# Microscale Heat Exchanger Design

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As the number and density of devices on IC's continue to increase the power that needs to be effectively dissipated is also on the rise. Along with this there is also a simultaneous need to maintain or even reduce the junction temperatures of IC's. Previous versions of the International Technology Roadmap for Semiconductors (ITRS) indicate that there are no known commercial solutions to deal with both these requirements. One solution, made famous by Prof. Pease at Stanford and commercialized by companies such as Cooligy, is the use of single-phase fluidic cooling, where fluids such as water would be pumped through the IC packaging in order to remove the large heat fluxes.

Though single-phase fluidic cooling is seeing commercial use, the dissipation provided is not sufficient to deal with very high heat flux systems and the junction temperatures cannot be easily maintained. The answer to both these problems is the use of two-phase fluidic cooling, where the working fluid is vaporized in the heat exchanger. The large latent heat of vaporization involved in this process can greatly increase the amount of heat removed while still maintaining the junction temperature at the saturation temperature of the fluid. Unfortunately the vapor that is formed during the process can seriously impact the overall performance of the heat exchanger by creating 'plugs.' These vapor plugs block the passage of new liquid reaching the hot-spot and this in turn results in very high junction temperatures locally. In multi-channel systems the formation of vapor can additionally result in flow-redistribution via the manifolding resulting in flow and thermal instabilities that can be very difficult to predict and control.

This project seeks to fabricate a device that eliminates some of the problems caused by the formed vapor. The solution requires some method to passively (or actively) separate out the vapor phase from a boiling flow such that liquid can continue to freely flow through the microchannel while the vapor can be condensed and recycled through the system. The solution would involve the research and possible development of the use of unique channel geometries, surface treatments and/or materials. One solution proposed by Prof. Goodson and Santiago, is the use of hydrophobic porous films (Nafion, Goretex, etc) to 'cap' the heat-exchanger channels thus allowing the formed vapor to freely escape from the heat-exchanger channels. Due to the 'research' nature of this project, there is considerable flexibility in the type of solution and novel approaches are welcomed. The deliverable is demonstrating a device that can provide better cooling and flow characteristics compared to a normal fluidic heat-exchanger.

This project is a great opportunity to explore the areas of materials, fluids, heat-transfer and microfluidic-MEMS. It is also a great way to get a better understanding of the very important area of power dissipation in IC's and also review current solutions in use by the semiconductor industry. A successful device would be a significant leap in the area of fluidics cooling and would also significantly help further our understanding of two-phase flows at micro-scales. The successful device is also not limited to IC cooling and could see important lab-on-a-chip applications such as gas analysis and pretty much anything where gas/liquid systems are in use.