Abstract

In this work, a novel cooling scheme based on micro thermo-fluidic technology is investigated for the thermal management of power electronics. This cooling scheme combines the micro-channel heat sink with micro-synthetic jets. The basic idea is to utilize the flow control aspects of synthetic jets to modify the flow field in micro-channels for better heat transfer performance.

Hydrodynamic and thermal characteristics of both single-phase and two-phase flow with the new cooling scheme were studied experimentally and numerically. Specifically, for the single-phase flow, the effects of synthetic jet on the micro-channel flow pressure dynamics and heat transfer performance were investigated respectively. Up to 138% enhancement heat transfer coefficient was achieved with this cooling scheme compared to the micro-channel without synthetic jets. Based on the single-phase experimental results, a numerical investigation was performed by using FLUENT to improve our understanding of the fundamental mechanisms involved in the hybrid cooling scheme. Parametric studies were also performed with this numerical model to optimize the thermal effects with respect to the number of jets and their position along the micro-channel.

For the two-phase flow, effects of the synthetic jets on the suppression of flow boiling instabilities in micro-channels were investigated experimentally. Both the condensation effect and pressure dynamics effect introduced by the synthetic jets on the instabilities were examined respectively. The results indicate that synthetic jets can substantially delay the onset of boiling instabilities, and reduce the pressure fluctuations. Jet operating frequency is also found to have profound effect on its ability to suppress the instabilities.