



## CMOS IC Application Note

# WLP User's Guide

Rev.2.0\_00

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This document is a reference manual that describes the features, bump specifications, and mounting procedures of ultra-small WLP (Wafer Level Packages) for semiconductor mounting engineers.

In addition, mounting evaluation results are also provided as reference data.

For the quality assurance system, notes on use and product details and specifications of ABLIC Inc. CMOS ICs, refer to our website and individual data sheets available from ABLIC Inc.

Note that the conditions and other information listed in this document may require adjustment or modification depending on the customer's equipment, materials, conditions, environment, and other factors.

### [Target Packages]

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

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## 1. Features of WLP

### 1.1 General description

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.

In WLP, terminals (solder bumps) are formed on the surface of a bare silicon chip for connecting to the printed circuit board (PCB), and they are mounted to the PCB face down, which enables high-density mounting while also making them suited to overall downsizing, thinning, and weight reduction of electronic devices and modules.

### 1.2 Structure of WLP manufactured by ABLIC Inc.

**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 IC, and solder bumps are placed on top of it. Because the IC surface is covered by a resin sealing layer, it also has no problems in terms of reliability.

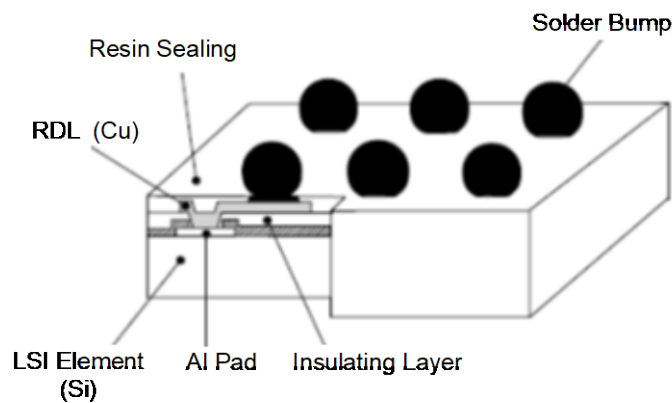


Figure 1 Cross Section

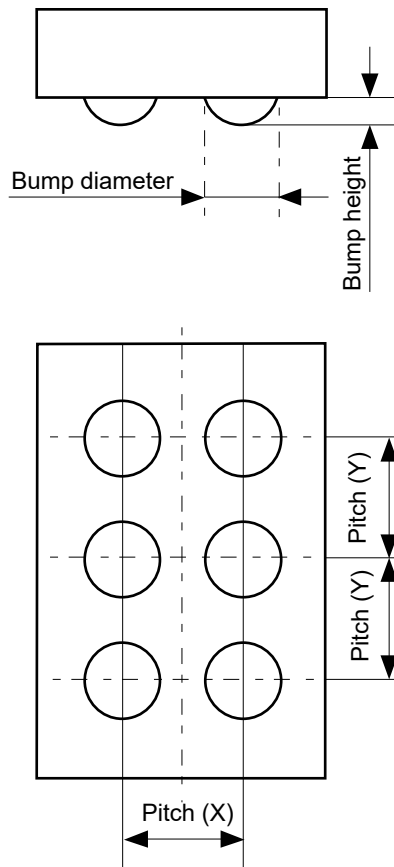
**1.3 Solder bump specifications**

Table 1 shows an example of solder bump specifications of WLP manufactured by ABLIC Inc. Figure 2 shows an example of bump specifications for WLP-6x.

The solder bump composition is Sn-Ag-Cu.

