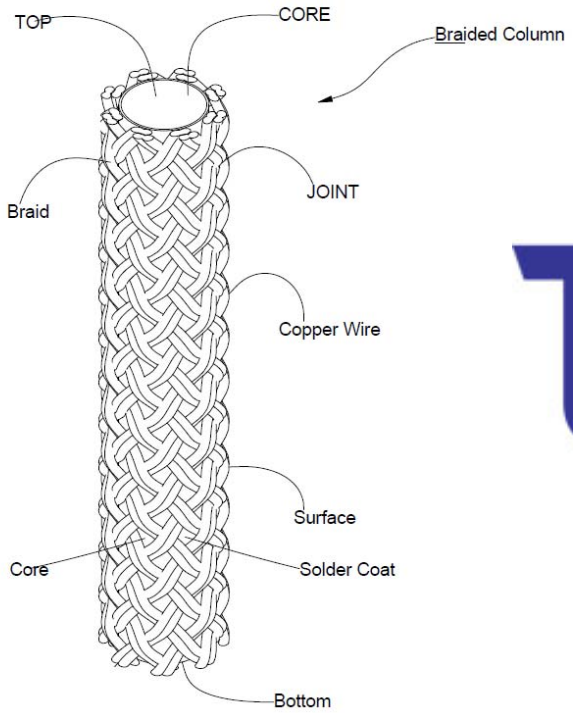
U.S. Patent 10,477,698

New Copper Braided Solder Columns for FPGA and Large Ceramic Modules



TopLine®

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Who is TopLine

TopLine is a U.S. manufacturer of solder columns for Column Grid Array (CCGA) devices.

TopLine also manufactures daisy chain BGA and CCGA packages, and a wide range of daisy chain semiconductor packages and test vehicle PC boards.

TopLine has assisted thousands of customers in commercial, test, aerospace and defense industries to define and refine their SMT and microelectronics assembly processes throughout the world.

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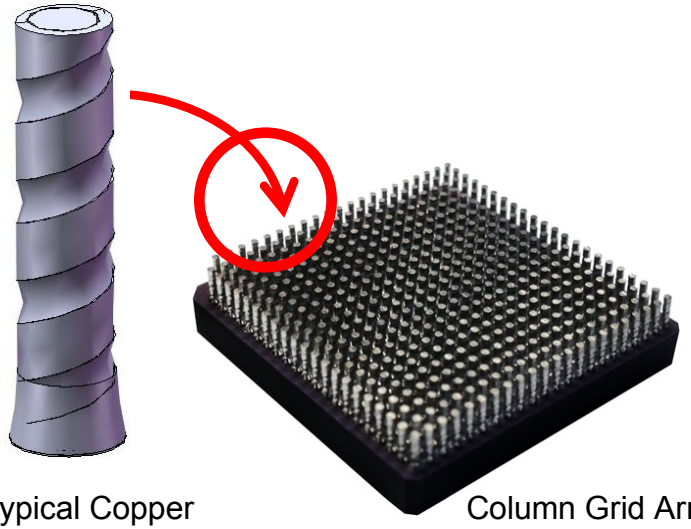
About Copper Wrapped Solder Columns



Typical Copper Wrap Column

Column Grid Array CCGA

Over the past 30 years, the Pb80 Sn20 copper wrap solder column has become accepted as the *preferred* choice for relieving stress due to CTE mismatch between Ceramic Column Grid Array (CCGA) packages and the PCB Board.

Numerous papers have been written by NASA JPL demonstrating the benefits of packages with solder columns for space missions.

In the past, CCGA package size reduction has been constrained because traditional columns require minimum pad pitch of 1.0mm.

In recent years, plastic grid array IC packages have emerged with fine pitch (~ 0.5mm) and/or very large body sizes exceeding 50mm x 50mm.

The roadmap for fine pitch packages with very high I/O (>10,000) makes it challenging to attach traditional copper wrap solder columns.

TopLine invented a new type of column using copper braiding, rather than copper wrap, to meet the industry's need for smaller pitch and high density CCGA.

