Braided Column

Road Map

Solder Columns for Quantum Computers

As well as improved reliability and thermal properties for cryogenic applications such as lunar landings, deep space, scientific sensors and instruments and AI/ML data centers.

IPC APEX

April 17, 2024

Who is TopLine:

Founded 35 years ago in 1989.

We are a U.S. based manufacturer providing novel interconnect solutions between the package and board.

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What TopLine makes:

Solder Columns

Daisy Chain Test Vehicles

Particle Impact Dampers (P.I.D)

We have 15 Patents granted in fields of Column Grid Arrays & Vibration Dampers.

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Column Attachment Services:

1. We provide full turnkey column attachment services.

2. We deliver materials, tooling and processes to your assembly partner to attach columns.

3. We provide R&D to develop novel solutions.

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TopLine Locations:

1. Orange County - California

Manufacturing and R&D Engineering Services,
Solder Columns, Tool Sets, Test Vehicles

2. Atlanta Area - Georgia

Sales, Logistics, Distribution, Finished Goods

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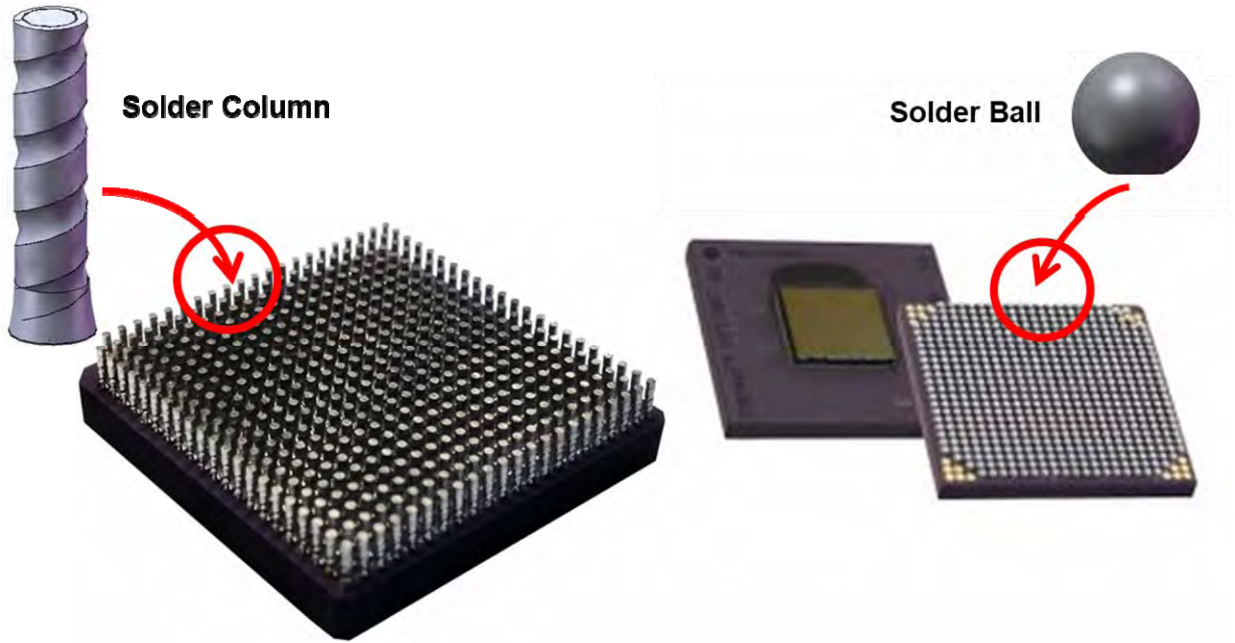
Why Solder Column Technology?

Solder Columns reduce fracture-strain in solder interconnections.

