AC190

Application Note

Ceramic Column Grid Array

Released

June 2019

Microsemi

a Microchip company

Contents

1 Revision History

The revision history describes the changes that were implemented in the document. The changes are listed by revision, starting with the most current publication.

1.1 Revision 5.0

Revision 5.0 was published in June 2019. The following is the summary of changes.

- Updated figure 15 (see page 17) CCGA PCB Layout Reference.
  - Added CG1657.
  - Corrected “1.3 mm line” to “0.3 mm line” (a typo, SAR 90909, SAR 103078).
  - Corrected “Polyimate” to “Solder Mask”.
- Updated figure 7 (see page 8) with adding CG1657 (SAR 103084).
- Changed Microsemi logo to Microchip/Microsemi logo.

1.2 Revision 4.0

In this revision, figure 17 (see page 19) and figure 18 (see page 20) (SAR 75744) were updated. Reference link to "Ceramic Column Grid Array Assembly and Rework" from References (see page 21) section (SAR 80183) was also removed.

1.3 Revision 3.0

This revision had the following changes in the document.

- Added figure 9 (see page 14), figure 11 (see page 15) and included CG484, CG896 packages and details of dimensions (SAR 65023).
- Updated Incoming Visual Inspection for CCGA Devices (see page 11) section (SAR 65023).
- Removed multiple images of CCGA and LGA and retained only representative images. (SAR 65023).
- Updated Handling and Storage of CCGA Component (see page 7) section (SAR 65023).
- Updated document for editorial corrections (SAR 65023).

1.4 Revision 2.0

- Modified table 1 (see page 4) (SAR 41355).
- Modified Column Attach and CCGA Board-Level Reliability (see page 6) section (SAR 42037).

1.5 Revision 1.0

This is the first publication of this document.

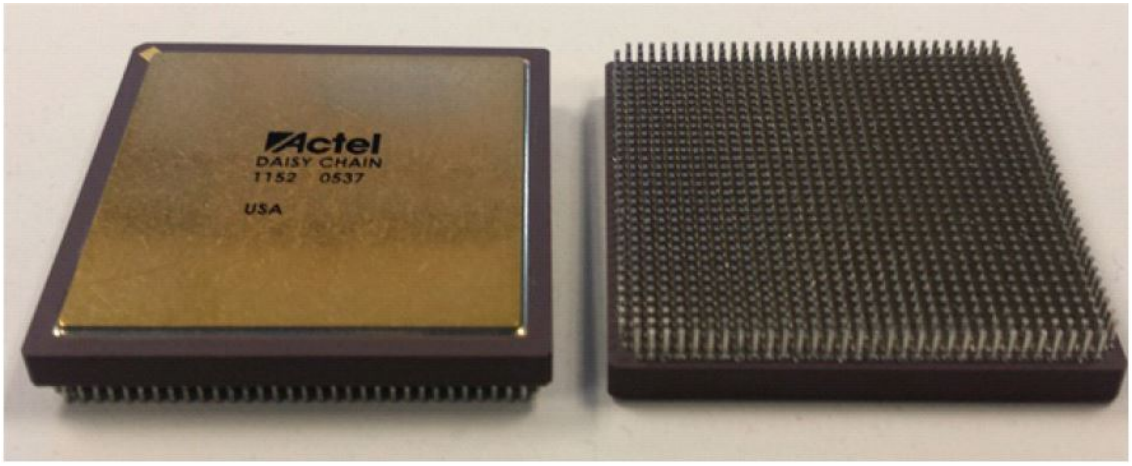
2 Introduction

Ceramic column grid array (CCGA) packages are becoming increasingly popular as an alternative to ceramic ball grid array (CBGA) packages for applications requiring very high-density interconnection with higher board-level reliability. The CCGA packages use high-temperature solder columns instead of high-temperature balls. This creates a greater standoff, providing a flexible interconnection with improved thermal characteristics, significantly increasing the thermal fatigue life of the package solder joint.

Microsemi has selected the CCGA technology as part of its high-density, high I/O count hermetic package offering. A 483-pin (CG484 with actual pin count of 483), 624-pin CCGA (CG624), 896-pin CCGA (CG896), 1152-pin CCGA (CG1152), and 1272-pin CCGA (CG1272) are offered for the RTAX-S, RTAX-SL, RTSX-SU, Axcelerator®, and ProASICPLUS® field programmable gate array (FPGA) product families. A 1657-pin CCGA is available for the RTG4® product family.

The following representative photograph of the CCGA shows top and bottom views. Figure 2 (see page 3) and figure 3 (see page 3) show a close upper view of the solder columns.

Figure 1 • Representative Photographs of CCGA Showing Top and Bottom View



3 CCGA Package Description

The CCGA is a multi-layer ceramic package with attributes including:

- Dark ceramic, same material as Microsemi CQ208, CQ256, and CQ352 packages.
- The solder column is either 80Pb/20Sn with a spiral copper ribbon, or 90Pb/Sn10 without a spiral copper ribbon (see figure 2 (see page 3) and figure 3 (see page 3)) attached to the ceramic substrate I/O pads through eutectic 37/63 Pb/Sn, forming a eutectic solder joint. See figure 4 (see page 4) for more details.
- CG484 to CG1272 uses bond wire to interconnect silicon to the package. The die cavity is on the top side of the package, and is hermetically sealed with AuSn eutectic material.
- The CG1657 uses eutectic bump (flip chip) to interconnect silicon to the package. The device has underfill between die and package, and has Thermal interface material between lid and package. The package is hermetically sealed using seam seal.
- The lid is connected to ground.

Note: The solder column from BAE with 90Pb/10Sn has been discontinued since 2007 under product discontinuation notice (PDN) 0703.

