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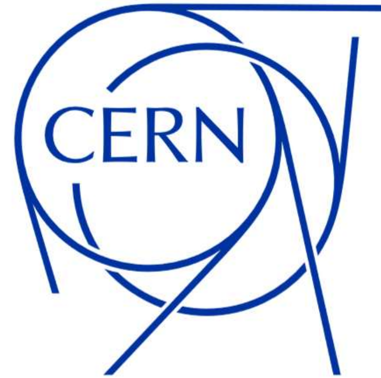

Evaluating Thermal Conductivity Enhancement:
A Comparative Study of Nanowire-Based Interconnection Materials

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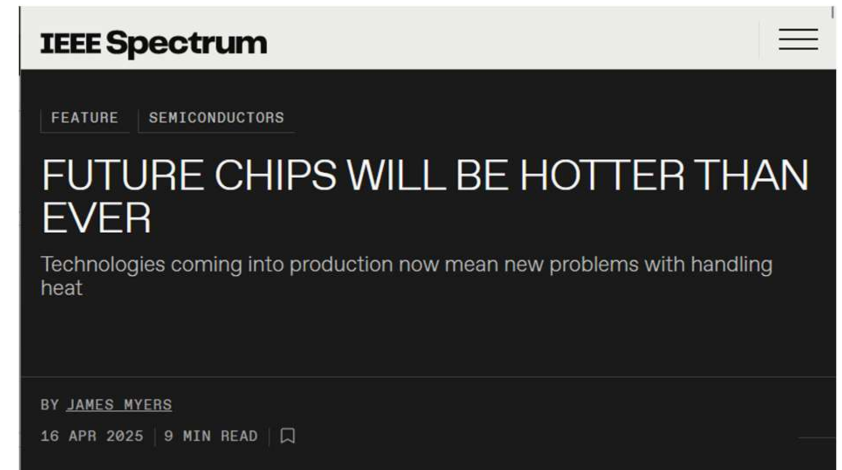
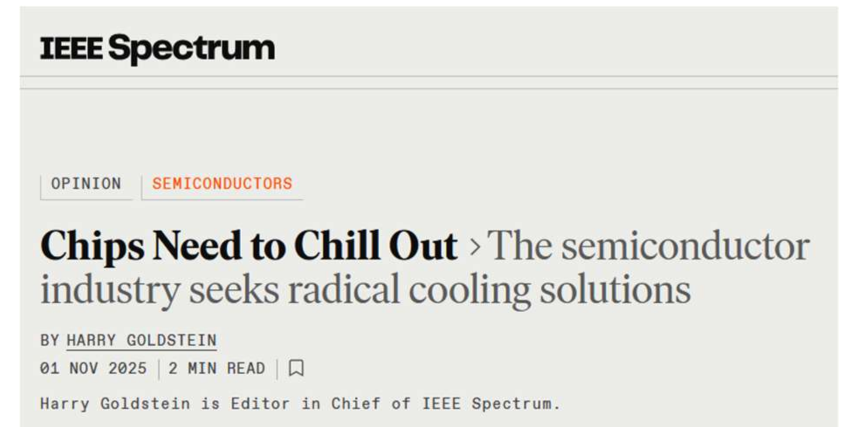
Thermal Management

- Modern chips demand advanced cooling due to increasing power density and functionality.
- Power converters and other hotspots require dedicated thermal management.
- Temperature rise directly impacts chip performance.



https://spectrum.ieee.org/hot-chips



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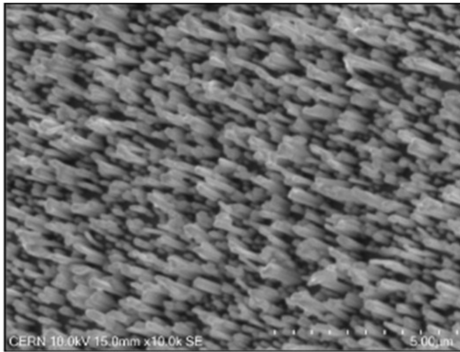
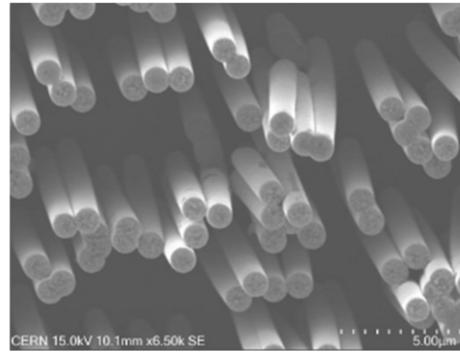
Copper Nanowires





