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**Master Thesis Defense**

*PERFORMANCE EVALUATION OF MEMS HEAT SINKS EMPLOYING STRAIGHT MICROCHANNELS WITH SIDEWALL CAVITIES*


by

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Abstract


This work conceptualizes a silicon-based MEMS heat sink employing straight microchannels with sidewall cavities in staggered and in-line arrangement for thermal management of microelectronic chips. Simulation-based studies are carried out to understanding the working of the proposed MEMS heat sink and to compare its performance with MEMS heat sink employing straight microchannel as well as to investigate the influence of different geometric parameters on the performance of the same. The performance of the MEMS heat sink is quantified in terms of thermal resistance and pumping power while that of the microchannel employed in the same is quantified in terms of Nusselt number and Poiseuille number. The model of the MEMS heat sink employing microchannels with sidewall cavities include continuity equation, Navier-Stokes equations, and energy equations. The simulations are carried out using Fluent module of Ansys Workbench for Reynolds number ranging from 100 to 750. Experimental data from literature is used for validating the simulation model.

Comparison of the performance of the MEMS heat sink employing straight microchannels with sidewall cavities against MEMS heat sink employing straight microchannels reveals that the former has lower thermal resistance and pumping power than the latter. This is a very unique characteristic as lowering of thermal resistance has always come at the expense of increased pumping power. The thermal resistance of the MEMS heat sink employing straight microchannels with sidewall cavities in staggered arrangement is ~98% of the thermal resistance of the MEMS heat sink employing straight microchannels at the lowest Reynolds number while at the highest Reynolds number, the thermal resistance of the former is ~76% of the latter. The pumping power of the MEMS heat sink employing straight microchannels with sidewall cavities in staggered arrangement is ~81% of the pumping power associated with the MEMS heat sink employing straight microchannels at the lowest Reynolds number and at the highest Reynolds number, the pumping power of the former is ~93% of the latter. The thermal resistance of the MEMS heat sink employing straight microchannels with sidewall cavities in in-line arrangement is ~92% of the thermal resistance of the MEMS heat sink with straight microchannels at the highest Reynolds number while difference in thermal resistances is negligible at the lowest Reynolds number. The pumping power of the MEMS heat sink with straight microchannels with sidewall cavities in in-line arrangement is ~95% of that of the MEMS heat sink with straight microchannels at the highest Reynolds number while at the lowest Reynolds number the pumping power of the former is ~87% of that of the latter. It is also observed that increase in Reynolds number leads to decrease in thermal resistance and increase in pumping power irrespective of the arrangement of sidewall cavities.

Parametric studies are done to understand the influence of different geometric parameters on the performance of the MEMS heat sink employing straight microchannels with sidewall cavities. It can be noticed that increase in length of the sidewall cavities lead to reduction of thermal resistance and pumping power. With increase in the length of the sidewall cavities has increased and decreased the Nusselt number and Poiseuille number of the microchannel with sidewall cavities, respectively. The increase in the width of the sidewall cavities influences the thermal resistance and pumping power of the MEMS heat sink employing straight microchannels with sidewall cavities. It is identified that for every Reynolds number there exists a unique width, of the sidewall cavities, for which the thermal resistance is the lowest. The pumping power is found to be almost independent of the width of the sidewall cavities. The relationship between Nusselt number and Reynolds number is same as the relationship between thermal resistance and Reynolds number. The number of sidewall cavities influences the thermal resistance and pumping power of the MEMS heat sink employing straight microchannels with sidewall cavities. Poiseuille number increases with decrease in the width of the sidewall cavities at low Reynolds numbers while at the high Reynolds numbers, the observed trend is that of Poiseuille number becoming independent of the width of the sidewall cavities. With initial increase in number of sidewall cavities there is reduction in the thermal resistance and pumping power; however, with further increase in the number of cavities the thermal resistance became independent of the number of cavities. Regarding Nusselt number and Poiseuille number, they increased with increase in the number of cavities. Increase in the hydraulic diameter of the microchannel at low Reynolds numbers leads to decrease in thermal resistance while at the high Reynolds numbers the thermal resistance starts to be independent of the hydraulic diameter. On the other hand, the pumping power decreased with increase in hydraulic diameter. Regarding the Nusselt number and Poiseuille number, they increased with increase in hydraulic diameter for all Reynolds numbers.