**Table 1 Example of Solder Bump Specifications of WLP**

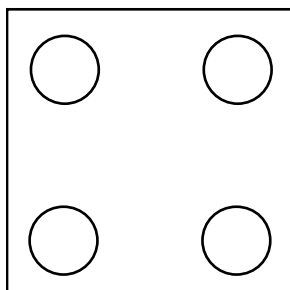
Type	Bump Number	Solder Bump specification			
		Bump Diameter	Bump Height	Bump Pitch	
				X	Y
WLP-4x	4	0.20 mm	0.13 mm	0.50 mm	0.50 mm
		0.22 mm	0.15 mm	0.40 mm	0.40 mm
WLP-6x	6	0.25 mm	0.08 mm	0.40 mm	0.40 mm
WLP-8x	8	0.16 mm	0.08 mm	0.58 mm	0.40 mm
		0.25 mm	0.08 mm	0.50 mm	0.35 mm



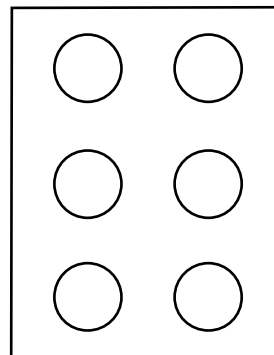
**Figure 2 Bump Specifications Diagram**

**Remark** Figure 2 shows an example for WLP-6x, however it represents the same locations for WLP-4x and WLP-8x.

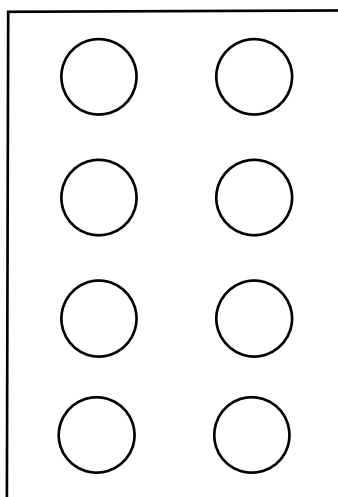
Solder bump layout examples are shown in **Figure 3** to **Figure 6**.



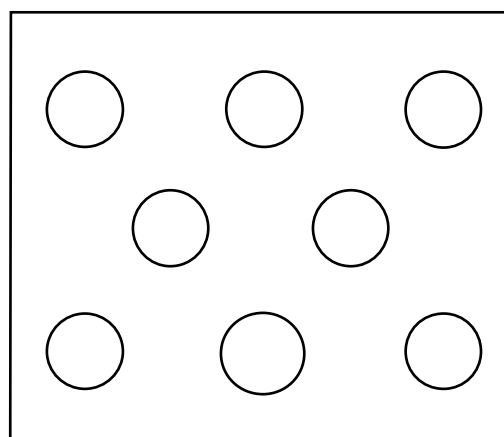
**Figure 3 WLP-4x**



**Figure 4 WLP-6x**



**Figure 5 WLP-8x Example 1**



**Figure 6 WLP-8x Example 2**

- Remark**
1. There are also bump layouts like the **Figure 6 WLP-8x Example 2**.
  2. The bump specifications in **Table 1** and **Figure 3** to **Figure 6** are just some of the possible examples.
  3. For bump specifications for each product, check the datasheet or consult with a sales representative.
  4. Bump specifications are subject to change at any time without notice.

**WLP User's Guide**

**1.4 Recommended land**

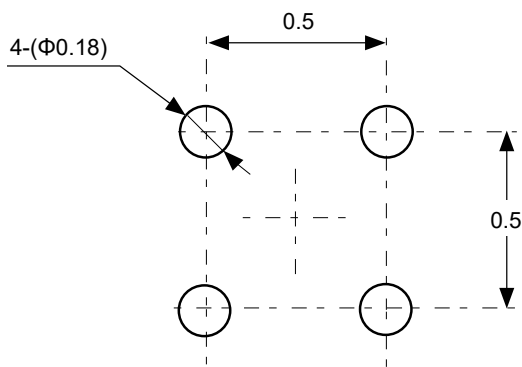
In general, it is recommended to match the PCB land size design to the WLP solder bump diameter. For example, if the WLP bump diameter is 0.25 mm, the PCB land diameter should be 0.25 mm.

However, the bump diameter and recommended land diameter differ for some WLP-4x of ABLIC Inc. Refer to WLP-4x in **Table 2**.

