# Ceramic Ball Grid Array Packaging, Assembly & Reliability

Freescale Semiconductor

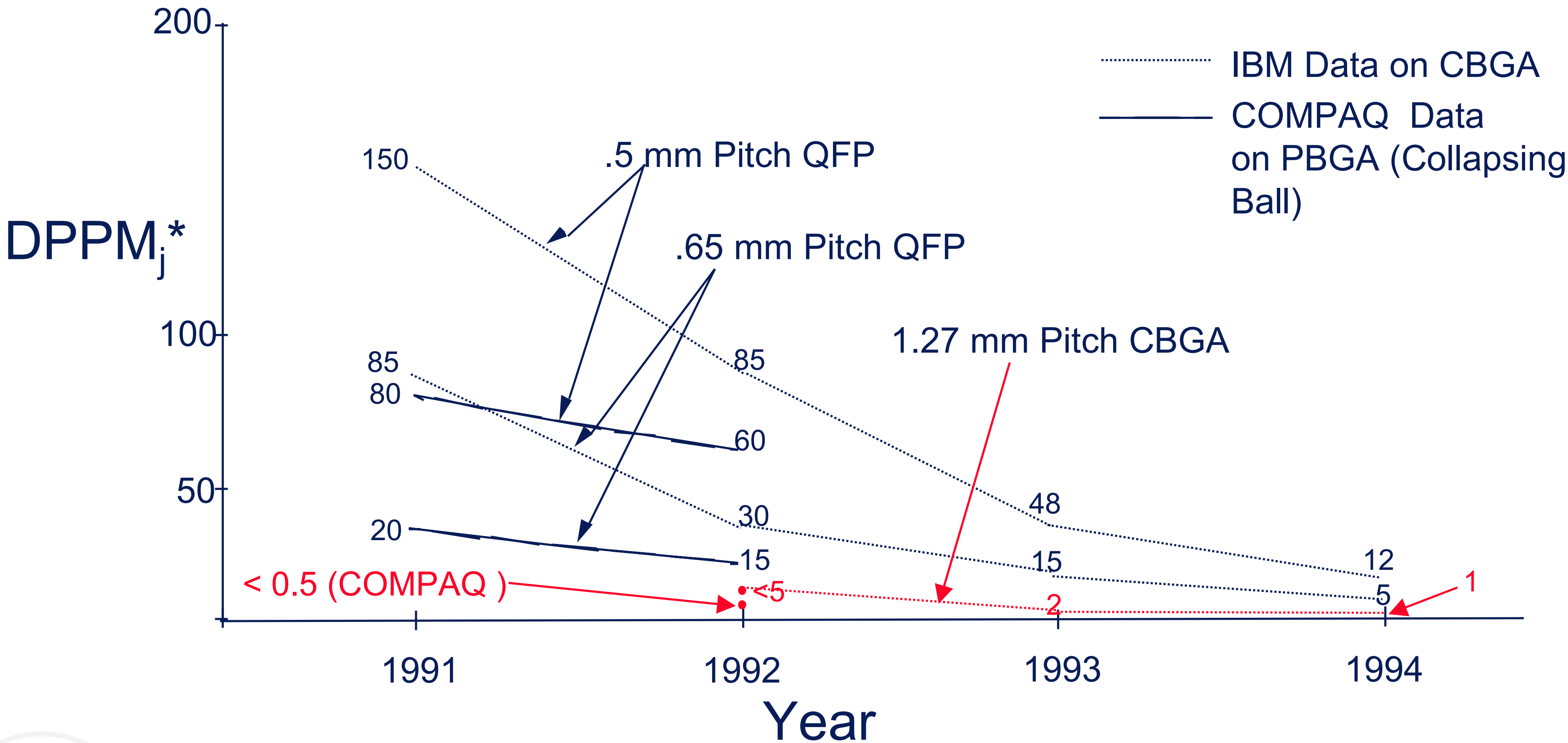
# Outline for Discussion

- **Why BGA????**
- **CBGA Introduction and Package Description**
- **PC Board Design for CBGA**
- **CBGA Assembly**
- **Rework**
- **Board-Level Solder Joint Reliability**

# Why BGA?????

- **Advantages:**
  - Higher Surface Mount Assembly Yield.
    - » Coarse Pitches Compared to Fine Pitch Leaded.
    - » Self-Centering.
    - » Not Easily Susceptible to Handling Damage.
  - High I/O Density and High Pin Count Capability.
  - "Drop-In" Multi-Chip Capability.
  - Potentially Better Electrical and Thermal Performance Than Leaded Packages.
  - Compatibility with Most or All Existing Surface Mount Equipment.
- **Limitations:**
  - More Difficult to Inspect (But You Do Not Need To).
  - Any Defect Requires Removal and Replacement of Entire Package (No Touch-Up).

# BGA Assembly Yields
## (As Reported by IBM and Compaq)




* DPPMj = Defective Joints Per Million Assembled

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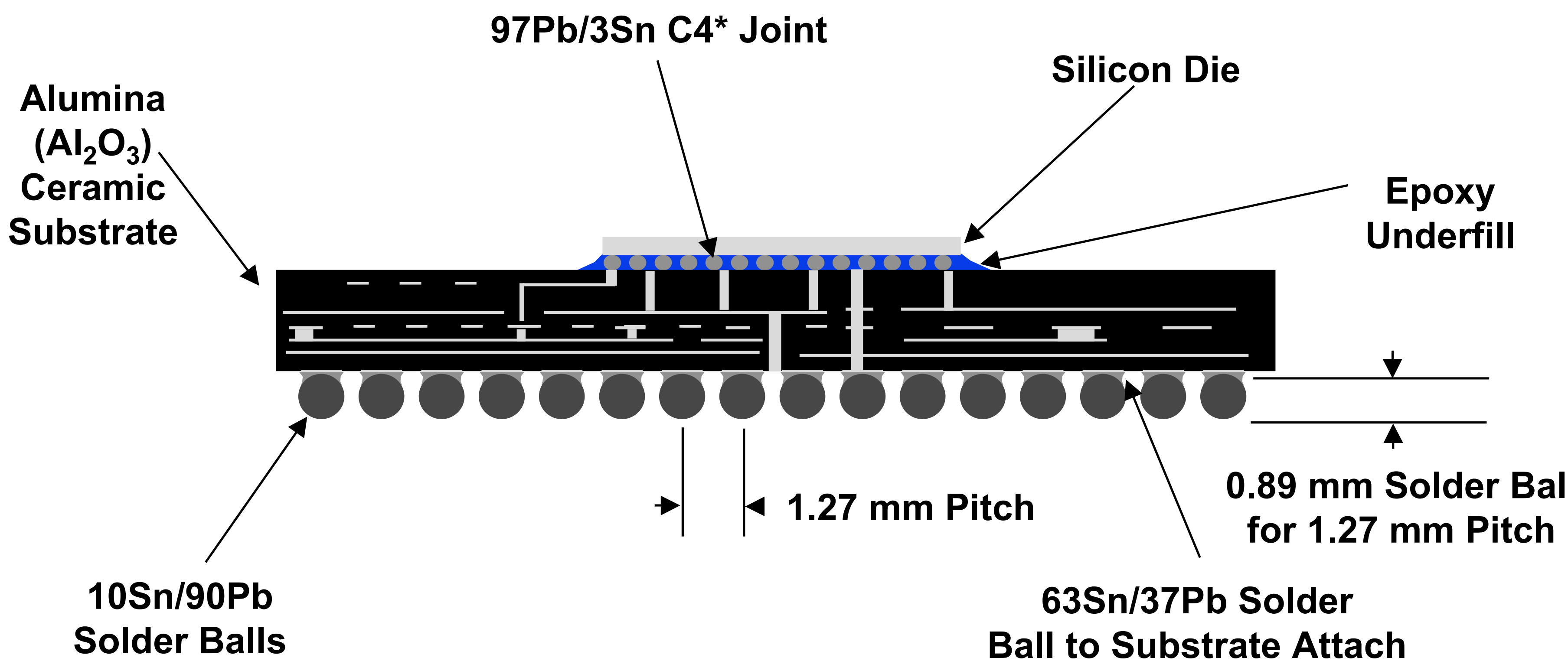
# CBGA Construction




C4 = Controlled Collapse Chip Connection (Evaporated 97Pb/3Sn Bump)

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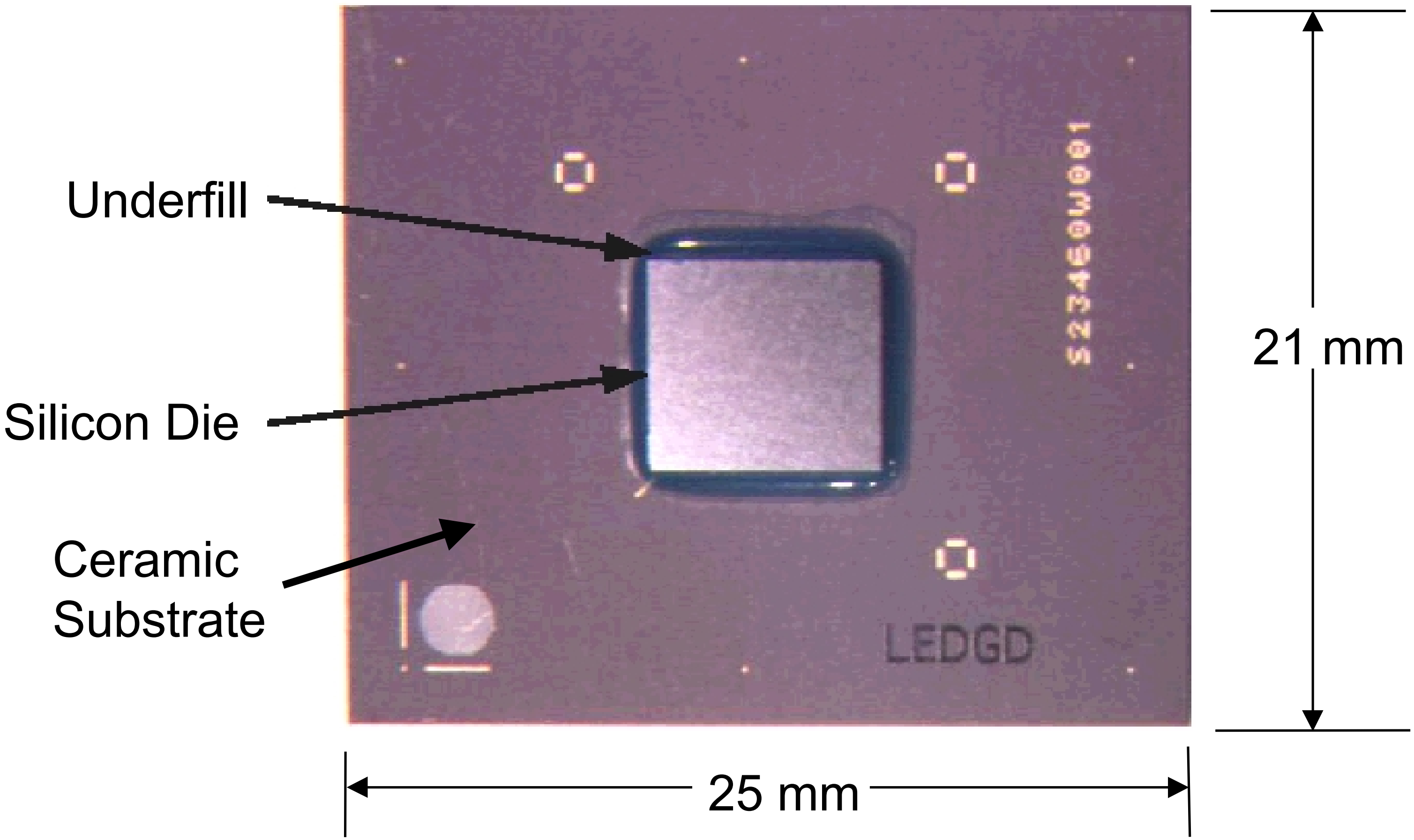
# CBGA Construction (Cont.)

