

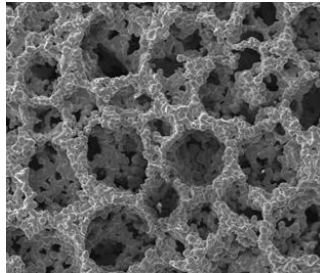
High Heat Load Capacity

Copper Foam Wick Structures

Founded in 2004, Metafoam designs, manufactures and commercializes open-cell copper foams through innovative patented and patent-pending manufacturing processes and technologies.

For electronic cooling manufacturers, Metafoam offers significant and proven advantages: the highest specific surface area in the industry, improved heat dissipation performance, and greater control on several key product parameters leading to wicks with increased dry-out point.

Metafoam's Copper Foam Microstructure



Open-cell Copper Foams

Open-cell foams are permeable and will allow fluids to pass through the foam whereas closed-cell foams are impermeable.

Unique Benefits

- Higher pumping speeds
- Higher dry-out point
- Faster response time
- Greater wick uniformity
- Higher production yield
- Better quality control
- Ease of assembly

65%+
Higher
Dry-Out
Point

Third-Party Test Results

Based on tests from independent labs and partners, Metafoam's copper foam wicks significantly increase the dry-out point of heat pipes and vapor chambers (compared to sintered copper wicks) while simplifying their manufacturing processes and keeping conventional designs and production processes of heat sinks intact.

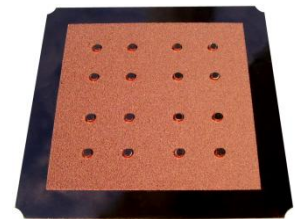
Wick Structures for Heat Pipes

The copper foam wick is pre-rolled and inserted in a copper tube



Wick Structures for Vapor Chambers

The wick is positioned and bonded on the vapor chamber base plate.



Value Proposition

- **Consolidation:** Replace two heat pipes by one of equal size
- **Substitution:** Replace one large heat pipe by one smaller
- **Next gen:** Enables ultra thin, high powered heat pipes for next gen notebooks

The Alternative to Sintered Powder

The maximum heat load capacity of heat pipes and vapor chambers is mainly driven by two parameters: the amount of fluid inside the wick and the speed at which the wick can bring the condensate fluid back to the heat source. In electronic cooling applications, where it is required to maintain CPUs or other similar devices temperatures below 100°C, the current sintered copper powder/water heat pipes and vapor chambers have reached their limits.

Metafoam's open-cell copper foam is used as an alternative wicking structure in both heat pipes and vapor chambers to more efficiently cool laptop and desktop CPUs, graphic card GPUs, 1U, 2U, and blade server CPUs, high brightness LED applications and high density memory devices.



Competitive Advantages

Metafoam's Wicks Over Sintered Powder Wicks

Properties	Units	Sintered Powder Wicks	Metafoam Wicks	Advantages
Permeability	m ²	Approximately 9.4E-12	Approximately 1.30E-11 to 1.37E-9	Higher wick permeability increases capillary limit by reducing condensate liquid pressure drop inside wick
Porosity	%	Approximately 30 to 50	Approximately 50 to 95	Higher porosity improves permeability, thus increasing capillary limit, and allows for greater working fluid charge volume, which increases dry-out point
Capillary radius	µm	Approximately 27	Approximately 47 to 200	Low capillary radius increases the capillary forces and thus the capillary limit
Wick thickness	µm	> 300	> 200	Thin and powerful wick leads to high powered thin flat heat pipe (2mm thick or less flat heat pipe)
Normalized permeability to capillary ratio	n/a	1	Approximately 1 to 40	Higher permeability to capillary ratio improves pumping speed and thus, the capillary limit

Current and Up-Coming Specifications of Heat Pipes Using Current Metafoam Wicks

Current foam thickness capabilities ¹		0.7 mm	0.9 mm	0.5 mm	0.3 mm
Resulting Heat Pipe		Tested		In development	
Heat Pipe Specifications	Heat Pipe OD (outside diameter)	6 mm			
	Thickness	Flattened at 3 mm	Round HP	Flattened at 2 mm	Flattened at 1.5 mm
	Length	260 mm	350 mm	250 mm	
	Configuration	Multiple bends and steps			
	# of heat source	2			
	Q-max ²	60 W	90 W	50 W	40 W
	Rec (internal resistance)	< 0.1 °C/W	< 0.05 °C/W	< 0.15 °C/W	

¹ Foams can also be produced at other thicknesses to match requirements

² Q-max with at least one bend and one step