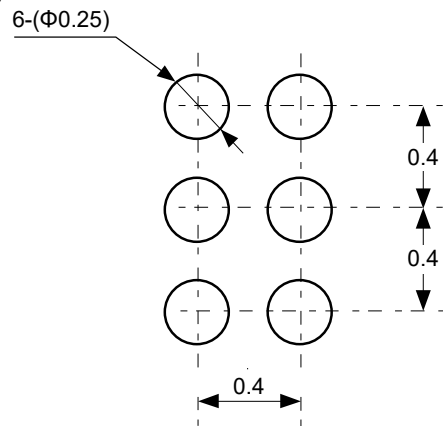
**Table 2 WLP Recommended Land Specification Examples**

Type	Bump Diameter	Recommended Land Specifications		
		Land Diameter	Bump Pitch	
			X	Y
WLP-4x	Φ0.20 mm	Φ0.18 mm	0.50 mm	0.50 mm
	Φ0.22 mm	Φ0.20 mm	0.40 mm	0.40 mm
WLP-6x	Φ0.25 mm	Φ0.25 mm	0.40 mm	0.40 mm
WLP-8x	Φ0.16 mm	Φ0.16 mm	0.58 mm	0.40 mm
	Φ0.25 mm	Φ0.25 mm	0.40 mm	0.35 mm

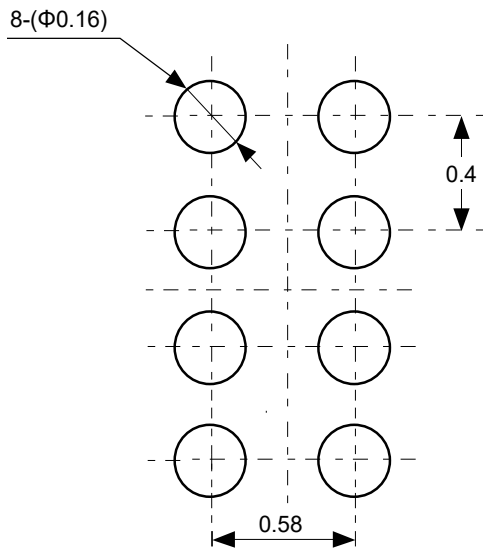
WLP recommended land examples are shown in **Figure 7** to **Figure 10**.



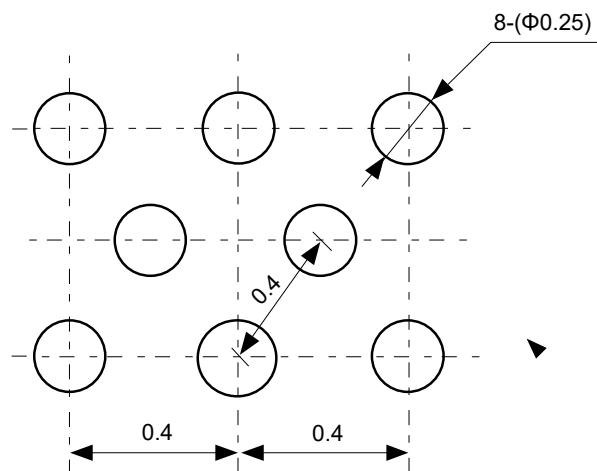
**Figure 7 WLP-4x**



**Figure 8 WLP-6x**



**Figure 9 WLP-8x Example 1**



**Figure 10 WLP-8x Example 2**

**Remark** Contact a sales representative for details on the recommended land for each product.

## 2. WLP Mounting Method

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.

### 2.1 Storage instructions of WLP

The resin used in WLP absorbs moisture from the air, and cracks can occur in the resin during reflow. In addition, if stored in high-temperature or high-humidity environments, the solder wettability of the solder bump may degrade, or the adhesive strength of the carrier tape and cover tape may change.

Store at the room temperature and humidity shown below.

Storage conditions: Ta = 5°C to 30°C, RH = 40% to 70%

### 2.2 Cautions when mounting

#### 2.2.1 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, for WLP with small solder bump diameters, the solder releasability from the solder printing metal mask used in the printing process is important. Use solder paste and a solder printing metal mask with excellent solder printability in order to improve solder releasability. Additionally, there may be cases where adjustments to the aperture size or shape of the solder printing metal mask are required.

