Ceramic Column Grid Array

Table of Contents

Introduction .................................................. 1
CCGA Package Description .................................. 2
Column Attach and CCGA Board-Level Reliability ............. 4
Manufacturing Handling and Assembly ......................... 5
  Manufacturing and Screening .............................. 5
  Handling and Storage of CCGA Component .................. 5
Programming with CCGA Packaged Part ....................... 7
  Damaged or Bent Columns ................................ 7
Incoming Visual Inspection for CCGA Devices .................. 7
Daisy Chain and Mechanical Samples ......................... 8
Conclusion ..................................................... 8
Appendix: CCGA Package Dimensions and Assembly Parameters (Reference only) ............. 9
  CCGA Package Outline Drawings .......................... 9
PCB Solder Stencil and Paste .................................. 16
PCB Reflow Reference ....................................... 17
References ...................................................... 18
List of Changes ............................................... 19

Introduction

Ceramic column grid array (CCGA) packages are increasingly becoming 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 characteristic, 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.
Figure 1 shows representative photograph of CCGA top and bottom views, while Figure 2 and Figure 3 on page 3 shows close upper view of solder columns.

**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 (refer to Figure 2 and Figure 3 on page 3) attached to the ceramic substrate I/O pads through eutectic 37/63 Pb/Sn, forming a eutectic solder joint. Refer to Figure 4 on page 3 for more details.
- Wire bond interconnect used to connect silicon to package.
- The die cavity is on the top side of the package and hermetically sealed with AuSn eutectic material.
- The lid is connected to ground.

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

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

*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
Table 1 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**

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<thead>
<tr>
<th></th>
<th>CG484</th>
<th>CG624</th>
<th>CG896</th>
<th>CG1152</th>
<th>CG1272</th>
<th>CG1657</th>
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<tr>
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<td></td>
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<tr>
<td>Column Attach Site</td>
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<td>Column Composition</td>
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<td>80Pb/20Sn</td>
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<tr>
<td>Copper Ribbon</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>Column Height</td>
<td>2.21 mm (0.087&quot;)</td>
<td>2.21 mm (0.087&quot;)</td>
<td>2.21 mm (0.087&quot;)</td>
<td>2.21 mm (0.087&quot;)</td>
<td>2.21 mm (0.087&quot;)</td>
<td>2.21 mm (0.087&quot;)</td>
</tr>
<tr>
<td>Column Diameter</td>
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<td>0.51 mm (0.020&quot;)</td>
<td>0.51 mm (0.020&quot;)</td>
<td>0.51 mm (0.020&quot;)</td>
<td>0.51 mm (0.020&quot;)</td>
<td>0.51 mm (0.020&quot;)</td>
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<tr>
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<td>0.15 mm (0.006&quot;)</td>
<td>0.15 mm (0.006&quot;)</td>
<td>0.15 mm (0.006&quot;)</td>
<td>0.15 mm (0.006&quot;)</td>
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<tr>
<td><strong>Package Information</strong></td>
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<td>Body Size</td>
<td>23.0 mm square</td>
<td>32.5 mm square</td>
<td>31.0 mm square</td>
<td>35.0 mm square</td>
<td>37.5 mm square</td>
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<td>Column Pins</td>
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<td>624</td>
<td>896</td>
<td>1152</td>
<td>1272</td>
<td>1557</td>
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<tr>
<td>Column Pin Notes</td>
<td>Orientation pin A1 – no column</td>
<td>Orientation pin A1 – no column</td>
<td>Corner stress relief – 1 pin each corner</td>
<td>Corner stress relief – 1 pin each corner</td>
<td>Corner stress relief – 6 pins each corner</td>
<td>Corner stress relief – 6 pins each corner</td>
</tr>
<tr>
<td>Lead Pitch</td>
<td>1.00 mm</td>
<td>1.27 mm</td>
<td>1.00 mm</td>
<td>1.00 mm</td>
<td>1.00 mm</td>
<td>1.00 mm</td>
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<tr>
<td>Ceramic Thickness</td>
<td>3.001 mm</td>
<td>2.28 mm</td>
<td>3.51 mm</td>
<td>2.77 mm</td>
<td>2.77 mm</td>
<td>2.00 mm</td>
</tr>
<tr>
<td>Total Weight of Columns</td>
<td>1.27 g</td>
<td>2.35 g</td>
<td>3.38 g</td>
<td>4.37 g</td>
<td>4.80 g</td>
<td>6.25 g</td>
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<td>JEDEC Registration</td>
<td>JEDEC MO-158 VAR xx-x</td>
<td>JEDEC MO-158 VAR BE-1</td>
<td>JEDEC MO-158 VAR CD-1</td>
<td>JEDEC MO-158 VAR CG-1</td>
<td>JEDEC MO-158 VAR CH-2</td>
<td>JEDEC MO-158 VAR xx-xx-x</td>
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**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.
Manufacturing Handling and Assembly

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, refer to Figure 5). 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 after post burn-in electrical test. The only processing conducted after solder column attachments is 100% QA electrical testing and 100% mechanical visual inspection.