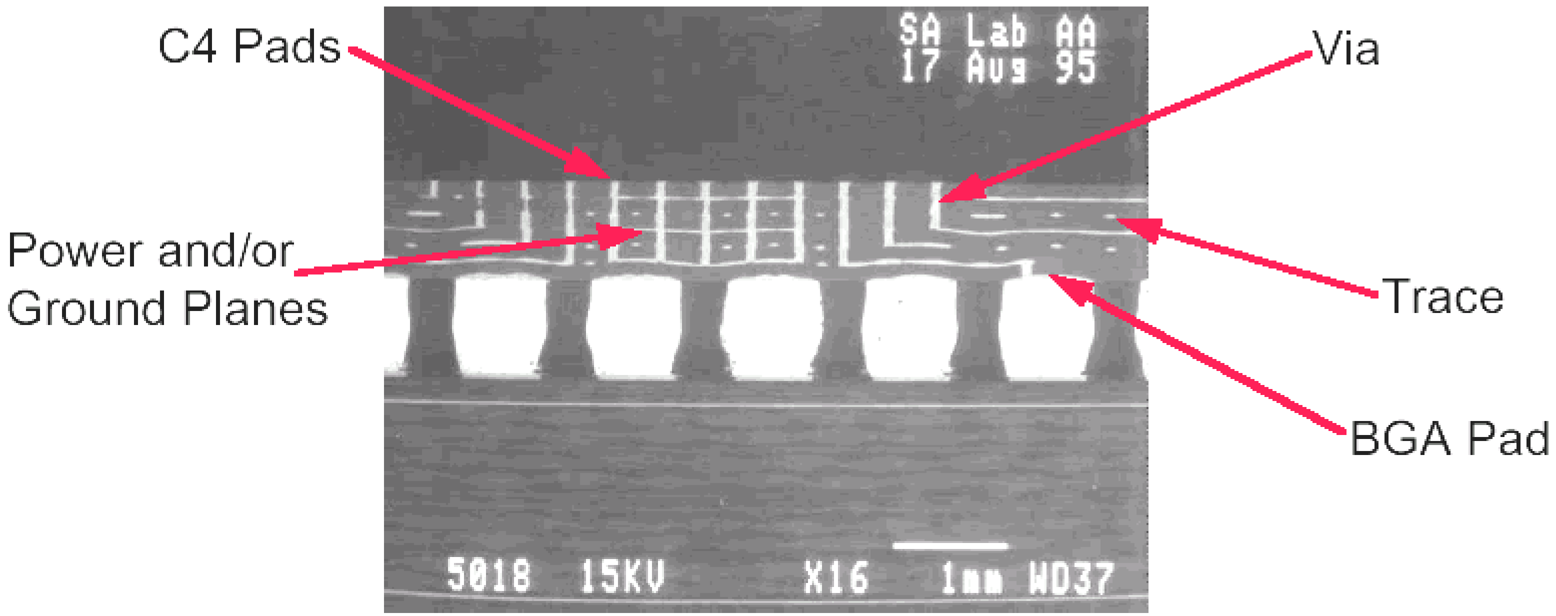
- 304 Pin C4*/CBGA MPC106 PCI Bridge Chip)




* C4 = IBM Developed Controlled Collapse Chip Conne

# CBGA Construction (Cont.)

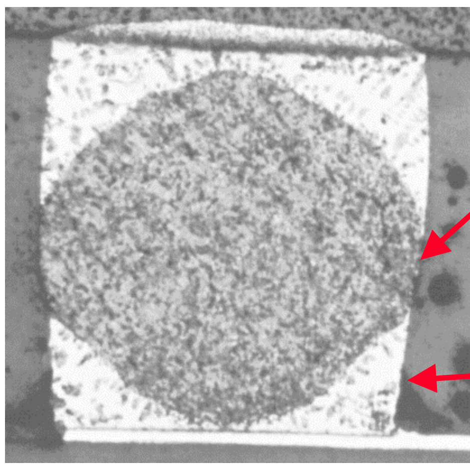
- SEM Micrograph of Board-Mounted CBGA Substrate (No Chip) Showing



# CBGA Solder Balls

Typically 0.89 to 0.94 mm

CBGA Substrate



Motherboard

0.89 mm Diameter 90% Pb and 10% Sn (by Weight) “High Melt” Solder Ball Held to CBGA Substrate and Motherboard with Eutectic (63Sn/37Pb) Solder.

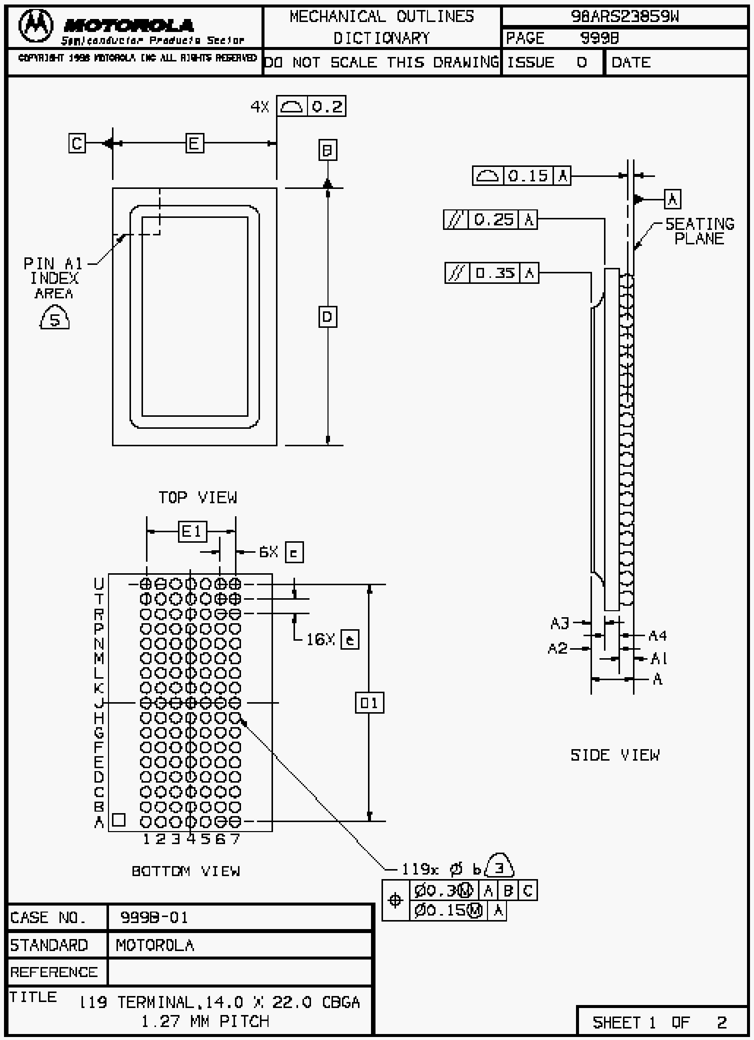
Eutectic Solder Applied to the Motherboard Before Reflow. Must Have Minimum Eutectic Solder Paste Volume of 4,800 $mils^3$.