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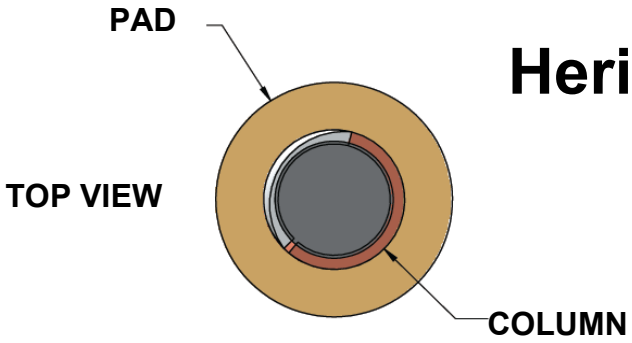
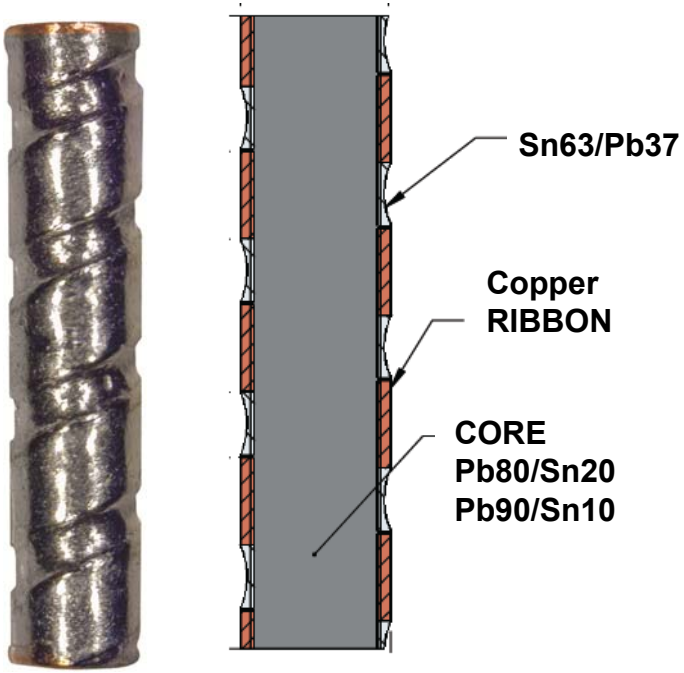
Heritage COPPER WRAP COLUMN





Copper Wrap Columns Materials & Reflow

Materials		Temperature	
Column Core	Column Coating	Reflow with Solder Paste	Reflow with Tacky Flux
Pb90/Sn10 Pb80/Sn20	Sn63/Pb37	Sn63/Pb37 ~215°C	N/A

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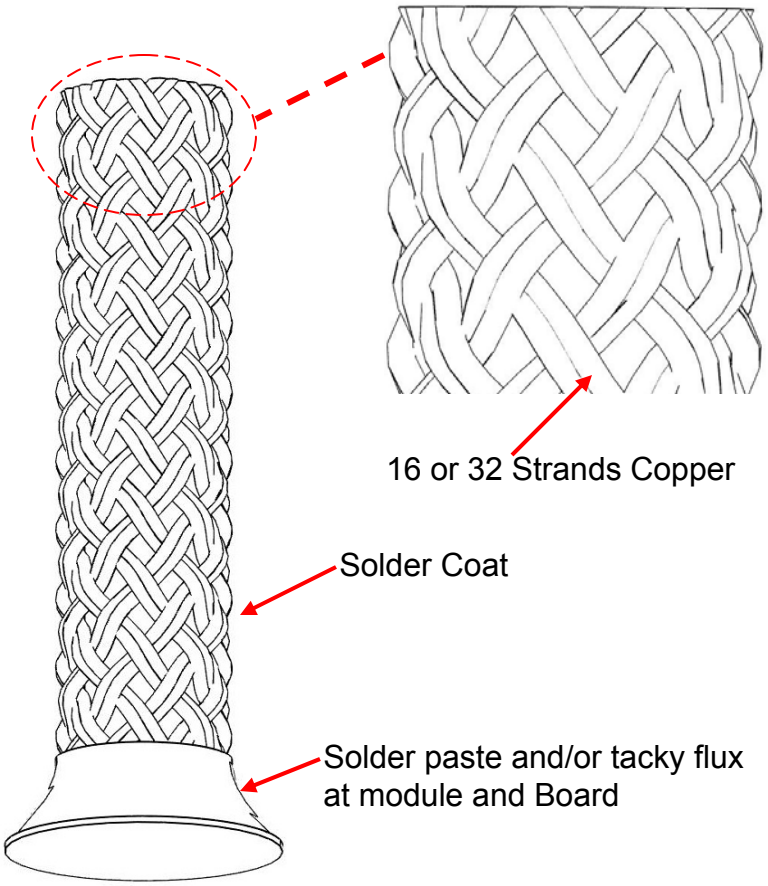
NEW - BRAIDED COLUMN



U.S. Patent 10,477,698

About Braided Column:

TopLine invented a new braided solder column with 16 or 32 copper strands exoskeleton sleeve:

1) No collapse construction.
2) Choice of cores available: Pb80/Sn20, Pb90/Sn10, Sn63/Pb37, Pb93.5/Sn5/Ag1.5 and SAC305 (Pb-Free) and other alloys.
3) Roadmap for Air Core and Elastomer Core.
4) Column diameter: 0.25mm ~ 0.50mm
   Column Length: 1.0mm ~ 4.0mm.
5) Pad Pitch 0.5mm to 1.0mm
6) Attachment methods: a) Solder Paste or b) Tacky Flux for wetting activation.
7) Shorter signal path, lower resistance and improved thermal conduction between module to board.
8) Potentially longer life than copper wrap columns (To be tested by NASA & JPL).