Figure 2 • 90Pb/10Sn Column Side-View and Tip-View, with 20 Mils Diameter

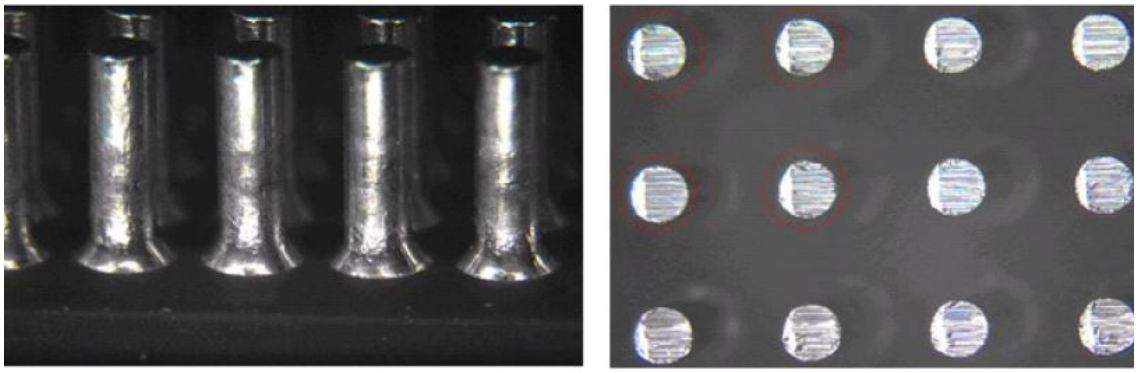


Figure 3 • 80Pb/20Sn Column Side-View and Tip-View, with 20 Mils Diameter

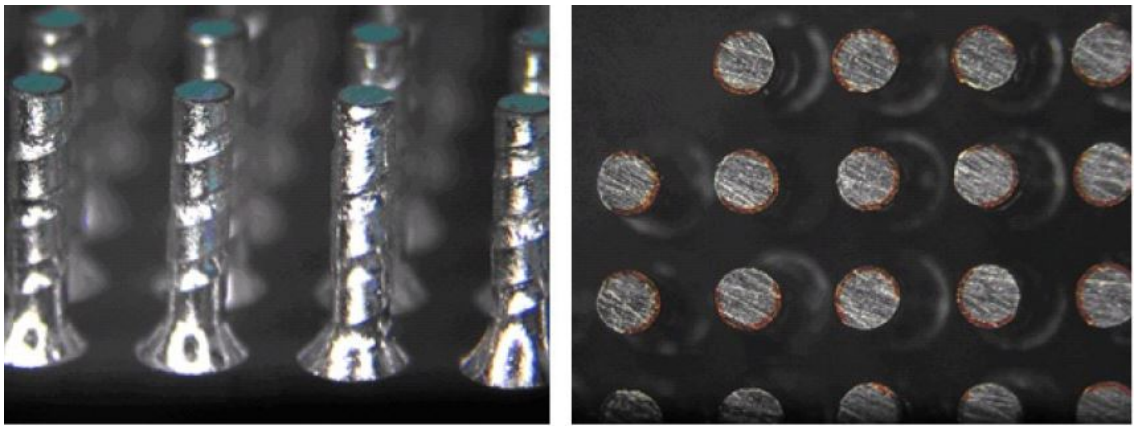
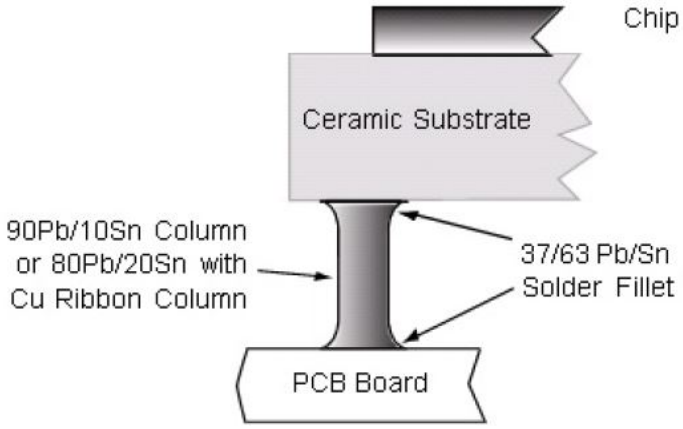


Figure 4 • CCGA on PCB



The following table contains package dimensions, descriptions, and details on the packaging and solder columns used in the assembly process for each of the Microsemi CCGA packages.

Table 1 • Microsemi CCGA Package and Solder Column Information

	CG484	CG624	CG896	CG1152	CG1272	CG1657
Column Information						
Column attach site	Six Sigma	Six Sigma	Six Sigma	Six Sigma	Six Sigma	Six Sigma
Column composition	80Pb/20Sn	80Pb/20Sn	80Pb/20Sn	80Pb/20Sn	80Pb/20Sn	80Pb/20Sn
Copper ribbon	Yes	Yes	Yes	Yes	Yes	Yes
Column height	2.21 mm (0.087")	2.21 mm (0.087")	2.21 mm (0.087")	2.21 mm (0.087")	2.21 mm (0.087")	2.21 mm (0.087")
Column diameter	0.51 mm (0.020")	0.51 mm (0.020")	0.51 mm (0.020")	0.51 mm (0.020")	0.51 mm (0.020")	0.51 mm (0.020")
Column coplanarity	0.15 mm (0.006")	0.15 mm (0.006")	0.15 mm (0.006")	0.15 mm (0.006")	0.15 mm (0.006")	0.15 mm (0.006")
Package Information						
Body size	23.0 mm^2	32.5 mm^2	31.0 mm^2	35.0 mm^2	37.5 mm^2	42.5 mm^2
Column pins	483	624	896	1152	1272	1657
Column pin notes	Orientation pin A1 (no column)	Orientation pin A1 (no column)	Corner stress relief (1 pin each corner)	Corner stress relief (1 pin each corner)	Corner stress relief (6 pins each corner)	Corner stress relief (6 pins each corner)
Lead pitch	1.00 mm	1.27 mm	1.00 mm	1.00 mm	1.00 mm	1.00 mm
Ceramic thickness	3.001 mm	2.28 mm	3.51 mm	2.77 mm	2.77 mm	2.00 mm
Total weight of columns	1.27 g	2.35 g	3.38 g	4.37 g	4.80 g	6.25 g

