

Thermal Management of Electronic Components

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Thermal management remains a challenging field for R&D over the past ten years. To assist in the development of high reliability electronics packaging with higher heat flux components in ever-smaller packaging volumes, several new cooling techniques have been proposed during the past decades. Considering the increased heat flux (up to 100 W/cm²), the traditional air cooling methods have reached their limits. Hence, various liquid cooling techniques have been considered after IBM produced its last water-cooled system in 1995. These promising ways include microchannels/minichannels, heat pipes, spray cooling, impinging jets etc.

In this project, we investigate numerically and/or experimentally some new electronic cooling methods such as use of tree-shaped microchannel networks and the new nanofluids as working fluids, phase change material (PCM)-based transient cooling systems, and impinging jet cooling with boiling heat transfer. The main objectives our effort are listed as follows:

1. Characteristics of tree-shaped microchannel nets. Geometrical optimization is an important way to enhance the heat transfer performance of channels. As compared to the conventional straight, serpentine, and even tapered channels, Tree-shaped channel nets demonstrate their advantages with respect to pressure drop and uniformity of temperature distribution. Following detailed parametric studies, we will be able to propose optimized tree-shaped nets such as tree-shaped nets with optimized scale ratio, tree-shaped nets with loops, and leaf-shaped nets.
2. Use of phase change materials (PCMs). Due to the high heat capacity during their phase change, PCM is a good candidate for transient electronic devices. In our project, the basic phenomena of PCMs such effect of partitions, multiple PCMs are examined. Additionally, PCM-based heat sink systems for electronic cooling will be numerically and experimentally investigated.
3. Nanofluids. With the rapid development of nanotechnology, nanofluids are emerging as next-generation cooling media. In this project, we examine the potential applications of nanofluids in electronic cooling using numerical simulation and experimental tests.
4. Impinging jet cooling. Numerical and experimental investigations of impinging jet cooling are also conducted to examine its potential in electronic cooling. Single phase and two phase (boiling) phenomena are being examined in this project.

Selected Publications:

Xiang-Qi Wang, Arun S. Mujumdar and Christopher Yap, Numerical analysis of blockage and optimization of heat transfer performance of fractal-like microchannel nets, *Journal of Electronic Packaging*, In press.

Xiang-Qi Wang, Arun S. Mujumdar, and Christopher Yap, Free convection heat transfer in horizontal and vertical rectangular cavities filled with nanofluids, submitted to 13th International Heat Transfer Conference, Sydney, Australia, 13-18 August, 2006, In review.

Z.Q. Lou, A.S. Mujumdar and C. Yap, Effects of geometric parameters on confined impinging jet heat transfer, Applied Thermal Engineering, Volume 25, Issues 17-18, December 2005, Pages 2687-2697.

Ravi Kandasamy and Mujumdar A.S., Thermal Analysis of a Flip Chip Ceramic Ball Grid Array(CBGA) Package, Submitted for review IEEE Transactions on Components and Packaging in October 2005.

Ravi Kandasamy and Mujumdar A.S., Interface Thermal Characteristics of Flip Chip Packages - A Numerical Study, Submitted for review IEEE Transactions on Components and Packaging in January 2006.