#### (1) Metal 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. In addition, metal masks which have had the aperture portion side walls smoothed via electrolytic polishing or other means after the aperture is formed via laser processing have superior solder releasability.

#### (a) Example of evaluation results (Reference)

**Table 3** shows the printability evaluation results related to the metal mask aperture size and thickness evaluated by ABLIC Inc. However, the results vary depending on conditions such as the printing machine, solder paste and metal mask quality being used. Set the conditions after prior confirmation.

**Table 3 Solder Printability Evaluation Results (Reference)**

Metal Mask Aperture Size (D)	Metal Mask Thickness		
	0.08 mm	0.10 mm	0.12 mm
$\Phi 0.16 \text{ mm} \leq D < \Phi 0.20 \text{ mm}$	○	×	×
$\Phi 0.20 \text{ mm} \leq D < \Phi 0.25 \text{ mm}$	○	○	×
$\Phi 0.25 \text{ mm} \leq D$	○	○	○

**Remark 1.** ○: Good printability

×: Poor printability

#### 2. Evaluation condition

Solder paste composition: Sn-3.0Ag-0.5Cu

Solder particle diameter:  $\Phi 15 \mu\text{m}$  to  $\Phi 25 \mu\text{m}$

Mask aperture portion side wall: Electrolytic polishing treated product

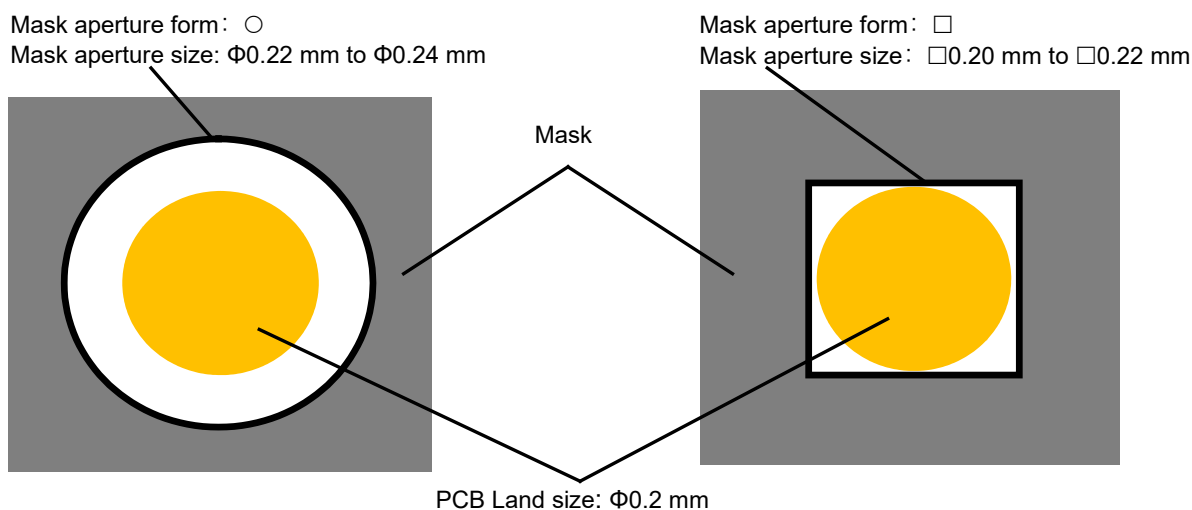
**(b) Metal mask aperture form**

Normally, the mask aperture size is set in accord with the land diameter of the PCB, but since the solder printability deteriorates when the metal 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 4 Example of Mask Aperture Specification**

Land Diameter of PCB Side	Recommended Mask Aperture Form, Mask Aperture Size
Φ0.2 mm	Φ0.22 mm to Φ0.24 mm
	□0.20 mm to □0.22 mm

**Figure 11 Example of Mask Aperture Specification****(2) Solder material**

Use a solder paste (cream solder) with excellent fine-pitch printability.

