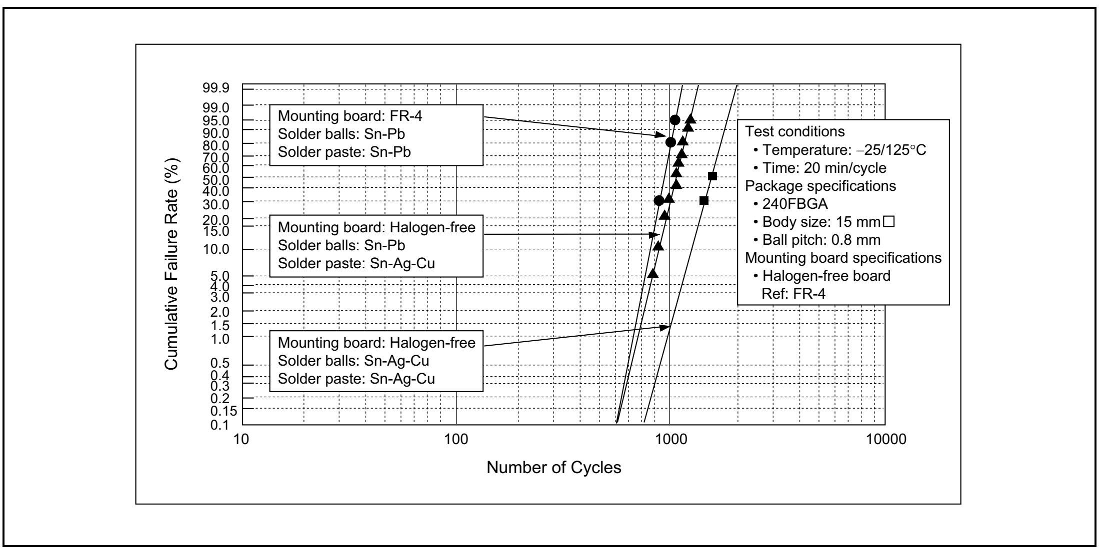
Section 3 Mounting Reliability

3.1 Temperature Cycle Endurance

(1) FBGA Mounting Reliability

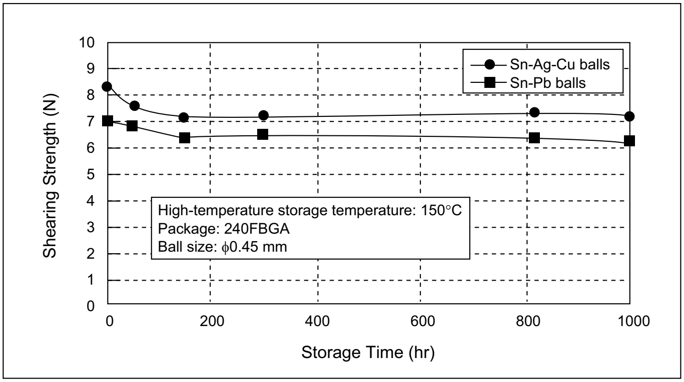


(2) FBGA Mounting Reliability (Comparison of Base Materials and Solder Composition)