Increase reliability when CTE mismatch is more than 10ppm / ^{o}C



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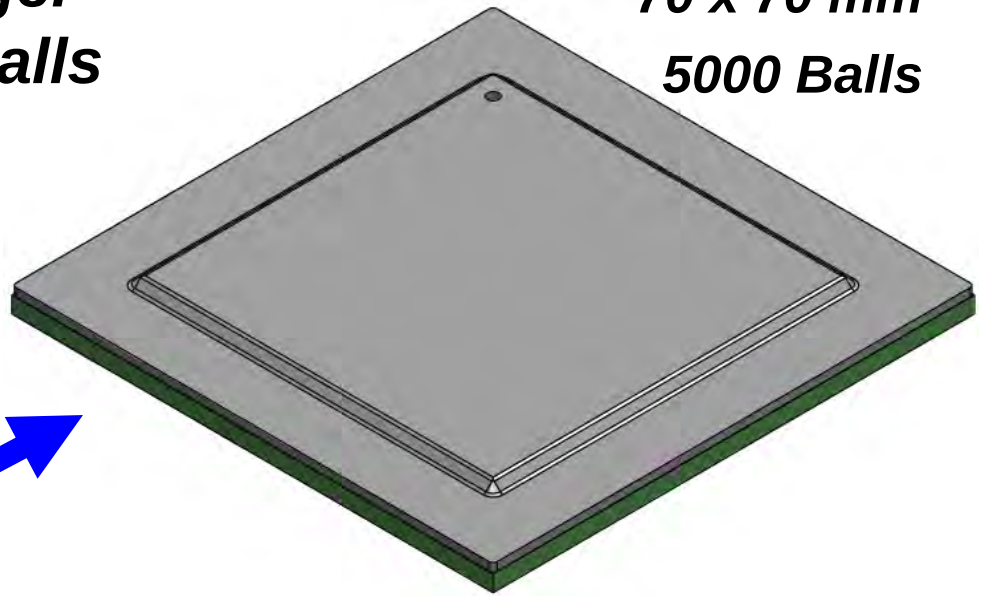
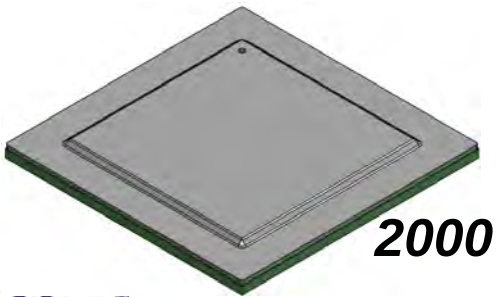
Trend is larger and larger packages with Solder Balls

Today
70 x 70 mm
5000 Balls



10 Years Ago
Size: 45 x 45 mm



2000 Balls

Coming Soon !
100 x 100 mm
10,000+ balls

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Key parameters that increase strain which leads to reduced reliability of the package to board interconnections:

- CTE Mismatch – Coefficient of thermal expansion
- DNP – Distance from the Neutral point
- Temperature Swings – Hot to Cold
- Thermal Cycles – Nbr of times the temperature swings
- Modulus –softness/hardness/flexibility of materials

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CTE Mismatch can rip balls off your packages.

PKG Size	Strain - Movement over Temperature Change					
	Mars Δ 160°C		**Lunar Equator** Δ 300°C		**Quantum Computing** Δ 300°C	
	-140°C	+20°C	-180°C	+120°C	-270°C	+30°C
45x45mm DNP 32mm	2.0 mil 51 um		3.8 mil 96 um		3.8 mil 96 um	
70x70mm DNP 49mm	3.0 mil 78 um		5.8 mil 147 um		5.8 mil 147 um	
100x100mm DNP 70mm	4.4 mil 112 um		8.2 mil 210 um		8.2 mil 210 um	

DNP = Distance from Neutral Point from the center of the package

10ppm/°C CTE mismatch between ceramic package and PC Board

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Quantum computers

(and other cryogenic applications)

have additional requirements:

1. Solders must withstand brittleness at cryogenic temperatures.

2. Selecting the right alloys prevents columns from disintegrating into powder at low temperatures.

3. Solder alloys experience fracture-strain as temperatures drop below their Ductile to Brittle Transition Temperature (DBTT).

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Some applications, including Quantum Computers, perform better below the superconductivity point.

Material	Onset Temperature of Superconductivity		Available from TopLine
	°K Kelvin	**°C** Celsius	
Aluminum (Al-1%Si)	1.9 °K	-271.24 °C	Bonding Wire
Indium (In)	3.4 °K	-269.75 °C	Solder Columns
Lead (Pb)	7.2 °K	-265.95 °C	Solder Columns
Niobium (Nb)	9.2 °K	-263.95 °C	Solder Columns
Tin (Sn)	3.7 °K	-269.45 °C	Solder Columns

Reason: ***Resistance drops to zero when certain materials become superconductive, allowing current to flow without energy loss.***

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TopLine has developed a family of Braided Solder Columns for cryogenic environments and next generation applications.

Competing technologies, such as solder balls and heritage copper wrapped solder columns, can't step up to the task.

