Evaluation of a new designed microchannel heat sink for CPU cooling based on IR – thermography synchronized with high-speed flow visualization

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\textbf{HIGHLIGHTS}

- Local measurements of experimental parameters such as wall temperature and flow pressure combined with visualization techniques can support the correct assessment of heat transfer at the microscale.
- Visualization confirms flow patterns in the microchannels and their evolution with increasing heat flux.
- The flow boiling curves suggest that when constrictions are included, the boiling incipience occurs at a lower heat flux resulting in a lower overshoot of wall temperature.
- Decreasing the constriction size comes at the expense of increasing pressure drop.

\textbf{ABSTRACT}

The design and implementation of the experimental boiling loop is studied in this work. MEMS fabrication techniques are used to assemble the integrated multi-microchannel evaporative cooling device (iMMECo) in a single silicon substrate with optical access to the coolant flow. Tests on thermo-fluid-dynamic performance of the integrated multi-microchannel evaporative cooling device (iMMECo) are performed making use of synchronized high-speed visualization and high-speed IR thermography, confirming the existence of flow instability, backflow and non-uniform distribution of flow among the channels, all necessary to define the optimum range of operation. Flow boiling curves experimentally obtained suggest that the smaller the inlet passage, the lower the heat flux for boiling incipience to occur, resulting in a lower overshoot of wall temperature and lower overall surface temperature. On the other hand, pressure drop is highly increased for smaller inlet passages, increasing the pumping needs.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{fig1.png}
\caption{Experimental results for evaporative cooling: a) effect of inlet contraction on microevaporator surface temperature and resulting pressure drop and b) dependence of microevaporator surface temperature on refrigerant mass flux and resulting pressure drop. Black error bars symbolize spatial standard deviation while grey error bars represent temporal standard deviation of average surface temperature. The colored columns indicate the experimental surface temperature interval obtained for each set of experimental conditions. Averaged pressure drop is plotted in red together with standard deviation bars.}
\end{figure}