CMOS IC Application Note

WLP User's Guide

Rev.1.0_03

This document is a reference manual that describes the handling of the mounting of super-small WLP (Wafer Level Package) for users in the semiconductor mounting technology fields.
Recommended conditions are subject to change depending on the external materials, conditions, environment, etc.
Warranty of products will be a warranty of the single product unit. Problems such as product degradation and characteristic changes, due to the user's mounting conditions and the like, will not be covered under the warranty.
For the quality assurance system of CMOS IC, notes on use, details of each product and specifications, refer to our website and datasheets.

[**Target Packages**]

- WLP-4
- WLP-6
- WLP-8

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1. Outline

WLP is manufactured using the process of wafer processing, and in the end it will form the individual packages after being separated by a dicing saw or the like.
Compared to general semiconductor packages (resin mold package), WLP can realize the downsizing and weight saving of the package body with a simple structure, due to not using wire such as Au or Cu in addition to not using sealing material and lead frames.
WLP forms terminals (solder bumps) on the surface of a bare silicon chip for connecting to the printed circuit board (PCB), and it connects to the PCB face down, so high-density mounting becomes possible while also contributing to the downsizing, thinning and weight saving of entire electronic devices and modules.

2. WLP of ABLIC Inc.

2. 1 Structure

Figure 1 shows the structure of WLP manufactured by ABLIC Inc. A redistribution layer (RDL) (Cu) pattern is formed from the Al pad of the LSI element, and solder bumps are placed on top of it. Because the package surface is covered by a resin sealing layer, it also has no problems in terms of reliability.

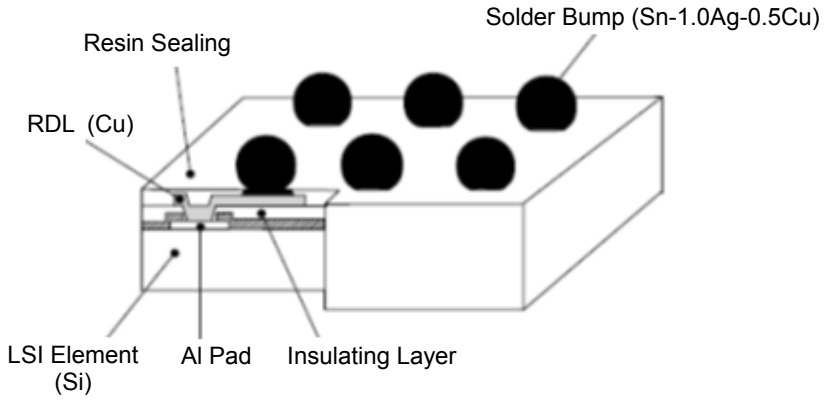


Figure 1 Cross Section

2. 2 WLP of ABLIC Inc.

Table 1 shows an example of solder bump specifications of WLP manufactured by ABLIC Inc.

Table 1 Example of Solder Bump Specifications of WLP

Type	Bump Number	Solder Bump specification		
		Bump Diameter	Bump Height	Bump Pitch
WLP-4	4	0.20 mm	0.13 mm	0.50 mm
WLP-6	6	0.25 mm	0.08 mm	0.40 mm
WLP-8	8	0.25 mm	0.08 mm	0.50 mm

Caution 1. The example of solder bump specifications in Table 1 is as of January 2014, and it is subject to change without prior notice.
2. In the case of designing a new WLP with a bump specification other than the one indicated in Table 1, there may be constraints on the design, such as the bump number, bump diameter, bump height and bump pitch, etc.

