Table of Contents

Preface ................................................................................................................................................................. 4
Purpose of this document ........................................................................................................................................ 4
Intended Audience .............................................................................................................................................. 4
References for package ..................................................................................................................................... 4
Abbreviation ....................................................................................................................................................... 4
1. Outline ............................................................................................................................................................ 5
2. Package structure .......................................................................................................................................... 5
3. Package Lineup .............................................................................................................................................. 6
4. Selection guide for printed wiring board .................................................................................................... 7
  4.1. Check items of pattern layout .................................................................................................................. 7
  4.2. Specifications of Printed Wiring Board ................................................................................................... 8
5. Design guide for printed wiring board ........................................................................................................ 9
  5.1. Land shape design .................................................................................................................................... 9
    5.1.1. Land pattern and solder resist design ................................................................................................. 9
    5.1.2. Metal mask design ............................................................................................................................ 10
6. Mounting guide for printed wiring board .................................................................................................... 11
  6.1. Mounting flow ......................................................................................................................................... 11
    6.1.1. Printing solder paste ......................................................................................................................... 11
    6.1.2. Mounting package .......................................................................................................................... 11
    6.1.3. Soldering (reflow soldering) ........................................................................................................... 11
    6.1.4. Visual inspection ............................................................................................................................ 11
  6.2. Reflow thermal profile ............................................................................................................................ 12
7. Rework .......................................................................................................................................................... 13
8. Design dimensions of mounting board for reference (package: P-VFBGA289-1111-0.50-001) ................. 14
9. Revision History .............................................................................................................................................. 15

REstrictions on product use ............................................................................................................................... 16
List of Figures

Figure 3-1  BGA package lineup .............................................................................................................. 6
Figure 4-1  Example of pattern layout between BGA land patterns ......................................................... 7
Figure 4-2  Example of through-hole position between BGA land patterns .............................................. 7
Figure 5-1  Example of mounting sectional view of BGA package ............................................................ 9
Figure 5-2  Design example of over resist (SMD) .................................................................................... 9
Figure 5-3  Design example of clearance resist (NSMD) ............................................................................ 9
Figure 5-4  In case likely to occur Short-circuit (land for soldering is narrow pitch) ................................. 10
Figure 5-5  In case likely to occur Open (land size for soldering is small) .............................................. 10
Figure 6-1  Thermal profile example ....................................................................................................... 12
Figure 7-1  Rework overview ................................................................................................................ 13

List of Tables

Table 2-1  Package characteristic ............................................................................................................ 5
Table 3-1  Maximum number of balls in BGA package ........................................................................... 6
Table 4-1  Examples of selections for a printed wiring board ................................................................. 8
Table 5-1  Merit and demerit of each design methods ............................................................................. 9
Table 9-1  Revision History ..................................................................................................................... 15
Preface

Purpose of this document

The purpose of this document is to mount our product to a printed wiring board simply and with high quality.

Intended Audience

This document is intended for use as a guide for those who are involved in the printed wiring board design and soldering process. The knowledge of heat dissipation and package mounting methods is required for use.

References for package

This document describes the printed wiring board selection and design, and the PCBA (which means the printed circuit board assembly, referred to as mounting board hereinafter) guidelines. Since each package has a different land pattern dimension, refer to the following documents for each package.

<table>
<thead>
<tr>
<th>Document</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Package Mounting Guide</td>
<td>This document</td>
</tr>
<tr>
<td>Technical data sheet</td>
<td>Package information (dimensions)</td>
</tr>
</tbody>
</table>

Abbreviation

Some of the abbreviations used in this document are shown below.

BGA            | Ball Grid Array                     |
JEITA          | Japan Electronics and Information Technology Industries Association |
SMD            | Solder Mask Defined                 |
NSMD           | Non Solder Mask Defined             |
1. Outline

Recently, many circuits are integrated in semiconductor devices because of downsizing of a product and advanced features. Therefore, the practical use of BGA package with easy formation of many pins in limited component size is increasing. While the BGA package is suitable for high-density of printed circuit board, it may affect low cost and high quality mounting. The design technique for improving easiness and reliability of mounting method is explained as an example which solves this problem.

2. Package structure

Packages are divided into two types by the mounting method; the pin insertion type and the surface-mount type. This document is targeted to the BGA in the surface-mount type packages. The package characteristics are as follows.