	CG484	CG624	CG896	CG1152	CG1272	CG1657
JEDEC registration	JEDEC MO-158 VAR xx-x	JEDEC MO-158 VAR BE-1	JEDEC MO-158 VAR CD-1	JEDEC MO-158 VAR CG-1	JEDEC MO-158 VAR CH-2	JEDEC MO-158 VAR xx-xx-x

4 Column Attach and CCGA Board-Level Reliability

The 80Pb/20Sn solder column with copper ribbon attachment process for Microsemi CCGA devices is provided by Six Sigma in Milpitas, California. Microsemi 80Pb/20Sn CCGA packages follow the CCGA design and manufacturing rules of Six Sigma. A copy of the Six Sigmas CCGA qualification summary can be obtained by contacting either Microsemi or Six Sigma directly.

Until 2007, Microsemi supplied the CCGA with 90Pb/10Sn columns and attachment by BAE systems in Manassas, Virginia. BAE licensed their CCGA technology directly from IBM and has completed extensive board-level reliability testing, including thermal cycle, pro shock, and vibration tests for its CCGA packaging process, qualifying it for space-flight-level applications. A copy of the BAE systems CCGA qualification summary can be obtained by contacting Microsemi.

In addition to the qualification data provided by BAE systems and Six Sigma, Microsemi completed its own CCGA board-level thermal cycling test on both the 90Pb/10Sn column and 80Pb/20Sn column devices. This test report can be downloaded at Thermal Cycling Test Report for Ceramic Column Grid Array Packages — CCGA.

Board-level reliability is influenced by many factors such as PCB design, layout, fabrication rules, PCB construction method and material, assembly process variations (solder paste screening, component placement, solder reflow, thermal profile, cleaning, inspection, and rework process, and so on), and various application environments. Microsemi recommends that the end user of CCGA devices evaluate their application conditions and define a specific qualification plan.

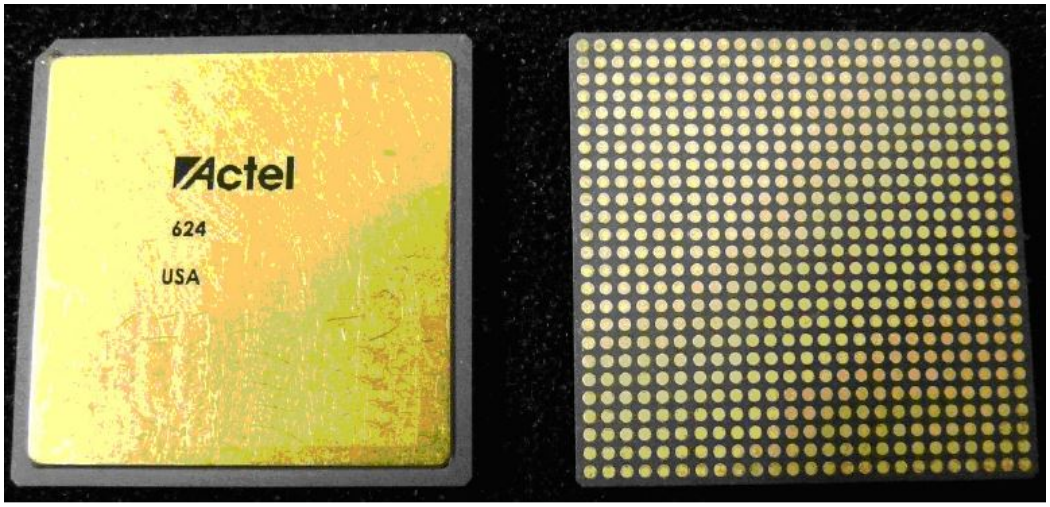
5 Manufacturing Handling and Assembly

This section describes the manufacturing handling and assembly for the device.

5.1 Manufacturing and Screening

Solder columns are ductile and susceptible to bending. For this reason, Microsemi processes the CCGA packages in the land grid array (LGA) format. (Solder columns are not attached at this stage, see figure 5 (see page 7)). CCGA devices are assembled as LGA packages until they have completed all the mechanical/environmental screening, electrical test, and burn-in). Solder columns are attached to the LGA following post burn-in electrical test. The processes that are conducted after solder column attachments are 100% QA electrical testing and 100% mechanical visual inspection.