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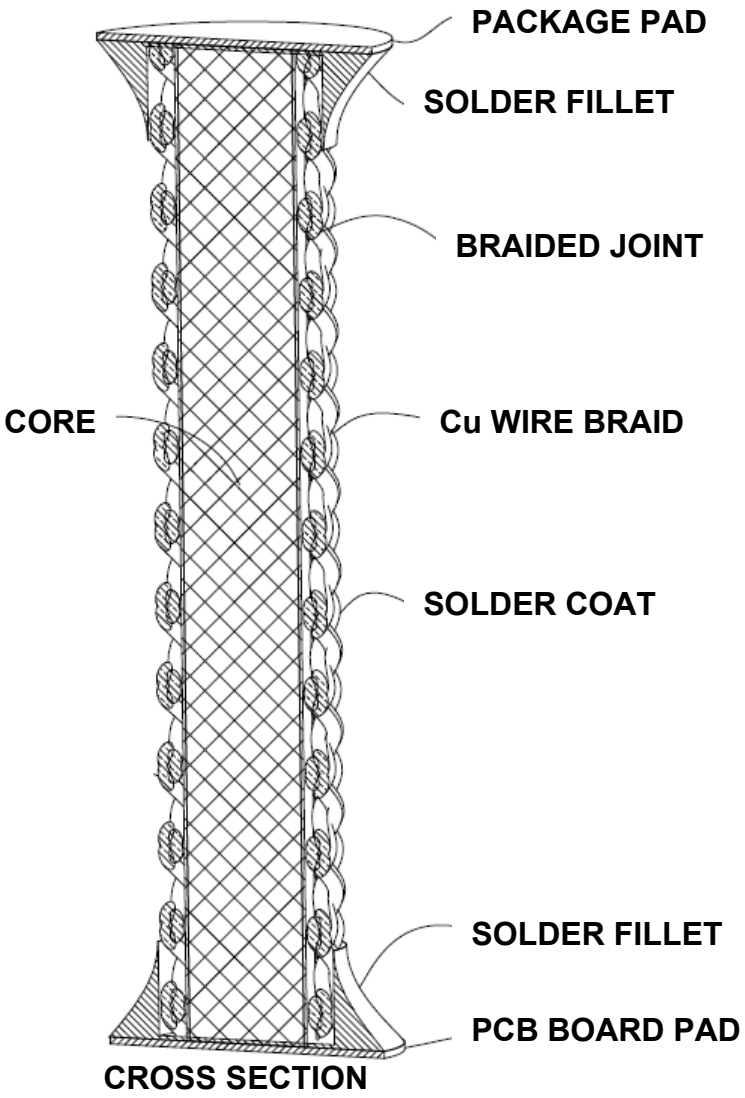
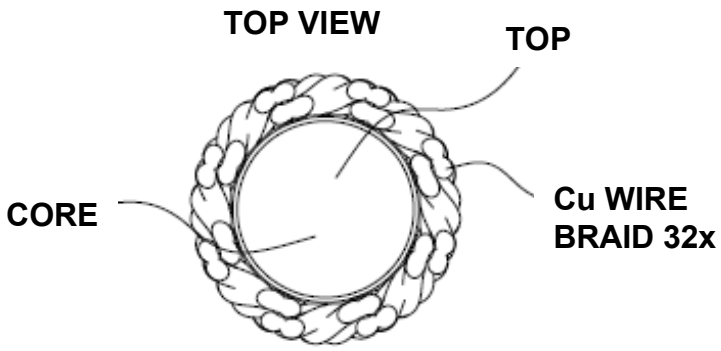
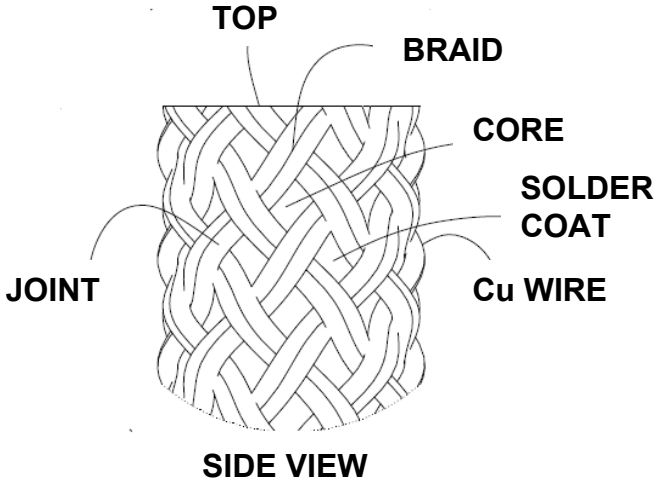
SECTION VIEW BRAIDED COLUMN