<table>
<thead>
<tr>
<th>Table 2-1 Package characteristic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
</tr>
<tr>
<td>BGA</td>
</tr>
</tbody>
</table>

The BGA package is able to arrange many balls on the bottom of the package, and suitable for high-density design. However, since a soldering state cannot be easily checked by appearance, the easiness and reliability of soldering are required.
3. Package Lineup

The following table shows the package lineup. The package size and ball pitch can be adjusted according to the number of balls to be required.

<table>
<thead>
<tr>
<th>Ball pitch (mm)</th>
<th>Package size (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.40</td>
<td>64 121 169 256 324 441 676 - - -</td>
</tr>
<tr>
<td>0.50</td>
<td>49 81 121 169 225 289 441 625 - -</td>
</tr>
<tr>
<td>0.65</td>
<td>25 49 64 100 121 169 256 361 484 625</td>
</tr>
<tr>
<td>0.80</td>
<td>16 25 49 64 81 100 169 256 324 400</td>
</tr>
</tbody>
</table>

Table 3-1   Maximum number of balls in BGA package

Figure 3-1   BGA package lineup
4. Selection guide for printed wiring board

For the BGA package, high-density of the printed wiring board is required because leading pattern is difficult by the number of arranging balls or the arranging position of them. Therefore, when using the BGA package, it is important to determine the specification to be matched to the printed wiring board in the package selection phase. In this specification check, it should be checked that a pattern layout of a printed wiring board can be designed by a land pattern, taking consideration with ball arranging positions (pitch, columns, and unused pins) and a pin assignment (such as a power supply and GND). Then a printed wiring board which will be suitable balance between costs and mounting quality can be selected.

4.1. Check items of pattern layout

Check items (an example) are shown as follows.

1. Check the pattern layout between BGA land patterns
   Check the pattern layout is possible from balls inside the package to the connection point through between the BGA land patterns.

   ![Figure 4-1 Example of pattern layout between BGA land patterns](image)

   (2) Check the through-holes position between BGA land patterns
   Check the pattern layout is possible from balls inside the package to the connection point through the through-holes between BGA land patterns via the internal layer or back layer.

   ![Figure 4-2 Example of through-hole position between BGA land patterns](image)
4.2. Specifications of Printed Wiring Board

Examples of selections for a printed wiring board according to the ball pitch is shown as follows.

<table>
<thead>
<tr>
<th>Ball pitch (mm)</th>
<th>Specifications of printed wiring board</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.40</td>
<td>Buildup wiring board</td>
</tr>
<tr>
<td>0.50</td>
<td>Buildup wiring board or plating through-hole wiring board</td>
</tr>
<tr>
<td>0.65</td>
<td>Buildup wiring board or plating through-hole wiring board</td>
</tr>
<tr>
<td>0.80</td>
<td>Plating through-hole wiring board</td>
</tr>
</tbody>
</table>

The buildup wiring board is easy to connect to an internal layer and suitable for a layout of narrow pitch BGA package. However, it is expensive because a manufacturing process is complicated.

On the other hand, the plating through-hole wiring board is low price, however, a through-hole cannot be positioned between balls, so that the pattern layout becomes difficult.
5. Design guide for printed wiring board

5.1. Land shape design
To distribute the stress after mounting solder to a solder junction equally, it is advisable that the land size of mounting board is same as a solder resist opening size of package. However, the optimization is necessary in consideration of the soldering intensity to be required and the restrictions of a board design.

![Example of mounting sectional view of BGA package](image)

For consideration, please contact us about the solder resist opening size of the package.

5.1.1. Land pattern and solder resist design
A land for soldering is formed by the combination of a land pattern and a solder resist. The design methods of this formation are as follows: the over resist design (SMD) of which the solder resist opening becomes the land size, and the clearance resist design (NSMD) of which the land pattern becomes the land size. Each design has the following merits and demerits, so that proper use is required.