**(a) Recommended particle diameter**

Use materials with small solder particle size in order to obtain good printability. Particularly, if the mask aperture size is small, the recommended particle diameter is as follows.

Particle diameter: Φ15 μm to Φ25 μm

**(b) Example of composition**

Sn-3.0Ag-0.5Cu

**(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.

### 2. 2. 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. Use the mounter pickup nozzle to remove the WLP from the carrier tape using vacuum suction.

**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.
3. It is recommended to use an electric feeder to minimize carrier tape vibration.

2. The position of the WLP removed from the carrier tape is corrected by carrying out processing with an automatic image recognition device or other means, 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.

#### (1) Mounter mounting accuracy

Because the solder bumps of the WLP are small, use a mounter with high mounting accuracy. The recommended mounting accuracy of the mounter is as follows.

Mounting accuracy:  $\pm 50 \mu\text{m}$  or less is recommended.

### 2. 2. 3 Reflow process

#### (1) Reflow oven internal settings

WLP are small and lightweight, so they can be affected by airflow and vibration inside a reflow oven, causing them to shift or be displaced, so adjustments should be made to ensure that airflow and vibrations during transport do not affect the mounting.

There is also an upper limit to the heat resistance of WLP. The WLP reflow profile for heat resistance evaluation is compliant with JEDEC J-STD-020.

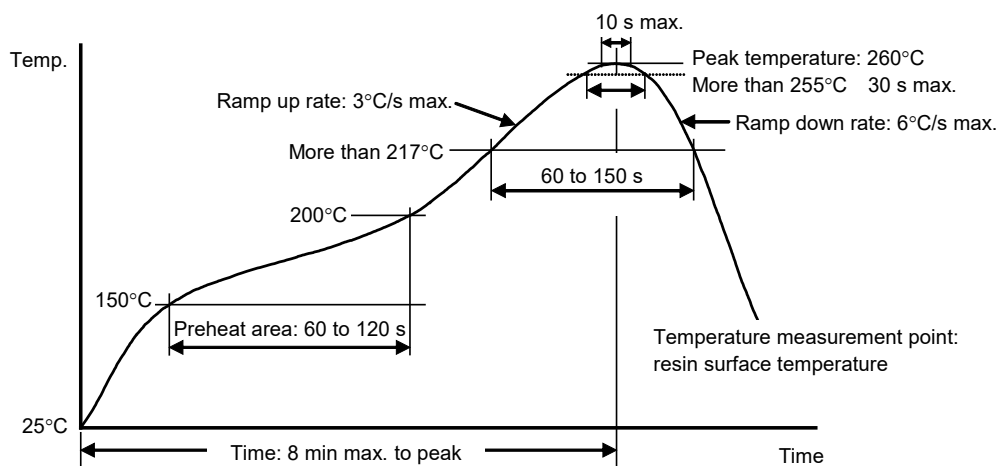


Figure 12 Reflow Profile for Heat Resistance Evaluation

### 2.3 Land pattern design

Refer to "1.4 Recommended Land" for the recommended land for WLP of ABLIC Inc.

#### 2.3.1 Land structure

In PCB land structure, there are Non Solder Mask Defined (NSMD) and Solder Mask Defined (SMD) structures (see **Figure 13** and **Figure 14**). Generally, bonding strength is improved more in NSMD because it is possible to bond the solder to the land side walls as well. However, when mounting the small bumps of a WLP to a PCB, the solder printability becomes extremely important, and SMD may have superior printability when printing extremely small size paste. 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.