2. 2. 1 Example of solder bump size and layout specification

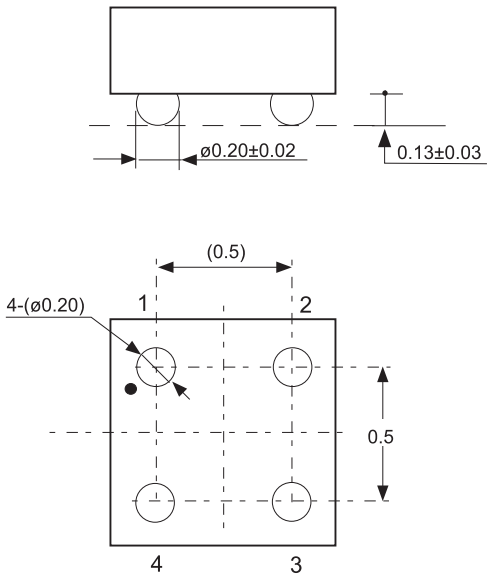


Figure 2 WLP-4

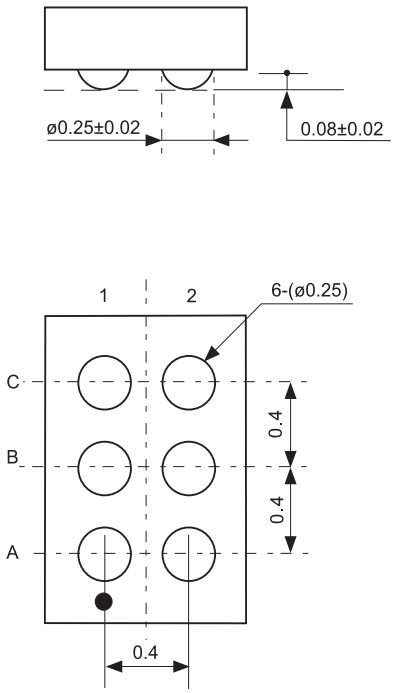


Figure 3 WLP-6

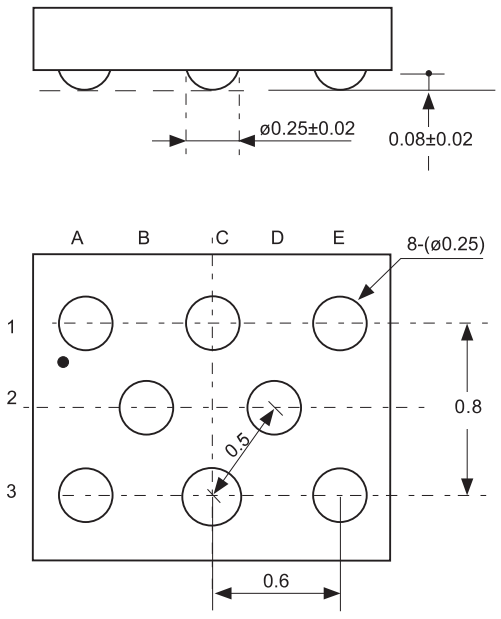


Figure 4 WLP-8

Remark For the package dimensional drawing, carrier tape drawing, reel drawing, recommended land drawing, etc. of each WLP product, contact our sales office.

3. WLP mounting process

Although the mounting of WLP is performed through solder printing process, package mounting process and reflow process, just as in normal surface-mounting (SMT), greater care is required for handling in each of the processes, compared to the resin-sealed packages.
Cautions for each process are listed below, but set the optimal conditions for your production process on the occasion of actual use.

3. 1 Solder printing process

In the mounting processes of WLP, the solder printing process is an important process that affects the quality after mounting. The solder print quality will determine the connection strength of the package and PCB as well as the reliability test results. In particular, in terms of WLP with small solder bump diameter, there is a need to improve release characteristics in a solder printing process. Use solder paste and solder print mask that have excellent solder printability. In addition, there are also cases in which the aperture size and aperture shape of the solder printing metal mask need to be devised.

3. 1. 1 Mask specification for printing solder

Generally, the releasability of solder improves if the metal mask used when printing cream solder has thin mask thickness and greater aperture size. Particularly, if the solder printing size is small, it is necessary to make the metal mask thickness thinner. Moreover, because masks in which electrolytic polishing treatment has been performed after being opened by laser processing have less unevenness in the side walls of the aperture portion, they have superior releasability of solder.

(1) Example of evaluation results by ABLIC Inc. (Reference)

Table 2 shows the printability evaluation results related to the mask aperture size and the mask thickness evaluated by ABLIC Inc. However, the results vary depending on conditions such as the printing machine, solder paste and mask being used. Set the conditions after prior confirmation.