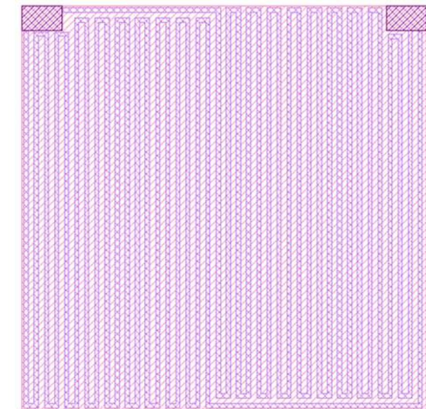
100 nm and 1000 nm Diameter Cu Nanowire Structures.
Photographed using the Electron Microscope at CERN

A Sample sheet cut up for bonding

Heating Elements as Controlled Testers

Aluminium Meanders

- Meander heaters: 100 W, optimized thermal distribution, no hotspots.
- Materials: Gold contacts (soldering), copper backside (bonding tests).
- Fabrication: Cleanroom (Campus Biotech & CMi) | PECVD, lithography, sputtering.



Bonding to Heat Sinks

Bonding is performed with a modified bonding tool.

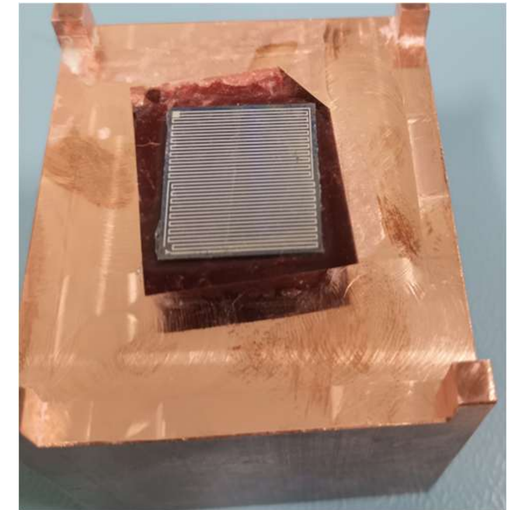
- Surface activation to clean any oxides on the nanowires is done.
- C-Clamp is modified so that required pressure (5 Mpa - 50Mpa) is applied for bonding.
- A dynamometric torque wrench is used to measure force delivered.
- Heat gun used to deliver required heating for sintering

Bonding of the samples

Bonding to Heat Sinks

Limitations of Setup

- Bonding in atmospheric air (N2 atmosphere preferred for optimal results).
- Heat gun heating lacks precise temperature control.