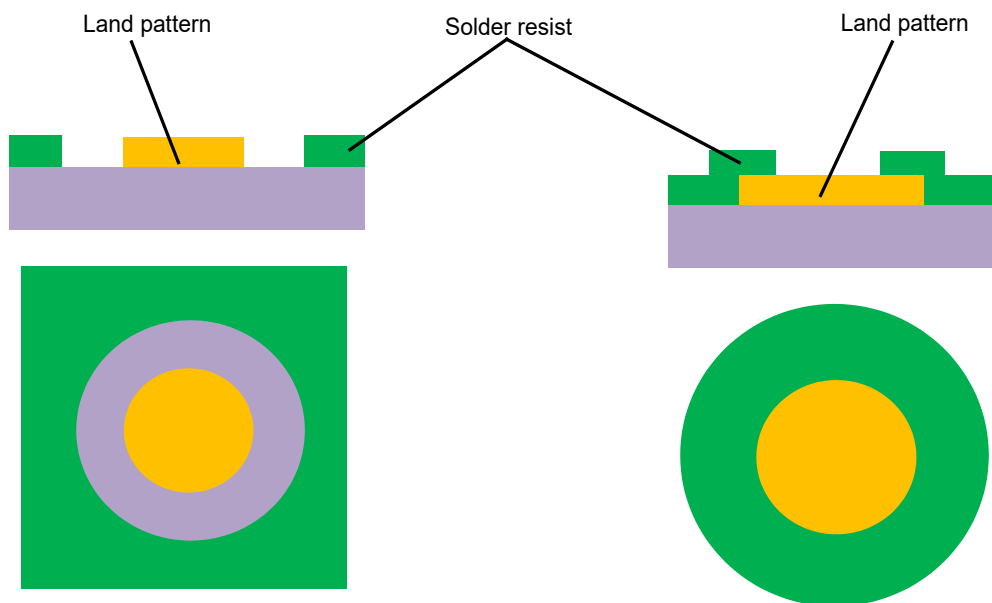


Figure 13 NSMD

Figure 14 SMD

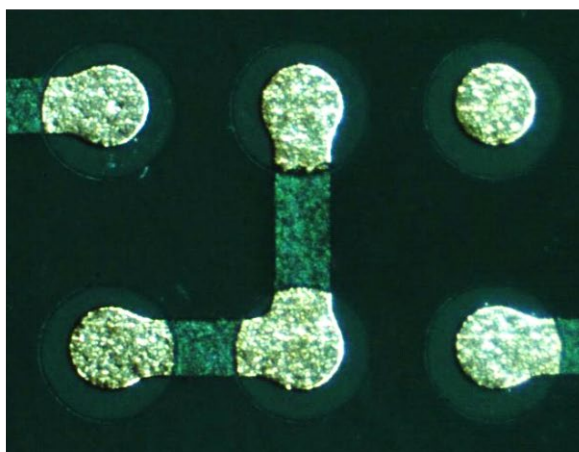


Figure 15 Photo Example of NSMD Board

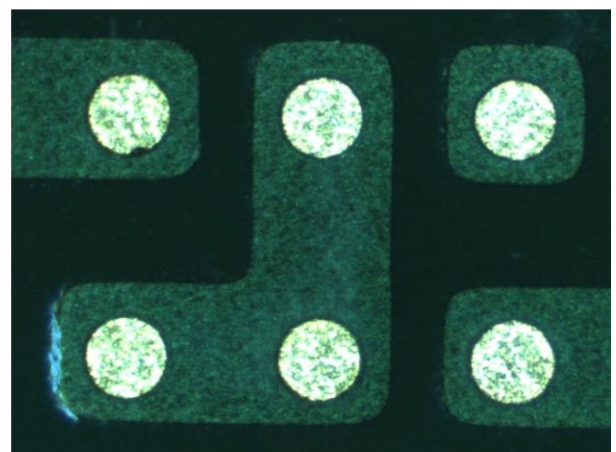


Figure 16 Photo Example of SMD Board

### 3. Mounting Evaluation Results

WLP mounting evaluation results are shown as reference data in **Table 5**. The evaluation results are not guaranteed.

