Loop Refrigeration Using Advanced Fluidics and Thermoelectric Coolers

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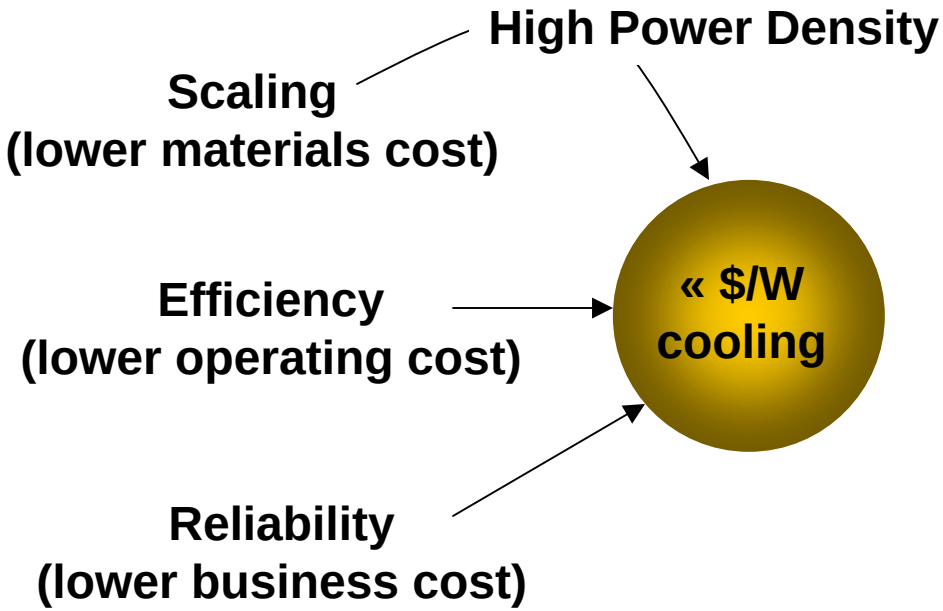
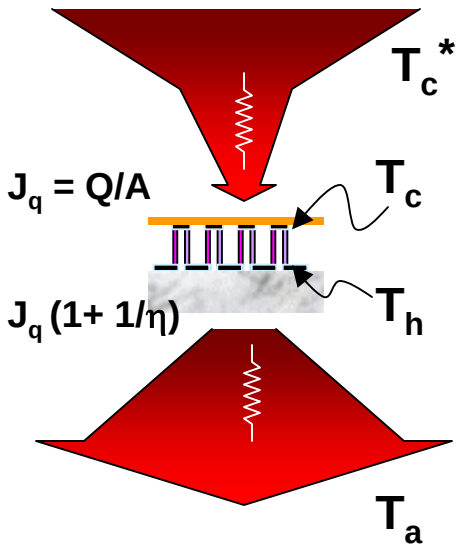
Drive Towards Low Cost



