General

STANDARD FOR BGA/CGA MOUNTING PROCESS FOR SPACE USE

May 8, 2023

Japan Aerospace Exploration Agency

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Whenever this document conflicts with the original document in Japanese, the original document takes precedence.

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1. GENERAL

1.1 Purpose

This standard applies to the mounting of BGA/CGA (Ball Grid Array/Column Grid Array) on spacecraft such as launch vehicles and artificial satellites and the equipments installed on such spacecraft (hereinafter referred to as the “Spacecraft”) and the purpose is to establish a mounting process and carry out quality assurance to minimize the risks in relation to quality and reliability that arise from mounting.

1.2 Scope

(1) This standard shows the requirements for design, mounting and inspection of the printed wiring boards (hereinafter referred to as “PWBs”) that are necessary to obtain highly reliable electrical connections for BGA/CGA, which are new terminal shapes that cannot be handled with JERG-0-043.

(2) This standard shall apply to cases prescribed in the contractual specifications. In such a case, this standard shall apply to both the supplier and their subcontractors responsible for performing parts of the contract. However, when the mounted PWB specified in the contract is lead through mounting, surface mounting or the mixed type with BGA/CGA, apply JERG-0-039 to the inserted mounting and apply JERG-0-043 to the surface mounting except for the BGA/CGA.

(3) When applying BGA/CGA, an implementation process and set production control items shall be established in accordance with the provisions of this standard.

(4) Table 1-1 shows the structure and characteristics of BGA/CGA defined as the scope of application in the N/C edition and A edition of this standard as reference.

Table 1- 1-1 BGA/CGA structure and characteristics

Manufacturer	Xilinx		Microsemi		TEXAS INSTRUMENTS	NIPPON AVIONICS		
Model name	CF1140	CF1144	CG624	CG1152	S-CBGA-N429	SABG572-100	SABG357-100	SABG165-100
BGA/CGA	CGA	CGA	CGA	CGA	BGA	BGA	BGA	BGA
Column/ball composition	90Pb/10Sn	90Pb/10Sn	80Pb/20Sn	80Pb/20Sn	46Sn/46Pb/8Bi	Sn10/Pb90 (center 8X8 ball) Sn63/Pb37 (periphery ball)	Sn10/Pb90 (center 5X5 ball) Sn63/Pb37 (periphery ball)	Sn10/Pb90 (center 3X3 ball) Sn63/Pb37 (periphery ball)
Copper ribbon	No	No	Yes	Yes	No	No	No	No
Column/ball height	2.20mm	2.20mm	2.21 mm (0.087")	2.21 mm (0.087")	0.6mm	0.50mm	0.50mm	0.50mm
Column/ball diameter	0.52mm	0.52mm	0.51mm (0.020")	0.51mm (0.020")	0.75mm	0.70mm	0.70mm	0.70mm
Coplanarity	—	—	0.15mm (0.006")	0.15mm (0.006")	—	—	—	—
Base material of the package	Ceramics	Ceramics	Ceramics	Ceramics	Ceramics	Ceramics	Ceramics	Ceramics
Body size	35.0mm square	35.0mm square	32.5mm square	35mm square	27.0mm	26.0mm square	21.0mm square	15.0mm square
No. of pins	1140	1144	624	1152	429	572	357	165
Pitch	1.00mm	1.00mm	1.27 mm	1 mm	1.27mm	1.00mm	1.00mm	1.00mm
Base material thickness	1.5mm	1.5mm	2.25 mm	2.77 mm	1.11mm	2.85mm	2.85mm	2.35mm
JEDEC Registration	JEDEC MS-034-AAR-1	JEDEC MS-034-AAR-1	JEDEC MO-158 VAR BE-1	JEDEC MO-158 VAR CG-1	JEDEC MO-156	—	—	—
Primary mount structure	Flip chip	Flip chip	Wire bonding	Wire bonding	Wire bonding	Wire bonding	Wire bonding	Wire bonding

1.3 Tailoring

(1) The Japan Aerospace Exploration Agency (hereinafter referred to as "JAXA") may tailor the requirements in this standard for each contract in accordance with the purpose, functions, importance, scale, costs, etc. of target articles.

(2) The supplier in the contract may make proposals for appropriate tailoring in the process of consultations related to the contract. When tailoring, an examination shall be performed of the elements related to the purpose, etc. of target articles shown in the above paragraph (1).

2. RELATED DOCUMENTS

2.1 Applicable documents

The documents listed below form a part of this standard to the extent specified herein. Unless otherwise specified, their latest versions at the time of application of this standard shall be used.

Note that in the case that there is any discrepancy between this standard and the applicable documents, this standard shall be given priority.

(1) JAXA standards (in Japanese)

a. JERG-0-039 Standard for Soldering Process for Space Use

b. JERG-0-040 Standard for Electronic Bonding Process for Space Use

c. JERG-0-042 Standard for Printed Wiring Boards and Assemblies for Space Use

d. JERG-0-043 Standard for Surface Mount Soldering Process for Space Use

(2) Public standards

JIS standards

JIS Z 3282 Soft Solders—Chemical Compositions and Forms

JIS Z 3284 Solder Paste

IPC standards

J-STD-005 Requirements for Soldering Pastes

J-STD-006 Requirements for Electronic Grade Solder Alloys and Fluxed and Non-Fluxed Solid Solders for Electronic Soldering Applications

ESA standards

ECSS-Q-ST-70-38C Space product assurance High-reliability soldering for surface mounting and mixed technology

ECSS-Q-ST-70-61C High reliability assembly for surface mount and through hole connections

Papers and other materials

ESA STM-266 Assessment of the Reliability of Solder Joints to Ball and Column Grid Array Packages for Space Applications

2.2 Reference documents

The following documents provide information supplementary to the contents of this standard.

JEITA standards

JEITA ET-7407A Environmental and Endurance Test Methods for CSP/BGA Package on Mounting Condition

JEITA ED-7306 Measurement Methods of Package Warpage at Elevated Temperature and the Maximum Permissible Warpage

MIL standards

MIL-STD-202 Test Method Standard, Electronic and Electrical Component Parts

MIL-P-28809A Printed Wiring Assemblies

MIL-STD-883H Method 2009.10, EXTERNAL VISUAL, paragraph 3.3.6

NASA standard

GSFC-STD-6001 Ceramic Column Grid Array Design and Manufacturing Rules for Flight Hardware

IPC standards

IPC-7095B Design and Assembly Process Implementation for BGAs

IPC-7351B Generic Requirements for Surface Mount Design and Land Pattern Standard

IPC-7711/21B Rework, Modification and Repair of Electronic Assemblies

IPC LF-005 BGA Inspection & Lead-Free Defect Guide

IPC-9701A Performance Test Methods and Qualification Requirements for Surface Mount Solder Attachments

JEDEC standards

MO-156C Square Ceramic Ball Grid Array Family 1.00, 1.27, and 1.50 mm Pitch

MO-158D Ceramic Column Grid Array Family - Square

MS-034D Plastic Square Ball Grid Array Family

ESA standard

ECSS-Q-ST-70-28C Repair and modification of printed circuit board assemblies for space Use

IEC standards

IEC 60191-6-4 1.0 Mechanical standardization of semiconductor devices - Part 6-4: General rules for the preparation of outline drawings of surface mounted semiconductor device packages - Measuring methods for package dimensions of ball grid array (BGA)

IEC 60191-6-19 1.0 Mechanical standardization of semiconductor devices - Part 6-19: Measurement methods of the package warpage at elevated temperature and the maximum permissible warpage

IEC 61188-5-8 1.0 Printed boards and printed board assemblies - Design and use - Part 5-8: Attachment (land/joint) considerations - Area array components (BGA, FBGA, CGA, LGA)

IEC 61191-6 1.0 Printed board assemblies - Part 6: Evaluation criteria for voids in soldered joints of BGA and LGA and measurement method

IEC 62137-1-4 1.0 Surface mounting technology - Environmental and endurance test methods for surface mount solder joint - Part 1-4: Cyclic bending test

IEC 62137-1-5 1.0 Surface mounting technology - Environmental and endurance test methods for surface mount solder joint - Part 1-5: Mechanical shear fatigue test

JAXA documents

JERG-0-054-TM001 Collection of Technical Data of Standard for BGA/CGA Mounting Process for Space Use (JERG-0-054)

JERG-0-054-HB001 Handbook of Standard for BGA/CGA Mounting Process for Space Use (JERG-0-054)

Research Papers, etc.

ESA STM-261 An Investigation into Ball Grid Array Inspection Techniques

ESA STM-265 Evaluation of Thermally Conductive Adhesives as Staking Compounds during the Assembly of Spacecraft Electronics

Converting Ball Grid Array Components to Column Grid Array (SM-4028 Rev B SIX SIGMA)

Ceramic Column Grid Array (Actel Application Note AC190)

CBGA Surface Mount Assembly and Rework User's Guide (IBM)

Ceramic Column Grid Array Assembly and Rework User's Guide (IBM)
Thermal Cycling Test Report for Ceramic Column Grid Array Packages--CCGA (ACTEL)
JEDEC PUBLICATION JEP150 Stress-Test-Driven Qualification of and Failure Mechanisms Associated with Assembled Solid State Surface Mount Components
JPL Microelectronics Reliability Volume 43, Issue 5 Qualification approaches and thermal cycle test results for CSP/BGA/FCBGA
Virtex-4 QV FPGA Ceramic Packaging and Pinout Specifications (UG496 (v1.0) Xilinx)
IPC ELEC-SOLDER - Modern Solder Technology for Competitive Electronics Manufacturing

3. TERMS AND DEFINITIONS

The Terms and Definitions used in this standard are based on paragraph 3 (Terms and definitions) of JERG-0-043. In addition, reference shall be made to Appendix I of this standard.