# Products in CBGA

| Body Size | Pin Count | Pitch | Array | Comments/Products |
|---|---|---|---|---|
| 14 x 22 | 119 and 153 | 1.27 | 7 x 17<br>9 x 17 | Fast SRAMs |
| 21 | 255 | 1.27 | 16 x 16 | 60X PowerPC™ products. |
| 21 x 25 | 303 | 1.27 | 16 x 19 | MPC105 and 106 PCI Bridge chips. |
| 25 | 360 | 1.27 | 19 x19 | 7XX and 7410 PowerPC™ products. |
| 29 | 483 | 1.27 | 22 x 22 | 7450 PowerPC™. |
| 32.5 | 503 | 1.27 | 25 x 25<br>**(7 perim rows)** | MPC107 PCI Bridge chip. |
| 37.5 | 838 | 1.27 | 29 x 29 | C-Port C-5 product. High CTE ceramic. |

# Example CBGA Case Outline Drawings: 119, 360 and 483 Pin CBGAs

# 119 Pin, 14x22 mm CBGA Case Outline Drawing

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MECHANICAL OUTLINES DICTIONARY — 98ARS23859W — PAGE 999B



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NOTES

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994.
2. ALL DIMENSIONS IN MILLIMETERS.
3. DIMENSION b IS THE MAXIMUM SOLDER BALL DIAMETER MEASURED PARALLEL TO DATUM A.
4. DATUM A, THE SEATING PLANE, IS DEFINED BY THE SPHERICAL CROWNS OF THE SOLDER BALLS.
5. AN A1 INDEX MARK WILL BE LOCATED IN THIS AREA.

| DIM | MILLIMETERS MIN | MILLIMETERS MAX | INCHES MIN | INCHES MAX | DIM | MILLIMETERS MIN | MILLIMETERS MAX | INCHES MIN | INCHES MAX |
|---|---|---|---|---|---|---|---|---|---|
| A | -- | 3.02 | | | | | | | |
| A1 | 0.80 | 1.00 | | | | | | | |
| A2 | 1.70 | 2.02 | | | | | | | |
| A3 | 0.80 | 0.92 | | | | | | | |
| A4 | 0.90 | 1.10 | | | | | | | |
| D | 22.00 BSC | | | | | | | | |
| D1 | 20.32 BSC | | | | | | | | |
| E | 14.00 BSC | | | | | | | | |
| E1 | 7.62 BSC | | | | | | | | |
| b | 0.82 | 0.93 | | | | | | | |
| e | 1.27 BSC | | | | | | | | |

| | |
|---|---|
| CASE NO. | 999B-01 |
| STANDARD | MOTOROLA |
| REFERENCE | |
| TITLE | 119 TERMINAL, 14.0 X 22.0 CBGA 1.27MM PITCH |

SHEET 2 OF 2

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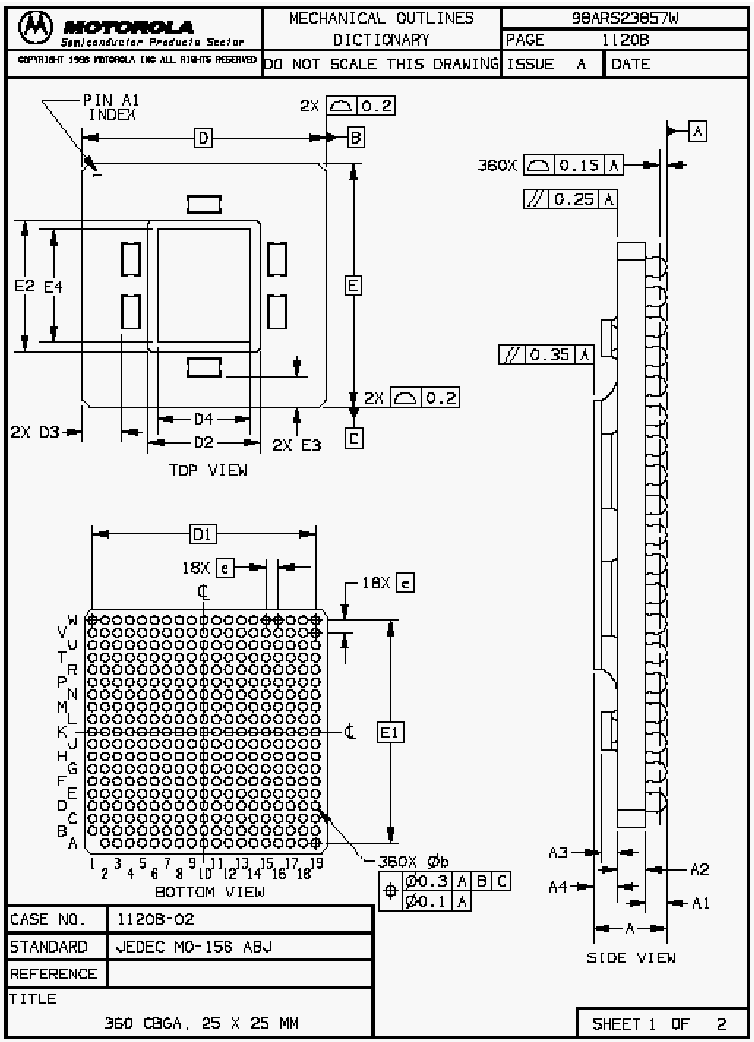
# 360 Pin, 25 mm CBGA Case Outline Drawing

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2. DIMENSIONS IN MILLIMETERS.
3. DIMENSION b IS THE MAXIMUM SOLDER BALL DIAMETER MEASURED PARALLEL TO DATUM A.
4. D2 AND E2 DEFINE THE AREA OCCUPIED BY THE DIE AND UNDERFILL. ACTUAL SIZE OF THIS AREA MAY BE SMALLER THAN SHOWN. D3 AND E3 ARE THE MINIMUM CLEARANCE FROM THE PACKAGE EDGE TO THE CHIP CAPACITORS.
5. CAPACITORS MAY NOT BE PRESENT ON ALL DEVICES.
6. CAUTION MUST BE TAKEN NOT TO SHORT EXPOSED METAL CAPACITOR PADS ON PACKAGE TOP.

| DIM | MILLIMETERS MIN | MILLIMETERS MAX | INCHES MIN | INCHES MAX | DIM | MILLIMETERS MIN | MILLIMETERS MAX | INCHES MIN | INCHES MAX |
|---|---|---|---|---|---|---|---|---|---|
| A | 2.72 | 3.20 | | | | | | | |
| A1 | 0.80 | 1.00 | | | | | | | |
| A2 | 1.10 | 1.30 | | | | | | | |
| A3 | 0.60 | 0.80 | | | | | | | |
| A4 | 0.82 | 0.90 | | | | | | | |
| b | 0.82 | 0.93 | | | | | | | |
| D | 25.00 BSC | | | | | | | | |
| D1 | 22.86 BSC | | | | | | | | |
| D2 | -- | 12.50 | | | | | | | |
| D3 | 3.80 | -- | | | | | | | |
| D4 | 6.00 | -- | | | | | | | |
| e | 1.27 BSC | | | | | | | | |
| E | 25.00 BSC | | | | | | | | |
| E1 | 22.86 BSC | | | | | | | | |
| E2 | -- | 14.30 | | | | | | | |
| E3 | 3.00 | -- | | | | | | | |
| E4 | 8.00 | -- | | | | | | | |

| | |
|---|---|
| CASE NO. | 1120B-02 |
| STANDARD | JEDEC MO-156 ABJ |
| REFERENCE | |
| TITLE | 360 CBGA, 25 X 25 MM |
| | SHEET 2 OF 2 |

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# 483 Pin, 29 mm CBGA Case Outline Drawing

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|---|---|---|
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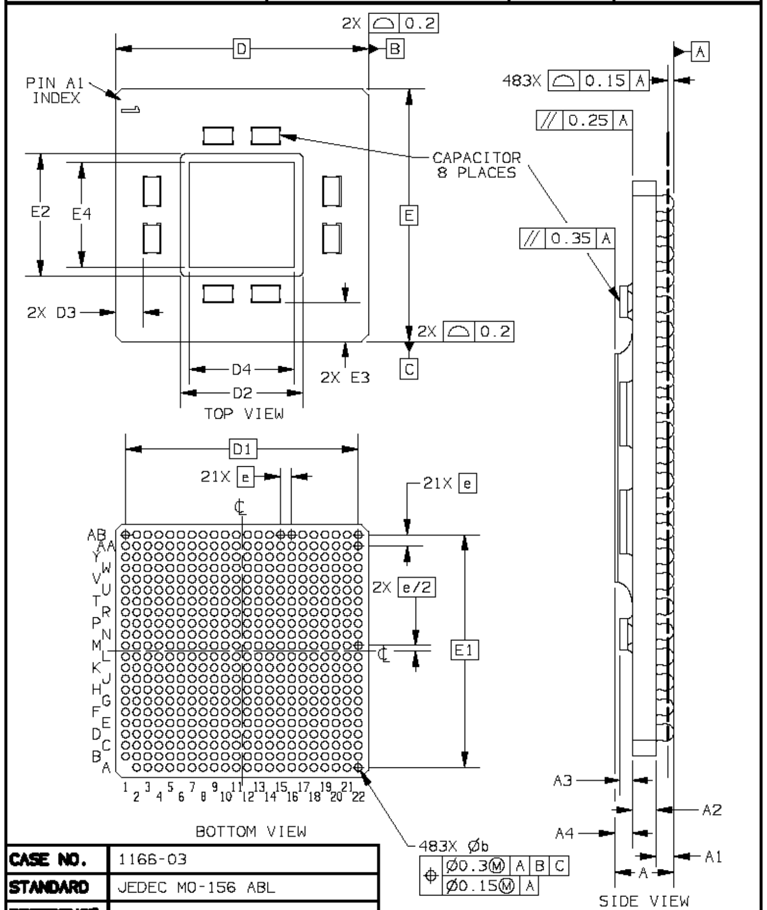


| | |
|---|---|
| CASE NO. | 1166-03 |
| STANDARD | JEDEC MO-156 ABL |
| REFERENCE | |
| TITLE | 483 CBGA, 29 X 29 MM, 8 CAPS |

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5. CAPACITORS MAY NOT BE PRESENT ON ALL DEVICES.
6. CAUTION MUST BE TAKEN NOT TO SHORT EXPOSED METAL CAPACITOR PADS ON PACKAGE TOP.

| DIM | MILLIMETERS MIN | MILLIMETERS MAX | INCHES MIN | INCHES MAX | DIM | MILLIMETERS MIN | MILLIMETERS MAX | INCHES MIN | INCHES MAX |
|---|---|---|---|---|---|---|---|---|---|
| A | -- | 3.22 | | | | | | | |
| A1 | 0.80 | 1.00 | | | | | | | |
| A2 | 1.08 | 1.32 | | | | | | | |
| A3 | -- | 0.60 | | | | | | | |
| A4 | 0.82 | 0.90 | | | | | | | |
| b | 0.82 | 0.93 | | | | | | | |
| D | 29 BSC | | | | | | | | |
| D1 | 26.67 BSC | | | | | | | | |
| D2 | -- | 14.00 | | | | | | | |
| D3 | 3.00 | -- | | | | | | | |
| D4 | 10.00 | -- | | | | | | | |
| e | 1.27 BSC | | | | | | | | |
| E | 29 BSC | | | | | | | | |
| E1 | 26.67 BSC | | | | | | | | |
| E2 | -- | 14.00 | | | | | | | |
| E3 | 4.00 | -- | | | | | | | |
| E4 | 10.00 | -- | | | | | | | |

| | |
|---|---|
| CASE NO. | 1166-03 |
| STANDARD | JEDEC MO-156 ABL |
| REFERENCE | |
| TITLE | 483 CBGA, 29 X 29 MM, 8 CAPS |