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Comparison New Braided Columns and Heritage Copper Wrap Columns

Attribute	New Braided Column	Heritage Copper Wrap Column	Benefit of Braided Column
Column Diameter	0.25mm ~ 0.50mm 10 ~ 20mil	0.30mm ~ 0.50mm 12 ~ 20mil	Braided columns allows finer pitch with higher density I/O (Pitch: 0.5mm ~ 0.8mm)
Core Material	Pb80/Sn20 Pb90/Sn10 Pb93.5/Sn5/Ag1.5 Sn63/Pb37 SAC305 Air or Peek / Elastomer	Pb80/Sn20 Pb90/Sn10	Braided columns can be attached without collapsing using tacky flux. Alternatively, solder paste can be used to attach Braided Columns.
Signal & Heat Path	16 or 32 strands braided copper non-collapse exoskeleton sleeve.	Single copper ribbon wrapped has a longer helix pattern	Braided columns provide shorter signal path with lower impedance and higher thermal conductivity for transferring heat.
Elasticity	Variety of core materials provides potential for optimizing compliancy	Pb80/Sn20 Pb90/Sn10	Life cycle testing is planned by NASA Marshal Space Flight Center and JPL

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New Braided Columns Materials & Reflow

Materials		Temperature	
Column Core	Column Coating	Reflow with Solder Paste	Reflow with Tacky Flux
Pb90/Sn10 Pb80/Sn20	Sn63/Pb37	~215°C Sn63/Pb37	NA
Pb93.5/Sn5/Ag1.5 HMP-High Melt Point	Pb93.5/Sn5/Ag1.5 HMP-High Melt Point	~310°C Pb93.5/Sn5/Ag1.5	NA
Sn63/Pb37 Eutectic	Sn63/Pb37	~215°C Sn63/Pb37	~215°C
SAC305 Lead Free	SAC305	~235°C SAC305	~235°C
Air, PEEK or Elastomer	Sn63/Pb37 or SAC305	200~240°C Sn63/Pb37 or SAC305	NA

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COPPER BRAIDED COLUMNS

Pitch	∅ Column	∅ Pad
0.5mm	0.30mm	0.40mm
0.8mm	0.35mm	0.50mm
1.0mm	0.40mm	0.63mm
1.0mm	0.50mm	0.80mm

Choice of Braid Material

1) PCC Copper + 2% Pd (Standard)
2) Be-Cu Beryllium-Copper for springiness
3) Pure Gold Au or Pure Silver Ag

Choice of Core material

1) Pb90/Sn10 or Sn63/Pb37
2) SAC305 (RoHS) Pb-Free
3) Pb93.5/Sn5/Ag1.5 HMP

Choice of Coating

1) Sn63/Pb37 (Tin-Lead)
2) SAC305 Lead Free
3) Pb93.5/Sn5/Ag1.5 HMP

Module / IC Package

1) Ceramic
2) Organic
3) Wafer Level – Silicon die

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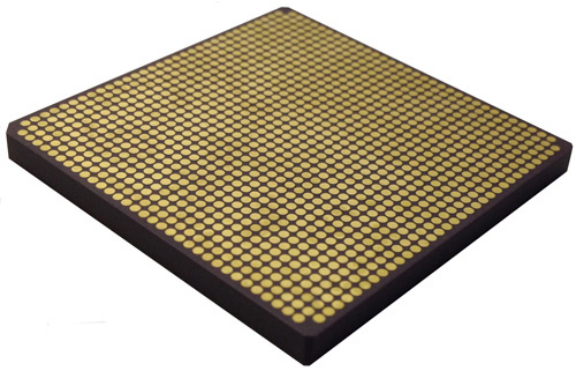
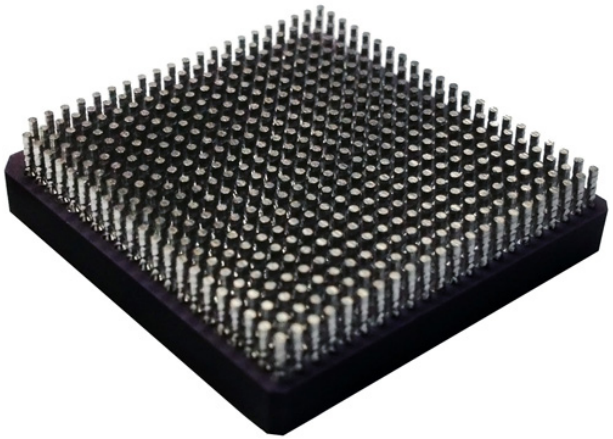
Ceramic Module (FPGA)