4. GENERL REQUIREMENTS

4.1 General

General requirement shall conform to paragraph 4.1 (General) of JERG-0-043.

4.2 Training and certification

Training and certification shall conform to paragraph 4.2 (Training and certification) of JERG-0-043.

4.3 Design requirements

(1) The design requirements related to PWBs shall be as per paragraph 6.1 of this standard.

(2) The temperature requirements for solder joint(s) during storage and operation shall conform to paragraph 4.3(1) (Design requirements) of JERG-0-043.

(3) Application of solder and flux shall conform to paragraph 5.3.1 (Solder and flux) of JERG-0-043. As a rule, solder pastes conforming to J-STD-005 or JIS Z 3284 shall be used in soldering. When resin flux cored solder is used, the type of the flux shall be either RO-L0 or RO-L1 (R or RMA). Composition of the solder shall be Sn63/Pb37 or Sn60/Pb40 or the equivalent in accordance with J-STD-006 or JIS Z 3282. Lead-free solder shall not be used in lieu of Sn63/Pb37 or Sn60/Pb40 solder.

(4) The metals to be joined shall conform to paragraph 4.3(3) (Design requirements) of JERG-0-043.

(5) The solder joint parts shall be as per Table 1-1 in this standard.

(6) The application of parts staking, conformal coating, etc. shall be as per JERG-0-040 and in addition paragraph 6.1.3, 6.2.4 and 6.2.5 of this standard.

(7) Inspection of the soldered joints shall be as per JERG-0-043 and in addition paragraph 6.3 and 7.3 of this standard.

4.4 Process certification tests

When certifying the process, a certification plan shall be submitted to JAXA and approval for the plan shall be received in advance.

The general matters are stated below. The details shall be as per paragraph 6.4 of this standard.

4.4.1 Vibration/shock tests

The vibration/shock test shall be conditioned taking into consideration the applicable environmental conditions, etc., and shall be reconditioned as necessary in cooperation with JAXA.

4.4.2 Thermal shock tests

In the case that the temperature of the solder joint(s) cannot satisfy the temperature range between -30°C and +100°C during warehousing, storage and operation, paragraph 4.4.2 (1) of this standard shall be applied. In the case that the temperature range is satisfied, paragraph 4.4.2 (2) of this standard shall be applied.

(1) Thermal shock test (I)

The test shall establish the upper and lower limit temperature with allowance for the pattern of temperature change predicted by thermal analysis. The condition where exposure of the solder joint of the sample to the upper and lower limit temperature for 30 minutes, respectively, shall be employed, however when longer duration of exposure is expected due to the pattern, the time of exposure shall be adjusted accordingly.

(2) Thermal shock test (II)

Thermal shock test (II) shall conform to paragraph 4.4.2(1) (Process certification test (II)) of JERG-0-039, or to 4.4.2(2) (Test method and conditions) of JERG-0-043.

4.4.3 Electrochemical migration test

Electrochemical migration test shall conform to paragraph 6.4.3 of this standard.

4.5 Manufacturing conditions

4.5.1 General

(1) Paragraph 4.5(1) and (3) to (5) (Manufacturing conditions) of JERG-0-043 shall be applied in this section.

(2) For soldering rework shall be applied paragraph 8 of this standard.

4.5.2 Manufacturing environment

Manufacturing environment shall conform to paragraph 4.5.1 (Manufacturing environment) of JERG-0-043.

4.5.3 In-process storage and handling

In-process storage and handling shall conform to paragraph 4.5.2 (In-process storage and handling) of JERG-0-043.

4.5.4 Electrostatic discharge control

Electrostatic discharge control shall conform to paragraph 4.5.3 (Electrostatic discharge control) of JERG-0-043.

4.6 Quality assurance

Quality assurance shall conform to paragraph 4.6 (Quality assurance) of JERG-0-043.

5. APPROACH TO QUALITY ASSURANCE IN BGA/CGA MOUNTING

5.1 Definition of process assurance

Conventionally, visual inspections to directly confirm the workmanship of the soldering have been one of the important measures in quality assurance for solder joints in spacecraft. However, BGA/CGA packages are different from general parts because they have a shape with bottom only terminations, so visual inspections are not possible to be performed for all of the solder joints.

For this reason, to guarantee the quality of the solder joint that cannot be visually inspected, it is necessary to introduce the new approach of process assurance that builds quality inside the processes. Process assurance refers to activities guaranteeing that quality is being ensured by stipulating the people, materials, manufacturing equipment (machinery), work methods (procedures, conditions) necessary to ensure that if the process is carried out in accordance with the predetermined procedures and methods then the results of the process will be in accordance with the purpose of the process, and then implementing the process accordingly. Process assurance in BGA/CGA mounting indirectly guarantees that the quality of the BGA/CGA solder joint is being ensured, instead of using a direct visual inspection, by obtaining evidence that the three processes of (i) design and process verification, (ii) manufacturing process confirmation, and (iii) product inspections are being implemented appropriately.

5.1.1 Design and process verification

In design and process verification, obtain evidence to prove that the design and manufacturing process that applies the BGA/CGA mounting is valid. Firstly, use an engineering sample equivalent to the product to carry out a demonstration and comprehensive evaluation and verification in order to realize the process. It is not necessary for the engineering sample used here to be identical to the product; it is sufficient if it can be used to implement a confirmation of the workmanship of the solder joints and an evaluation and verification of reliability.

However, the selected members (parts and materials including the BGA and CGA package and PWB*1, solder materials, staking materials, coating materials, etc.) and the properties of the engineering sample (thermal properties such as the coefficient of linear expansion, thermal capacity, etc., and mechanical properties), structure (parts arrangement, mass, etc.) must be nearly identical as the target product. Furthermore, the soldering process conditions such as the amount of solder, the temperature profile, etc. and the manufacturing equipment used shall be identical to the conditions and manufacturing equipment for processing the product. In the case that the shape or structure of the product differs greatly from the engineering sample or in the case that different manufacturing equipment is used, reimplement the design and process verification.

In the comprehensive evaluation and verification, carry out not only nondestructive inspections including observations of the exterior appearance, etc. but also employ destructive inspections to confirm the condition of the workmanship in detail, including the condition of the voids and the solder joints on the back surface of the BGA/CGA, where cannot be verified nondestructively. Moreover, implement a reliability evaluation test to investigate the thermal and mechanical durability, and utilize that data to confirm the validity of the design and process.

If it cannot be proven that the new products are equivalent to the products for which evaluations had been performed in the past, the product or an equivalent engineering sample shall conduct reperformance of the demonstration experiment, to confirm that the workmanship is equivalent to the evaluations that have been implemented in the past. However, the reliability evaluation test may be omitted in the case that only the manufacturing equipment is different and the case that there are grounds for inferring the thermal and mechanical durability from engineering samples for which reliability evaluation tests have already been implemented.

Note *1: A test board in which a test pattern, etc. has been formed is acceptable for the PWB used as an engineering sample but the specifications that have an effect on the soldering process such as the pad shape of the solder joints, the thermal capacity including the layer structure, board thickness, etc., and the fixing structure, etc. , shall be equivalent to those of the products.

5.1.2 Manufacturing process confirmation

In the manufacturing process confirmation, it shall be able to prove that the process used to manufacture the product is the same as the process that was verified as valid in the design and process verification.

Firstly, register the manufacturing equipment and the scope of the various process conditions and standards actually applied in the design and process verification described in paragraph 5.1.1 in the system of the quality assurance program possessed by the implementer, and cross-check against the implementation record for the product manufacturing in order to prove that those conditions are the same. For the quality record of the product manufacturing, information shall be included that the product specifications and the manufacturing equipment and various process conditions applied in the design and process verification are the same. Moreover, for conditions include elements that change with each implementation, it shall be able to implement inspections or measurements prior to manufacturing the product to provide the conditions that have not deviated from the scope of the registered standards. For example, for the amount of solder inspect the solder paste printing height and printing area of the product itself in order to prove the amount of solder is equivalent to the registered data. Furthermore, for the heating profile when soldering, create a record showing that the product was made with an equivalent heating profile by putting into a furnace and measuring a dummy board right before putting the product into the furnace.

5.1.3 Product inspections

A visual inspection of the product's exterior appearance and nondestructive inspections such as X-ray observations, etc. are implemented to determine the quality condition of the products. In product inspections of BGA/CGAs for which destructive inspections cannot be performed, evidence which shows the quality condition is limited to partial information, and only information unique to the individual products (solder wetting, amount of foreign materials remaining in the periphery, metal foreign materials between the electrodes, installation position alignment, and electrode absence) is verified. For example, in the visual inspection observe only the condition of the direct-view surface of the periphery of the solder joint to confirm the condition of the solder wetting and the amount of foreign materials remaining in the periphery. The condition of the back of the electrode and the central part of the package cannot be observed so confirm evidence that shows the soldering process in paragraph 5.1.2 is appropriate, in order to infer the overall condition, and deem that the places that cannot be observed visually are equivalent. Carry out observations using transmission type X-rays for nondestructive inspections of the places that cannot be observed visually. However, inspections using X-rays entail the risk of exposure damage (degradation), including the surrounding parts, so sufficient examinations shall be performed before establishing the inspection conditions.