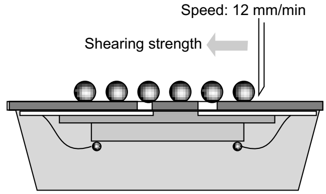


3.2 Mechanical Strength

(1) FBGA Ball Shearing Strength after High-Temperature Storage

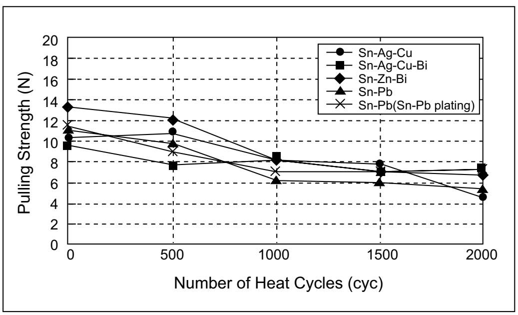


Test Condition Diagram

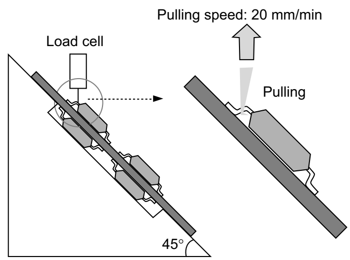


(2) QFP Solder Joint Strength after Temperature Cycles

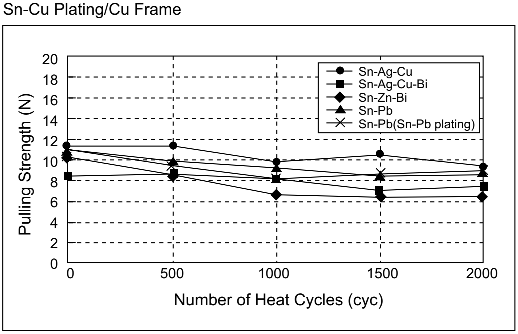
Sn-Cu Plating/42 Alloy Frame



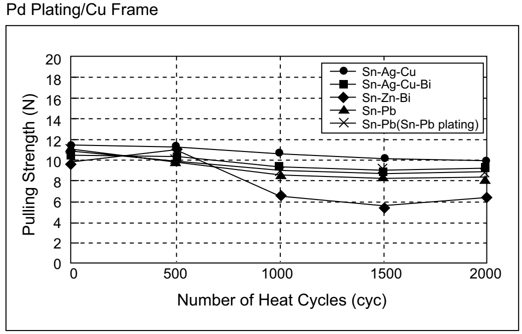
Test Condition Diagram



Sn-Cu Plating/Cu Frame



Pd Plating/Cu Frame

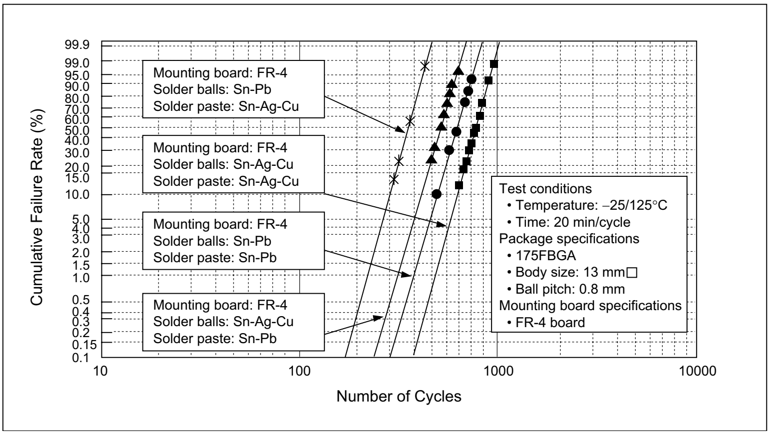


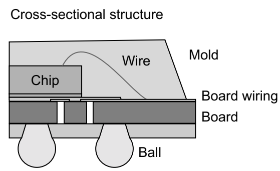
3.3 Mounting Reliability with Mixture of Lead-Free Solder Material and Eutectic Solder Material

When mounting is carried out with a mixture of lead-free solder and Sn-Pb eutectic solder materials, reliability (temperature cycle endurance and shock resistance) may decrease. Mounting with the same solder constituents is recommended. Refer to the temperature cycle endurance and shock resistance data given below.

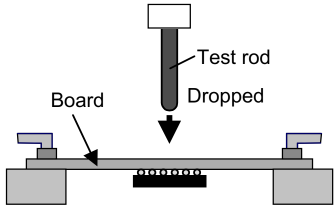
(1) Temperature Cycle Endurance

- Evaluated Balls and Paste
  - — Sn-3.0Ag-0.5Cu balls/Sn-3.0Ag-0.5Cu paste
  - — Sn-37Pb balls/Sn-3.0Ag-0.5Cu paste
  - — Sn-37Pb balls/ Sn-37Pb paste
- Evaluated Package
  175FBGA (13 mm□, 0.8 mm pitch)
- Evaluated Board
  FR-4 t = 0.8mm, 4 layers Land diameter: 0.32 mm
  Resist aperture diameter: 0.52 mm