![Design example of over resist (SMD)](image)

![Design example of clearance resist (NSMD)](image)

**Table 5-1 Merit and demerit of each design methods**

<table>
<thead>
<tr>
<th>Design specifications</th>
<th>Over resist design (SMD)</th>
<th>Clearance resist design (NSMD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Merit</td>
<td>The sizes of package and land pattern become even. The junction intensity of a land pattern and a base material is strong.</td>
<td>The junction intensity of a land pattern and a solder is strong. Layout area between land patterns is large.</td>
</tr>
<tr>
<td>Demerit</td>
<td>The junction intensity of a land pattern and a solder is weak. Layout area between land patterns is small.</td>
<td>According to the pattern layout, the land pattern changes and the soldering state tends to become uneven. The junction intensity of a land pattern and a base material is weak.</td>
</tr>
</tbody>
</table>
5.1.2. Metal mask design

A metal mask is a lithograph for printing a solder paste on the land pattern of a printed wiring board. Recommended thickness of the metal mask is from 100 to 150 (μm). However, the adjustment of the thickness may be also required due to the balance of peripheral parts size.

The metal mask design of the BGA package is basically recommended to design of the same size as the land for soldering. However, when using a narrow pitch package or a solder bump, a soldering defect tends to occur.

**Figure 5-4** In case likely to occur Short-circuit (land for soldering is narrow pitch)

**Figure 5-5** In case likely to occur Open (land size for soldering is small)
6. Mounting guide for printed wiring board

6.1. Mounting flow
The recommended soldering method for each package is reflow process. For the reflow process, refer to section 6.1.1 to 6.1.4.

6.1.1. Printing solder paste
A solder paste is a pasty composite material made by mixing solder, flux, and the like. The solder paste is printed through a metal mask to the land pattern of the printed wiring board.

6.1.2. Mounting package
A package is mounted to the position where the solder paste is printed. In addition, use of the package which absorbed moisture may generate a crack because of the heat generated by soldering. Please observe the precautions for unpacking conditions.

6.1.3. Soldering (reflow soldering)
The printed wiring board mounting a package is soldered by the heating of a reflow oven. The package should be heated so that the temperature of the soldering may not exceed the maximum reflow temperature profile.

6.1.4. Visual inspection
In the visual inspection, a position gap, a solder bridge, and a poor-wetting soldering are confirmed with X ray observation equipment.
6.2. Reflow thermal profile

Figure 6-1 shows an example of the reflow thermal profile. In this example, a surface temperature of the package is preheated for 60 to 120 seconds at about 180 to 190°C. After that, the temperature raises gradually, and the surface temperature of the package continues the state which is about 230 to 260°C (peak temperature) for 30 to 50 seconds. In addition, temperature profiles differ due to a package. Confirm the temperature profile of the package to be used.

- Temperature and time should be set less than the above profile.
- Optimum temperature should be set due to solder paste types.

Figure 6-1 Thermal profile example
7. Rework

Use a heater nozzle which heats the target package only to remove the package. The mounting board is preheated using a convection-type heater. Thermal profile at removal is the same as that of mounting, however, the peak time should be as short as possible. When the package is difficult to remove, heat the back of the mounting board with a heater. In the case of removal, please take care so that the land on the board does not exfoliate.

In addition, reuse of the removal package and the soldering reliability of removal part is out of a guarantee range.

Figure 7-1  Rework overview
8. Design dimensions of mounting board for reference
(package: P-VFBGA289-1111-0.50-001)

Unit: mm

Notes
- All linear dimensions are given in millimeters unless otherwise specified.
- TOSHIBA is not responsible for any incorrect or incomplete drawings and information.
- You are solely responsible for all aspects of your own land pattern, including but not limited to soldering processes.
- The drawing shown may not accurately represent the actual shape or dimensions.
- Before creating and producing designs and using, customers must also refer to and comply with the latest versions of all relevant TOSHIBA information and the instructions for the application that Product will be used with or for.
## 9. Revision History

<table>
<thead>
<tr>
<th>Revision</th>
<th>Date</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>2017-03-17</td>
<td>Newly released</td>
</tr>
</tbody>
</table>
RESTRICTIONS ON PRODUCT USE

- Toshiba Corporation, and its subsidiaries and affiliates (collectively “TOSHIBA”), reserve the right to make changes to the information in this document, and related hardware, software and systems (collectively “Product”) without notice.

- This document and any information herein may not be reproduced without prior written permission from TOSHIBA. Even with TOSHIBA’s written permission, reproduction is permissible only if reproduction is without alteration/omission.