Ceramic **Column** **CCGA**





HTCC or LTCC

Al_2O_3

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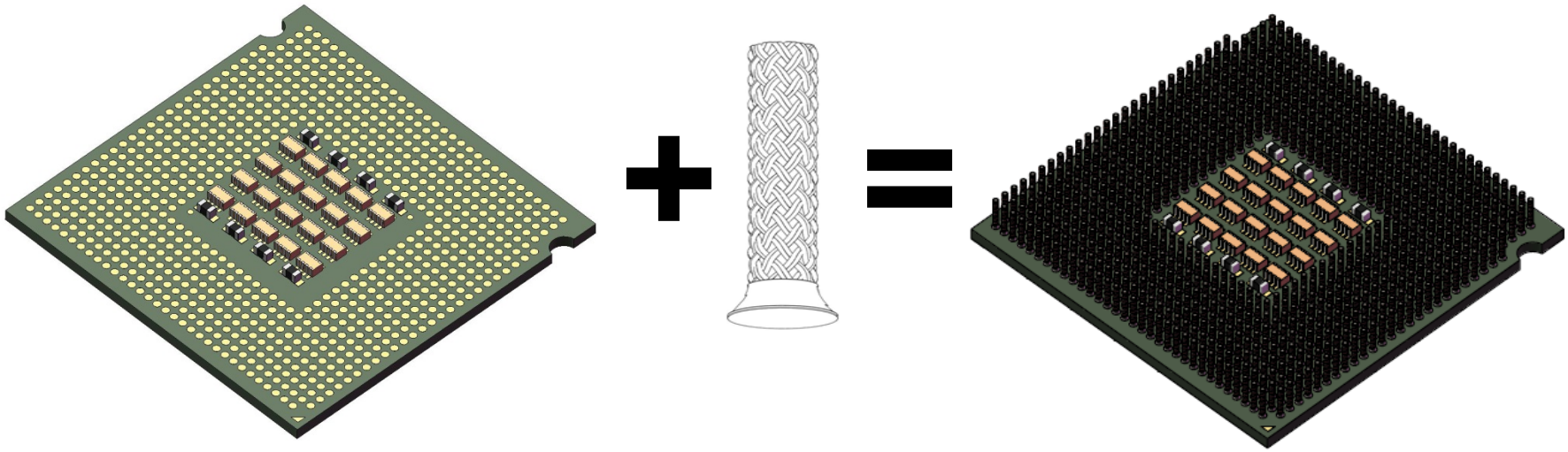
Organic (Plastic) Module

Substrate **Column** **CGA**



Organic

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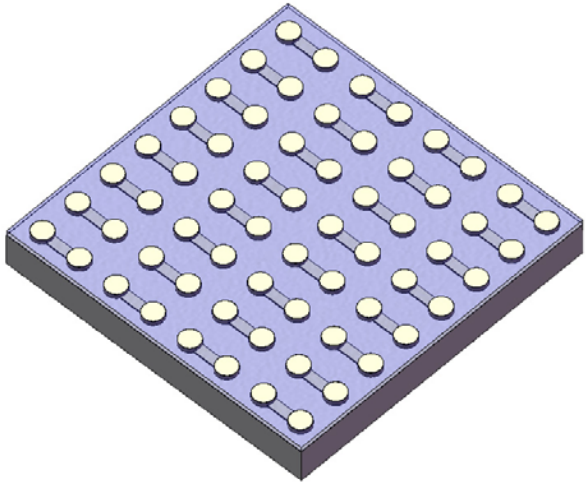
Direct Attach Wafer Level - Die

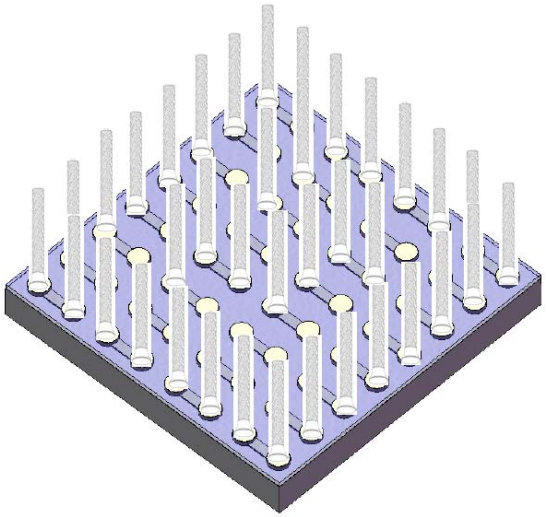
Si



Wafer Level Flip Chip

Braided Column

CGA



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Quick Technical Review:

Why Use Columns ?