Figure 5 • LGA624 Top and Bottom View



5.2 Handling and Storage of CCGA Component

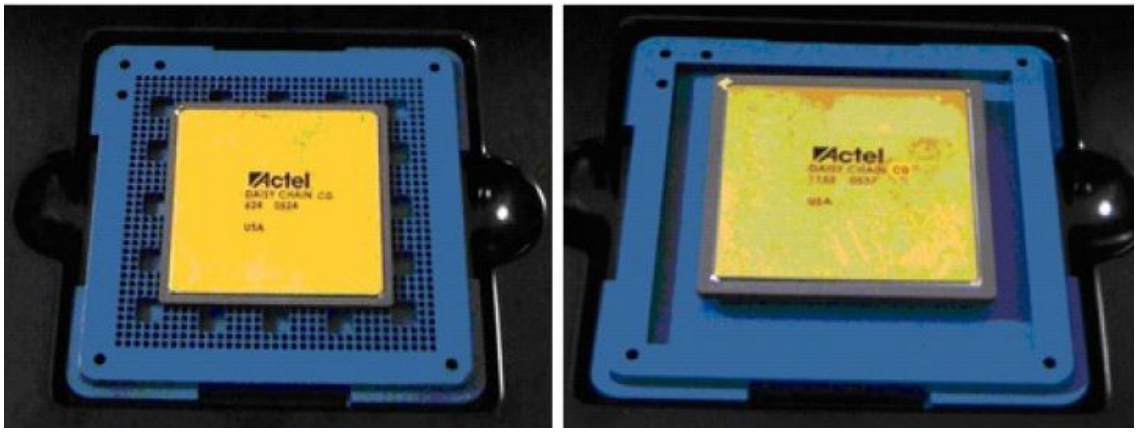
It is very important for end users to handle CCGA packages properly in order to prevent damage to the column pins. Extreme care must be taken when handling CCGA devices during programming, testing, and PCB assembly.

- Microsemi ships each CCGA component in a tray carrier with a column protection feature. The tray carrier is then stored in a black ESD-protective jewel box and is sealed inside a moisture barrier bag (MBB). See figure 6 (see page 8) and figure 7 (see page 8) for photographs of the tray carrier and CCGA component seating on the tray carrier.
- Always open the black jewel box from the top to ensure that the blue carrier is facing up inside (product label and ESD warning stickers are on the top side of the box lid).
- Do not handle CGA with fingers. Use vacuum pen when removing CGA component from the blue carrier.
- CCGA component must remain sealed in moisture barrier bag until ready for use. In the event that the MBB must be opened for visual inspection of the unit, this must be resealed prior to storage. Removal of the dry pack material may initiate the solder column oxidation that occurs over time.

The MBB provides sufficient protection for several years. When end-users intend to store CCGA beyond two years after receiving from Microsemi, it is recommended to store them in a nitrogen cabinet.

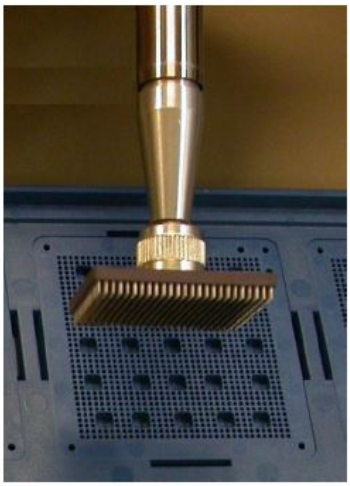
Figure 6 • The Blue Tray Carrier for CGA with 1.27 mm Column Pitch (Left) and the Carrier for CGA with 1.0 mm Column Pitch (Right)

Figure 7 • CG624 in its Carrier (Left) and CG1152 in Blue Carrier with 1.0 mm Column Pitch (Right)



Note: The same carrier with 1.0 mm column pitch is used for CG484, CG896, CG1272, and CG1657.

Figure 8 • Vacuum Pen Picks up and Returns the CCGA Component to the Blue Carrier



6 Programming with CCGA Packaged Part

In preparation for device programming, open the moisture barrier bag (MBB) and use a vacuum pick-up pen to lift the unit from the tray carrier. Do not handle manually; column pins can be easily bent if carelessly handled while picking up the unit from the carrier.

1. Carefully place the unit into the programming socket. Align the CCGA component with the socket frame.
2. Make sure that the unit is fully seated into the socket alignment frame without any misalignment. Carefully close the socket lid and begin programming.
3. When programming is complete, use the vacuum pick-up pen to gently remove the unit from the socket, placing it back to the tray carrier. Conduct board-level assembly as soon as possible or return the part to MBB until it is ready for board-level assembly. This step is to prevent solder oxidation.
4. When resealing the MBB bag, do not apply excess vacuum pressure. During re-dry-pack, it may damage the black ESD jewel box, which in turn may damage the CG package.

6.1 Damaged or Bent Columns

- If the solder column is bent in such a way that the center of the solder column is offset by less than 15° and will not fit into the shipping carrier, then rework must be done to straighten the damaged column.
  - Solder columns that are bent more than 15° should not be straightened.
  - For Class V devices, column straightening is not allowed.
- A solder column that is slightly bent (≤7°) will self-align when inserted back to socket. This is not classified as rework.
- Microsemi does not offer solder column rework. Damaged columns are expensive and time consuming to repair. Therefore, it is important for end users to closely follow the CCGA package handling instructions in order to prevent costly solder column damage.
- Microsemi Silicon Sculptor programming module is designed specifically for solder columns manufactured and attached by both BAE Systems and Six Sigma. Microsemi does not guarantee that Silicon Sculptor operates correctly with solder columns reworked by third parties or columns other than those supplied by Microsemi and its column attach partners.

7 Incoming Visual Inspection for CCGA Devices

End users may require incoming visual inspection of CCGA devices after they are received from Microsemi. Extra caution must be exercised to ensure that the CCGA devices are not damaged during inspection and the devices are seated properly on the tray carrier, which is then stored in the black jewel box and secured there with extra ESD tape. After the inspection, all devices must be resealed with dry pack as soon as possible. For long-term storage, Microsemi strongly recommends the use of a nitrogen-filled environment.

See MIL-STD-883 TM2009 for visual inspection criteria.

8 Daisy Chain and Mechanical Samples

Daisy-chain packages are used to conduct assembly process development and board-level qualifications and are available from Microsemi. End users may contact Microsemi to purchase daisy-chain samples of the CG484, CG624, CG896, CG1152, CG1272, or CG1657 packages.

Frequently, end users of Microsemi FPGAs request mechanical samples for production setup. These will not be available for the CCGA packages due to the high cost of solder column attachment.