- Though TOSHIBA works continually to improve Product’s quality and reliability, Product can malfunction or fail. Customers are responsible for complying with safety standards and for providing adequate designs and safeguards for their hardware, software and systems which minimize risk and avoid situations in which a malfunction or failure of Product could cause loss of human life, bodily injury or damage to property, including data loss or corruption. Before customers use the Product, create designs including the Product, or incorporate the Product into their own applications, customers must also refer to and comply with (a) the latest versions of all relevant TOSHIBA information, including without limitation, this document, the specifications, the data sheets and application notes for Product and the precautions and conditions set forth in the “TOSHIBA Semiconductor Reliability Handbook” and (b) the instructions for the application with which the Product will be used with or for. Customers are solely responsible for all aspects of their own product design or applications, including but not limited to (a) determining the appropriateness of the use of this Product in such design or applications; (b) evaluating and determining the applicability of any information contained in this document, or in charts, diagrams, programs, algorithms, sample application circuits, or any other referenced documents; and (c) validating all operating parameters for such designs and applications. TOSHIBA ASSUMES NO LIABILITY FOR CUSTOMERS’ PRODUCT DESIGN OR APPLICATIONS.

- PRODUCT IS NEITHER INTENDED NOR WARRANTED FOR USE IN EQUIPMENTS OR SYSTEMS THAT REQUIRE EXTRAORDINARILY HIGH LEVELS OF QUALITY AND/OR RELIABILITY, AND/OR A MALFUNCTION OR FAILURE OF WHICH MAY CAUSE LOSS OF HUMAN LIFE, BODILY INJURY, SERIOUS PROPERTY DAMAGE AND/OR SERIOUS PUBLIC IMPACT (“UNINTENDED USE”). Except for specific applications as expressly stated in this document, Unintended Use includes, without limitation, equipment used in nuclear facilities, equipment used in the aerospace industry, medical equipment, equipment used for automobiles, trains, ships and other transportation, traffic signaling equipment, equipment used to control combustions or explosions, safety devices, elevators and escalators, devices related to electric power, and equipment used in finance-related fields. IF YOU USE PRODUCT FOR UNINTENDED USE, TOSHIBA ASSUMES NO LIABILITY FOR PRODUCT. For details, please contact your TOSHIBA sales representative.

- Do not disassemble, analyze, reverse-engineer, alter, modify, translate or copy Product, whether in whole or in part.

- Product shall not be used for or incorporated into any products or systems whose manufacture, use, or sale is prohibited under any applicable laws or regulations.

- The information contained herein is presented only as guidance for Product use. No responsibility is assumed by TOSHIBA for any infringement of patents or any other intellectual property rights of third parties that may result from the use of Product. No license to any intellectual property right is granted by this document, whether express or implied, by estoppel or otherwise.

- ABSENT A WRITTEN SIGNED AGREEMENT, EXCEPT AS PROVIDED IN THE RELEVANT TERMS AND CONDITIONS OF SALE FOR PRODUCT, AND TO THE MAXIMUM EXTENT ALLOWABLE BY LAW, TOSHIBA (1) ASSUMES NO LIABILITY WHATSOEVER, INCLUDING WITHOUT LIMITATION, INDIRECT, CONSEQUENTIAL, SPECIAL, OR INCIDENTAL DAMAGES OR LOSS, INCLUDING WITHOUT LIMITATION, LOSS OF PROFITS, LOSS OF OPPORTUNITIES, BUSINESS INTERRUPTION AND LOSS OF DATA, AND (2) DISCLAIMS ANY AND ALL EXPRESS OR IMPLIED WARRANTIES AND CONDITIONS RELATED TO SALE, USE OF PRODUCT, OR INFORMATION, INCLUDING WARRANTIES OR CONDITIONS OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, ACCURACY OF INFORMATION, OR NONINFRINGEMENT.

- Do not use or otherwise make available Product or related software or technology for any military purposes, including without limitation, for the design, development, use, stockpiling or manufacturing of nuclear, chemical, or biological weapons or missile technology products (mass destruction weapons). Product and related software and technology may be controlled under the applicable export laws and regulations including, without limitation, the Japanese Foreign Exchange and Foreign Trade Law and the U.S. Export Administration Regulations. Export and re-export of Product or related software or technology are strictly prohibited except in compliance with all applicable export laws and regulations.

- Please contact your TOSHIBA sales representative for details as to environmental matters such as the RoHS compatibility of Product. Please use Product in compliance with all applicable laws and regulations that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive. TOSHIBA ASSUMES NO LIABILITY FOR DAMAGES OR LOSSES OCCURRING AS A RESULT OF NONCOMPLIANCE WITH APPLICABLE LAWS AND REGULATIONS.