6. EXAMINATION ITEMS AND INSPECTION METHODS FOR THE ESTABLISHMENT OF A BGA/CGA MOUNTING PROCESS

6.1 Examination items in board and mount structural design

6.1.1 Points to consider when selecting the PWB

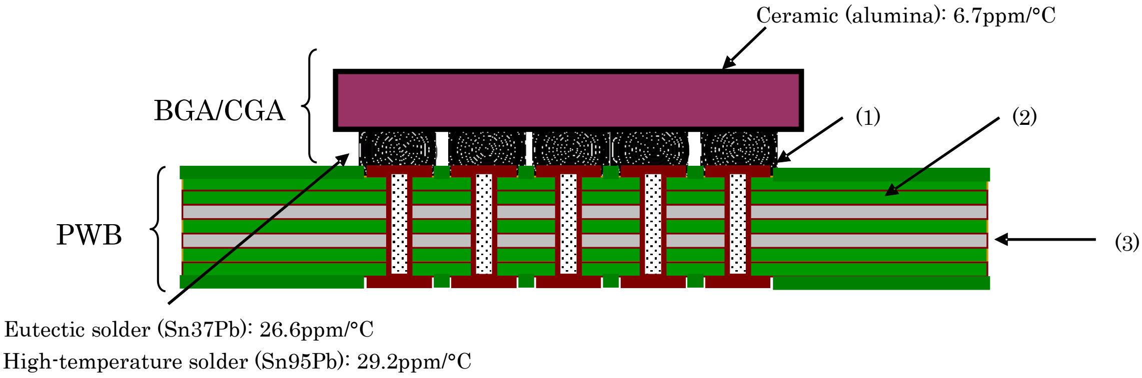
Compared to SOP and QFP packages, BGA/CGA packages have poor stress relief properties, so it is difficult to relieve stress caused by the difference in thermal expansion between the package and the PWB. Therefore, regarding the new combination of the PWB and the installed BGA/CGA, sufficient caution shall be taken for the design and adequate reliability evaluations of the prototypes shall be implemented (refer to Table 6-1).

Furthermore, the warping and flatness of the PWB influence the quality of the mounting finish and have an effect on solder joint reliability. Therefore, the PWB shall be designed taking into consideration mountability and reliability.

In the baking and reflow heating of the PWB, confirm in advance that warping of the PWB before and after heating is at a level that will not become a problem.

Table 6-1 Materials used in the PWB and examples of their characteristic values

No.	Materials	Tg (°C)	Modulus of elasticity (MPa)	Poisson's ratio	CTE (ppm/°C)
(1)	Conductor (Copper foil)	-	129000	0.35	17
(2)	Base material (modified polyimide)	200 ~213	25000	0.15	12 ~ 15 (X) 12 ~ 16 (Y) 50 ~ 80 (Z)
(3)	CIC (Copper Inver Copper)	-	140000	0.259 (Inver)	3.6 ~ 5.6 (X, Y)



6.1.2 PWB design

(1) Wiring design

The wiring design of the PWB shall be in accordance with JERG-0-042 however in the case that the wiring design requirements prescribed in JERG-0-042 are not satisfied anywhere, make those places clear. Furthermore, regarding the areas in which the requirements are not satisfied, make sure through design verifications, evaluations, etc. that a sufficient allowance has been made for withstand voltage, the electrical field, etc. in the wiring design using an appropriate method.

(2) Pad design

As shown in Figure 6-1, there are two types of pad design: Dog-Bone and Via in Pad/Pad on Via. One of these types shall be applied.

In the case of arranging vias, etc. which indents will occur inside the pad, sufficient consideration shall be given to the amount of voids remaining.

Regarding the pad size, it is necessary to use the size (as the joint including the amount of solder) capable of relieving the stress of the difference in thermal expansion between the package and the PWB in a well-balanced manner with the upper and lower joints of the columns and solder balls.

In the case of the Dog-Bone pad design, an adjacent through-hole that goes through to the lower layer is required, and normally the pad is not covered by the solder resist. Therefore, when steadily implementing solder flow prevention or implementing underfill packing, it is desirable to fill the through-hole with resin to block up the hole, and then cover all areas other than the pad aperture with the solder resist.

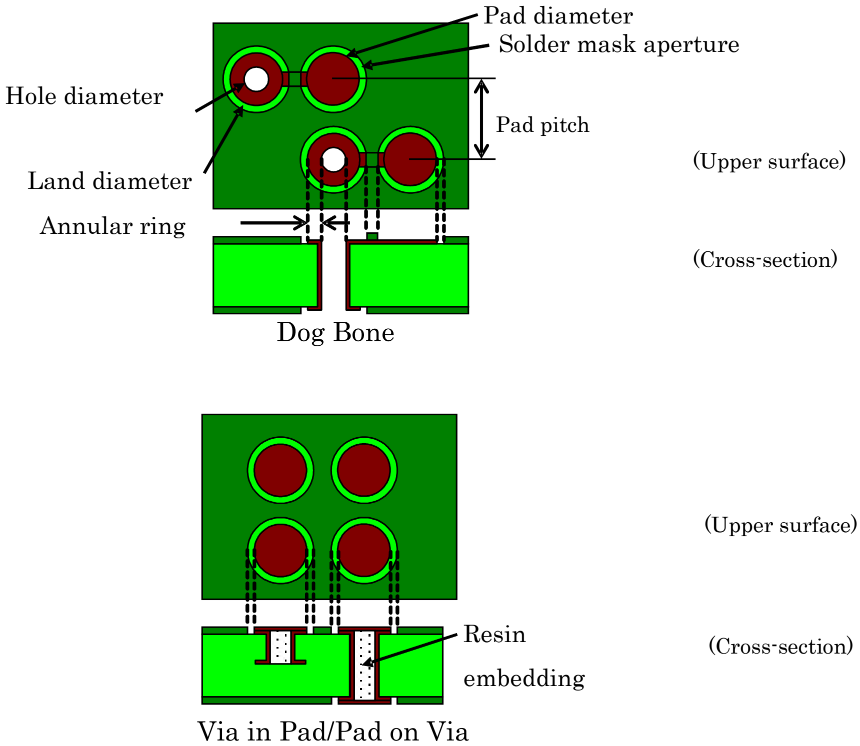


Figure 6- 1 Pad design image

(3) Solder resist design

There are two types of solder resist design applied to pads as shown in Figure 6-2: NSMD (Non-solder mask defined pad) and SMD (Solder mask defined pad).

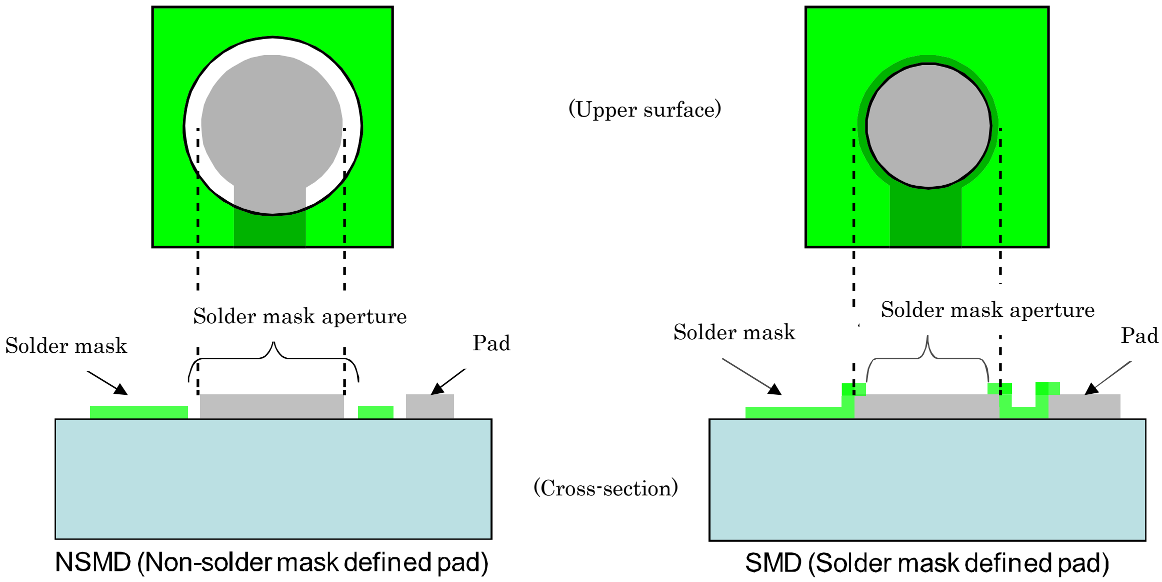


Figure 6- 2 Solder resist designs applied to the pads

(4) Other matters to consider

When using surface treatment other than a solder coat, an evaluation of joint reliability shall be implemented.

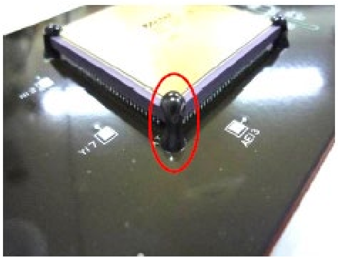
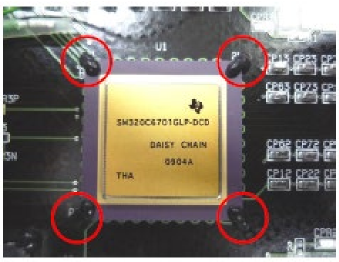
When employing specifications not in the JAXA qualified specifications in the PWB design, it is necessary to implement a design verification and evaluation in advance.

The PWB shall be designed so that it conforms to all of the parts. A clearance around the BGA/CGA to allow proper insertion of repair and rework instruments and tools shall be ensured.

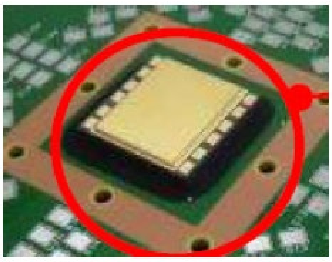
In particular in the case that rework is anticipated, the board design shall take rework into consideration.

