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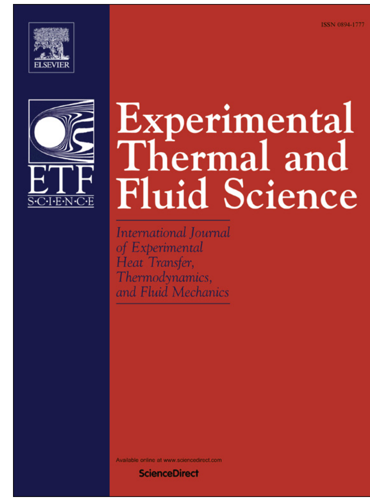

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Heat Transfer Performance of Boiling Jet Array Impingement on Micro-Grooved Surfaces

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Abstract

Jet array impingement heat transfer is investigated for two phase forced convection of water at atmospheric pressure and subcooling of 7°C with flow rates up to 660 mL/min. A jet array consisting of nine 1 mm jets with 5 mm inter-jet spacing and a 2 mm jet to target spacing was employed to cool a 15 mm by 15 mm heated surface. A linear micro-groove and a radial micro-groove surface were investigated and compared to a flat surface. The results show that the heat transfer performance of the impinging jet is insensitive to Reynolds number for fully developed boiling. A maximum heat transfer coefficient of h=230 kW/m^{2}K was achieved with the radial micro-groove surface, transporting a substantial heat flux of 380 W/cm^2. This was a 2.3 fold improvement compared with the flat surface. The linear micro-groove surface also performed well, achieving a 2 fold enhancement. Finally, the performance of the jet array impingement onto micro-grooved surfaces is compared with other recent compact water cooled two phase heat exchanger concepts from the recent literature showing comparable thermal performance.

Keywords: Heat transfer, impinging jet, boiling heat transfer, two phase flow, electronics cooling.

1. Introduction

Air cooling of high performance microprocessors and other high performance electronics is becoming obsolete as heat flux levels continue to escalate. The poor thermophysical properties of air coupled with geometric and acoustic restrictions have limited the performance of the conventional fan-fin heat sink based cooling systems. Extreme heat fluxes in excess of 1kW/cm^2 are expected in the near future from high performance electronics [1] and therefore more advanced cooling methodologies must be adopted to accommodate the increasing power densities. Hence, there is a need for technologies which can cool small areas with high thermal loads in order to reduce junction temperatures to acceptable levels with scalable and implementable designs.

There are two main candidates which are thought to have the potential to meet these requirements: open microchannel manifolds (OMM) and liquid jet impingement boiling. Single phase flow has provided extremely high heat transfer performance [2], but large pressure drops and temperature gradients on the heated surfaces are some of the main limitations of this technology. Kandlikar has shown that two phase flow using an OMM design provides excellent heat flux dissipation potential at moderate pressure drops [3]; while other researchers have shown jet impingement to outperform the OMM design by a considerable amount [4].

Kandlikar [3, 5] has shown that scalable OMM designs can be developed which suit the application of microprocessor cooling quite well. However, there are many stability concerns associated with two phase flow in microchannels. CHF is limited by instabilities such as explosive bubble growth, parallel channel instability, Ledinegg instability and upstream compressibility volume [1]. Solutions such as tapering manifolds have been proposed to reduce instabilities [3]; however, currently there is no