Experimental Characterizations of Non-uniform Wick Thermal Performance

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Advanced high heat flux thermal management is essential for desired operations and lifetime of various applications including miniaturized electronic devices, conventional power plants, renewable energy conversion systems, and spacecraft designs. Two-phase, liquid-vapor-based thermal management systems, e.g., vapor chamber and heat pipe, have been widely used due to their high heat flux heat removal capability. A novel wick structure design is used to maximize cooling capability and minimize the thermal/hydraulic resistances. A thin sintered-particle wick combined with thick capillary body with high permeability significantly prolongs surface dryout and decreases the overall thermal resistance. The characteristic size of the thin sintered-particle evaporator wick is similar to the capillary meniscus radius, which in turn leads to capillary-meniscus-recess-driven thermal resistance changes prior to the complete surface dryout. However, the relation of the capillary-meniscus recess to the thermal resistance change is primarily studied in a uniform particle-distribution wick structure.

In this study, the capillary-meniscus-recess-driven thermal resistance of the thin evaporator wick structure is measured using home-made water-pool system with water as a working fluid at ambient conditions. A gravity feeding liquid supply is used to maintain the water level in the liquid pool at the tip of the upside-down columnar posts wick. The thermal resistance is also compared to the evaporator wick structure with uniform particle-size distribution. The thin evaporator wick with particle-size distribution is fabricated with copper particles, 50-200 μm in diameter, via a sintering process. The experimental results show that the thermal resistance decreases by effectively reducing the thermal conducting pathway through the smaller particles and increasing the effective evaporation sites. The obtained experimental results validate the pore network model, predicting the effective thermal resistance and surface dryout limit.