6.1.3 Structural design

When mounting the BGA/CGA, implement structural analyses to adequately examine the fixed pitch, number of fixing points, and board thickness, etc. of the PWB and the chassis, the reliability of the structural design shall be ensured. It is acceptable to implement underfill and corner staking for the purpose of improving vibration resistance and shock resistance when necessary. (Refer to Figure 6-3)

Notes ○ : corner staking



Upper : corner staking

Lower: Under fill (left)

Figure 6- 3 Examples of fixing using corner staking

6.1.4 Points to consider regarding mounting design

The CGA columns covered by this standard are comprised of solder (Sn10-Pb90 or Sn20-Pb80) and copper ribbon. The joint of the CGA package and column is Sn63-Pb37 eutectic solder. Furthermore, the columns winding copper ribbon on the outside of the solder core are connected so that the core and copper ribbon are coated with Sn63-Pb37 solder.

BGA is also connected not only with Sn63-Pb37 eutectic solder, but also with a combination of solders with different compositions.

Since the BGA/CGA mounting has this structure, adequate caution shall be taken in the mounting design regarding the combination with the solder and the reliability of the joint.

6.2 Examination items in mounting

This section shows the examination items necessary for the establishment of the BGA/CGA mounting process.

However, the examination items shown in this section are the standard items implemented to establish the mounting process, and they can be replaced in the case that equivalent mounting quality/reliability can be established using the own process design and process management of each manufacturer.

6.2.1 Mounting materials

For the materials used in mounting, basically the materials prescribed in JERG-0-039 or JERG-0-043 shall be used. The handling/use methods for the materials shall satisfy the requirements in the specifications prescribed by each manufacturer.

6.2.2 Soldering mounting

When examining the soldering mounting, specifications regarding the following items shall be established.

(1) Baking of the members

(1-1) Baking of the BGA/CGA

BGA/CGAs for which there are baking requirements shall be baked before the reflow soldering, under the baking conditions recommended by the parts manufacturer. (This does not apply in the case that the reflow soldering is completed after unsealing within the time prescribed by the parts manufacturer.)

In some cases there is a concern of oxidation of the balls or columns due to the baking, so prior to baking the members, the specifications such that the baking equipment, the atmosphere in the baking furnace, the baking method, the baking temperature, the baking time, and the storage method from after the baking to the mounting shall be established. The major items and points to be cautious about are shown next.

(a) Oxidation inhibition

・A baking method inside an inert gas shall be used.

・In the case that baking inside an inert gas is difficult, the method of removing, etc. the oxidized film of the soldering joint is also allowed but the reliability of the solder connections shall be verified.

(b) Method

A baking method that will not damage the balls and columns during the baking shall be used.

(c) Storage

A storage method that will inhibit the oxidation and absorption of moisture of the columns and balls after the baking shall be used. The time from after the baking to the reflow soldering shall be controlled.

(1-2) Baking of the PWB

It is necessary to bake the PWB prior to mounting the parts. In the case that the flatness of the PWB becomes worse due to the baking, there is a possibility that it will affect the joint reliability of the BGA/CGA. Therefore, in the case that there is a risk that the warping of the PWB due to the heat of the baking might have an effect on joint reliability, use a method that reduces warping as necessary. Prior to baking the PWB, the specifications of the baking temperature, the baking time, and the method of storage until the mounting onto the PWB shall be established. The duration from after the baking to the reflow soldering shall be controlled.

(2) Solder paste printing

When establishing the printing process for the solder paste, the specifications such that the solder paste printing equipment, the solder paste materials, the time from the solder paste mixing to the printing, the volume after the solder paste printing, the appearance accept/reject criteria after the solder paste printing, and the time from solder paste printing until parts installation shall be established. The major items and points to be cautious about are listed next.

(a) Time

The time from the solder paste mixing until the commencement of the printing taking into consideration the adhesiveness and moisture absorption properties of the solder paste shall be controlled. Furthermore, the time from the end of the printing work until the commencement of the reflow soldering shall be established.

(b) Finish

・A method with no shortage and uniform thickness shall be used.

・ The solder paste finish (shape, volume, etc.) after printing shall be managed. (It is desirable to manage it numerically using volume, solder height, etc.)

・ The allowable value for the maximum alignment amount of the printing with respect to the pattern of the PWB shall be established.

(3) Parts installation

When establishing the parts installation process, the specifications such that installation equipment, the inspection method after the parts installation, the accept/reject criteria for the parts installation position, and the standards for the exterior appearance of the parts before the parts mounting shall be established.

(a) Handling

For the installation of the BGA/CGA on to the PWB, a method that does not cause deformation of the balls and columns shall be used.

(b) Installation sequence

The sequence for installing the BGA/CGA mounted on the PWB and the electrical parts other than the BGA/CGA on the PWB is not prescribed.

(4) Reflow soldering

Basically the reflow temperature profile should be in accordance with the temperature profile recommended by the parts suppliers and manufacturers but the temperature profile while ensuring adequate consistency with the reflow temperature profile of the other mounting parts and considering the temperature distribution of the PWB shall be determined.

When establishing the process for reflow soldering, the specifications of the reflow equipment, the atmosphere inside the reflow furnace, the reflow profile, the time from the printing work end until the beginning of the reflow soldering, the acquisition frequency of the reflow profile, the parts temperature at the time of the reflow soldering, the fixing methods of the PWB to the conveyancing fixtures of the package, and the reflow configuration shall be established. The major items and points to be cautious about are shown next.

When using local (individual) reflow equipment, the differences in management items from reflow equipment shall be clarified.

(a) Temperature profile

A temperature profile that does not exceed the upper limit for temperature/time in the temperature profile recommended by the parts suppliers and manufacturers shall be established.

(b) Temperature data acquisition

In the case that parts with a large thermal capacity are to be mounted in the neighborhood of the mount position of the BGA/CGA and in the case that there are no parts in the neighborhood, there is a possibility that the reflow temperature distribution of the BGA/CGA will change. Therefore, in the case that the parts are to be mounted on the peripheries of the BGA/CGA, the temperature data after taking into consideration their thermal capacity shall be acquired.

(c) Warping of the PWB

There is a possibility that warping of the PWB due to reflow soldering may have an effect on the joint reliability of the BGA/CGA. When doing the reflow soldering of the BGA/CGA, a method that reduces the warping amount of the PWB as much as possible shall be used.

(d) Changes to the base material of the PWB

There is a possibility that the temperature distribution of the BGA/CGA will change due to the base material changing, even in PWBs that are the same size. In the case that even a PWB for which reflow has been implemented has a different base material in comparison to the previous PWB, it shall be verified that there is no effect on the temperature distribution of the BGA/CGA.

(e) Changes to the pad design

There is a possibility that even with the same size and base material, discrepancies in heat conductivity will occur due to the pad design changing, and therefore the melt timing (melt time) of the solder will change. In the case that even a PWB for which reflow has been implemented has a different pad design than the previous one, it shall be verified that there is no effect on the fillet form, etc. of the BGA/CGA solder joint(s).

(f) Changing the parts

In the case that the size of the BGA/CGA has changed even for a board size/base material for which reflow has been implemented, there is a possibility that the temperature distribution of the BGA/CGA will change. In the case that the size of the BGA/CGA is different than the previous one, it shall be verified that there is no effect on the temperature distribution of the BGA/CGA.

The same applies if the surrounding heat capacity of components other than the target BGA/CGA or PWB size is changed.

6.2.3 Cleaning

When establishing the cleaning process for the BGA/CGA, the specifications related to the cleaning equipment, the cleaners (solvents), contamination management, the cleaning temperature, the cleaning time, the cleaning method, the accept/reject criteria for the exterior appearance after cleaning, the method of inspecting the exterior appearance after cleaning, the method of preventing the migration of foreign materials after cleaning, the method of inspecting foreign materials on the back surface of the BGA/CGA, and the standards for the size and amount of foreign materials on the BGA/CBA back surface shall be determined. The major items and points to be cautious about are shown next.

(1) Flux residue

A cleaning method with which flux residue will not occur in the solder joint places of the BGA/CGA shall be established. However, allow for flux residue by acquiring data providing technical backing for the fact that migration does not occur as a result of implementing an electrochemical migration test due to flux, and implementing underfill and conformal coating.

(2) Foreign materials including solder balls, etc.

A cleaning method that can remove foreign materials such as solder balls shall be established.

(3) Cleaning method

For the cleaning, a method that will not damage the balls and columns shall be applied.

6.2.4 Staking and fixing

(1) CGA

The CGA is a structure that supports the ceramic package with solder columns, and a load is imposed on the columns due to vibrations and shocks. There is a possibility that an excessive load will damage the joint reliability of the CGA, so in some cases measures such as fixing the CGA in place, etc. are necessary. When establishing the fixing method, refer to paragraph 4 of JERG-0-040, and the selection of the materials, the coating method, the curing conditions, and the standards and inspection method for the exterior appearance of the finish shall be considered. The major items and points to be cautious about are shown next.

(a) Materials

The difference in coefficient of thermal expansion from the CGA and PWB shall be considered.

(b) Inspections

・ The structure shall enable confirmation of the condition of the fixing by the visual verification.

・In the case that the condition of the fixing cannot be verified by the visual verification, the process of the fixing method shall be established

・The staking materials shall not attach to the column.

(2) BGA

When applying the underfill, there is a risk that the BGA underfill will impose constraints on the removal of the BGA, so adequate caution is necessary.

There are cases in which it has been evaluated that the underfill expedite thermal fatigue in the solder joints due to the difference in the coefficient of thermal expansion between the underfill materials and the ceramics in the thermal cycles, and therefore causes cracks (refer to ESA STM-266).

In the case that the underfill materials are to be used for the BGA, the following matters shall be considered when selecting the underfill materials.

(a) Materials

The viscosity, the glass-transition temperature, the coefficient of thermal expansion, and the adhesiveness with the board, etc. shall be considered.

(b) Method

A method capable of uniform fill shall be used.

(c) Inspection

In the case of underfill, the condition of the filling cannot be verified using visual verification, so the process of the filling method shall be established.

In the case of staking materials, the staking materials shall not attach to the balls.

