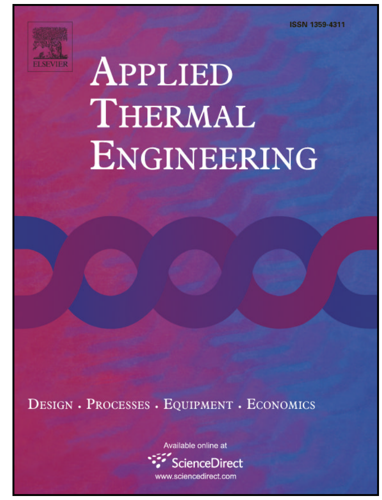
Accepted Manuscript



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PII: S1359-4311(17)33123-X
DOI: https://doi.org/10.1016/j.applthermaleng.2017.11.039
Reference: ATE 11409

To appear in: *Applied Thermal Engineering*

Received Date: 11 May 2017
Revised Date: 30 October 2017
Accepted Date: 5 November 2017

Please cite this article as: H. Ermagan, R. Rafee, Geometric optimization of an enhanced microchannel heat sink with superhydrophobic walls, *Applied Thermal Engineering* (2017), doi: https://doi.org/10.1016/j.applthermaleng.2017.11.039

Geometric optimization of an enhanced microchannel heat sink with superhydrophobic walls

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Abstract

This paper compares the optimal geometry of a rectangular microchannel heat sink (MCHS) for different channel wall surfaces, namely, conventional (uncoated and smooth), hydrophobic, and superhydrophobic. For this purpose, the three-dimensional Navier-Stokes and energy equations with the slip boundary conditions are numerically solved using the finite volume method. Shape optimization is then carried out based on the response surface methodology and the desirability function approach. The optimal channel width ratio (β) and the number of channels (N), that yield the lowest thermal resistance of the heat sink for a fixed pumping power (Ω), are reported. The results show that as the wall hydrophobicity increases, the optimal β decreases, whereas the optimal N increases. For instance, the optimal N increases from 80 for an MCHS with hydrophobic walls to 140 for its counterpart with superhydrophobic walls. This trend is attributed to the strengthening effect of interfacial slip as channel width shrinks. It is also found that the overall thermal resistance of hydrophobic and superhydrophobic MCHS is reduced by 5 and 20%, respectively, compared with that of conventional one. The results also show that the beneficial effect of increasing wall hydrophobicity on the thermal performance weakens with an increase in Ω, and almost vanishes for $\Omega > 2$ Watts.

Keywords: Microchannel heat sink, Superhydrophobic walls, Slip boundary conditions, Geometric optimization, Thermal performance enhancement.

Nomenclature

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