SHEET 2 OF 2

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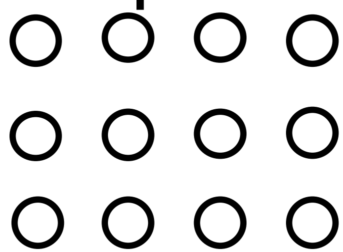
# ıncoming PCB Requirements for CBGA

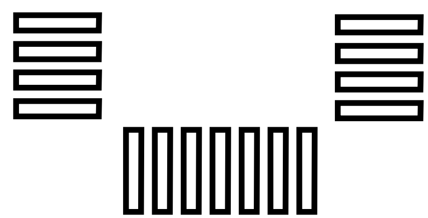
- Solder Pad Metal Finish Options
  - HAL or HASL (Hot Air Solder Leveled).
  - Entek Plus™ (from Enthone) or Other Organic Coatings.
  - Both Used Successfully with CBGA.
- Board Flatness
  - Planarity Within Industry (i.e., IPC) Standards Is Fine.
  - CBGA Typically More Forgiving Than Fine Pitch QFPs.
- Recommended Material Physical Properties
  - Glass Transition Temperature (Tg) ~115 °C.
  - Planar Coefficient of Thermal Expansion (CTE): Industry Typical 16~18 ppm/°C.
  - Lower CTE May Be Used to Increase Reliability.
  - Large Number of Vias within Area of BGA Increases CTE Locally.

# Stencil Printing Solder Paste

- **Nominal CBGA Solder Paste Volume Needs to Be 7,000 Mils$^3$. Minimum Volume of 4,800 Mils$^3$.**
  - **7.5 Mil Stencil With 34 Mil Apertures Accomplishes This.**
- **Stencil Thickness Can Be From 5 to 14+ Mils Thick to Acheive This.**
- **May Want to Make Stencil Openings the Same Size As Pad Size (or Slightly Smaller).**
  - **Large Round Apertures Print Easily.**



**1.5 mm Pitch BGA**



**0.5 mm Pitch QFP**

  - **Print Accuracy Needs to Be Only ± 5 Mils, With No Paste Touching Adjacent Exposed Metallization.**

# CBGA Solder Paste Stencil Thickness Versus Aperture Diameter Table

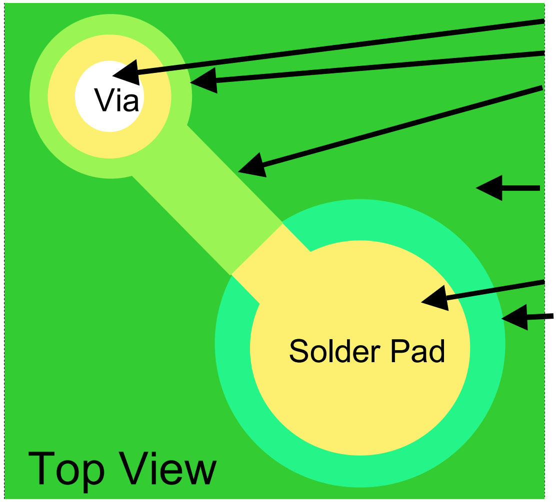
(Use to Achieve Nominal 7,000 mils$^3$ or Minimum 4,800 mils$^3$ Solder Paste Volume)

| Stencil | deposit base diameter (mils) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| thickness (mils) | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 |
| 5 | 2925 | 3137 | 3358 | 3585 | 3820 | 4063 | 4313 | 4570 | 4835 |
| 6 | 3510 | 3765 | 4029 | 4302 | 4584 | 4875 | 5175 | 5484 | 5802 |
| 7 | 4095 | 4392 | 4701 | 5019 | 5348 | 5688 | 6038 | 6398 | **6769** |
| 8 | 4680 | 5020 | 5372 | 5736 | 6112 | 6500 | **6900** | **7312** | 7736 |
| 9 | 5265 | 5647 | 6044 | 6453 | **6876** | **7313** | 7763 | 8226 | 8703 |
| 10 | 5850 | 6275 | 6715 | **7170** | 7640 | 8125 | 8625 | 9140 | 9670 |
| 11 | 6435 | **6902** | **7387** | 7887 | 8404 | 8938 | 9488 | 10054 | 10637 |
| 12 | **7020** | 7530 | 8058 | 8604 | 9168 | 9750 | 10350 | 10968 | 11604 |
| 13 | 7605 | 8157 | 8730 | 9321 | 9932 | 10563 | 11213 | 11882 | 12571 |
| 14 | 8190 | 8785 | 9401 | 10038 | 10697 | 11375 | 12075 | 12796 | 13538 |

**notes:** 0.95 multiplier for typical non-cylindrical deposit shape
minimum allowable paste volume for CBGA = 4800 cubic mils
recommended target paste volume for CBGA = 7000 cubic mils
non-tapered aperture opening

# CBGA NSMD Motherboard Solder Pad Geometry

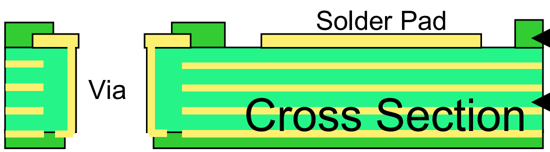
- Recommended Non-Soldermask Defined (NSMD) Pad Dimensions.
  - 0.72 mm solder pad diameter.
  - Minimum solder paste volume of 4,800 mils$^3$ (0.079 mm$^{3)}$ per pad.
  - Surface finish may be any consistently solderable surface such as organic solderability protectant (OSP), HASL, electroless or electrolytic nickel/gold or immersion silver.




0.30 mm (12 mil) Finished Plated Through Hole (Adjustable)
0.65 mm (25 mil) Annular Pad (Adjustable)
0.30+ mm (12+ mil) Wide Line Between Pads

Liquid Photoimageable Solder Mask

0.72 ± 0.037 mm (28.5 ± 1.5 mil) Copper Pad Diameter
0.076 ± 0.025 mm (3 ± 1 mil) Clearance Between Copper Pad and Solder Mask (Adjustable)




Solder Mask Away From Copper Pad
PCB Laminate

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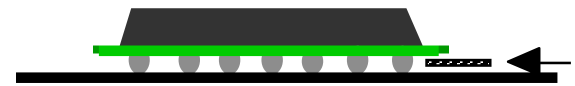
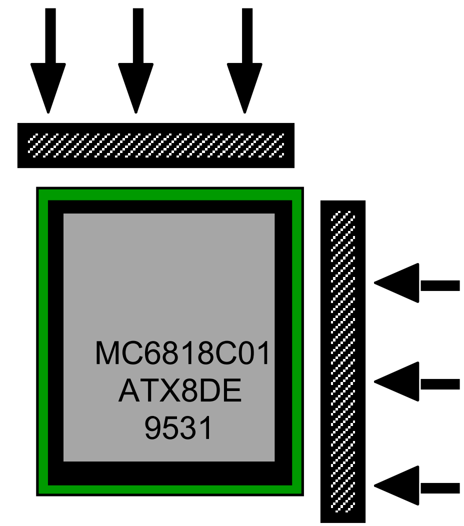
# BGA Placement

- **Most Newer Pick and Place Equipment Have Upward Looking Vision Systems That Can Recognize BGA.**
  - **Most Vendors of Older Equipment Have Retrofits Available.**
- **Alignment Can Be From All Balls, Package Body or Perimeter Row of Balls Only.**
- **No Vision Required for BGA With Mechanical Centering Device.**
  - **Place in Vibratory Nest, or on Precisor Stand, Then Pick From That “Known” Pick up Point.**
- **Loose Requirement for Placement Accuracy: Half the Diameter of the Pad, Compared to ±4 Mils for 20 Mil Pitch QFPs.**
- **BGAs (Both PBGA and CBGA) Will Perfectly Self Center in Reflow.**






**Example of a Mechanical Precisor**

# Reflow Guidelines for BGA

- Follow Guidelines Recommended by Solder Paste Supplier.
  - Flux Requirements Must Be Met for Best Solderability.
- Recommended Profile: 210-215°C Peak, ≥75 Seconds Above 183° C (or Any Standard Surface Mount Reflow Profile).
- Temperature Profile Should Be Carefully Characterized to Ensure Uniform Temperature Across the Board and Package.
  - Solder Ball Voiding May Be Affected by Ramp Rates and Dwell Times Below and Above Liquidus.
- Nitrogen Atmosphere Not Required, but Will Make the Process Even More Robust, and Can Make a Big Difference in the Case of Marginally Solderable PC Board Pads.
- Full Convection Forced Air Furnaces Work Best, but IR, Convection/IR or Vapor Phase Can Be Used.