Table 2 Solder Printability Evaluation Results (Reference)

Mask Aperture Size (D)	Mask Thickness		
	0.08 mm	0.10 mm	0.12 mm
ϕ0.16 mm ≤ D < 0.20 mm	○	×	×
ϕ0.20 mm ≤ D < 0.25 mm	○	○	×
ϕ0.25 mm ≤ D	○	○	○

Remark 1. ○: Good printability
×: Poor printability
2. Evaluation condition
Solder paste composition: Sn-3.0Ag-0.5Cu
Solder particle diameter: 15 μm to 25 μm
Mask aperture portion: Electrolytic polishing treated product

(2) Mask aperture form

Normally, the mask aperture size is set in accord with the land diameter of the PCB, but since the solder printability deteriorates when the mask aperture size is small, the following is recommended:

- To make the aperture shape a square (□) shape
- To design the mask aperture size slightly larger than the land diameter of the PCB

Table 3 Example of Mask Aperture Specification

Land Diameter of PCB Side	Recommended Mask Aperture Form, Mask Aperture Size
ϕ0.2 mm	ϕ0.22 mm to 0.24 mm
	□0.20 mm to 0.22 mm

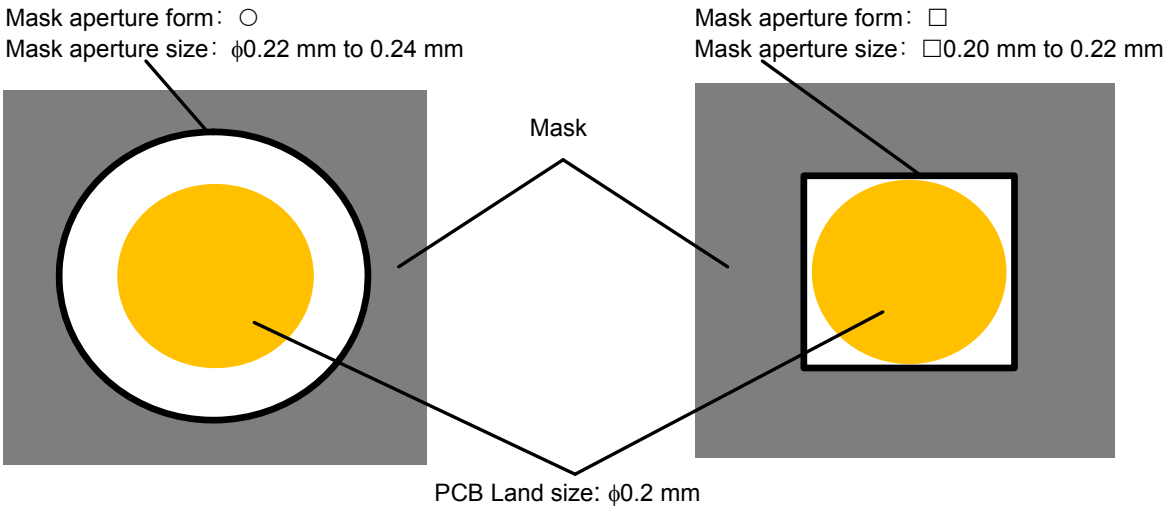


Figure 5 Example of Mask Aperture Specification

3. 1. 2 Solder material

Use a solder paste (cream solder) with good printability.

(1) Recommended particle diameter

Use materials with small solder particle size in order to obtain good printability. Particularly, if the mask aperture size is small, a particle size of 25 μm or less is recommended.

(2) Example of composition

Sn-3.0Ag-0.5Cu

3. 1. 3 Printing machine

Use a printing machine with good printing position accuracy and set up the conditions such as the selection of squeegee material, squeegee pressure and speed, so that the solder paste is printed onto the PCB with absolute certainty. The target for printing accuracy is within ±25 μm.

3. 2 Mounting process

All WLPs manufactured by ABLIC Inc. are stored in the pocket of the carrier tape. Perform the mounting process according to the following steps:

(1) Take out the WLP from the carrier tape pocket using the pickup tool of the mounter.

Caution 1. Be careful not to give excessive shock when picking up the WLP.
2. If the position of the WLP has changed within the pocket due to vibration such as by the feeder, the pickup tool may collide with the WLP and cause damage. Check in advance the position of the WLP at the time of the feeder's tape feeding.