9 Conclusion

CCGA packages will continue to be the high-reliability and high-density package solution of choice for space applications. Similar to CBGA in methodology and board-level manufacturing techniques, proper storage and good handling must be exercised to avoid solder column damage and oxidation. CCGA packages, with their enhanced reliability due to heat dissipation and reduced thermal expansion, enable a more reliable interconnection to the PCB and provide the best solution for achieving high I/O counts on a reduced footprint.

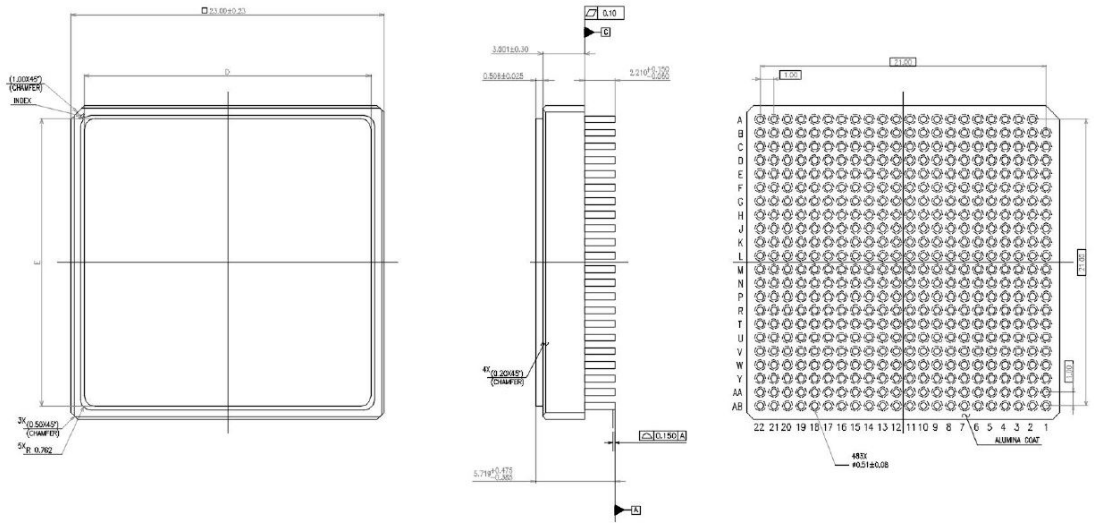
This application note provides general guidelines to assist end users in implementing CCGA packages in their high-reliability applications. For further assistance, contact either your local Microsemi sales representative, email Technical Support at soc_tech@microsemi.com or call the Microsemi hotline at (800) 262-1060.

10 Appendix: CCGA Package Dimensions and Assembly Parameters (Reference Only)

10.1 CCGA Package Outline Drawings

The following sections describe the dimensions of the CCGA package and the assembly parameters. This information is for reference only.

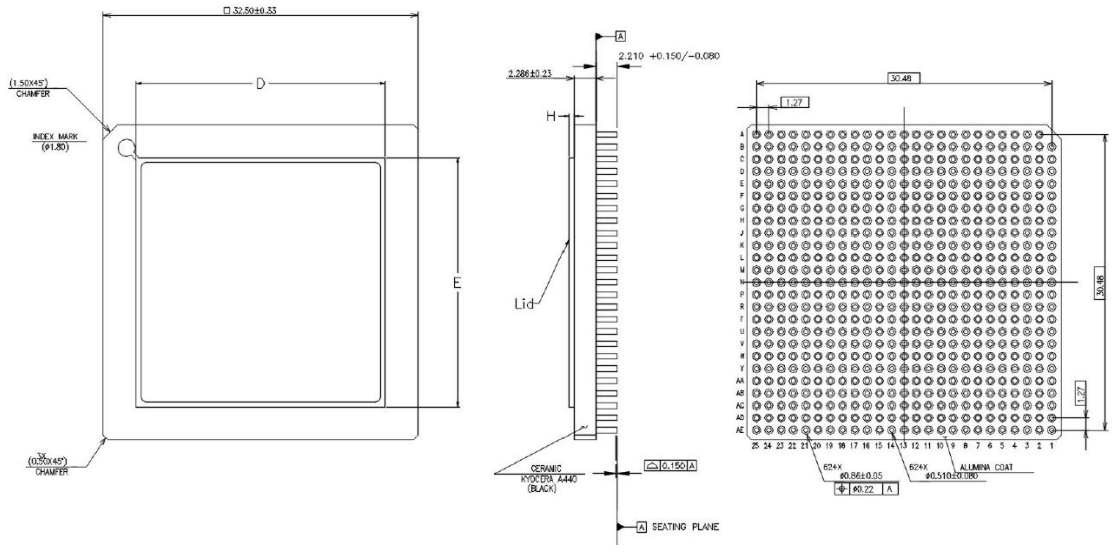
Figure 9 • Package Outline Drawing of CG484



Notes:

1. *Solder Column Material: 80Pb/20Sn with Cu Ribbon.*
2. *Units: mm.*
3. *LID size D and E varies due to different die and package cavity sizes.*

