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Assessment of an active-cooling micro-channel heat sink device, using electro-osmotic flow- A pilot study

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ABSTRACT:

Non-uniform heat flux generated by microchips causes “hot spots” in very small areas on the chip surface. These hot spots are generated by the logic blocks in the microchip bay; however, memory blocks generate lower heat flux on contrast. The goal of this research is to design, fabricate, and test an active cooling micro-channel heat sink device that can operate under atmospheric pressure while achieving high-heat dissipation rate with a reduced chip-backside volume, particularly for spot cooling applications. An experimental setup was assembled and electro-osmotic flow (EOF) was

used thus eliminating high pressure pumping system. A flow rate of 82 µL/min was achieved at 400 V of applied EOF voltage. An increase in the cooling fluid (buffer) temperature of 9.6 oC, 29.9 oC, 54.3 oC, and 80.1 oC was achieved for 0.4 W, 1.2 W, 2.1 W, and 4 W of power, respectively. The substrate temperature at the middle of the microchannel was below 80.5 oC for all input power values. The maximum increase in the cooling fluid temperature due to the joule heating was 4.5 oC for 400 V of applied EOF voltage. Heat transfer coefficient (h) for the 4 W case reached a maximum of 292 W/m2.K at the channel inlet and decreased to reach 92 W/m2.K at the channel outlet. Numerical calculations of temperatures and flow were conducted and the results were compared to experimental data. It was found that using a shorter channel length and an EOF voltage in the range of 400 – 600 V allows application of a heat flux in the order of 104 W/m2, applicable to spot cooling. For elevated voltages, the velocity due to EOF increased, leading to an increase in total heat transfer for a fixed duration of time; however, the joule heating also got elevated with increase in voltage.

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