(2) The position of the suctioned WLP is corrected by performing processing such as by an automatic image recognition device, and the WLP is moved to the preset PCB mounting position.

Caution 1. Do not, in any way, perform the WLP position correction mechanically.
2. Touching the package side walls may result in damage to the WLP.
3. Also when mounting the WLP to the PCB, be careful not to damage the WLP by applying excessive load.

3. 2. 1 Mounter mounting accuracy

Because the solder bumps of the WLP are small, use a mounter with high mounting accuracy. The target for mounting accuracy is within ±50 μm.

3. 3 Reflow process

Soldering is possible by using a standard temperature profile in accordance with the solder paste being used. There are cases in which the package is blown away by the hot air in the reflow oven such as when there is little solder printing volume. Optimize the solder printing volume and airflow in a way that corresponds to the WLP to be mounted.
There are limits, such as to the peak temperature of the reflow oven, due to the heat resistance of the package. For the heat resistance evaluation profile, refer to "**5. 1. 2 Heat resistance**".

4. PCB design

4. 1 Land size

In general, it is recommended that the design of the PCB land size matches the solder bump diameter of the WLP. For example, if the bump diameter of WLP is 0.25 mm, the land diameter of the PCB should also be 0.25 mm.
However, there are also cases in which the bump diameter and land diameter differ, such as in WLP-4. The land diameter of WLP-4 is 0.18 mm, while its bump diameter is 0.20 mm.

Table 4 Recommended Land Specifications of WLP

Type	Recommended Land Specification	
	Land Diameter	Land Pitch
WLP-4	0.18 mm	0.50 mm
WLP-6	0.25 mm	0.40 mm
WLP-8	0.25 mm	0.50 mm

4. 1. 1 Recommended land of WLP

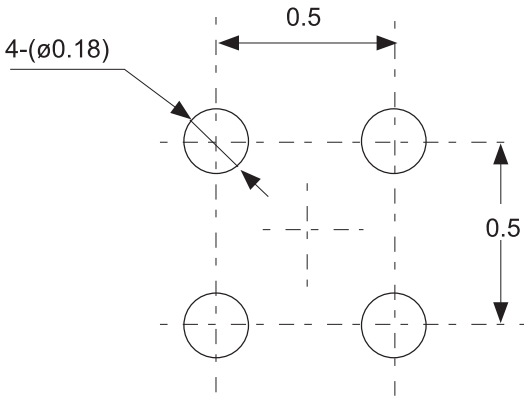


Figure 6 WLP-4

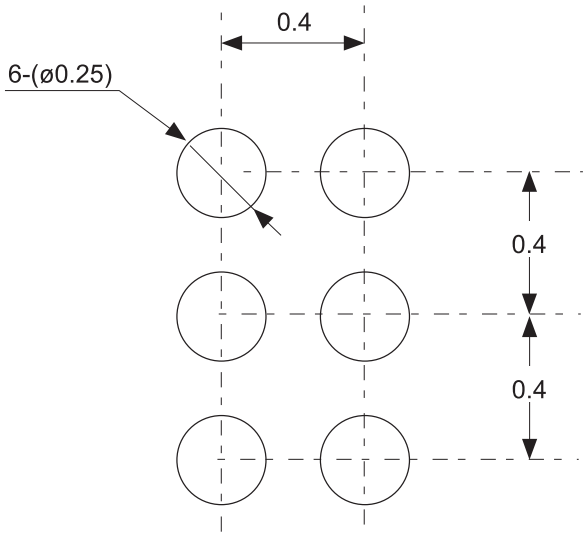


Figure 7 WLP-6

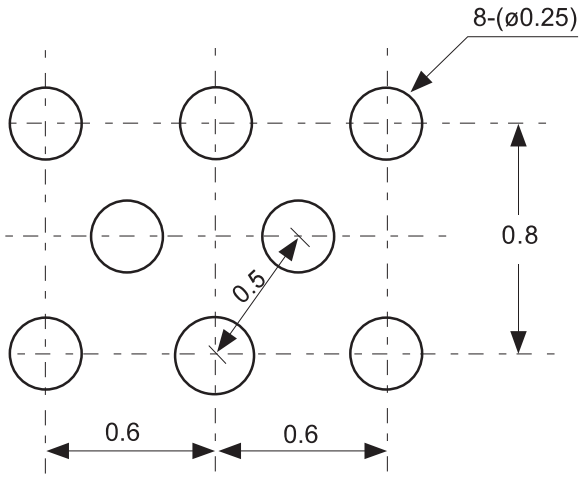


Figure 8 WLP-8

Remark For the package dimensional drawing, carrier tape drawing, reel drawing, recommended land drawing, etc. of each WLP product, contact our sales office.