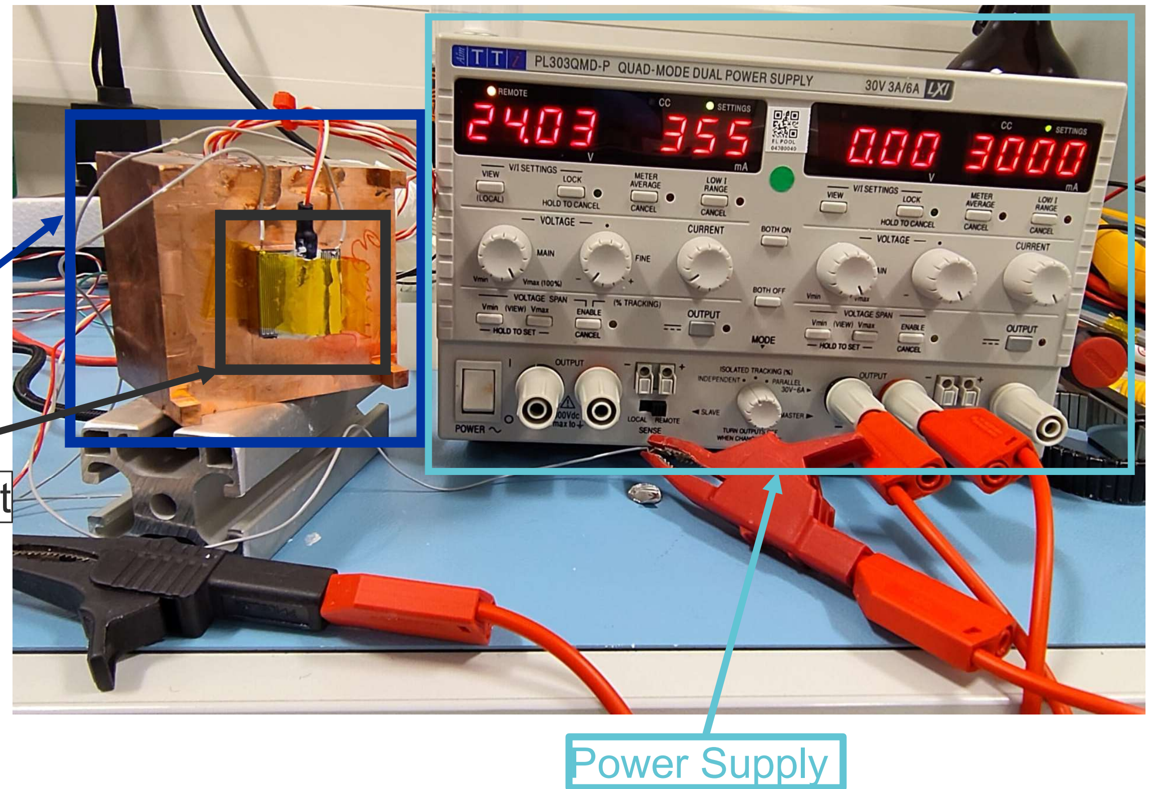
Sintered Nanowires sample

Testing Setup

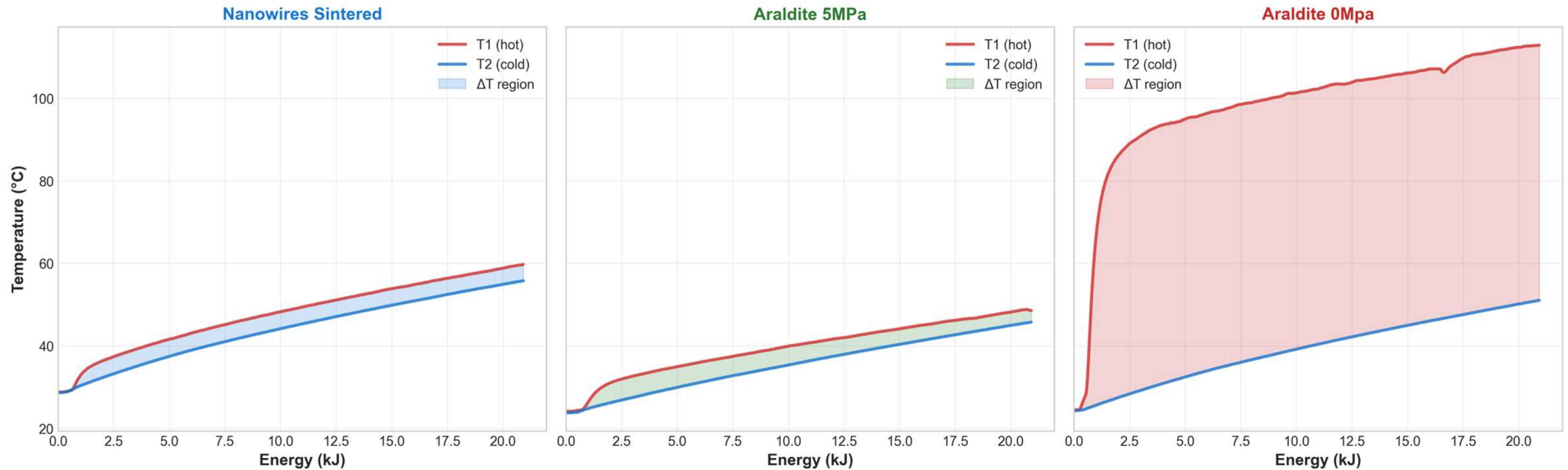
- 2 Pt 1000 RTDs, each placed before and after the interconnection to measure temperature gradient.
- TTi Power Supply programmed to deliver constant Power.