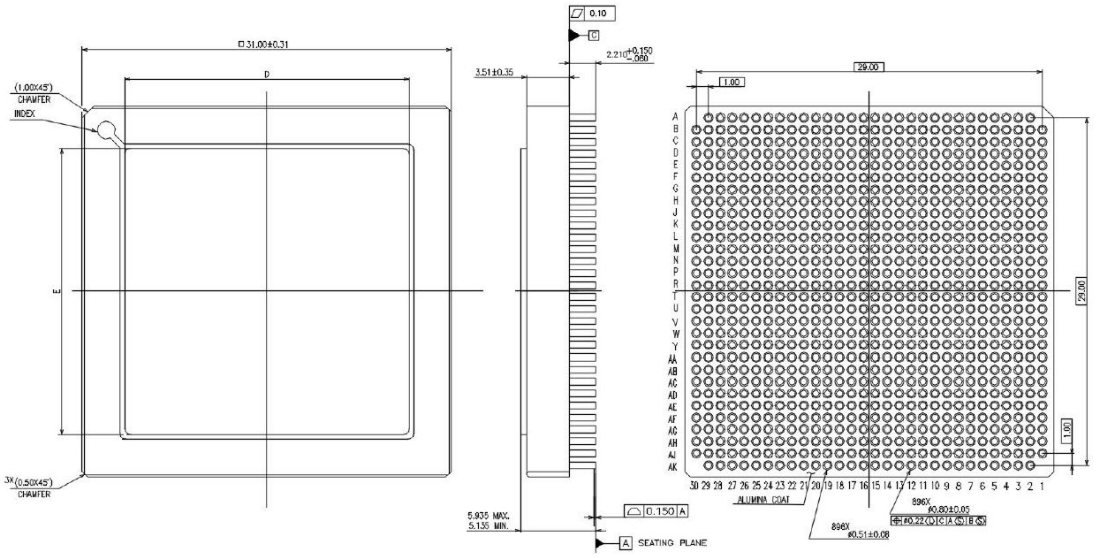
Figure 10 • Package Outline Drawing of CG624



Notes:

1. *Solder Column Material: 80Pb/20Sn with Cu Ribbon.*
2. *Units: mm.*
3. *LID size D and Evaries due to different die and package cavity sizes.*

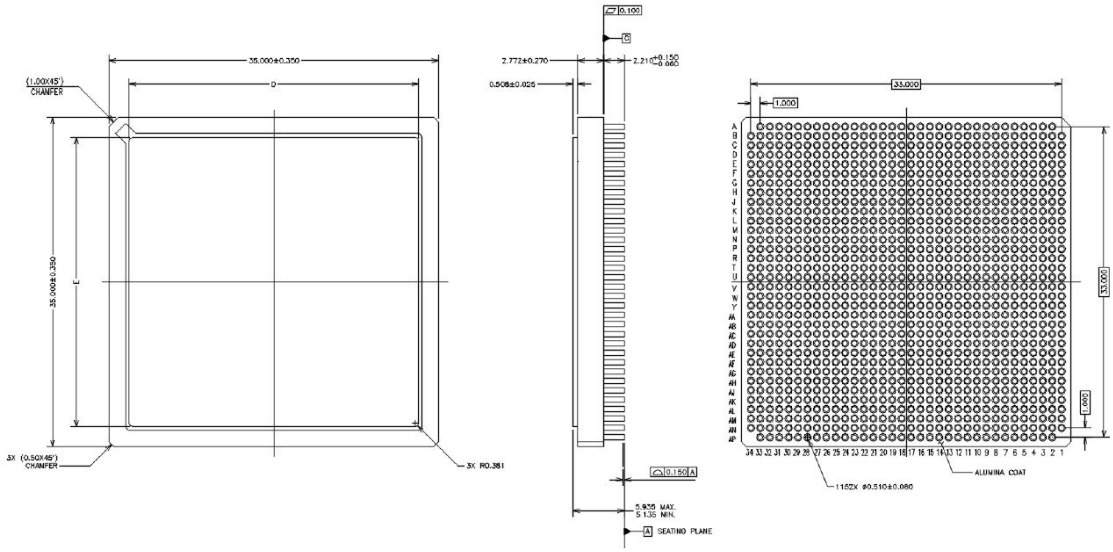
Figure 11 • Package Outline Drawing of CG896



Notes:

1. *Solder Column Material: 80Pb/20Sn with Cu Ribbon.*
2. *Units: mm.*
3. *LID size D and E varies due to different die and package cavity sizes.*

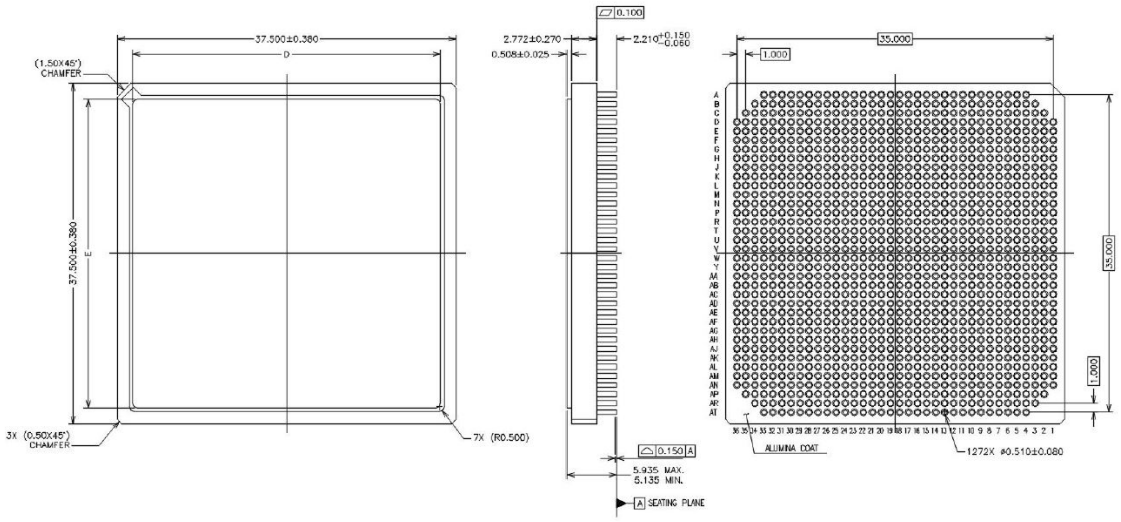
Figure 12 • Package Outline Drawing of CG1152



Notes:

