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NUMERICAL INVESTIGATION INTO THE THERMAL PERFORMANCE OF TWO-LAYERED MICROCHANNELS WITH VARYING AXIAL LENGTH AND TEMPERATURE DEPENDENT FLUID PROPERTIES

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ABSTRACT

This study numerically investigates the thermal performance of a two-layered microchannel heat sink with varying axial length, varying solid substrate aspect ratio (ratio of height to width of the silicon solid substrate) but with a fixed total volume constraint and water as the working fluid. The optimal geometry in terms of channel hydraulic diameter, channel aspect ratio and the solid substrate aspect ratio was selected based on the minimised peak temperature on the heated base of the solid substrate with a constant heat load of 100W. The optimal aspect ratio *AR* of the solid substrate was discovered to be 4 for all pressure drop range considered in this study but the optimal axial length shows a dependence on pressure drop. Results of the effect of varying axial length on surface heat flux, minimised thermal resistance and temperature variation on the heated base of the solid substrate were also presented and discussed.

Keywords: two-layered microchannels, varying axial length, minimised peak temperature, temperature variation

INTRODUCTION

After the pioneering work of Tuckerman and Pease (1981) on using microchannel heat sinks to remove high heat fluxes from microelectromechanical systems, it was discovered that single microchannels with coolant flow in one direction does not solve the problem of temperature non-uniformity. Temperature non-uniformity is detrimental to microelectronic devices as it leads to shortened life-span of these devices. As a result, a double-layered microchannel heat sink with counter-flow of fluid was proposed (Vafai and Zhu, 1999). The objective of the study carried out by Vafai and Zhu was to improve temperature non-uniformity in microelectronic devices. The thermal performance of the double-layered microchannels with parallel and counter-flow configurations have also been compared and findings have been published in open literature (Hung et al., 2012; Jeevan et al., 2004; Wu et al., 2014; Xie et al., 2013).

Wei et al (2007) in their study observed that for a fixed axial length of 10 mm, uniform heating with a heat input of 70 W/cm^2, and equal flow rate through the top and bottom layer of a two-layered microchannel, the temperature distribution on the bottom wall was more uniform for the counter-flow arrangement when compared to the parallel flow. Also, the maximum temperature for the counter-flow case was higher than the parallel flow which resulted in higher overall thermal resistance for the counter flow than the parallel flow.

In a more recent study by Xie et al (2013), observations similar to the one made by Wei et al. (2007) was also reported for two-layered microchannel with a fixed length of 35 mm and inlet velocity of 0.5 m/s. Xie et al. (2013) also optimized the geometric parameters of the double-layered microchannel by adjusting the height of the channels thereby, changing the flow rate distribution in the channels. Leng et al (2015) in their work proposed and improved the design of the double-layer microchannel by truncating the top channels. It was confirmed from their study that their proposed design improved the overall thermal resistance of the heat sink but only the counter-flow condition was examined in their work. Also, to further enhance the thermal