# Profiling Furnace for BGA

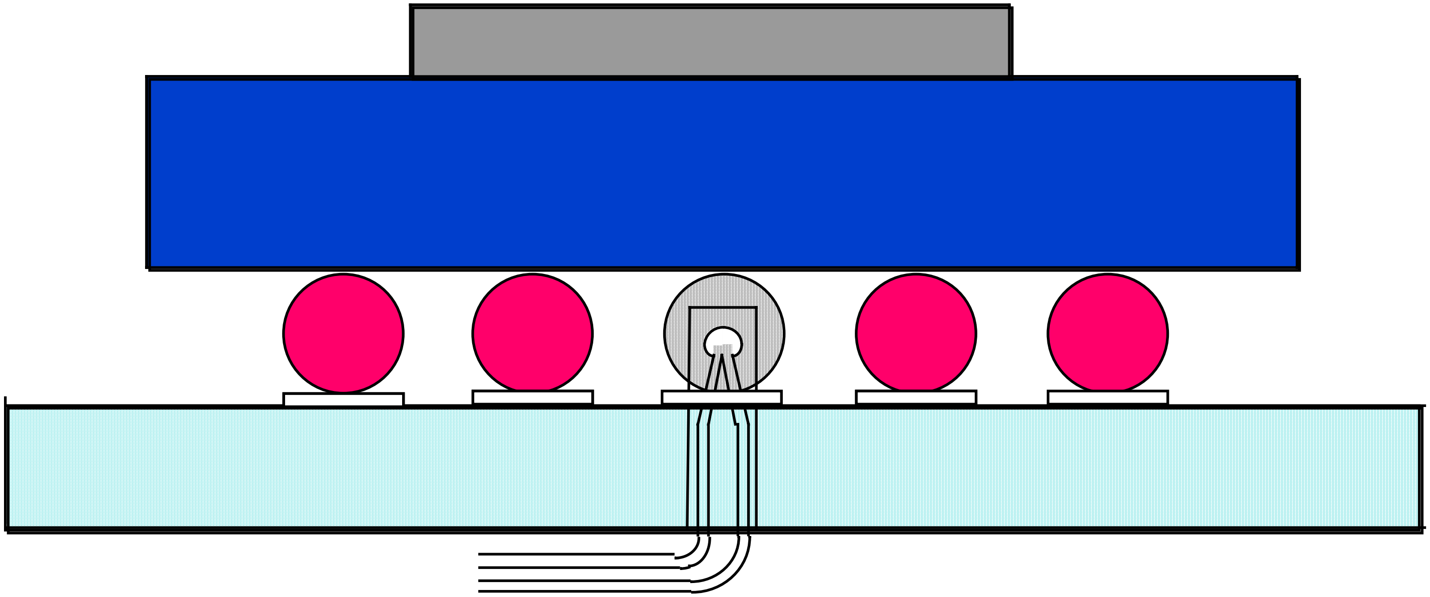
- **Profile Board Must Be Fully Populated to Simulate Thermal Load of the Production Board.**
- **Reflow Profile Board to Keep All Parts in Place.**
  - **Guess at a Profile. Start Low and Increase Temperature Until High Mass Parts Solder.**
- **Select Components to Monitor.**
  - **Highest Mass Part Near Center of PC Board.**
  - **Low Mass Part on One Corner of Leading Edge of Board.**
  - **Low Mass Part on Diagonal Trailing Corner.**
  - **CBGA, Whatever Location.**
  - **Any Other Critical or High Mass Part.**

# Thermocouple Attachment Method for CBGA

- Before Soldering Parts on Profile Board:
  - Drill Hole in PC Board (Just Large Enough for Thermocouple Wire) Through a Solder Pad in the Center of the CBGA Site.
- Assemble All Components and Reflow by Normal Method.
- Using Same Drill Bit, Drill Into Ball, About 20 Mils Deep.
  - Use Small Amount of Thermally Conductive Epoxy to Fix Thermocouple Weld Into Center of Solder Ball, (the Exact Point of Critical Temperature).

# Thermocouple Attachment Method for CBGA (Cont.)

- Thermocouple Attachment Inside CBGA Solder Ball



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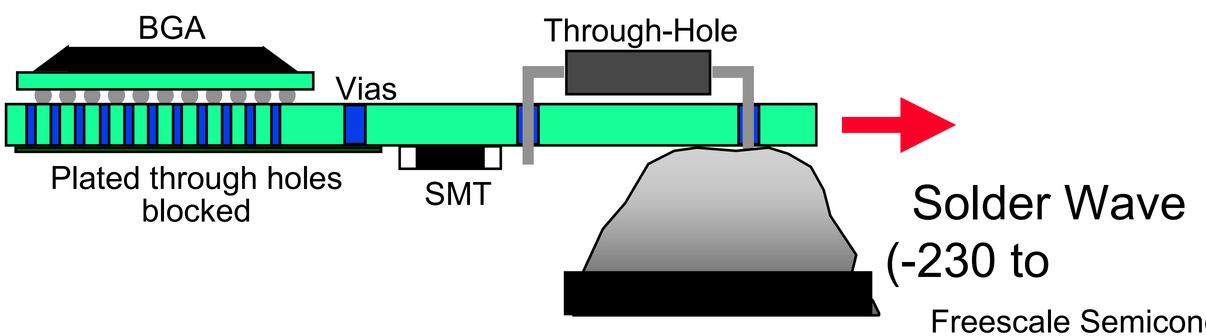
# Secondary Reflow of BGA in Wave Soldering

- A Wave Solder Operation Is Often Required After Surface Mount Devices Have Been Soldered on the Board.
- The Partial Re-Reflow of BGA Solder Joints in This Secondary Operation Must Be Avoided.
  - The Result Can Be Open BGA Solder Joints.
    - PBGAs Are Low Thermal Mass Packages (They Can Heat Rapidly).
    - The Large Number of Plated Through Holes Transmit Heat Well.

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# Avoiding Secondary Reflow Of BGA in Wave Soldering

- Optimize Wave Solder Operation to Minimize BGA Temperature (As Measured Below the BGA).
- Utilize Wave Solder Pallets to Block Solder From BGA Area.
- Block Heat Transfer Through BGA Vias by Plugging Them or Tenting With Soldermask on Bottomside.
  - May Not Be Desirable From Test Standpoint.
    - Eliminates Direct Test Contact to Via Pads.
- Apply Polyimide Tape to BGA Area on the Bottomside.
  - Undesirable Hand Operation, but Can Be Used Temporarily.
- Redesign Board for Surface Mount Devices Only.
  - Eliminate Wave Solder Operation.

# Cleaning After Reflow

- The Industry Is Moving to No-Clean Fluxes, but Due to Large Pitch and High Standoff, Any Conventional Cleaning Process Can Typically Be Used.
  - Ensure That Spray Nozzles Direct Flow at an Angle to Potentially Clean Under the Part.

# BGA Inspection

- External Solder Joints Can Be Visually Inspected. If Uniform Reflow Temperature Is Maintained, and Outer Joints Look Good, the Internal Joints Will Be Good.
- Internal Solder Joints Can Be Inspected by X-Ray.
- The Entire Assembly Process Should Be Carefully Characterized; Then, Due to the Very High Yielding Nature of the Product, Solder Joint Inspection Can Be Eliminated.
- No Need for In-Line X-ray. Having Off-Line X-Ray Capability May Be a Good Idea for Debugging Purposes.

# BGA Assembly Yield - Top Ten Causes of BGA Assembly Defects

- In No Particular Order:
  - Popcorning of Plastic BGA Parts Due to Not Following Out of Dry-Pack Requirements. Results in Shorting Balls. This Is a PBGA Issue Only Since CBGA Is Level I.
  - Poor Incoming Board Quality (Unsolderable Pads Due to Oxidation, Soldermask or Other Contamination or Intermetallics).
  - Complete Lack of Flux on the Solder Pad (i.e., Solder Paste Skips) Insufficient Solder Paste Volume.
  - Part Misorientation (i.e., Rotated 90, 180 or 270°).
  - False Indictment of the BGA by the Test Program or Operator.
  - Operator "Tweaking" Before Reflow (Causes Solder Paste Smearing and Shorts).
  - Board Design Errors (i.e., Solderable Surface Under Soldermask or No Soldermask at All in the Area of the BGA Which Causes Solder to Wick Down Vias with Dog-Bone Pads).
  - Incorrect Reflow Furnace Profile (Usually Due to Improper Thermocouple Placement on Profile Board or No Profiling).
  - Partial Secondary Reflow During Wave Soldering.
  - Component Defects (Missing Balls, Unsolderable Balls, Coplanarity).

# BGA Rework

- Due to Lack of Solder Joint Visibility BGAs Are Often Falsely Blamed for Board Electrical Problems.
  - In Study Done by Compaq Computers (Suzanne Fauser, et al) [1] 75% of All BGAs Removed From Production Boards During the Period of Study Were Found Have Been Incorrectly Removed Due to Inability of Test Technicians to Identify the Real Cause.
    - Easy to Blame.
    - Hidden Solder Joints.
    - BGA Is Typically the Largest, Highest Pin Count Device.
- Special Care Must Be Taken to Develop Good in-Circuit Test Programs That Accurately Pin-Point the Failing Part.

[1] *S. Fauser Et Al, Compaq Computer Corp., "High Pin Count PBGA Assembly: Solder Defect Failure Modes and Root Cause Analysis" Originally Published in the Proceedings of Surface Mount International*

# BGA Component Removal in Rework

- If the Board Is Thick With Internal Ground Planes:
  - Use Additional Localized Bottom Side Heat.
  - Preheat Entire Board to at Least 80°C (or Higher, As Permitted by Least Heat Tolerant Components Involved).
    - –Elevating the Temperature of the Entire Board Will Reduce Total Cycle Time and Prevent or Reduce Board Warpage.
- Avoid Collateral Moisture Damage (i.e., Popcorning) to Neighboring Moisture Sensitive Components. If It Is Unavoidable That They Go Over 150°C, Bake Board Overnight at Low Temperature (≥80°C) to Remove Moisture If Necessary.
- CBGA Typically Require Top and Bottomside Heating for Removal Due to High Thermal Mass of Ceramic.
- Apply Localized Heat to BGA Package.
  - When Solder Is Molten, Lift Package off Immediately With Vacuu

# Example of BGA Rework Nozzle With Exhaust (One Type of Patented Air-Vac Nozzle Shown)

- Advantages:
  - Minimum Heating of Neighboring Parts.
  - Rapid Heating (Lower Rework Cycling Time).
- Potential Issues:
  - Gradients Across Part May Make One Side Reflow First (Part Tilt).
  - Narrow Process Window (i.e., Can Heat Extremely Rapidly).

