



**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.***

**TopLine Corporation © 2024**

**IPC APEX**



# ***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.**



# ***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.***

# ***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.***

# ***TopLine Locations:***

## ***1. Orange County - California***

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

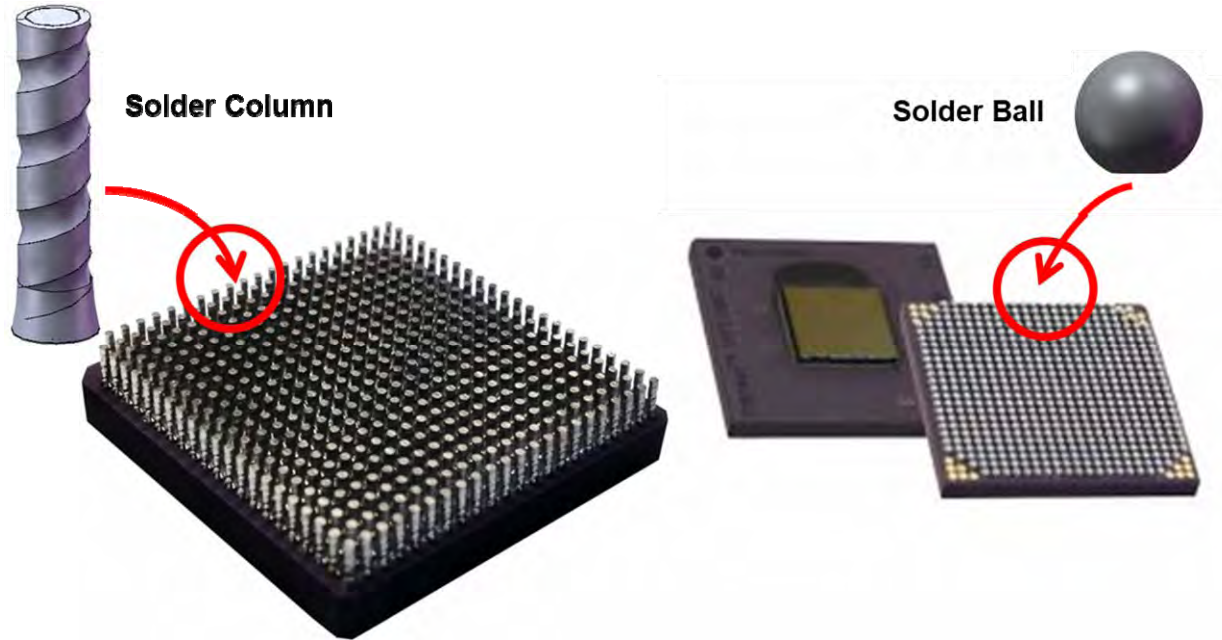
## ***2. Atlanta Area - Georgia***

***Sales, Logistics, Distribution, Finished Goods***

# ***Why Solder Column Technology?***

# ***Solder Columns reduce fracture-strain in solder interconnections.***

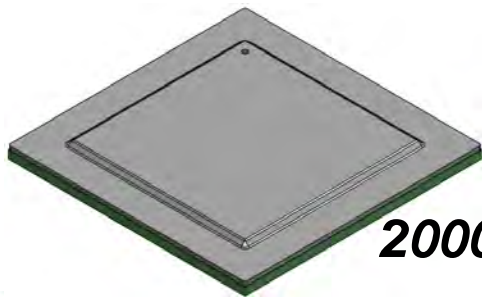
***Increase reliability when CTE mismatch is more than 10ppm / °C***