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Superconducting Braided Solder Columns

Core	Braid	Superconducting	Flux Disturbance in Quantum Computers	Samples
Pb90/Sn10	C172 (Be-Cu)	Core	Trace Nickel	Ready Now
Indium	C172 (Be-Cu)	Core	Trace Nickel	Q2 - 2024
Indium	Gold Au 4N	Core	None	Q3 - 2024
Indium	Niobium	Core & Braid	None	Q4 - 2024
Indium	*New Alloy*	Core & Braid	None	Q1 - 2025

We can help you choose the right materials to optimize your application.

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Braided Solder Columns for General & Cyrogenic Applications

Core	Braid	Application	Ambient Temperature Min	Max	Samples
Pb90/Sn10	C172 (Be-Cu)	Space - Moon	-184°C	+120°C	Ready Now
Pb90/Sb10	C172 (Be-Cu)	Space - Mars	-140°C	+20°C	Ready Now
HMP	C172 (Be-Cu)	Earth – Downhole Drilling	+110°C	+200°C	Ready Now
Sn/Sb	C172 (Be-Cu)	Large Scale Package AI/ML	-140°C	+150°C	Ready Now
Indium	C172 (Be-Cu)	General Cryogenic	-269°C	+125°C	Q2 - 2024
Indium	*Niobium*	Quantum Computer	-273°C		Q1 - 2025

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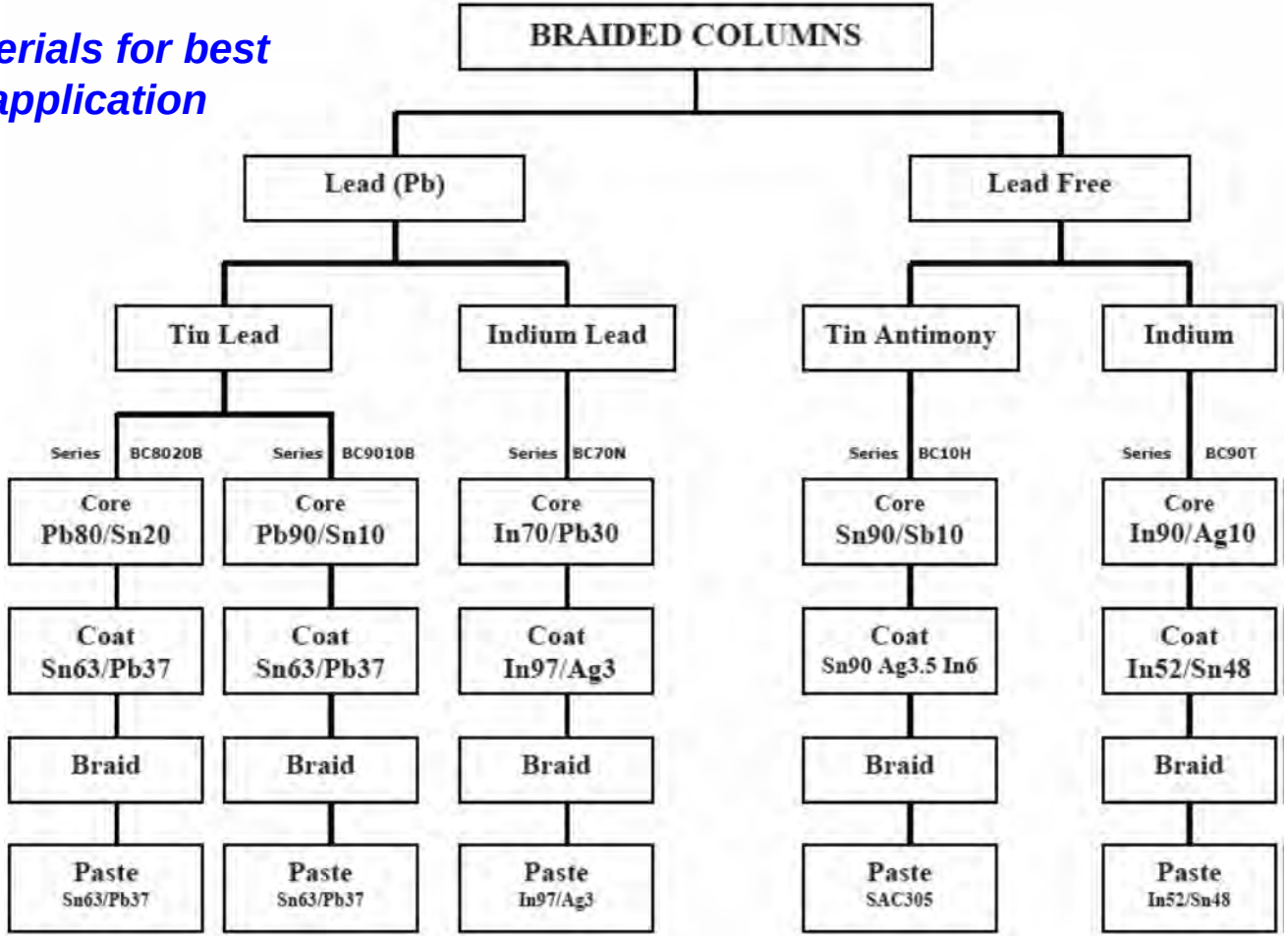
Choose materials for best for your application