4. 2 Land structure

In PCB land structure, there are Solder Mask Defined (SMD) and Non Solder Mask Defined (NSMD) structures (see **Figure 9 and Figure 10**). Generally, bonding strength is improved more in NSMD because it is possible to bond the solder to the land side walls as well. However, depending on the printing conditions and mask specifications (aperture size, thickness, etc.) when printing the solder paste, there are cases in which SMD has better printability. Conduct the selection of SMD or NSMD carefully.
In addition, to prevent short-circuit between lands, it is recommended to form solder resists between all lands.

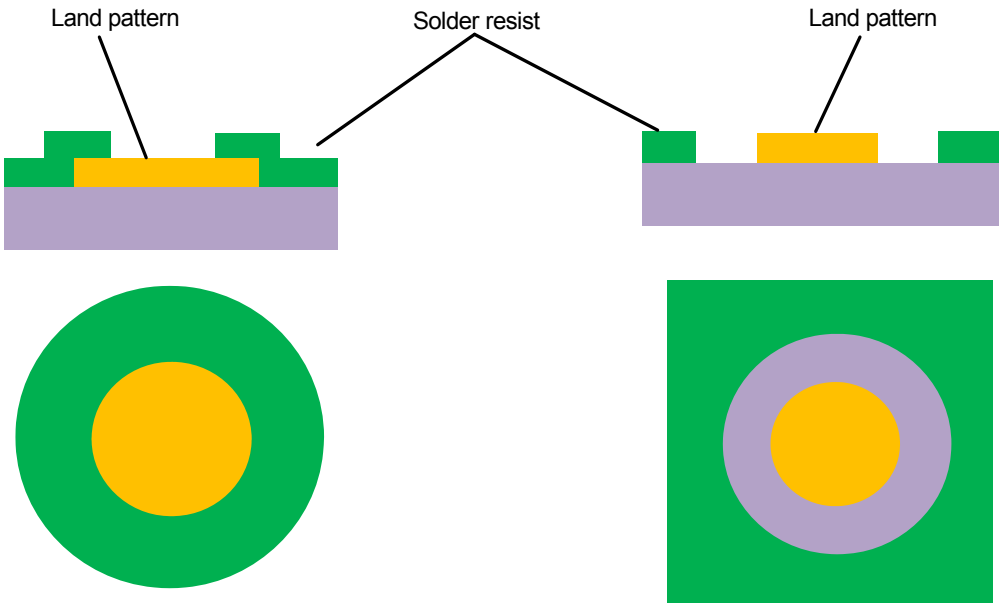


Figure 9 SMD

Figure 10 NSMD

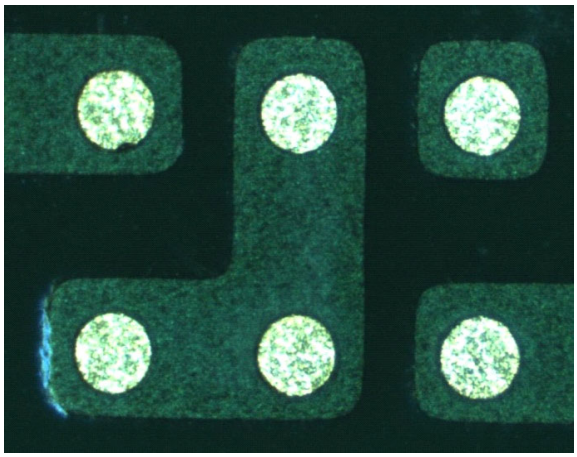


Figure 11 Photo Example of SMD Board

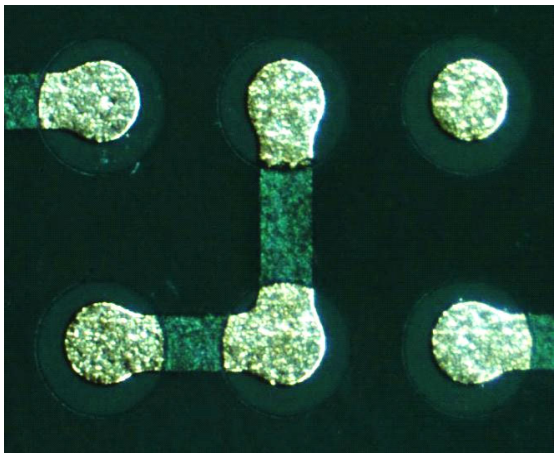


Figure 12 Photo Example of NSMD Board

5. Evaluation results (Reference values)

5. 1 Mounting reliability evaluation results

The results of the mounting reliability evaluation carried out at ABLIC Inc. are indicated below. There are cases in which varying results are obtained depending on user's mounting conditions and materials used (PCB, solder material, etc.). Conduct prior confirmation.

5. 1. 1 Mounting reliability

Table 5 Mounting Reliability Evaluation Results