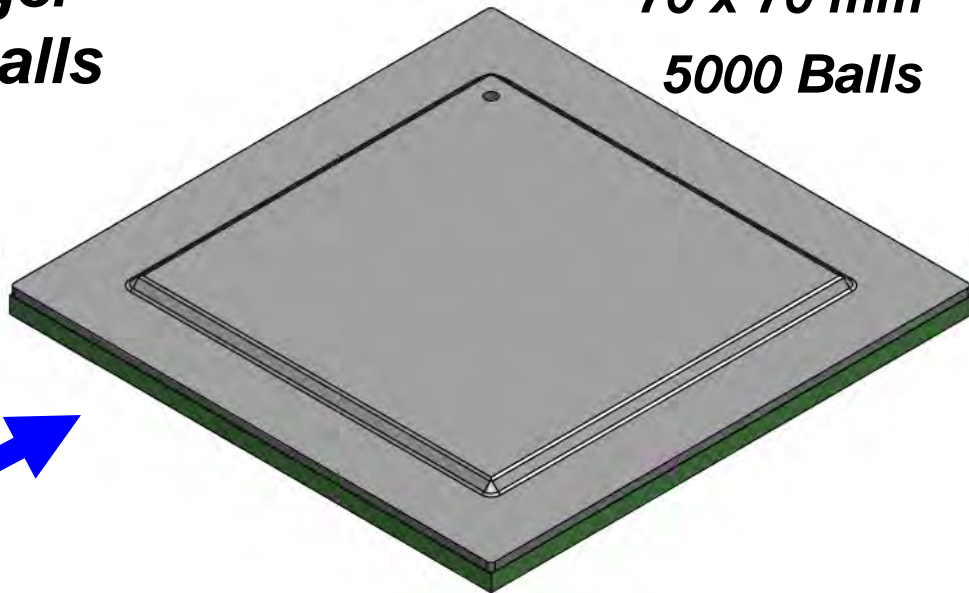
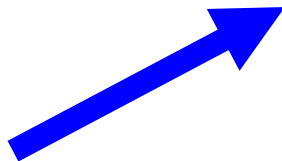
***Trend is larger and larger packages with Solder Balls***

***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***



***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

# ***CTE Mismatch can rip balls off your packages.***

PKG Size	Strain - Movement over Temperature Change					
	Mars $\Delta$ 160°C		Lunar Equator $\Delta$ 300°C		Quantum Computing $\Delta$ 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***

# **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**).**

***Some applications, including Quantum Computers, perform better above 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.***

***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.***

# 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	<i>New Alloy</i>	Core & Braid	None	Q1 - 2025

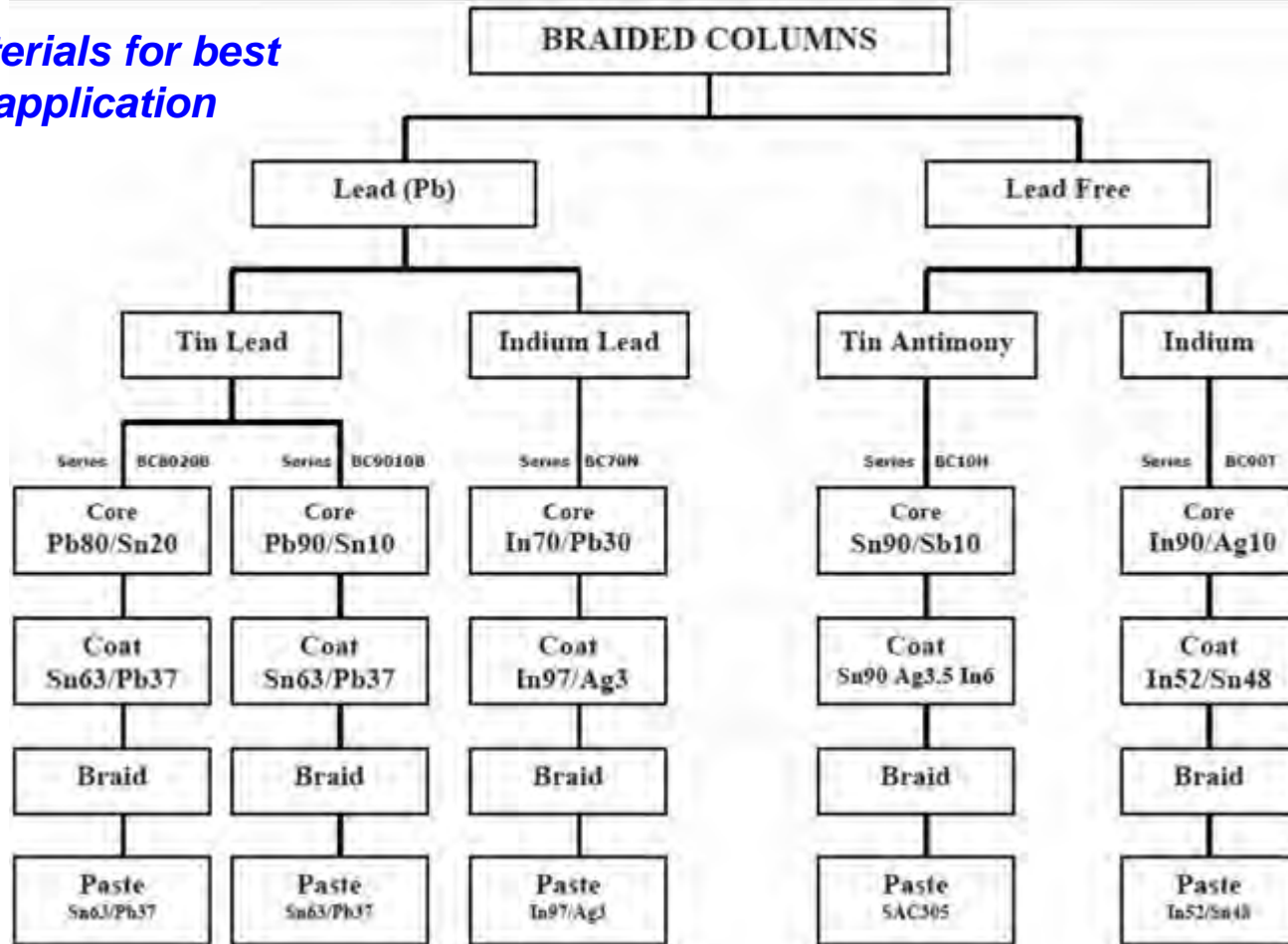
***We can help you choose the right materials to optimize your application.***