6.2.5 Coating

As a general rule, conformal coating shall be implemented to take measures for corrosion prevention and insulation for the PWB on which the parts are mounted and the electrodes of the parts. It is necessary to carry out conformal coating of the solder joint(s) of the CGA for a similar purpose but if the coating materials are filled into the entire bottom surface of the package there is a possibility of damaging the properties of the CGA (mitigation of the thermal strain using the expansion, contraction, etc. of the columns) so it is acceptable to apply the coating to the solder joint rather than the entire column.

However, in the case of coating only the solder joint, measures to ensure that foreign materials do not migrate to the bottom surface of the parts shall be taken. In the case that the coating materials are to be filled into the entire bottom surface of the package, carry out an adequate evaluation and it shall be confirmed that the properties of the CGA have not been damaged by the coating. Regarding the BGA as well, in the case that a conformal coating is to be applied, an adequate evaluation shall be conducted. When establishing the process for conformal coating, the specifications related to the selection of the coating materials, the coating method, the curing conditions, and the standards and inspection method for the exterior appearance of the finish shall be established by referring paragraph 4 of JERG-0-040. The major items and points to be cautious about are shown next.

(a) From mounting to before coating

Measures to prevent the migration of foreign materials between the balls or columns shall be carried out.

(b) Scope of the coating

・There is a possibility that solder balls will occur at the time of the reflow soldering, and those solder balls will exist on the board. Consequently, conformal coating shall be implemented for at least the PWB and the solder joints between the balls/columns and the PWB.

・The coating shall be uniform with no unevenness.

(c) Coating method

A manufacturing process for carrying out process assurance shall be established.

6.3 Inspections

6.3.1 Visual inspection

The scope that can be verified from the peripheral side surface shall be visually inspected in accordance with JERG-0-043. The criteria shall be as shown in shown in Table 0-1.

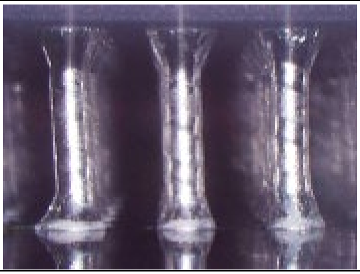
The visual inspection is carried out using a stereomicroscope capable of magnification of 20 times or more (when necessary, a microscope with a prism mechanism) or a fiberscope microscope, depending on the joint size.

Table 6-2 Visual inspection items and criteria for BGA/CGA (1)

Items	Requirements	
	BGA	CGA
Pad-ball (column) alignment	The ball offset from the pad shall be 25% or less of the PWB pad diameter	The column overhang amount from the pad shall be 15% or less of the PWB pad diameter
Column tilt (CGA)	—	5° or less
Ball (column) shape	Chips are nonexistent	Chips and deflections are nonexistent
Ball (column) absences	Nonexistent	
Solder bridge	Nonexistent	
Soldered connection (2)	The solder paste has melted and smoothly connected to the ball	The solder joint is smoothly connected from the column to the pad
Solder fillet	—	The solder is filled between the bottom of the column and the pad is wet, and forms a solder fillet that moistens 180° or more of the circumference of the column
Foreign materials	Metal foreign materials of 0.1mm or more are nonexistent	

Note (1) Inspect the scope that can be visually verified from the peripheral side of the package (Figure 6-4).

Note (2) Appearance (surface condition) varies depending on the solder composition of the balls and columns.

	After reflow
Xilinx-made CGA (Vertex4 CF1144)	
Microsemi-made CGA (CG1272)	

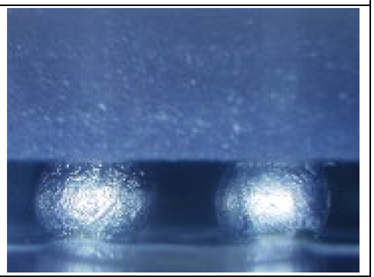
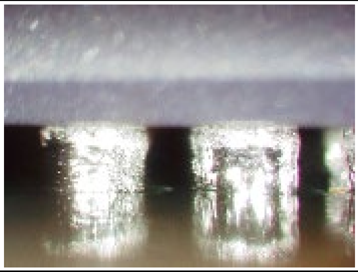
	After reflow
TI-made CBGA	
CBGA (Reference)	

Figure 6- 4 Examples of observations of the exterior appearance

6.3.2 Nondestructive inspection

Regarding the back surface of the BGA/CGA which cannot be visually inspected, an appropriate nondestructive inspection such as X-ray inspection, etc. shall be carried out in accordance with Table 0-2.

In the case that X-ray inspection equipment is to be used, the resolution of the X-ray equipment shall be able to detect solder balls having a diameter of 0.03 mm at least. Furthermore, in the case that foreign materials have migrated into the back surface of the BGA/CGA after the mounting, inspection and removal may be difficult, so measures to reduce the risk of foreign materials migration shall be examined.

As shown in Figure 0-2 and Figure 0-3, the void ratio is defined by area. As shown in the A-A' cross-section of Figure 0-3, in the case of the CGA the solder joint between the column and PWB side pad shall be observed.

Furthermore, in the case that multiple voids exist in one joint, calculate the void ratio from the sum total of the void area as shown in Figure 0-4. Note that in the case that large volumes of voids occur, by revising the process including the reflow heating conditions, etc., the number of voids shall be reduced.

Note that when performing non-destructive inspection using X-ray, the X-ray irradiation time becomes an issue. So for X-ray inspection, it shall be ensured that there is no effect on BGA/CGA by calculating radiation resistance in advance.

Table 6-3 X-Ray inspection items and criteria for BGA/CGA

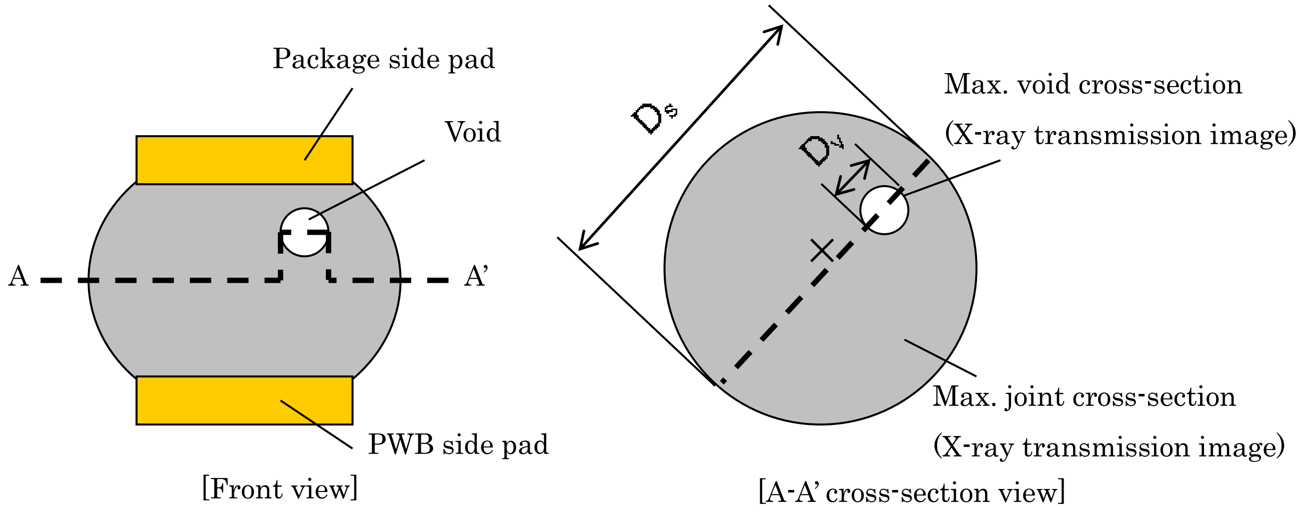
Items	Requirements	
	BGA	CGA
Pad-ball (column) alignment	The ball offset from the pad shall be 25% or less of the PWB pad diameter	The column overhang amount from the pad shall be 15% or less of the PWB pad diameter
Column tilt (CGA)	-	Marked tilts are nonexistent (1)
Ball (column) absences	Nonexistent	
Solder bridge	Nonexistent	
Soldered connection	Unmelted and unconnected places are nonexistent	
Voids	The void ratio of the BGA ball joint cross-section shall be 25% or less (2)	The void ratio of the CGA column joint cross-section shall be 25% or less (2) (3)
Foreign materials	Impermeable foreign materials of 0.1mm or more are nonexistent (4)	

Notes (1) Refer to Figure 16-23 in ECSS-Q-ST-70-38C.

(2) The void ratio is defined using the cross-sectional area (refer to Figure 0-2 and Figure 0-3).

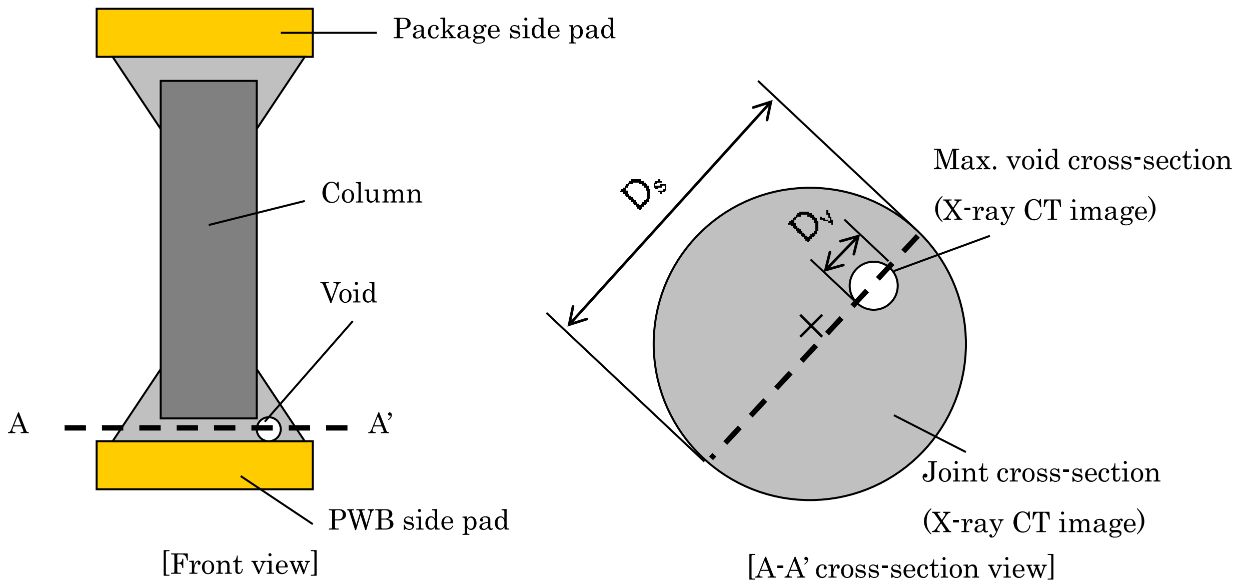
(3) The place that is observed is the solder connection of the pad and column on the PWB side.