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Braided Column Configurations and Test Results

Solder Column relative size

Braided Solder Column

16x wire braided over non-collapsible solder core

Shown before Solder Coating

Column Length 1.0mm ~2.2mm

Shown After Solder Coating

Fillet

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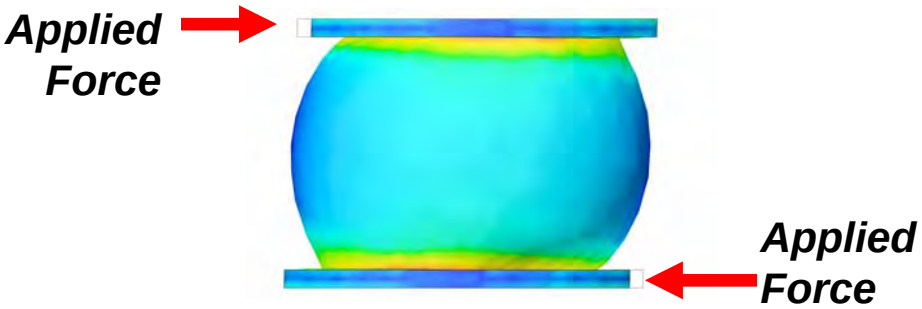
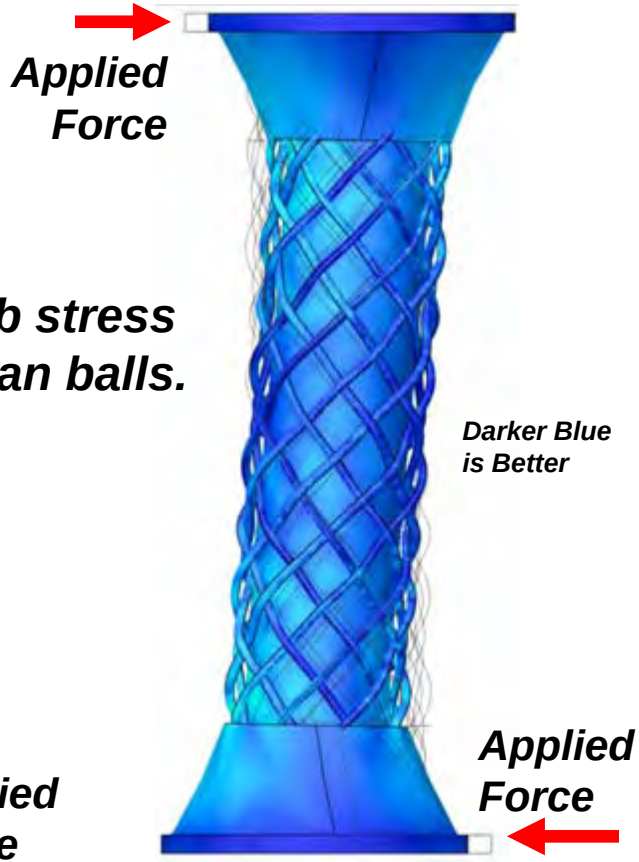
Patents:
US 10,477,698 B1
CN 1118822899 B

Planarized Braided Solder Columns

Finite Element Analysis Comparison Bend Strain Ball vs Column

Observation: ***Braided Columns absorb stress and distribute the load more evenly than balls.***





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TopLine can assist you to select the column length to improve reliability.

Pitch	"D" mm	Aspect Ratio (D x L)		
		3:1	4:1	5:1
0.65mm	0.20	0.6mm	0.8mm	1.0mm
0.8mm	0.25	0.8mm	1.0mm	1.3mm
	0.30	0.9mm	1.2mm	1.5mm
	0.35	1.0mm	1.4mm	1.7mm
1.0mm	0.40	1.3mm	1.6mm	2.2mm
	0.50	1.5mm	2.2mm	2.5mm

Package (substrate) pitch and pad diameter determines the column diameter "D".