Handling and Storage of CCGA Component

It is very important for end users to handle CCGA packages in the proper manner 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). Refer to Figure 6 and Figure 7 on page 6 for the photographs of the tray carrier, and CCGA component seating on the carrier tray.

- 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 • At Left Shows the Blue Tray Carrier for CGA with 1.27 mm Column Pitch, While at Right is the Carrier for CGA with 1.0 mm Column Pitch

Figure 7 • At Left Shows CG624 in its Carrier, and at Right is CG1152 in Blue Carrier with 1.0 mm Column Pitch. The Same Carrier with 1.0 mm Column Pitch is used for CG484, CG896, CG1272

Figure 8 • Vacuum Pen Must be Used to Pick up and Return the CCGA Component to the Blue Carrier
The same carrier with 1.0 mm column pitch is used for CG484, CG896, CG1272, and CG1657.

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 with no 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 may damage the black ESD jewel box, which in turn may damage the CG package.

Damaged or Bent Columns

1. 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 column which are bent more than 15° should not be straighten.
   - 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.
2. 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.
3. 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.

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 devices 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.

Refer to MIL-STD-883 TM2009 for visual inspection criteria.
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.

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.
Appendix: CCGA Package Dimensions and Assembly Parameters (Reference only)

CGGA Package Outline Drawings

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 9 • Package Outline Drawing for 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 for CG624*
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 11 • Package Outline Drawing for CG896
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 12 • Package Outline Drawing for 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 for CG1272
Appendix: CCGA Package Dimensions and Assembly Parameters (Reference only)

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 for CG1657
PCB Pad Layout Reference

Ceramic Column Grid Array

Figure 15 • CCGA PCB Layout Reference

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<th>CG624</th>
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<tr>
<td>Diameter A</td>
<td>1.27 mm Rth</td>
<td>1.00 mm Rth</td>
</tr>
<tr>
<td>Diameter B</td>
<td>0.851 mm</td>
<td>0.90 mm</td>
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<td>Diameter C</td>
<td>0.740 mm</td>
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<tr>
<td>Diameter D</td>
<td>0.720 mm</td>
<td>0.57 mm</td>
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<tr>
<td>Diameter E</td>
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<tr>
<td>Diameter F</td>
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<tr>
<td>Diameter G</td>
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<td>Diameter H</td>
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Notes:
1. Functional surface
2. Normal diameter at Copper/Polyimide interface with typical edge angle
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.

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Figure 16 • Solder Paste on CCGA624 PCB (upper) and on CCGA1152/1272 (lower)
Figure 17 • CCGA Thermal Cycling Test PCB Reflow Profile

Probe Mounting Drawing

Figure 18 • CCGA Assembly Reflow Profile (upper) and Temperature Probe Locations (lower)
Notes:
1. Probe 1 is mounted on PCB top surface and in center of package.
2. Probe 2 is mounted on top LID of package.
3. Probe 3 is mounted on PCB top surface.
4. Adjust reflow oven parameter to achieve the 3 probes with similar profile (without large variation).

References

Thermal Cycling Test Report for Ceramic Column Grid Array Packages – CCGA
# List of Changes

The following table shows important changes made in this document for each revision.

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<td>Revision 4 (June 2016)</td>
<td>Updated Figure 17 and Figure 18 (SAR 75744).</td>
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<tr>
<td>Revision 3 (March 2015)</td>
<td>Added Figure 9, Figure 11 and included CG484, CG896 packages and details of dimensions (SAR 65023).</td>
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<td>Updated &quot;Incoming Visual Inspection for CCGA Devices&quot; section (SAR 65023).</td>
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<td>Removed multiple images of CCGA and LGA and retained only representative images. (SAR 65023).</td>
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<td>Modified Table 1 (SAR 41355).</td>
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