**Table 5 Mounting Evaluation Results**

Evaluation Item	Result	Test Condition, Criteria
(1) Solderability test	Pass	The package bump and printed solder paste must fuse to form a solder joint.
(2) Self-alignment test	Pass	The package must be shifted 50 μm in the X and Y direction compared to the PCB land position, and then returned to the proper position after reflow.
(3) Push strength test for soldering joint	Pass	The package mounted to the board is pressed with a jig from the side to test for break resistance. Criteria: 5 N or more
(4) PCB bending test (constant stress method)	Pass	Bend amount: 1 mm Repetitions: 1500 Span: 90 mm Criteria: Resistance value fluctuation must not exceed twice the initial value. Must be without visual defects.
(5) PCB bending test (Monotonic bending test)	Pass	Maximum bend amount: 3 mm Bend span: 90 mm Criteria: Resistance value fluctuation must not exceed twice the initial value. Must be without visual defects.
(6) Drop test	Pass	WLP mounted boards are fixed to a 100-g jig. Dropped 10 times to 30 times from a 170 cm height (Differs by product) Drop surface: Concrete Criteria: Resistance value fluctuation must not exceed twice the initial value. Must be without visual defects.

In tests (4) to (6), a daisy chain was formed in the package to confirm that the resistance value did not increase.

<Mounting Evaluation Conditions>

- Printed circuit board for evaluation
  - FR4 and FR5: 4 layer double-sided board
  - Thickness = 1.0 mm
  - Surface processing of mounting land: Gold flash plating
- Packages are preprocessed before each test (before PCB mounting).  
(Preconditioning = 105°C × 100% × 8 hours)
- Solder print mask
  - Mask thickness: 100 μm
  - Aperture ratio: The same size as the PCB land diameter for each product.  
Refer to "**Table 4 Example of Mask Aperture Specification**".
- Solder
  - Composition: Sn-3Ag-0.5Cu
  - Solder particle diameter: Average Φ15 μm to Φ25 μm
  - Flux: ROL1
- Under filling
  - Unused

• Reflow Conditions

This is the reflow profile used when evaluating mountability. The reflow atmosphere is air.

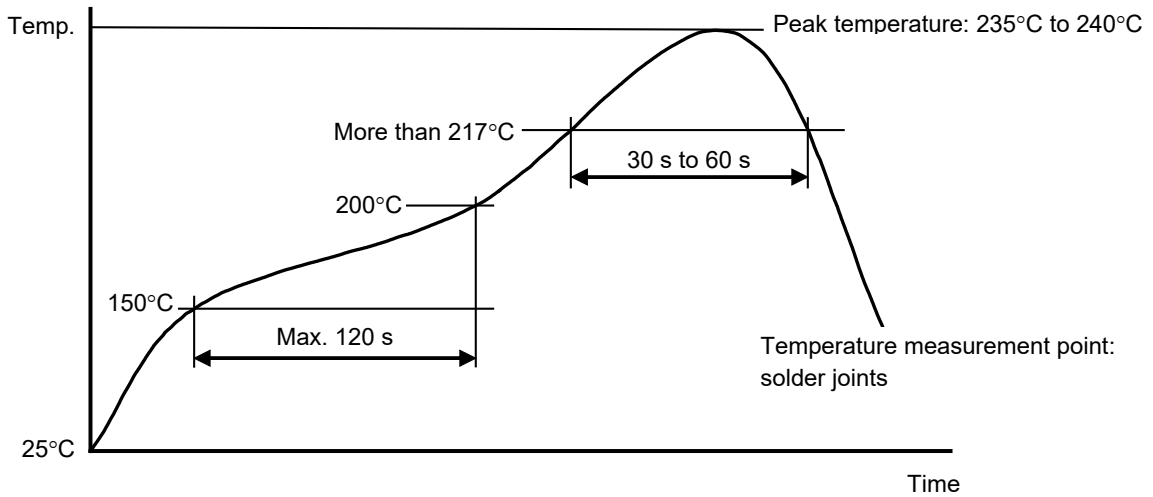


Figure 17 Mountability Evaluation Reflow Profile

## **4. Precautions**

### **4.1 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.

### **4.2 Under filling**

Mounting reliability testing for WLP of ABLIC Inc. is carried out 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.

### **4.3 Repair**

It is not possible to remove a WLP that has been mounted once and then to re-mount it. ABLIC Inc. has no assessment results for repair, and so cannot provide specific repair procedures or product warranties.

### **4.4 Flow soldering, hand soldering**

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

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