1. *Solder Column Material: 80Pb/20Sn with Cu Ribbon.*
2. *Units: mm.*
3. *LID size D and E can be varies due to different die size.*

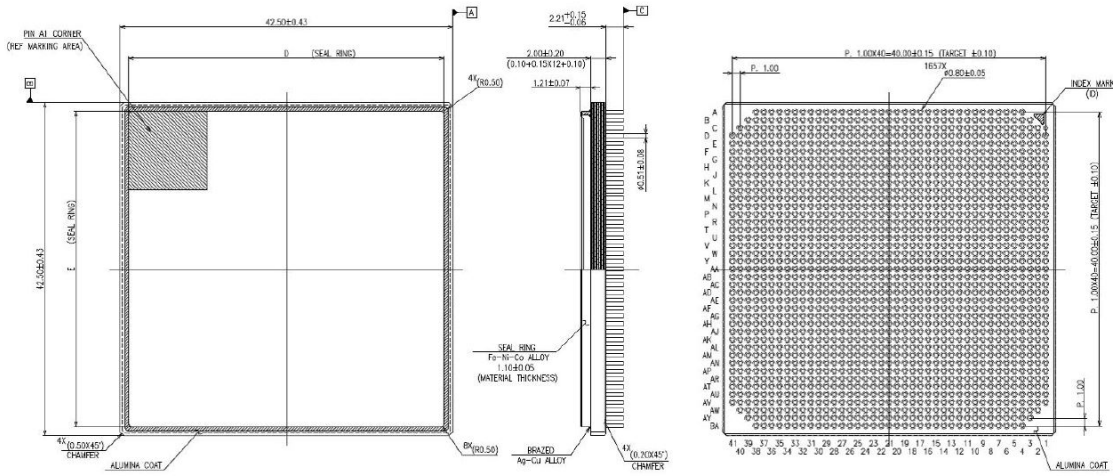
Figure 13 • Outline Drawing of CG1272



Notes:

1. *Solder Column Material: 80Pb/20Sn with Cu Ribbon.*
2. *Units: mm.*
3. *LID size D and E can be varies due to different die size.*

Figure 14 • Outline Drawing of CG1657

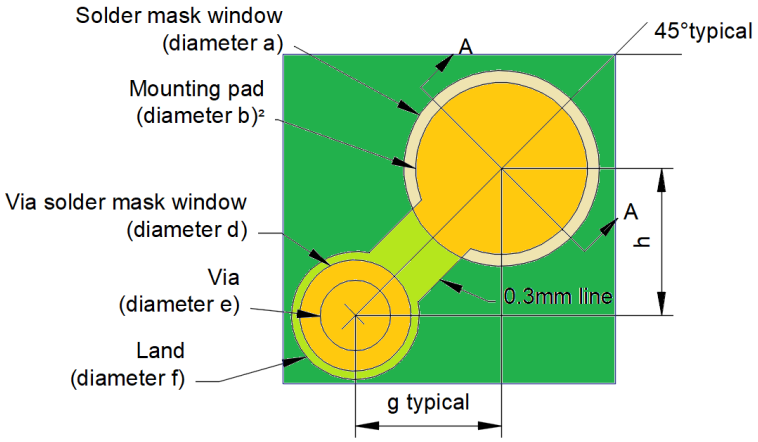


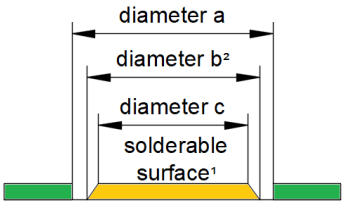
Notes:

1. *Solder Column Material: 80Pb/20Sn with Cu Ribbon.*
2. *Units: mm.*
3. *LID size D and E can be varies due to different die size.*

10.2 PCB Pad Layout Reference

Figure 15 • CCGA PCB Layout Reference





Section A-A

diameter	1.27mm pitch	1.00mm pitch
a	0.851	0.800
b	0.749	0.700
c	0.720	0.670
d	0.483	0.380
e	0.305	0.200
f	0.560	0.460
g	0.635	0.500
h	0.635	0.500

CCGA package list	
1.27mm pitch	CG624
1.00mm pitch	CG484, CG896, CG1152, CG1272, CG1657

All dimensions are in mm unless otherwise specified

Notes:
1. Functional surface
2. Normal diameter at Copper/Solder Mask interface with typical edge angle