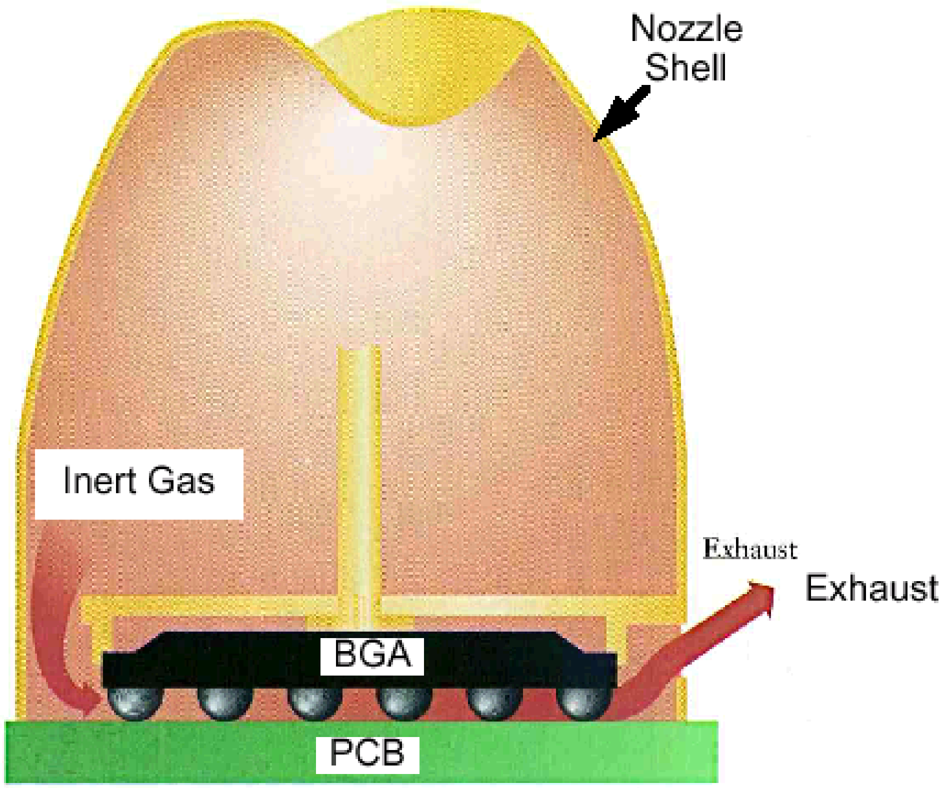


Figure: Brian Czaplicki, Air-Vac Engineering

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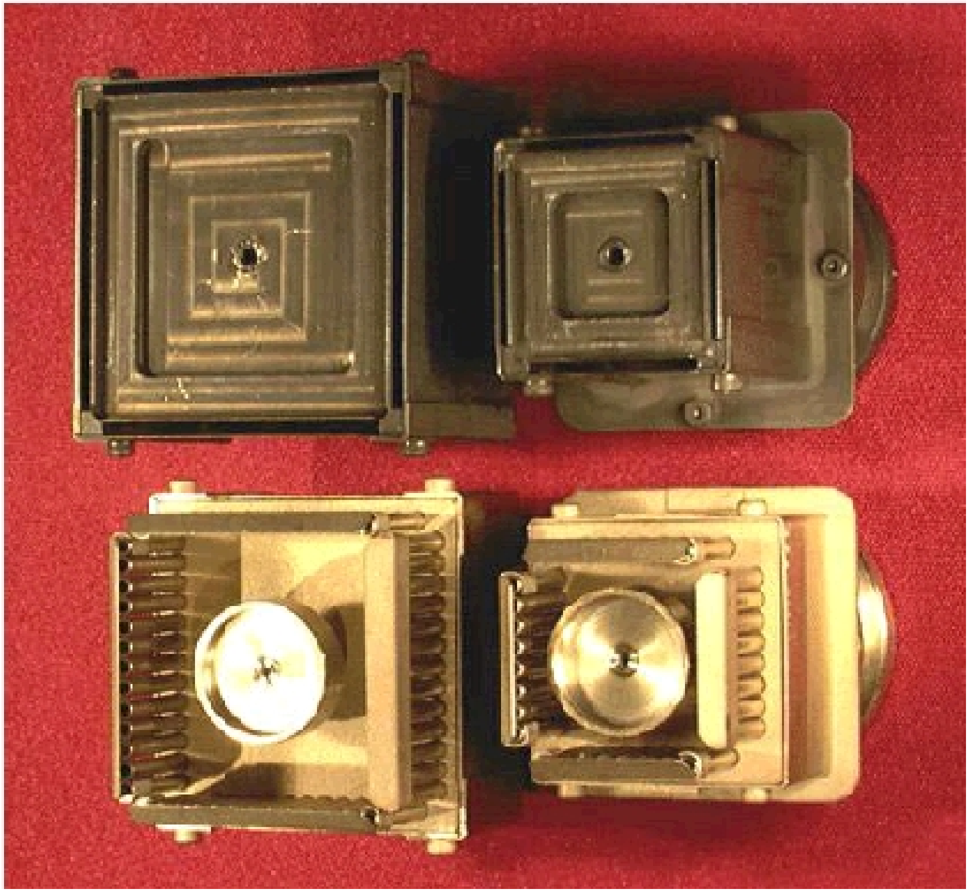
# Examples of Non-Shell Type BGA Versus QFP Rework Nozzles

QFP Nozzles (Note Slots for Perimeter Heating Only)



BGA Nozzles (Note Pipes and Shrouds for Directing Gas Under Package)

- Advantages:
  - Smaller Clearance Around Part Required.
  - One Nozzle Can Potentially Work for More Than One Body Size.
  - Wide Process Window.

# Removing Excess Solder from Mother-board Solder Pads After BGA Removal

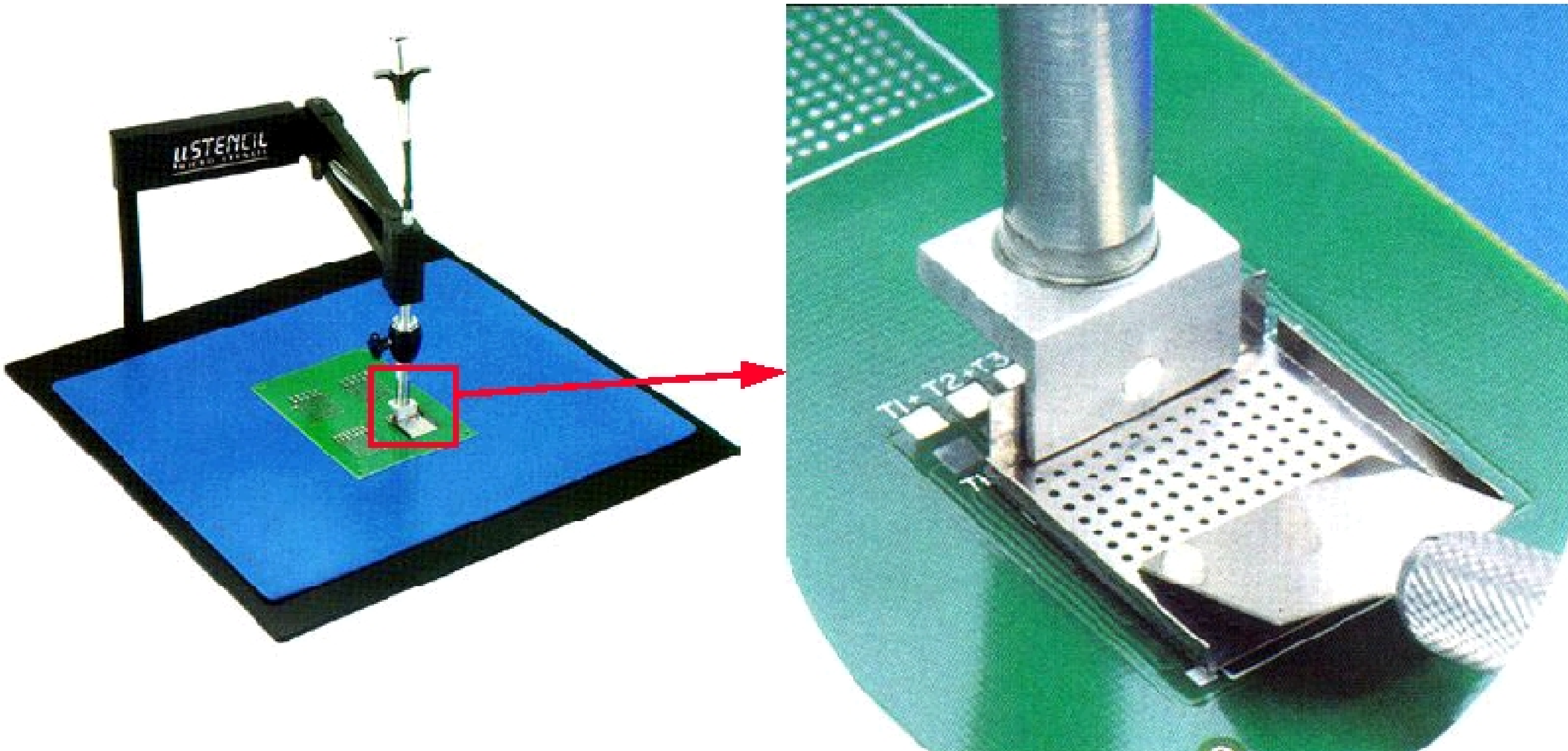
- Redress of the Site without Damaging Soldermask Required to Achieve Relatively Flat Pads.
  - CBGA Sites May May Have Solder That Has a Higher Liquidus Due to Higher Lead Content as of a Result of Dissolution from the Solder Balls.
- Avoid an Additional Heat Cycle by Removing Excess Solder From the Pads Immediately After Package Removal, While Board Is Hot.
- Skill and Experience of Rework Operator Should Be the Key Factor in Determining the Removal Technique.
  - A Hand-Held Solder Vacuum Tool Can Do  an Excellent Job Quickly.
  - Solder Wicking Braid Requires Heat and Pressure, Usually Requires More Time and Is More Likely to Damage the Board or Pads.

# Flux/Solder Paste Application in Rework

- CBGA Requires Exact Volume of Solder Paste (4,800 Mils$^3$ Minimum for 1.27 mm Pitch) to Be Reapplied.
- Several Options for Reapplying Solder Paste.
  - Custom Mini-Stencil (Preferred).
  - Screen Solder Paste Directly Onto CBGA Component.
  - Dispense of Solder Paste in Known Volumes on Each Pad.
  - Use Solder Preform Disks That Match the Array.

# Solder Paste Application in Rework

- Mini-Stencil Required to Apply Paste for CBGA/CCGA and Leaded Part Rework (Optional for PBGA).



(Photos Courtesy of OK Industries)

# Placing New Component on Site

- The Rework Station Should Have Good Look-Up/Look-Down Capability.
  - Either Video or Optical Vision.
  - Split Prism Optics to Simultaneously View the BGA Balls and the Footprint Is Helpful.
- Once Again, High Placement Accuracy Not Required Due to the Self-Aligning Nature of the BGA.