Type	Bump Number	Bump Diameter	Terminal Robustness	PCB Bending Test (constant stress method)	PCB Bending Test (step stress method)	Drop Test	Temperature Cycle Test
WLP-4	4	0.20 mm	6.1 N	pass	pass	pass	pass
WLP-6	6	0.25 mm	17.3 N	pass	pass	pass	pass

Table 6 Mounting Reliability Evaluation Condition, Criteria

Test Item	Test Condition	Criteria
PCB bending test (constant stress method)	Bend span: 90 mm Bend amount: 1 mm Repetitions: 2000 times	Resistance value fluctuation must not exceed twice the initial value. Must be without visual defects.
PCB bending test (step stress method)	Bend span: 90 mm Bend amount: 3 mm Repetitions: 1 time	
Drop test	WLP mounted boards are fixed to a 100-g jig. Drop height: 1.7 m Drop times: 16 times (six times on bottom side, two times each on the other five sides) Drop surface: Concrete or steel sheet	
Temperature cycle test	Ta = −40°C ⇔ +125°C, 500 cycles	

Remark Samples for mounting reliability evaluation form a daisy chain in the package and measure the connection resistance with the PCB.

Table 7 Mounting Condition

Item	Condition
PCB for evaluations	Material: FR4
	Thickness: 1 mm
Solder paste	Particle diameter: 15 μm to 25 μm
Mask	Thickness: 100 μm
	Aperture size: Same as bump diameter
Reflow atmosphere	The atmosphere
Under filling	Unused

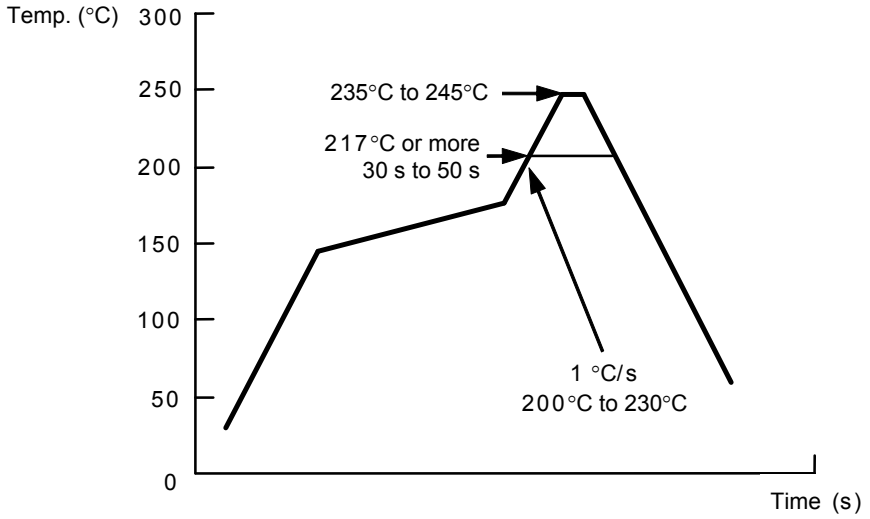
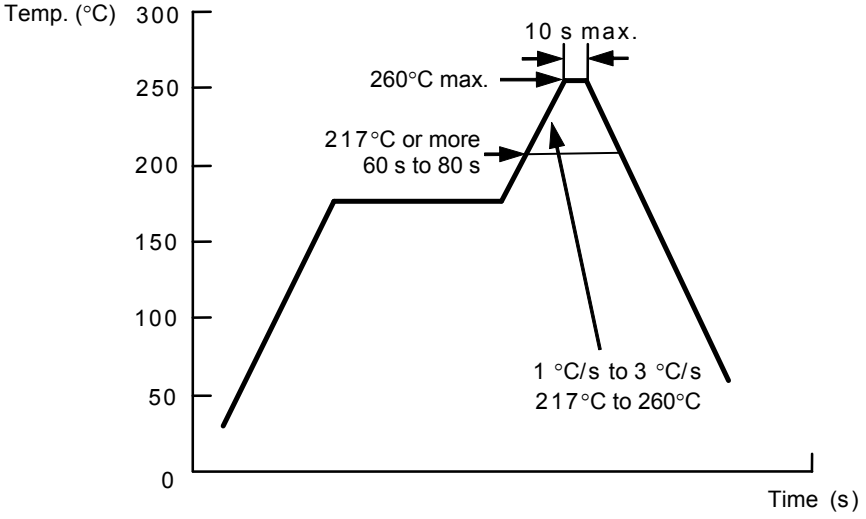


