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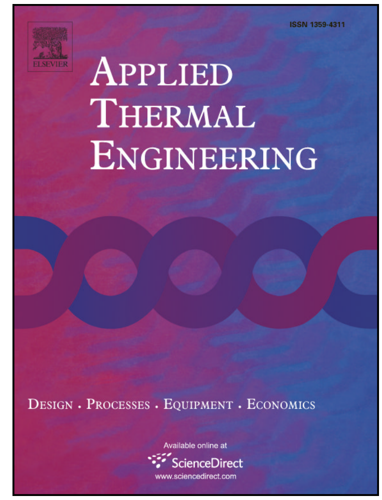

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A Single Phase Hybrid Micro Heat Sink Using Impinging Micro-Jet Arrays and Microchannels

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Abstract

This work describes the development of a single phase water-cooled microfluidic heat exchanger for cooling very high heat flux electronics. The heat sink was designed so that it can be manufactured using the MICA Freeform process, which is an ultra-precision additive manufacturing method for millimeter-scale metallic parts with micron-scale features. The heat sink targets a heat flux of 1000 W/cm^2 with an average base temperature constraint of 65^{o}C for a 4 mm x 3 mm heat source. The hydraulic constraints that were imposed on the design were that the pressure drop and flow rates could not exceed 100 kPa and 0.5 L/min respectively. The design was undertaken using Simulation-Driven Design whereby the commercial Computational Fluid Dynamics software ANSYS Fluent was utilized. The final embodiment of the design is a hybrid Microjet-Microchannel heat sink. The thermal performance is quite extraordinary, with a predicted effective thermal conductance of 400 kW/m^{2}K for a flow rate of 0.5 L/min. With such an exceptionally high thermal conductance, the heat sink is predicted to maintain an average base temperature of under 58^{o}C with a maximum variation about the mean of ±3^{o}C for an imposed heat flux of 1000 W/cm^2.

Keywords: liquid cooling, additive manufacturing, microjets, microchannels, MEMs heat exchanger, high heat flux, microfluidics

Nomenclature

A area, m^2

COP Coefficient of Performance, -

P pressure, kPa

h thermal conductance, W/m^{2}K

k thermal conductivity, W/m-K

$q^{//}$ heat flux, W/m^2

Q power, W

T temperature, ^{o}C

u velocity, m/s

$\dot{V}$ volumetric flow rate, m^3/s

Greek symbols

ρ mass density, kg/m^3

μ dynamic viscosity, N-s/m^2