# Rework Reflow

- Batch Oven Preheating (Typically 80°C) of Entire Board May Be Advisable, Especially With Large Multilayer Boards, to Prevent Board Warpage or Localized “Oil-Canning”.
  - Pre-Heat Temperature Cannot Exceed Rating of Least Heat Tolerant Part on the Board.
- Characterize Temperatures to Provide Uniform Heat and Ramp Rates Similar to Reflow Furnace.

# Cleaning After Rework

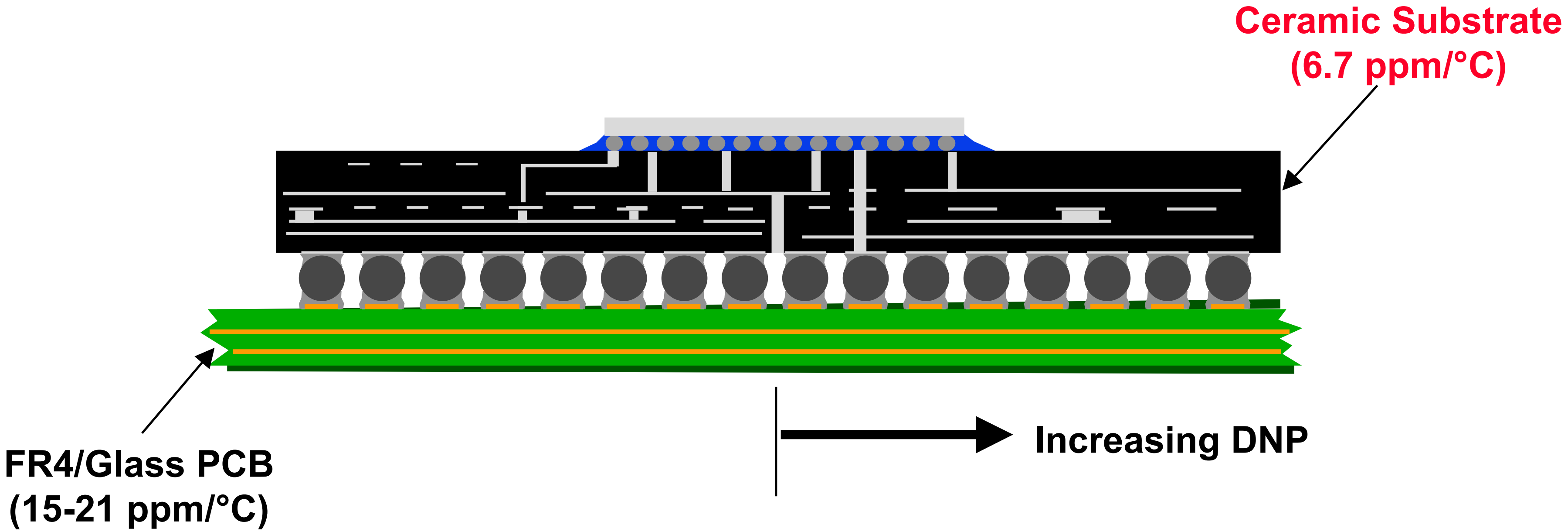
- If Cleaning Is Required, Use Standard Production Cleaning Method or Use a No-Clean Flux for Rework (Even If a Non No-Clean Flux Used in Initial Assembly).

# Summary of BGA Rework Process

- The Rework Process Goal Is Joint Structure and Quality at Least As Good As the Initial Assembly.
- Robust Initial Assembly Process Reduces the Need for Reworking BGA Packages.
- Removing and Replacing a BGA Can Be Easier Than for a QFP Due to Self Alignment.
  - However, Individual Solder Joints Cannot Be Repaired (i.e., No Touch-up).
- BGA Package Rework Can Be Accomplished with Off-the-Shelf Equipment.
- The Entire Rework Process Must Be Carefully Characterized.

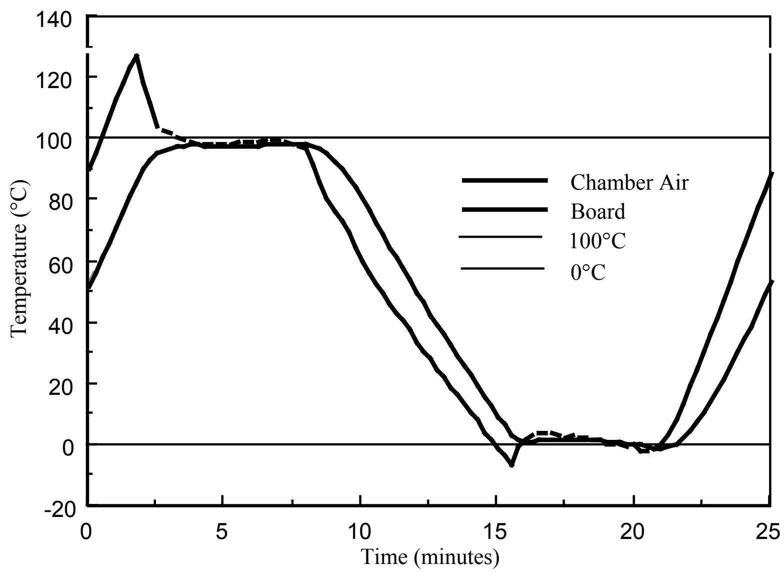
# CBGA Construction Influence on Attachment Reliability

- For CBGA, Ceramic Substrate Mismatched to FR4/Glass PCB.
- Causes Joints Farthest from the Center to Fail First (i.e., Greatest Distance from the Neutral Point or DNP)

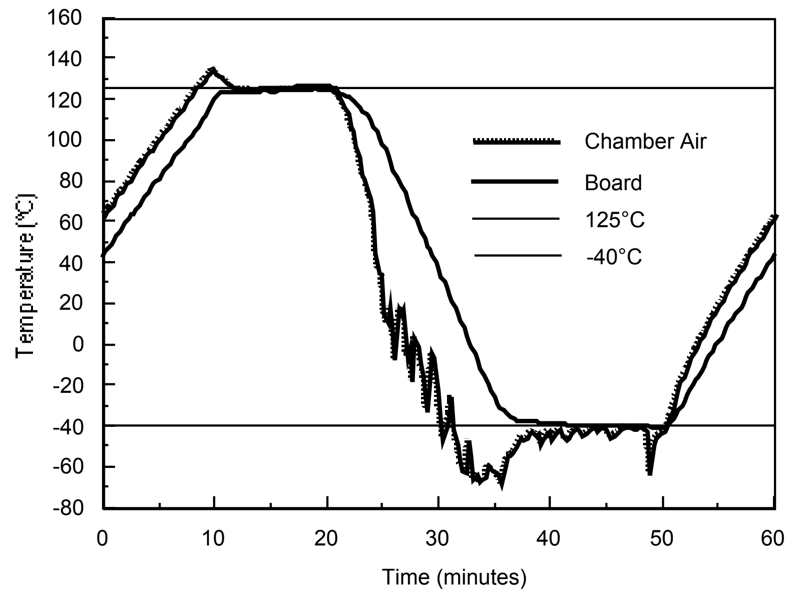


# Accelerated Thermal Cycling Conditions

- Accelerated Thermal Cycling (ATC) Performed on Mounted Daisy-Chain Packages to Obtain Failure Distributions.
  - Two Conditions Used Are 0 to 100°C (-48 cpd) & -40 to 125°C (24 cpd).
  - Testing Continues Until >50% Packages Exhibit at Least One Joint Fail.