Figure 13 Reflow Profile for Mounting Reliability Evaluation of Package (Reference)

5. 1. 2 Heat-resistance

Figure 14 shows the reflow profile used at ABLIC Inc. when evaluating heat resistance.



Remark Number of maximum reflow cycles: three times

Figure 14 Reflow Profile for Heat-resistance Evaluation of Package (Reference)

5. 2 Reliability test data

Table 8 shows the results of the reliability test carried out at ABLIC Inc.

Table 8 Reliability Test Data

Test Item	Test Condition	Results
High-temperature bias test	Ta = 125°C, V_{DD} = V_{abs} max. × 0.9, 1000 h	pass
High-temperature, high-humidity bias test	Ta = 85°C, RH = 85%, V_{DD} = V_{abs} max. × 0.9, 1000 h	pass
Un-saturated Pressure Cooker Bias	Ta = 125°C, RH = 85%, P = 2 × 10^5 Pa, V_{DD} = V_{abs} max. × 0.9, 100 h	pass
High-temperature storage test	Ta = 150°C, 1000 h	pass
Low-temperature storage test	Ta = −65°C, 1000 h	pass
Temperature cycle test (Gas phase)	Ta = 150°C ⇔ −65°C, 30 min each, 200 cycles	pass
Thermal shock test (Liquid phase)	Ta = 150°C ⇔ −65°C, 5min each, 100 cycles	pass

Remark V_{abs} max.: Absolute maximum voltage

6. Precautions

6. 1 WLP handling precautions

Unlike plastic packages, WLP does not have anything to protect the outer periphery of the package. Avoid handling WLP by hand as much as possible to prevent damage. If handling by hand is absolutely necessary, suction the WLP upper surface (marking surface) using tools such as vacuum tweezers with a tip made of resin. Do not use a pair of tweezers made of metal to touch the WLP side surface, because it may cause damage to the WLP.

6. 2 Under filling

Under filling is not required for WLP manufactured by ABLIC Inc., which has passed the reliability test and mounting reliability test without using under filling. If under filling is used, the reliability may be deteriorated compared to not using under filling due to causes such as the differential thermal expansion of the material. If it must be used by all means, select the material after sufficiently conducting evaluation.

6. 3 Repair

It is not possible to remove a WLP that has been mounted once and then to re-mount it. In the case of mounting a new WLP, thoroughly clean the land surface of the PCB, and after supplying new solder to the PCB, mount the WLP using devices such as a dedicated repair device.

6. 4 Flow soldering

WLP manufactured by ABLIC Inc. does not support flow soldering.

6. 5 X-irradiation

Do not irradiate the WLP by itself or the WLP after mounting to the PCB with an X-irradiation. The product characteristics may change.

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