(4) ECSS-Q-ST-70-38C contains the statement "The total number of solder balls having a diameter greater than 0.03 mm shall not exceed 10 per device." Carry out the process evaluation with that number as the target.



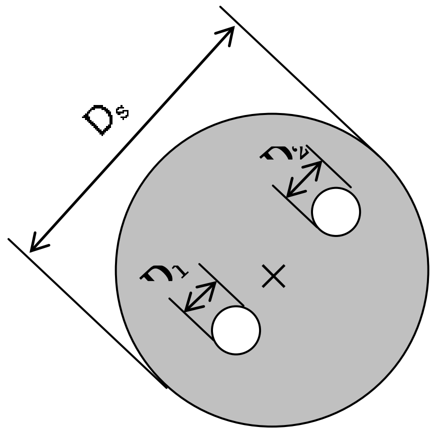
$$\text{Void ratio} \quad O_V = \frac{\pi\left(\frac{D_V}{2}\right)^2}{\pi\left(\frac{D_S}{2}\right)^2} = \frac{(D_V)^2}{(D_S)^2}$$

Figure 6- 5 Definition of the void ratio (BGA)



$$\text{Void ratio} \quad O_V = \frac{\pi\left(\frac{D_V}{2}\right)^2}{\pi\left(\frac{D_S}{2}\right)^2} = \frac{(D_V)^2}{(D_S)^2}$$

Figure 6- 6 Definition of the void ratio (CGA)



Void ratio $O_V = \frac{(D_1)^2 + (D_2)^2}{(D_S)^2}$

Figure 6- 7 Definition of the void ratio in the case that multiple voids exist (BGA/CGA)
(calculate the void ratio from the sum total of the void area)

6.3.3 Destructive inspection

Carry out a destructive inspection of the engineering sample to confirm the initial condition of the solder joint.

(1) It shall be ensured that there is no wetting on the solder joints between the package and the ball/column, and between the ball/column and the PWB, and abnormalities in the joint boundary are nonexistent.

(2) Inspection of the staking, underfill, and fixing

The following items shall be satisfied.

(a) In the case that staking materials are to be used, the staking materials shall not attach to the columns and solder joints.

(b) In the case that underfill materials are to be used, it shall be possible to fill them in uniformity.

(c) There shall be no cracks or peeling in the staking.

(d) The ball part shall not be bonded.

(3) Inspection of the coating

In the case that coating is to be applied to the products, apply the coating to a wiring board that was manufactured using a PWB, BGA/CGA and process equivalent to those of the product, and use a destructive inspection to confirm that the coating has been applied uniformly.

6.4 Reliability evaluation

The following evaluation tests shall be implemented in order to prove the validity of the design, structure, manufacturing process, etc. to be applied.

However, the evaluation items, conditions and criteria may be stipulated separately based on the product environment specifications.

Furthermore, in the case that the purpose is to evaluate validity with respect to partial changes to designs, structures, manufacturing processes, etc. which have already been evaluated, the evaluation items may be selected after taking into consideration their influence with respect to the changed parts.

6.4.1 Evaluation sample

The evaluation sample shall be an engineering sample produced with members, structures, manufacturing processes, etc. equivalent to those of the product, or a product extracted from an identical manufacturing lot.

For the engineering sample it is acceptable to use a TEG (Test Engineering Group) specifically designed for individual evaluation purposes, but it shall be a TEG for which the thermal and mechanical properties can be evaluated as equivalent to the products or at the threshold limit value.

As a general rule the test material amount of the evaluation sample shall be at least three items per package type. However, this shall not apply in the case that the validity of the evaluation results can be judged appropriately.

(1) The BGA/CGA to be used shall be one which has equivalent electrical functions to the product or is a mechanical sample (a dedicated evaluation package with daisy chain wiring, etc. for confirmation of conduction), however the shape, pitch, materials, and terminal treatment of the terminal shall be equivalent to the products to be applied. Furthermore, in the case that difference in size, the question of whether the vertical, horizontal, and thickness dimensions, the number and the arrangement of the terminals, the mass, and thermal capacity are appropriate based on the purpose of the evaluation shall be examined. Moreover, in the case that a package possessing equivalent functions to the product is to be used, and the threshold limit value is to be evaluated using this package, defect detectability with respect to the disconnections or short circuits shall be taken into consideration in advance.

(2) When deciding the PWB to be used, materials of the base material/solder resist/metal core, etc. of the insert, pattern shape/the cross-section structure/the surface treatment of

the solder joint, the size/the layer structure/the board thickness of the board, and the diameter/position of the through-hole shall be taken into consideration based on the evaluation purpose.

(3) In the case that the purpose is to evaluate the mechanical structure with vibration tests and shock tests, etc., the stiffness, fixing structure (in the case of fixing using bonding, this includes the properties of the bonding surface), and similarity of the PWB stiffness, including the mass of the dummy parts, etc. shall be considered.

(4) In the case that an environmental test entailing temperature changes is to be implemented, the insert materials arrangement in the PWB in the in-plane direction and thickness direction, and the positional relationships and spacing of the parts in the in-plane direction and on the front and back shall be considered.

(5) The evaluation sample shall go through a manufacturing process, including processes, management procedures and in-process inspections, etc. which are equivalent to those of the product.

(6) In the case that rework is to be implemented through removal and replacement of a rejectable package, care shall be taken to ensure that the rework is subject to evaluation in the reliability test; for example by using a sample that has been through an equivalent history.

6.4.2 Reliability verification program

Implement the tests in accordance with the flowchart shown in Figure 0-5 and if defect is detected, the tested subject shall be rejected.

However, in the case that defect is identified in a visual inspection or a DPA, the verification program can be acceptable if it can be verified using statistical methods, such as the Weibull Analysis, etc. based on the specimen size that the property service life in the thermal shock test (a cumulative defect ratio of 63.2%) is at least a cumulative 500 cycles or at least the number of equivalent cycles in the temperature cycling test.

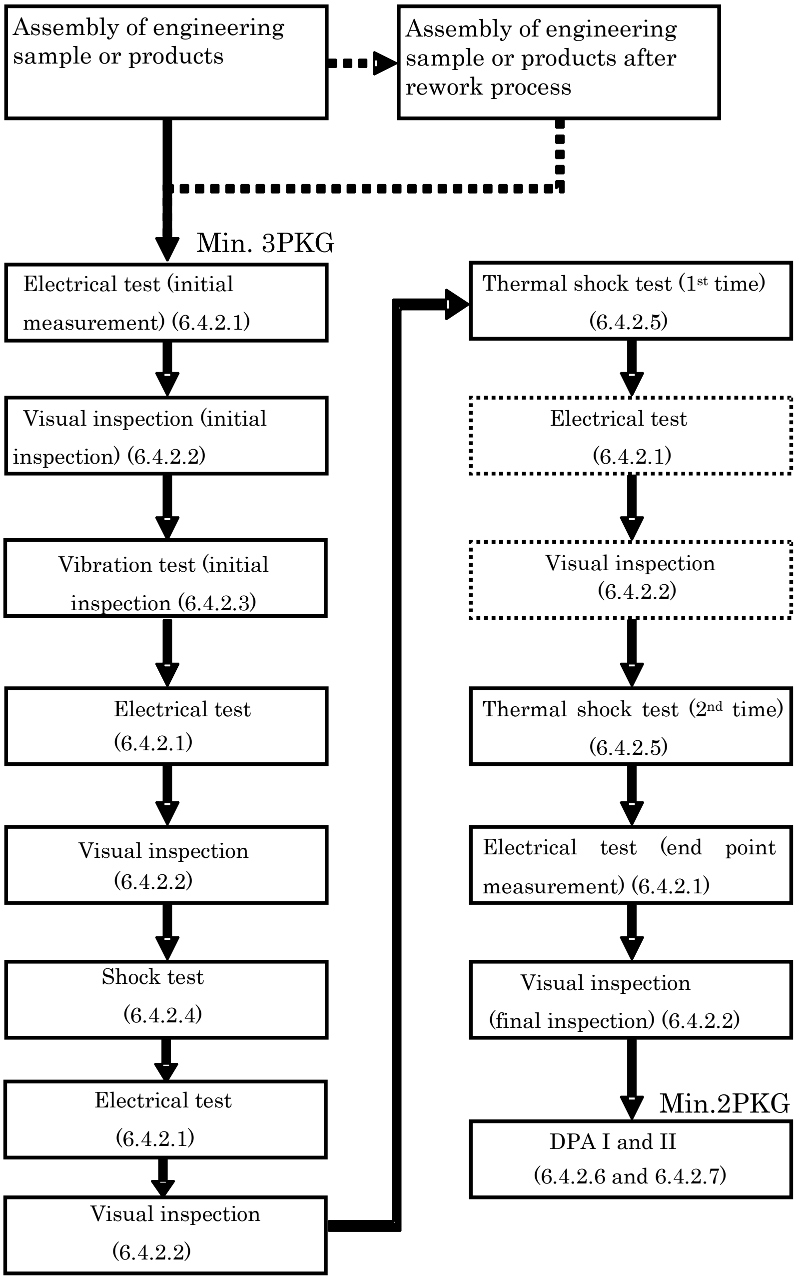


Figure 6- 8 Reliability verification program flowchart

6.4.2.1 Electrical test

Electrical test shall be as per Table 0-3.