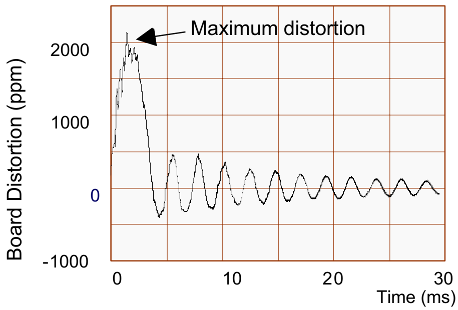




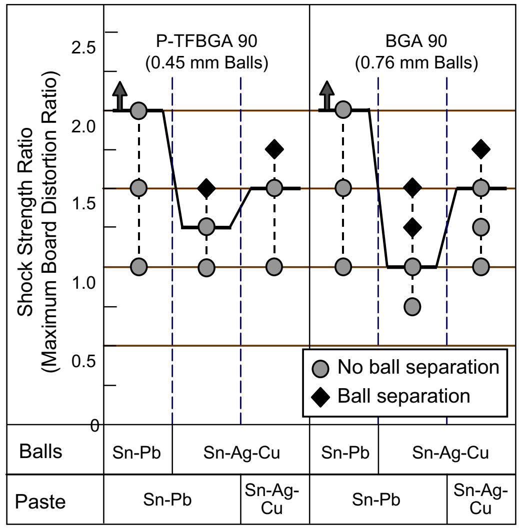
(2) Shock Resistance



Shock Resistance Test Method

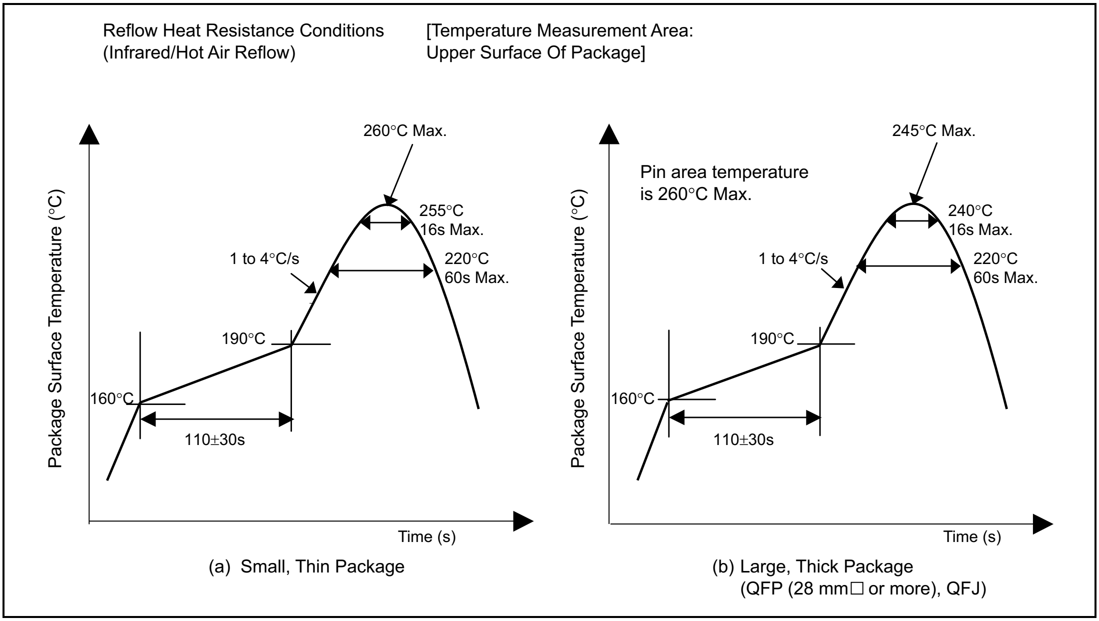


Example of Board Distortion Measurement



Shock Strength Test Results

3.4 Lead-Free Solder Soldering Heat Resistance



- Former Hitachi large, thick HQFP packages (28 mm □ or more) have a peak temperature of 240ºC Max. as a reflow condition.

  (Peak: 240ºC; main heating: 220ºC or more for 30 to 50 s; preheating: 150 to 180ºC for 90±30 s)

Note: Please contact a Renesas Technology sales representative for information on individual products.

Section 4 Cautions Concerning Storage and Mounting

Refer to the Renesas Technology Reliability Handbook for cautions concerning storage and damage from static electricity, and points to be noted prior to reflow soldering.

Renesas Surface Mount Package User's Manual

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