Cu Wrap
COLUMN

Cu Braid
New

Answer:

Columns absorb stress caused by mismatch of Coefficient of Thermal Expansion (CTE) between the module and Board.

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When are Columns Required?

Answer: Large ceramics with wide temperature swings

Ball Versus Column With Temperature Swing				
Ceramic Size	Δ 75°C -25° to +50°C	Δ 100°C -25° to +75°C	Δ 150°C -50° to +100°C	Δ 175°C -50° to +125°C
23 x 23mm 483 L	**Ball** 12um Strain	**Ball** 16um Strain	**Ball or Column** 25um Strain	**Column** 30um Strain
35 x 35mm 1152 L	**Ball** 18um Strain	**Ball or Column** 25um Strain	**Column** 37um Strain	**Column** 45um Strain
52.5 x 52.5mm 2577 L	**Ball or Column** 28um Strain	**Column** 36um Strain	**Column** 55um Strain	**Column** 64um Strain

CAUTION SAFE

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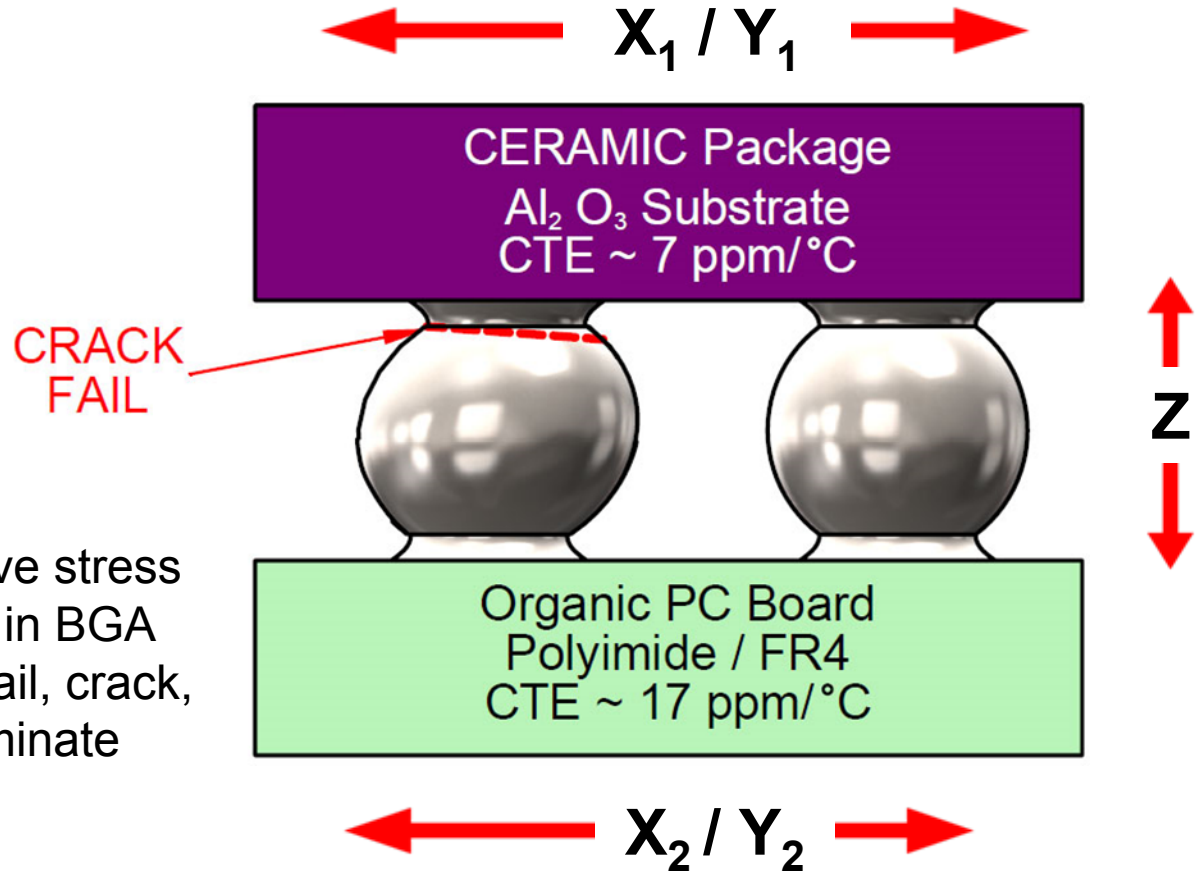
Solder balls fail due to excessive stress.