The types of evaluation sample used in the electrical tests, and the test content and criteria shall be as per Table 0-3.

Table 6-4 Electrical tests

	Evaluation sample	Test content (1)	Criteria
1	Parts and board with functions equivalent to the product	Electrical properties test equivalent to the products (2)	As per the parts specifications (2)
2	A TEG with daisy chain wiring	Conduction resistance test	A fluctuation of 10% or more with respect to the initial measurement is rejectable (3)

Notes (1) In the case of an end point measurement, in addition to the room temperature test also implement tests at the highest temperature and lowest temperature of the temperature range at which operation is guaranteed as prescribed in the product environment specifications (and as necessary add the temperature margin).

(2) The test and criteria shall be able to confirm the conduction of the all signal terminal.

(3) In the case of conduction resistance measurements at the highest temperature and the lowest temperature, make the determination excluding the fluctuation range that is expected based on the temperature coefficient of conductor resistance.

6.4.2.2 Visual inspection

The visual inspection shall be performed in accordance with paragraph 0 of this standard. However, this is limited to the case in which inspection of the solder joints, etc. is feasible.

The visual inspection is carried out using a stereomicroscope capable of magnification of 20 times or more (when necessary a microscope with a prism mechanism) or a fiberscope microscope, depending on the joint size, but the scope of the inspection shall be the visible area such as the outside of the outer peripheral balls / columns of the package, that can be practically inspected.

The requirement for the column tilt (CGA) shown in paragraph 0 and Table 0-1 of this standard does not apply in the visual inspection (final inspection) shown in the flowchart in Figure 0-5.

Regarding the determination of crack propagation, the package will be determined to be rejectable in the case that propagation is seen in the solder joints between the package and the ball/column and between the ball/column and the PWB of a cumulative 1/4 or more of the perimeter in the case that the entire circumference of the joint can be inspected, or a cumulative 1/2 or more of the terminal width in the case that the joint can only be inspected from one side.

However, sacrificial terminals, which are designed on the assumption that the crack would propagate, are excluded from the scope of the inspection. Furthermore, except in the initial inspection, in the case of surface wrinkles and dullness in the gloss and deformation of the ball and column for which a clear crack cannot be identified, and furthermore in the case that a metallic ribbon, etc. is embedded in the solder ball/column and the package is designed for the purpose of ensuring electrical continuity even when a crack propagates in the solder part of the column, and within the scope that a ribbon exists, these cases can be excluded from being determined rejectable.

6.4.2.3 Vibration test

The vibration test shall be in accordance with the product environment specifications.

Note that in the case that the test is to be applied to multiple projects, the test conditions that are severer for the fatigue life of the solder joints shall be applied. Consistency with the monitoring method of the vibration level and design concept in the evaluation test shall be ensured.

Furthermore, during the test it is desirable to carry out continuously or intermittently at appropriate intervals electrical monitoring that can confirm the connectivity of the joints, including the electrical operation, etc.

6.4.2.4 Shock test

The shock test shall be in accordance with the product environment specifications. Note that in the case that the test is to be applied to multiple projects, the severer test conditions shall be applied. Consistency with the monitoring method of the shock level and design concept in the evaluation test shall be ensured.

6.4.2.5 Thermal shock test

Implement the thermal shock test in paragraph 4.4.2 (2) of JERG-0-043 (-30°C for at least 30 minutes/temperature change within 5 minutes/+100°C for at least 30 minutes) for 200 cycles the 1st time and 300 cycles the 2nd time, or as an equivalent method implementation of the temperature cycling test in paragraph 4.4.2 (1) of JERG-0-039 (-55°C for at least 15 minutes/ temperature change of about 30 to 90 minutes/+100°C for at least 15 minutes) for 80 cycles the 1st time and 120 cycles the 2nd time.

Furthermore, during the test carry out continuously or intermittently at appropriate intervals electrical monitoring that can confirm the connectivity of the joints, such as electrical tests, etc.

It is also acceptable to omit the electrical tests and visual inspections implemented in the 1st and 2nd thermal shock tests and implement a consecutive 500 cycles (200 cycles in the temperature cycling test) instead.

6.4.2.6 DPA I (Cross-section inspection)

Extract at least one sample for each package type from the specimen and implement the cross-section inspection of at least one place in accordance with paragraph 6.3.3.

The position of the cross-section inspection shall be the area for which the greatest amount of damage is predicted in the design or the area which is judged to have a lot of damage by the visual inspection.

In the case that a crack is identified in a ball/column or the surrounding conductive materials, the package shall be determined to be rejectable in the case that it exceeds a cumulative 25% of the width (or diameter) of the conductive part in the cross-section area.

However, sacrificial terminals, which are designed on the assumption that the crack would propagate, are excluded from the scope of the inspection.

Furthermore, in the case that a metallic ribbon, etc. is embedded in the column and the package is designed for the purpose of ensuring electrical continuity even when a crack propagates in the solder part of the column, and within the scope that a ribbon exists, this case can be excluded from being determined rejectable as long as there is no damage to the metallic ribbon.

6.4.2.7 DPA II (Dye penetrant test)

Extract at least one sample for each package type from the specimen and implement the dye penetrant test.*2

The position of the inspection of the penetration part shall be the area for which the greatest amount of damage is predicted in the design or the area which is judged to have a lot of damage by the visual inspection.

In the case that in the dye penetrant test there are penetration traces exceeding 25% of the original joint area, the entire terminal shall be determined to be rejectable.

However, sacrificial terminals, which are designed on the assumption that the crack would propagate, are excluded from the scope of the inspection.

Furthermore, in the case that a metallic ribbon, etc. is embedded in the column and the package is designed for the purpose of ensuring electrical continuity even when a crack propagates in the solder part of the column, and within the scope that a ribbon exists, this case can be excluded from being determined rejectable as long as there is no damage to the metallic ribbon.

Note *2: Implementation of the dye penetrant test is difficult in the case that the conformal coat cannot be peeled off or in the case that the underfill has been applied, etc. In these cases, make the accept/reject determination by increasing the number of cross-section places and directions of the DPAI (cross-section inspection) to make the evaluation. Furthermore, in the case of CGA, it is acceptable to make the accept/reject determination using the DPAI (cross-section inspection) instead of the dye penetrant test.

6.4.3 Electrochemical migration test (insulation reliability test)

In the case that flux residue is allowed on the back surface part of the BGA/CGA, the following evaluation test shall be carried out to obtain the technical judgment that the flux residue is harmless.

Furthermore, in the case that flux residue is allowed, a conformal coating shall be applied.

(1) Use an evaluation sample that simulates the worst case for the condition of the cleaning (a comb-shaped electrode board, etc.) to carry out the electrochemical migration test, it shall be verified that insulation resistance degradation and migration does not occur under high temperature and humidity conditions.

(2) A base material, surface treatment, solder materials, flux materials, and coating materials equivalent to those of the product shall be used in the evaluation sample.

(3) The test conditions shall be in accordance with the insulation reliability test in paragraph 4.4.2 (4) (60°C, 90-95% RH, rating bias applied) of JERG-0-043.

7. CONTROL ITEMS IN BGA/CGA PRODUCTS PRODUCTION

7.1 Parts management

7.1.1 Receiving inspection

In the receiving inspection, carry out the confirmation of designation, the number of items, and the exterior appearance. However, in the case of the CGA the column is easily deflected, meaning that caution is required for the handling, so the acceptance inspection may be omitted.

Furthermore, to ensure that the column is not deflected in the processes from receiving to board mounting, such as repacking, transportation and storage, etc., identify the risks arising from the handling of the CGA in each process and clarify the handling rules in order to reduce the risks. In addition, after the receiving inspection, it is desirable not to unpack the parts during the intermediary processes leading up to the mounting.

7.1.2 Storage

In the electrodes of the BGA/CGA the solder materials and the copper of the end surface of the ribbon are exposed. For these materials, a storage method that inhibits oxidation and the absorption of moisture shall be used. In particular, in the case of parts that require management of the absorption of moisture, the parts as stipulated by the parts manufacturers shall be managed. Furthermore, it is desirable to store the parts using the packing configuration they were in when they were delivered from the parts manufacturers.

7.2 Control items in mounting and the standards for the items

When producing products based on the mounting processes established by each mount manufacturer using the results of evaluation test for the purpose of establishing the mounting process, the manufacturing equipment and conditions for those products shall be reliably maintained and managed. Moreover, in the following items statements are made with respect to the particularly important elements.

7.2.1 Soldering mounting

(1) Baking of the members

For baking of the members, the following items in addition to the equipment, conditions, and methods established in paragraph 6.2.2 (1) of this standard shall be managed.

(a) Baking of the BGA/CGA

When baking the BGA/CGA, the baking temperature and the baking time shall be managed and recorded. Furthermore, the storage method from after baking until the mounting on the PWB shall be managed.

(b) Baking of the PWB (Dehumidification)

As a general rule, the baking of the PWB in accordance with paragraph 5.3.1 (Parts and materials inspection) of JERG-0-039 shall be implemented. The baking temperature and the baking time shall be managed and recorded. The storage method until the mounting on the PWB shall be managed.