## ***Braided Solder Columns For Other Applications***

Core	Braid	Application	Ambient Temperature		Samples
			Min	Max	
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	<i>Niobium</i>	Quantum Computer	-273°C		Q1 - 2025

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

*Choose materials for best  
for your application*





# ***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**



**Shown After  
Solder Coating**



**Column  
Length  
1.0mm  
~2.2mm**

**Fillet**



**TopLine**<sup>®</sup>

*Patents:*

*US 10,477,698 B1*

*CN 1118822899 B*

***Planarized Braided Solder Columns***

Max Strain

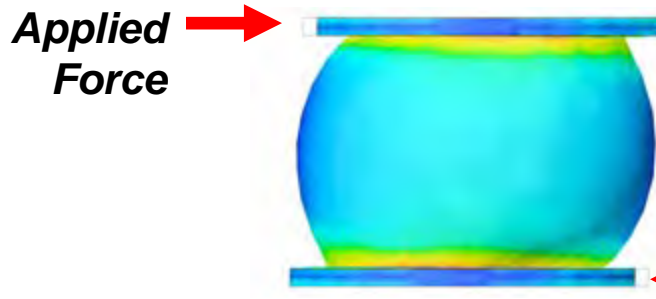


Min Strain

TopLine®

## *Finite Element Analysis Comparison Bend Strain Ball vs Column*

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



*Applied Force*

*Applied Force*



*Applied Force*

*Darker Blue  
is Better*

*Applied Force*

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

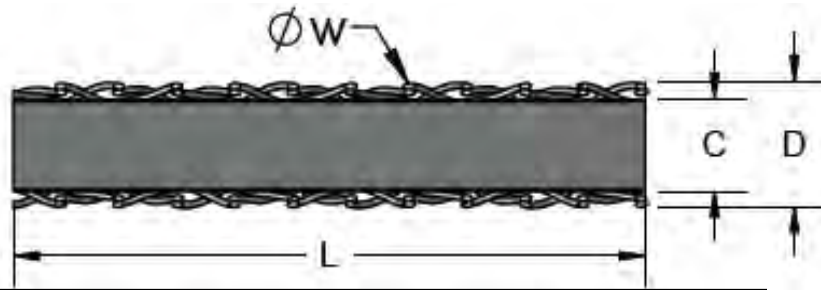


Pitch	“D” mm	Aspect Ratio (D x L)		
		3:1	4:1	5:1
0.65mm	0.20	0.6mm	0.8mm	1.0mm
0.8mm	0.25	0.8mm	1.0mm	1.3mm
	0.30	0.9mm	1.2mm	1.5mm
	0.35	1.0mm	1.4mm	1.7mm
1.0mm	0.40	1.3mm	1.6mm	2.2mm
	0.50	1.5mm	2.2mm	2.5mm

*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).*

# Column Diameter



<b>“D” Column Diameter</b>	$\phi W$ Braid Wire	<b>“C” Core Diameter</b>
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.***

**CRYOGENIC**

**SUPERCONDUCTING**

**SOLDER  
COLUMNS**

**GREAT FOR  
QUANTUM  
COMPUTERS**

**INDIUM NIOBIUM**  
Patent Pending

**CONNECTS  
CHIPS  
TO PCB**

**BETTER THAN  
BGA BALLS**

**TopLine**

# Let's Explore

*How solder columns can improve reliability for your cryogenic application.*

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**TopLine®**