High-Heat-Flux Flow Boiling using Liquid-Artery Wick

Brandon Shannon

Flow boiling in micro- and mini-channels has drawn significant attention for having great potential in cooling capability. A successful system application of flow boiling requires high heat flux removal and low thermal resistance. However, at high heat flux, significant vapor generation results in liquid-vapor hydrodynamic instabilities and channel wall dryout, which in turn limits the critical heat flux (CHF) and develops high thermal resistance. In this study, we employ a thin, monolayer wick with a liquid-artery capillary wick to simultaneously achieve the enhanced CHF and the low thermal resistance for flow boiling in micro and mini channels. The liquid artery capillary wick continuously supplies the liquid coolant to the heated area to increase the CHF, while the monolayer wick aims at providing low thermal resistance. Extensive experimental investigations are carried out using pure copper heat sinks with integral mini- and micro-channels and water as the working fluid. The monolayer and liquid-artery capillary wicks are fabricated by sintering ~ 60 μm copper particles. The different mini- and micro-channel heat sinks are tested with 1 cm^2 of heated area in a standard test flow loop at steady state with various temperature, differential pressure, and volumetric flow rate measurements. A numerical simulation is also performed to predict optimal capillary wick designs and operating conditions. The results may be interpreted into a guideline for an optimal capillary wick design for flow boiling in micro and mini channels.

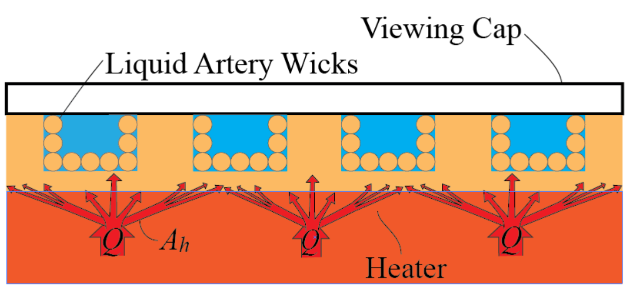

Figure 1: Schematic Representation of Heat Flow in Liquid Artery Wicks