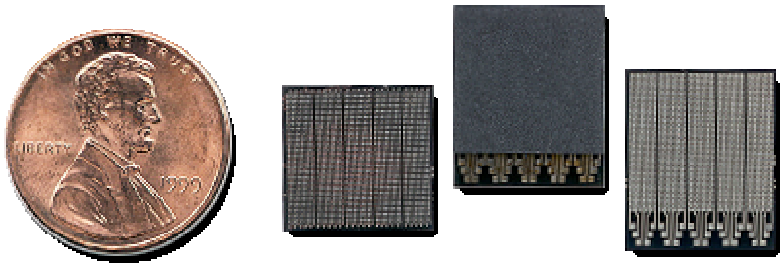
High-Power Density TECs



$$T_c^* = T_c + J_q / h$$

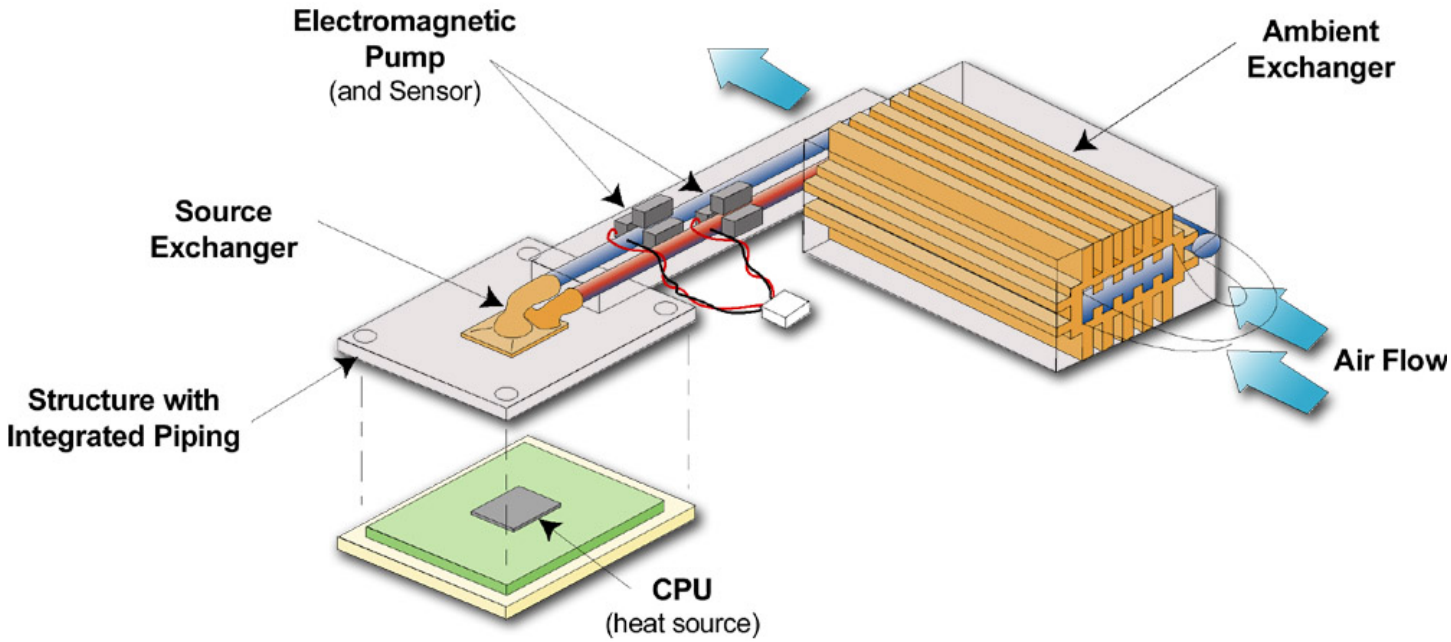
$$T_h = T_a + \frac{J_q}{h}\left(1 + \frac{1}{\eta}\right)$$

$$J_{qmax} \propto \frac{1}{L}$$



Traditional	Scaled TECs	Thick Film TECs	Thin Film TECs
L = 2 mm	200 μm	20 μm	< 2 μm
J_q = 1 W/cm^2	~10 W/cm^2	~100 W/cm^2	~1000 W/cm^2
Fans, Heat Sinks	Heat Pipes, Water	NanoCoolers' Fluidics	

Liquid Metal Cooling Loops



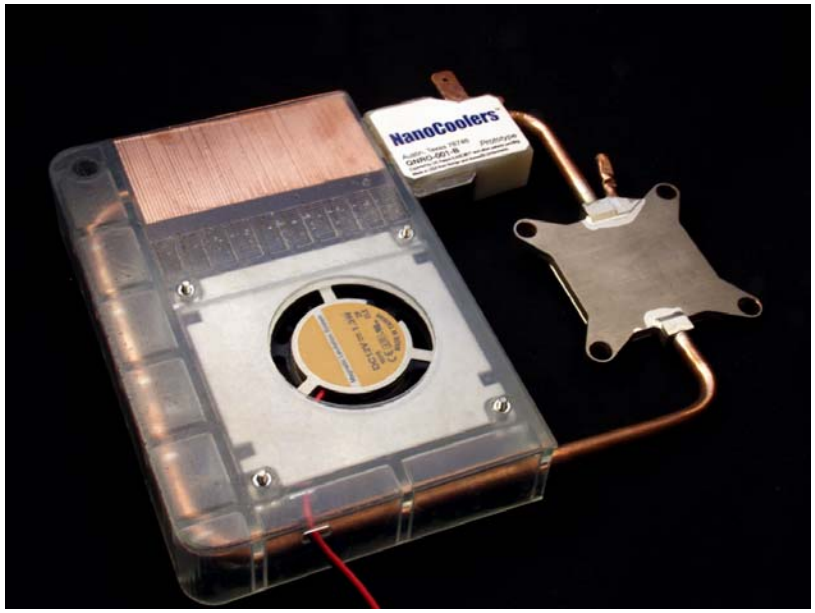
- **Silent, power-efficient, non-moving pumps**
- **High heat transfer coefficients (~ 50 W/cm^2.K)**

Liquid Metal Cooling Loops Features

- ✓ Extremely high heat transport capability
- ✓ Extremely high heat flux densities
- ✓ Low thermal resistance
- ✓ Small and flexible geometric solutions
- ✓ Scalable heat removal
- ✓ Low cost, volume solutions
- ✓ Ability to cool multiple heat sources
- ✓ Light weight, orientation independent solutions
- ✓ High reliability – no moving parts in pump
- ✓ Silent pump performance

Liquid Metal Cooling Loops

- Solutions are being developed for applications ranging from laptops to desktops to servers



Laptop Designs