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Better than Solder Balls: Solder Columns for Quantum Computers and Cryogenic Applications

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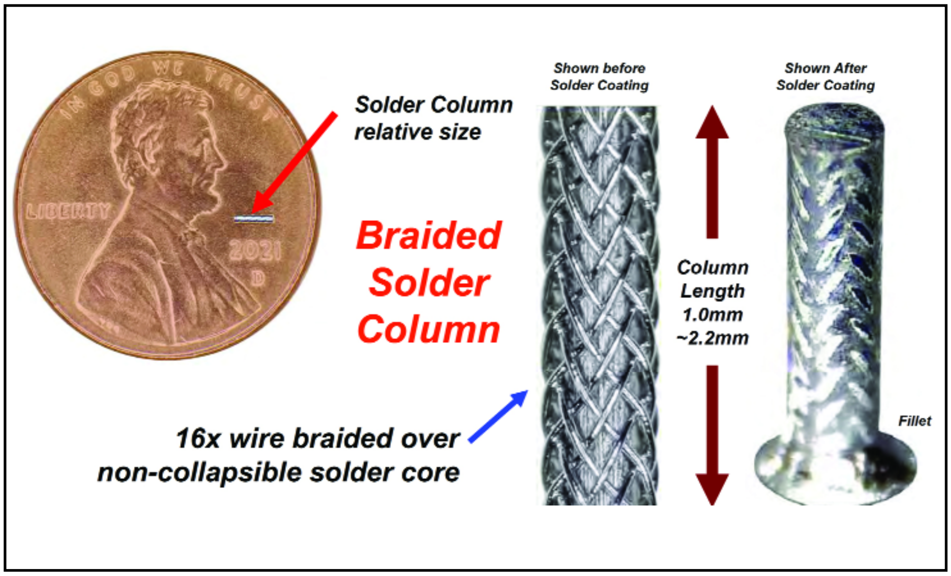
Some applications, including quantum computers, perform better at cryogenic temperatures, below what is known as the superconductivity point.

This is because electrical resistance drops to zero when certain materials become superconductive, allowing current to flow without energy loss.

The demands of cryogenic temperatures are quite rigorous. Many materials behave differently at cryogenic temperatures and their electrical and physical properties may change dramatically. They may become brittle, and some alloys practically disintegrate into powder when subjected to extremely low temperatures.

And yet, this super-cold world is the normal environment for extreme applications including lunar landings, deep space exploration, scientific sensors and instruments, and AI/ML data centers, to name only a few.

Electrical and electronic components will also expand and contract with wide swings in temperature. This movement, also known as the Coefficient of Thermal Expansion, can cause extreme physical stress and strain, thus affecting reliability of the chip package to board interconnections on PCBAs.



Braided solder columns.

Key parameters that increase stress and strain include the following: CTE mismatch between materials; distant from the neutral point (DNP); temperature swings — hot to cold; thermal cycles; and the modulus — softness, hardness or flexibility of materials.

Braided Solder Columns

The larger the integrated circuit in surface area and complexity (e.g., Ball Grid Array or BGA) the greater the amount of movement with greater DNP. As the DNP grows, the more pronounced will be the effects of thermal mismatch or CTE. CTE mismatch can quite literally rip balls off of your BGA packages.

The current trend is toward larger and larger packages, particularly BGA packages with solder balls. The average large BGA today is 70 x 70 mm with 5,000 balls. A decade ago it was 45 x 45 mm with 2,000 balls. Coming soon we will see 100 x 100 mm with 10,000+ balls. The larger the package, the more complex and difficult issues of package reliability and thermal properties become.

TopLine has developed a family of Braided Solder Columns suitable for cryogenic environments and next-generation applications, replacing solder balls on IC packages of varying sizes. These columns provide improved reliability and thermal properties over competing technologies, such as solder balls and heritage copper wrapped solder columns which simply aren't equal to the task.

Braided solder columns, instead of solder balls, provide increased reliability, absorb stress and distribute the load more evenly than balls. In a quantum computer structure, for example, solder must withstand brittleness at cryogenic temperatures.

Selecting the right solder alloys prevents columns from disintegrating into powder at low temperatures. Solder alloys experience fracture strain as temperatures drop below their ductile to brittle transition temperature (DBTT).

Superconducting braided solder columns are a viable replacement for solder balls. They are strong and flexible enough to absorb CTE mismatch, especially when CTE mismatch is more than 10 ppm/°C. Superconducting braided columns reduce fracture strain in solder interconnections. An exoskeleton braided sleeve supports the columns over a wide range of operating temperatures, enabling them to be non-collapsible and thus increasing reliability especially when there is a CTE mismatch over the DNP at the center of the package and the circuit board.

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