CTE Mismatch (Ceramic to FR4) ~ 10ppm/°C



Excessive stress results in BGA balls to fail, crack, delaminate

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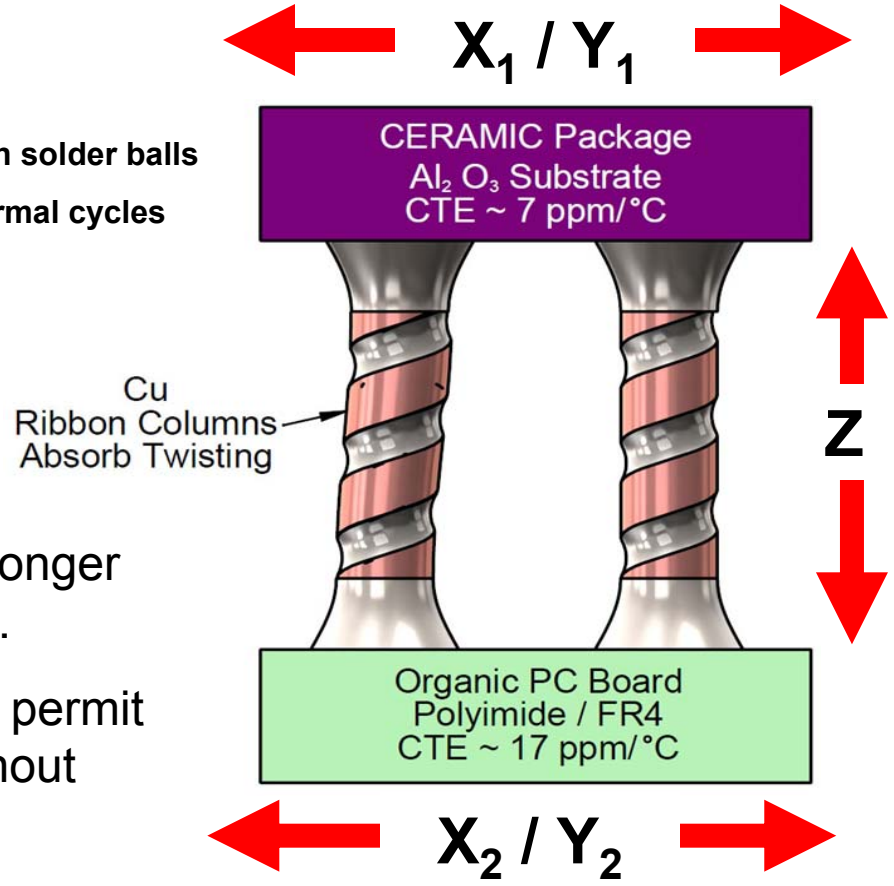
Columns Absorb Stress/Strain

CTE Mismatch ~ 10ppm/°C

Columns more reliable than solder balls

Columns survive more thermal cycles



Columns provide longer operating life.

Compliant columns permit deformation without breaking.

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Strain Formula Equation:

Deformation of a solid due to stress.

$$\Delta x = DNP * \Delta T * (CTE_1 - CTE_2)$$

DNP – Distance from Neutral Point

ΔT = Temperature Change

CTE_1 FR4 = 17.5 ppm/^oC @25^oC

CTE_2 Ceramic = 7.5 ppm/^oC @25^oC

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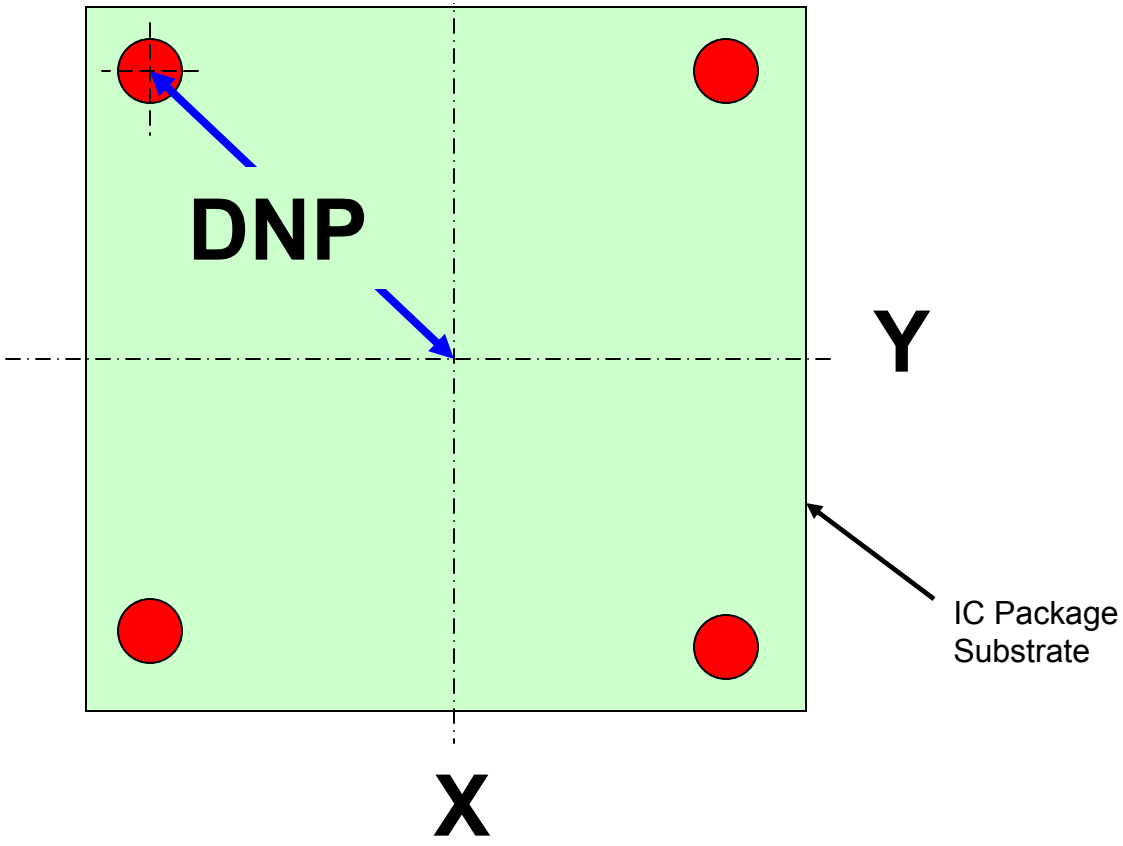
Distance from Neutral Point