11 PCB Solder Stencil and Paste

Stencil screen opening

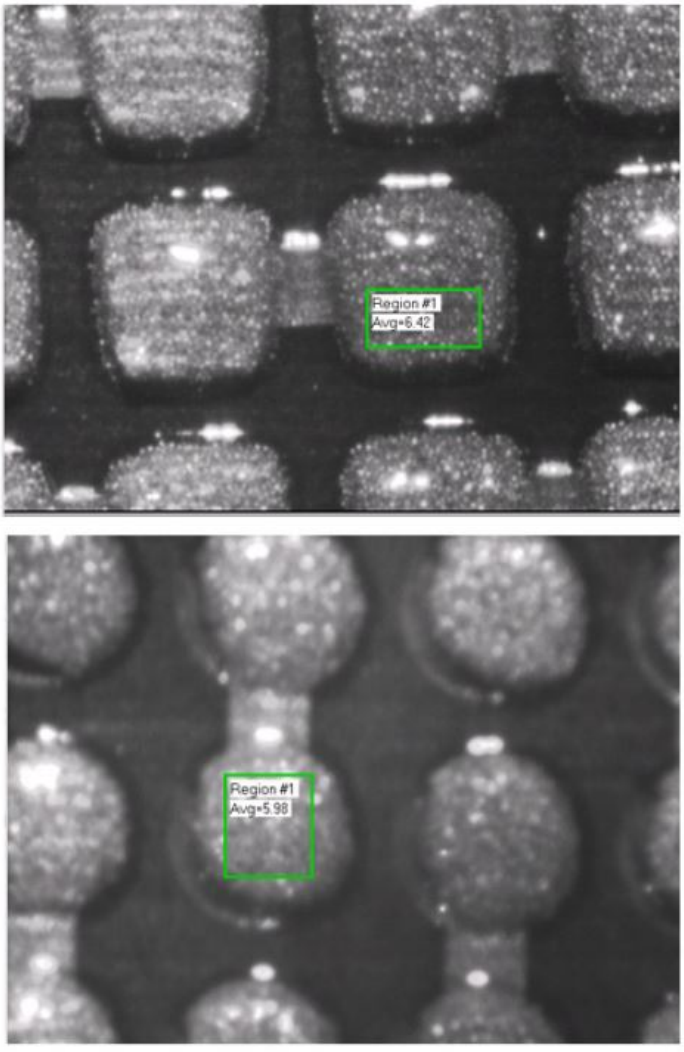
CG624: 30 × 30 × 7 mils

CG1152 and CG1272: Ø28 × 6 mils

Solder Paste: Qualitek, Type 798 Water Soluble, Alloy Sn63/Pb37

Note: Use circle screen opening (instead of square screen opening) for CG484, CG896, CG1152, CG1272, and CG1657 to avoid solder paste bridging for 1.0 mm pitch.

Figure 16 • Solder Paste on CCGA624 PCB (Upper) and on CCGA1152/1272 (Lower)



12 PCB Reflow Reference

Stencil screen opening

CG624: 30 × 30 × 7 mils

CG1152 and CG1272: Ø28 × 6 mils

Solder Paste: Qualitek, Type 798 Water Soluble, Alloy Sn63/Pb37

Note: Use circle screen opening (instead of square screen opening) for CG484, CG896, CG1152, CG1272, and CG1657 to avoid solder paste bridging for 1.0 mm pitch.

Figure 17 • CCGA Thermal Cycling Test PCB Reflow Profile

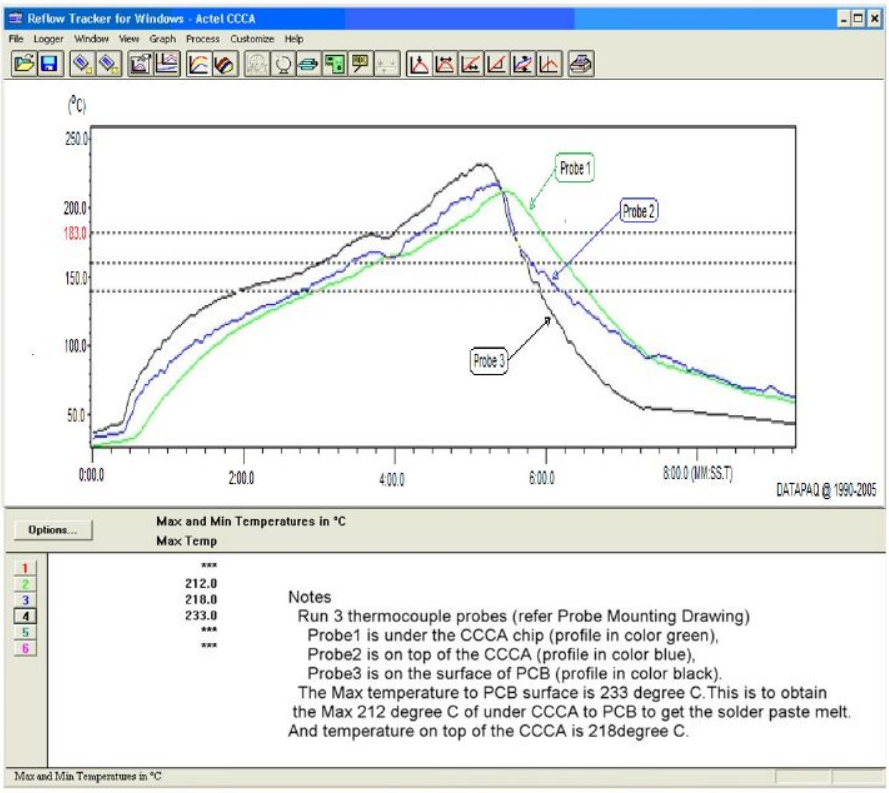
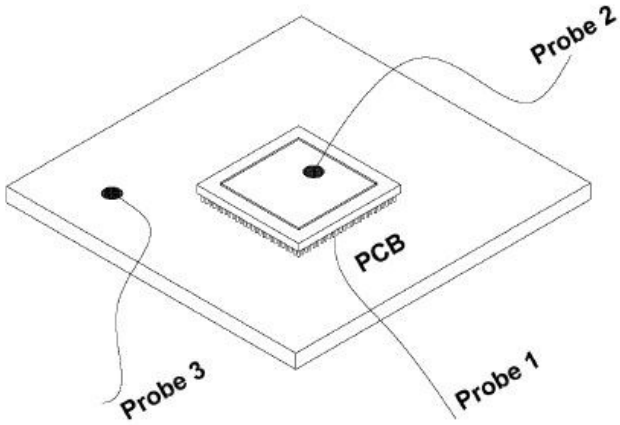


Figure 18 • CCGA Assembly Reflow Profile (Upper) and Temperature Probe Locations (Lower)



Notes:

- Probe 1 is mounted on PCB top surface and in center of package.
- Probe 2 is mounted on top LID of package.
- Probe 3 is mounted on PCB top surface.
- Adjust reflow oven parameter to achieve the 3 probes with similar profile (without large variation).

13 References

The following document is referred to in this document.

Thermal Cycling Test Report for Ceramic Column Grid Array Packages – CCGA

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