Aspect ratio is influenced by package X/Y and CTE mismatch (Min-Max Temperature Swing).

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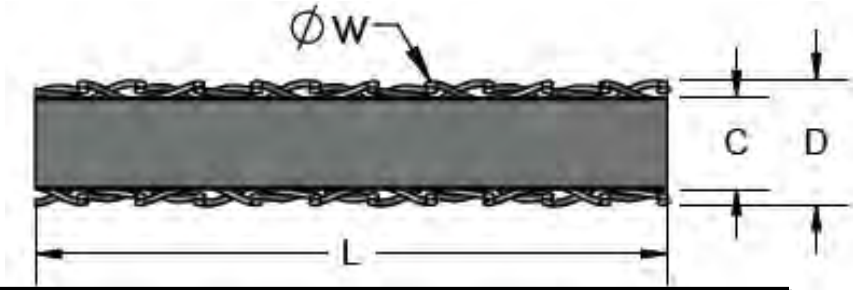
Column Diameter



"D" Column Diameter	Ø W Braid Wire	"C" Core Diameter
300um	25um	200um
350um	25um	250um
400um	38um	250um
450um	38um	300um
500um	38um	350um

Smaller and larger Diameter columns available. Please ask.

Column diameter "D" should be < 75% of the substrate pad diameter.

Thicker "W" Braid Wire 50um and 63um is available.

Benefits of Braided Solder Columns :

1. ***Non-Collapsible: Exo-skeleton braided sleeve supports columns over a wide operating temperature.***

2. ***Increased reliability - Columns absorb CTE mismatch.***

3. ***Columns are a viable replacement for solder balls.***

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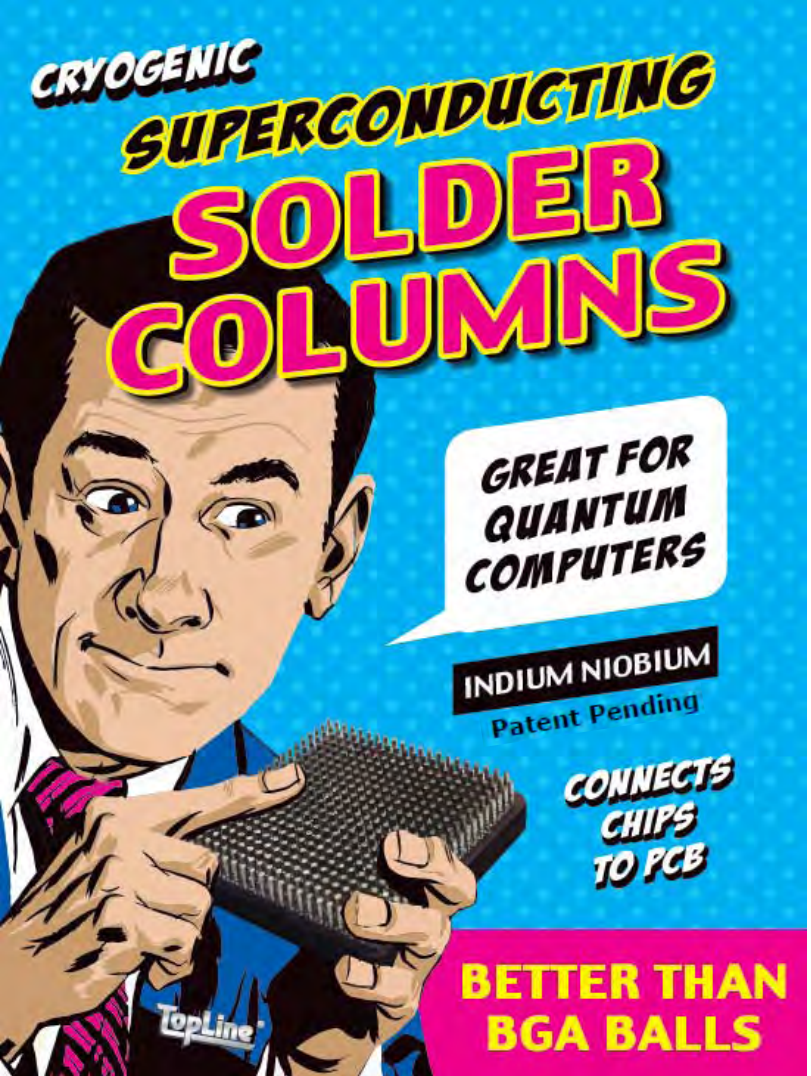

Let's Explore

How solder columns can improve reliability for your cryogenic application.

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