(2) Solder paste printing

When doing the solder paste printing, manage the following items in addition to the equipment, materials, and methods established in paragraph 6.2.2 (2) of this standard.

(a) The time from the solder paste mixing to the commencement of printing shall be managed and recorded.

(b) The time from the printing to the installation of the parts

(c) Regarding the printing height, shape or volume, etc. carry out a total inspection, it shall be confirmed that they are within the standards prescribed based on the establishment of the process. The results shall be recorded.

(d) Regarding the printing position, carry out a total inspection, it shall be confirmed that they are within the standards regarding maximum alignment amount prescribed based on the establishment of the process. The results shall be recorded.

(3) Parts installation

When installing the BGA/CGA, the following items in addition to the equipment and methods established in paragraph 6.2.2 (3) of this standard shall be managed.

(a) Visual standards for the parts before the mounting of the parts

(4) Reflow soldering

When doing the reflow soldering of the BGA/CGA, the following items in addition to the equipment, conditions, and methods established in paragraph 6.2.2 (4) of this standard shall be managed. A discrepancy between the test configuration in the establishment of the process (the BGA/CGA, the PWB, and the heat load dummy) and the actual configuration used for the reflow soldering (the BGA/CGA, the PWB, and the other electrical parts) is only allowed in the case that evidence is possessed proving that the temperature distribution of the BGA/CGA mounting area is equivalent.

(a) Confirmation of the reproducibility of the temperature profile

Prior to the reflow soldering, it shall be confirmed that the manufacturing equipment can reproduce a temperature profile equivalent to the reflow implemented in the establishment of the mounting process. When acquiring the temperature profile, the following items shall be managed. The results shall be recorded.

- Temperature measurement position
- Temperature and time of the acquired temperature profile data
- Confirmation frequency

(b) Reflow soldering

When doing the reflow soldering, the following items shall be managed.

- The time from the end of the printing work to the commencement of the reflow
- The reflow configuration (whether or not there are parts installed other than the BGA/CGA, the PWB transfer direction, the PWB transfer speed, etc.)

7.2.2 Cleaning

When cleaning a PWB with a BGA/CGA installed, the following items in addition to the equipment, materials, and methods established in paragraph 6.2.3 of this standard shall be managed.

- The method for preventing the migration of foreign materials to the bottom surface of the BGA/CGA

7.2.3 Staking and fixing

When staking and fixing a BGA/CGA installed in a PWB, the following items in addition to the materials, equipment, conditions, and methods established in paragraph 6.2.4 of this standard shall be managed.

- A method in which the staking materials do not attach to the columns

7.2.4 Coating

When applying the coating, the process using the materials, equipment, conditions, and methods established in paragraph 6.2.5 of this standard shall be managed.

7.3 Product inspections

7.3.1 Visual inspection

The inspection items are the same as in paragraph 0. The scope that can be verified from the peripheral side surface shall be visually inspected in accordance with Table 7-1.

The inspection results shall be recorded.

Table 7-1 Visual inspection items and criteria for BGA/CGA (1)

Items	Requirements	
	BGA	CGA
Pad-ball (column) alignment	The ball offset from the pad shall be 25% or less of the PWB pad diameter	The column overhang from the pad shall be 15% or less of the PWB pad diameter
Column tilt (CGA)	—	Marked tilts are nonexistent (2)
Ball (column) shape	Chips are nonexistent	Chips and deflections are nonexistent
Solder bridge	Nonexistent	
Soldered connection	The solder paste has melted and smoothly connected to the ball	The solder joint is smoothly connected from the column to the pad
Solder fillet	—	The solder is filled between the bottom of the column and the pad is wet, and forms a solder fillet that moistens 180° or more of the circumference of the column
Foreign materials	Metal foreign materials of 0.1mm or more are nonexistent	

Notes (1) Inspect the scope that can be visually verified from the peripheral side of the package.
(2) Refer to Figure 16-23 in ECSS-Q-ST-70-38C.

7.3.2 X-ray inspection

Regarding the back surface of the BGA/CGA which cannot be visually inspected, as a general rule carry out the inspection using transmission type X-rays in accordance with Table 7-2. If items shown in the table other than the X-ray inspection equipment can be detected, inspections using substitute equipment are allowed. The X-ray inspection equipment to be used shall have the resolution stated in paragraph 6.3.2. Furthermore, in the case that foreign materials have migrated into the back surface of the BGA/CGA after the mounting, inspection and removal may be difficult, so examine measures in advance to reduce the risk of foreign materials migration. The inspection results shall be recorded.

Table 7-2 X-Ray inspection items and criteria for BGA/CGA

Items	Requirements	
	BGA	CGA
Ball (column) absences	Nonexistent	
Solder bridge	Nonexistent	
Foreign materials	Impermeable foreign materials of 0.1mm or more are nonexistent. Impermeable foreign materials less than 0.1mm shall be a size of 1/2 or less of the gap between the pads	
Column tilt (CGA)	No significant collapse	

7.4 Storage and transportation

The method for preventing the migration of foreign materials to the bottom surface of the BGA/CGA shall be managed.

8. REWORK

Rework for the purpose of re-use of the BGA/CGA is prohibited. In this section the rules regarding the re-use of boards, etc. with the BGA/CGA removed are prescribed.

In the case that rework is to be implemented, on the assumption that the design considerations (paragraph 6.1.2 (4) of this standard) have been satisfied, processes such as the removal method and re-mounting method, etc. shall be established in advance and the reliability evaluation shall be implemented in accordance with paragraph 6.4.2 of this standard.

The re-heating method at the time of the rework is limited to local reflow.

When reworking, the following items; heating equipment, identification (ID) of the dedicated fixtures (if required), the heating method, the management standards related to the increased temperature and exposure time of the PWB, the management standards related to the increased temperature and exposure time of the peripheral parts, the management standards related to the number of reworks, and the state of damage to the pads and resists after removal shall be managed.

Appendix I Terms and definitions

(1) Back surface

This refers to the surface on the package side on which the electrode of the BGA/CGA is installed.

(2) Ball fall-out

This refers to the solder ball in the BGA package falling out so that it is not in the prescribed position.

(3) BGA (Ball Grid Array)

A BGA is a surface mounting LSI package that forms bumps in a grid pattern on the bottom surface of the package as the external connection terminal.

(4) Bottom surface

This refers to the space from the back surface of parts to the top surface of the PWB.

(5) CGA (Column Grid Array)

A CGA is a surface mounting LSI package that forms columns in a grid pattern on the bottom surface of the package as the external connection terminal.
(The CGA can achieve the effect of mitigating the thermal stress between the board and package by replacing the ball-shaped bumps of the BGA with metals, alloys or their compounds to form a cylindrical external connection terminal.)

(6) Column

The columns are cylindrical electrodes lined up in a grid pattern of the CGA.

(7) Column fall-out

This refers to the solder column in the CGA package falling out so that it is not in the prescribed position.

(8) Column tilt

This refers to the angle of tilt of the column with respect to the vertical direction of the CGA package.

(9) Coplanarity

This shows the coplanarity of the tips of the bumps or columns, and refers to the homogeneity of the external terminal tips (lowest surfaces) with respect to the PWB mounting surface of the BGA and CGA.

(10) Dog-Bone

This is the connection pad on the PWB that is opposite to the external connection terminal of the BGA and CGA, and is the connection structure of the PWB pattern that forms the land of the through-hole for the inner layer connection adjacent to the soldering pad.

It is called by this name because it looks similar to the toy for dogs which is a bone in the shape of a barbell.

(11) NMSD (non-solder mask defined) pad

This is a pad structure that defines the pad shape and dimensions using the conductor pattern rather than the aperture of the solder mask of SMD.

It establishes a resist aperture that is larger than the conductor pattern and has a structure in which the base material is exposed in the pad circumference and the surrounding area is covered by the resist pattern.

(12) Sacrificial terminal

This is a terminal that is set up for the subsidiary purpose of preventing the destruction of other terminals, and is set up in the case that even if this terminal itself is destroyed there will be no electrical or mechanical effect on the system overall. Note that it is the floating conductor so normally it is connected to a ground or power source.

It is sometimes called a dummy pin but in this standard we use this expression because it has the purpose of protecting or extending the service life of the other terminals.

(13) SMD (solder mask defined) pad

This is a pad structure that defines the pad shape and dimensions using the aperture of the solder mask (solder resist).

It establishes a resist aperture that is smaller than the conductor and has a structure in which the conductor pattern of the pad circumference is covered by the resist.

The expression is used in contrast to NSMD. Do not confuse it with SMD (Surface mounting Device) which generally refers to surface mounting parts.

(14) Staking

This refers to mechanically fixing of the BGA and CGA package to the PWB using bonding and attachments.

(15) Underfill

This is similar to staking but mainly organic resin is filled into the gap with the PWB for the purpose of terminal protection and sealing particularly when mounting on the PWB the parts formed by the external connection terminal on the bottom surface, such as the flip chip and BGA package, etc.

(16) Un-melted (BGA/CGA)

This refers to the condition in which the ball of the BGA or the column of the CGA does not melt with the printed solder paste and therefore is not wet.

(17) Via in Pad / Pad on Via

This is the connection structure of the PWB pattern that forms the soldering pad directly above the through-hole for the inner layer connection in contract to the Dog-Bone.

It is similar to the "stack via" structure piled up vertically that is seen in build-up boards, in which mainly organic resin is filled into the through-hole that goes through the rigid board of the layer system, and it is plated to form the pad.

(18) Void

This refers to the condition in which cavities and air bubbles occur inside the solder, organic resin, etc.

In engineering the term "void" refers to a vacuum, and cavities filled with gas are called air bubbles or pores but as a matter of common practice the term "void" is used with the meaning of something not being where it should be, including air bubbles.

(19) Void ratio

The ratio of the cross-sectional area of voids to the cross-sectional area of the solder joint (including void areas).