Typical Profile for 0 to 100°C Testing




Typical Profile for -40 to 125°C Testing

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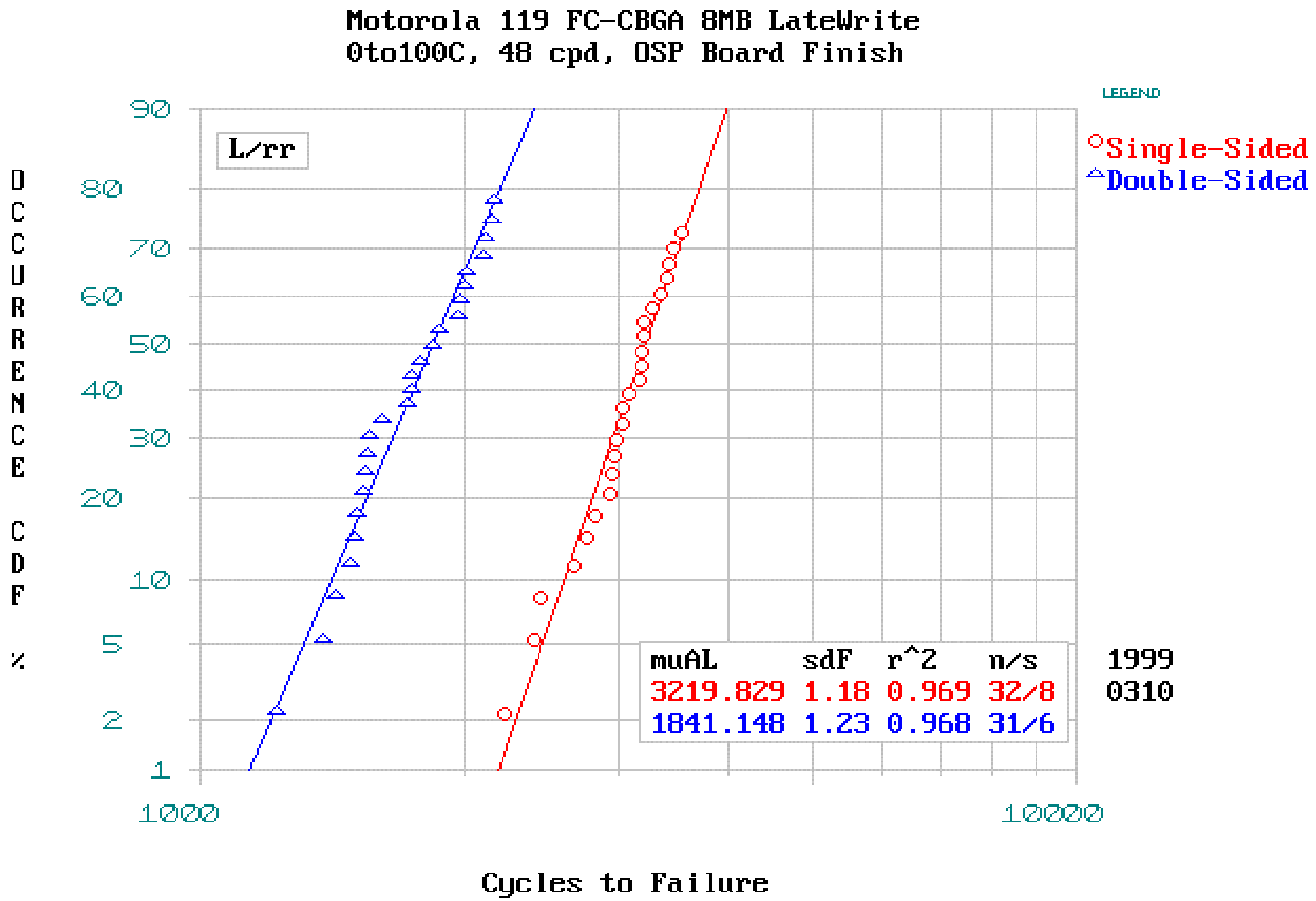
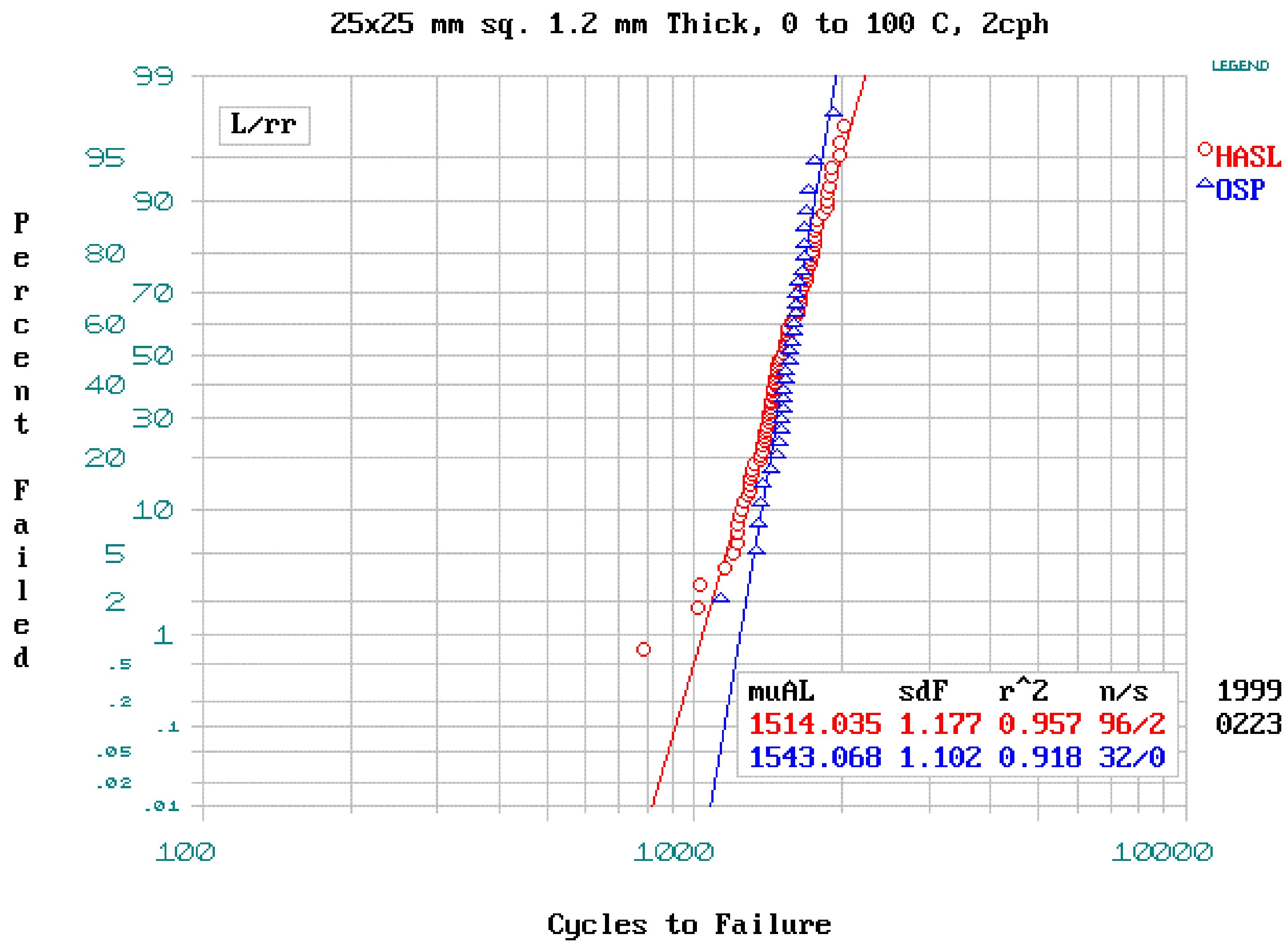
# Motorola Board-Level Cycling Typical Test Board Configuration

- Four Layer FR-4 Epoxy/Glass Test Board Used.
- Simulated Half-Ounce Power and Ground Planes Included.
- Nominal Solder Pad Diameters to Match the Device.
  - 0.0285” $\phi$ for 1.27 mm Pitch CBGA.
- 4.50” x 7.25” x 0.062” Thick Board.
- HASL and OSP (i.e., Bare Copper or Entek™) Solderable Surfaces.
- Copper Thieving Squares on Outer Layers.




28.5 mil board pad diamter. 7.5 mil thick stencil.
Double-sided used 35 mil stencil aperture opening. Single-sided used 28 mil stencil apertu

# 25 mm CBGA Board-Level Thermal Cycling Data Plotted on a Log-Normal Plot (Both HASL and OSP Surface Finishes Tested)

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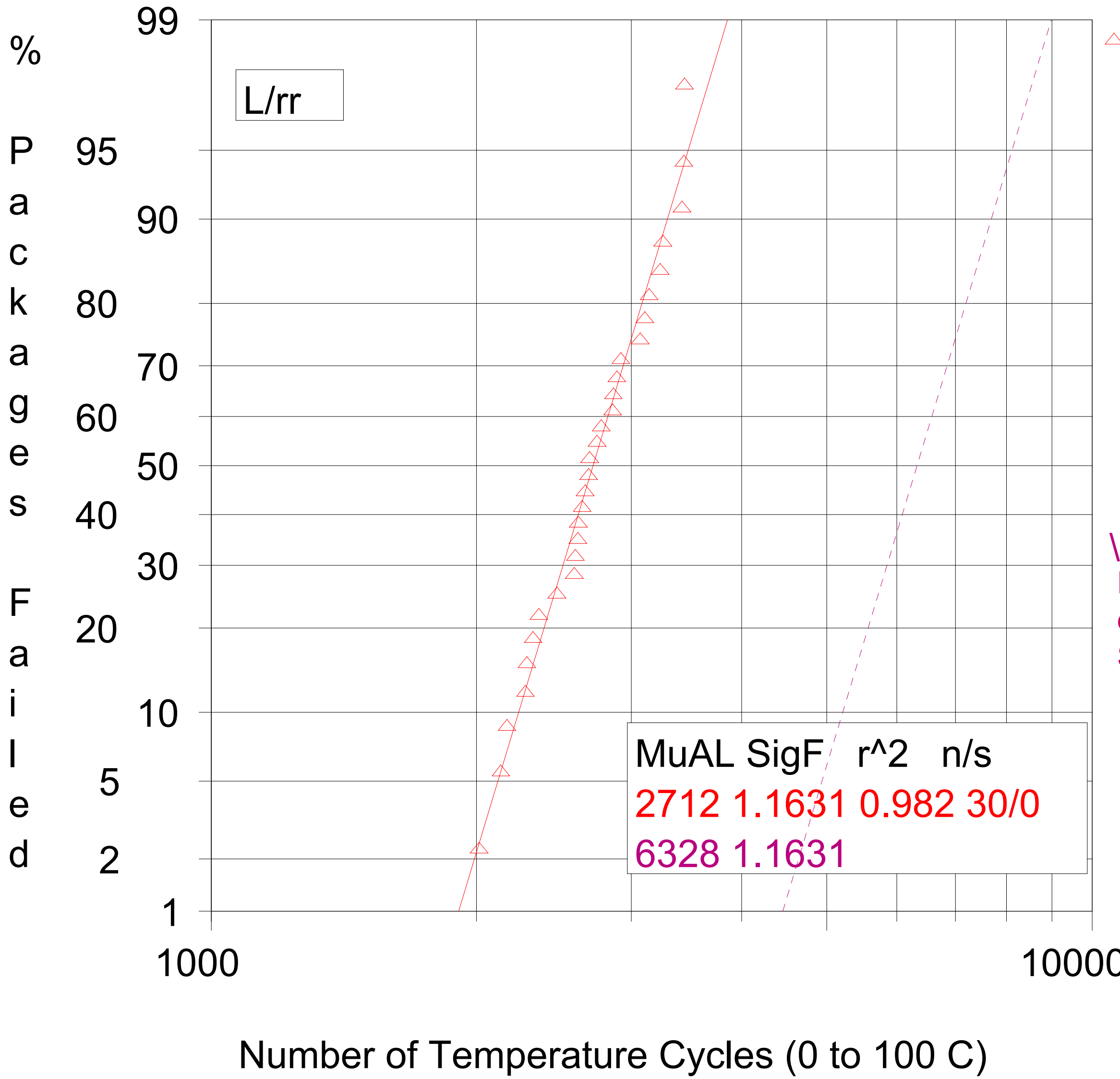
## Comparison of Ceramic Substrate Technology
## 1.27 mm Pitch Parts, 2 Cycles per Hour TC




360 - 25x25x1.2

Standard Ceramic Substrate - HTCC

\838 - 37.5x37.5x2.3

High Temp. Coefficient of Expansion Ceramic Substrate - LTCC

**Dotted Line Assumes 838 Pin Failure Today - No Failures As of 4700 Cycles.**

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