$$DNP = \sqrt{2} * (X/2)$$

Pads in the corners of the substrate (red color) are the furthest distance from the neutral point (center of package) and are most vulnerable to failure mode



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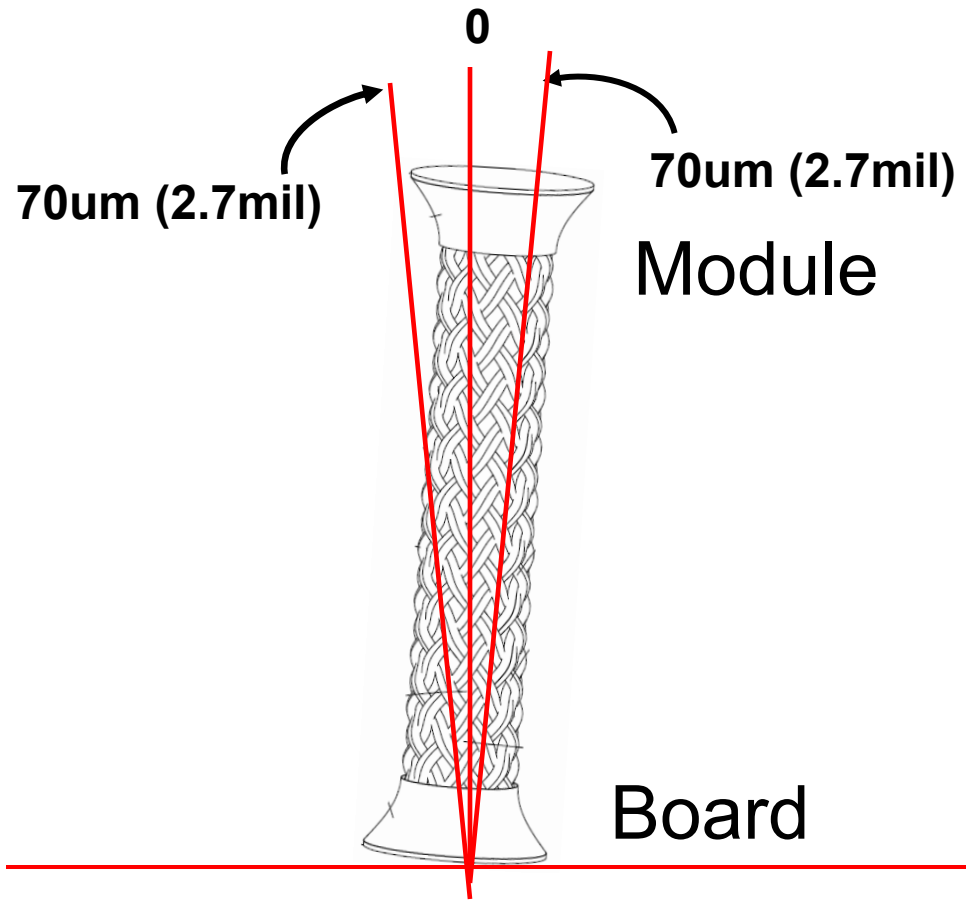
Compliancy Requirement
100 x 100mm Ceramic Substrate



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www.TopLine.tv/CCGA.html

Email: info@topline.tv

Tel: 1-800-776-9888

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