Heat sink

Heating Element



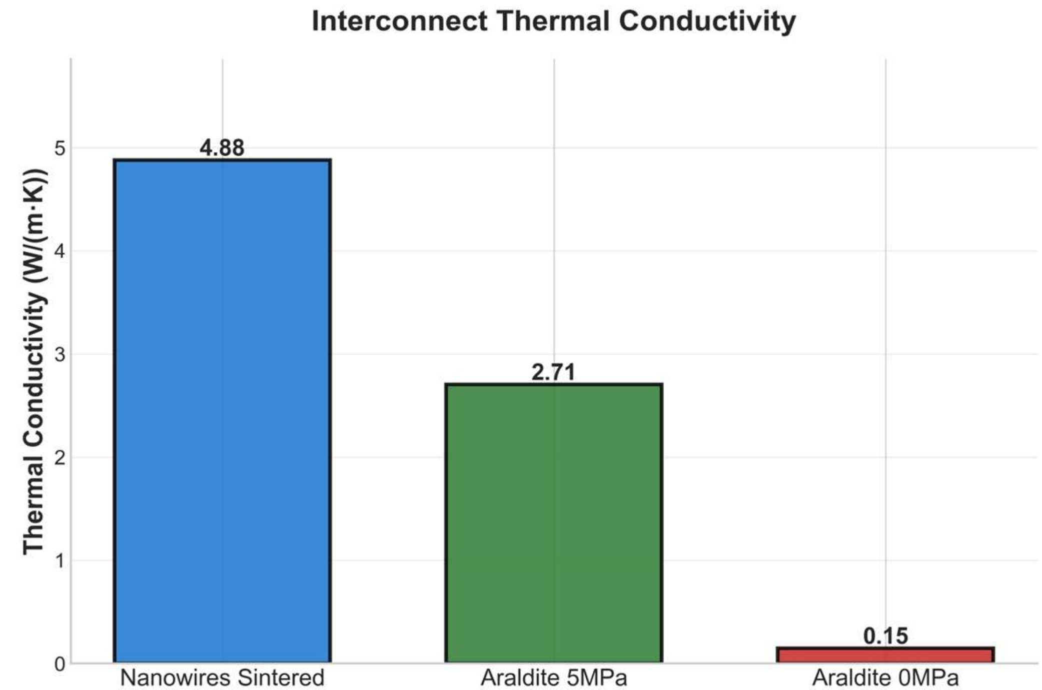
Preliminary Results



- T1:Temperature of Heating element.
- T2: Temperature measured inside the heat sink.

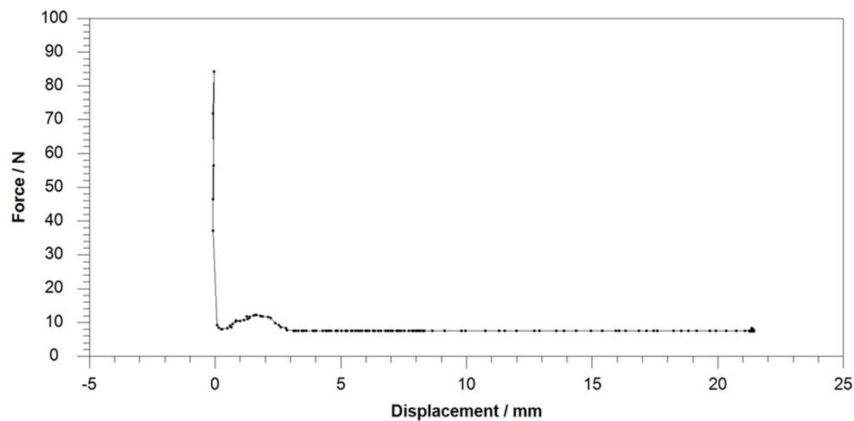
Preliminary Results

- Thermal conductivity derived from test results
- Thermal conductance corrected for 2×2 cm sample area.



Mechanical Tests

- Nanowires also provide mechanical stability.
- 80N of pull force required for separation of 2cm x 2cm piece.



Pull test data: Second force peak attributed to residual edge material during separation.

Further Tests

- **Glue + nanowires**: Improve adhesion for low-force/low-temp bonding.
- **Sintering**: Optimize process for better nanowire quality.
- **Testing**: Confirm thermal conductivity performance
- **Characterization**: Measure mechanical strength and bonding uniformity.
- **Scale-up**: Validate process repeatability and manufacturing feasibility.

Thank you

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