Enhanced Evaporative Heat Transfer Device Using Porous Membranes
Technology #16063

Applications

Applications for this technology are found in thermal management for high performance defense systems and electronic devices.

Problem Addressed

Currently, advancements in high performance defense electronics are bottle-necked by thermal management. This technology improves thermal management through an intrachip two-phase evaporative cooling solution.

Technology

This thermal management approach takes advantage of a supported nanoporous membrane with self-regulated microfluidic networks capable of dissipating >1kW/cm2 on a 1cm2 area with a 200x200µm2 hot spot dissipating 5kW/cm2. Previous developments in thermal ground planes have utilized micro/nanostructured wicks but are fundamentally limited by the coupling between the capillary pressure generated by the wick and the liquid transport through the wick. The proposed design decouples these through the device’s architecture and allows the flexibility to scale down the nanopore size to achieve large driving pressure without increasing the viscous losses. The membrane provides the required capillary pressure that allows for high heat transport, while a hierarchy of characteristic flow length scales transports liquid and minimizes the pressure drop. Also, the vapor escape above the membrane is separate from the liquid flow path such that flow instabilities are avoided with 100% vapor exit quality. The proposed coolant is pentane because of its favorable thermophysical properties and its non-polar and non-toxic nature. The supporting ridge structures are fabricated in silicon carbide (SiC) and the microfluidic network is fabricated in silicon (Si). This allows the Coefficient of Performance (CoP) – thermal power dissipated over power input – to be > 100. Finally, because the heat is dissipated primarily via evaporation, the overall heat transfer coefficient is 0.18 kW/cm2K and an order of magnitude higher than state-of-the-art. These improvements create the desired dissipated heat flux of 5kW/cm2 and seek to maintain a backside chip temperature of ~75-80oC.

Advantages

- Capable of dissipating >1kW/cm2
- Requires little power input because membrane is self-regulating
- Overall heat transfer coefficient is an order of magnitude higher than state-of-the-art

Categories For This Invention:
Electronics & Circuits
Cooling
Semiconductors & Integrated Circuits
Materials
Micro & Nanotech
Thin Films

Intellectual Property:
Evaporative heat transfer system
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External Links:
Device Research Laboratory
http://drl.mit.edu/
Nanoengineered Surfaces for Thermal Energy Applications (Professor Evelyn Wang)
https://vimeo.com/88468992

Image Gallery: