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Marangoni Convection and Thin-film Evaporation in Microstructured Wicks for Heat Pipes

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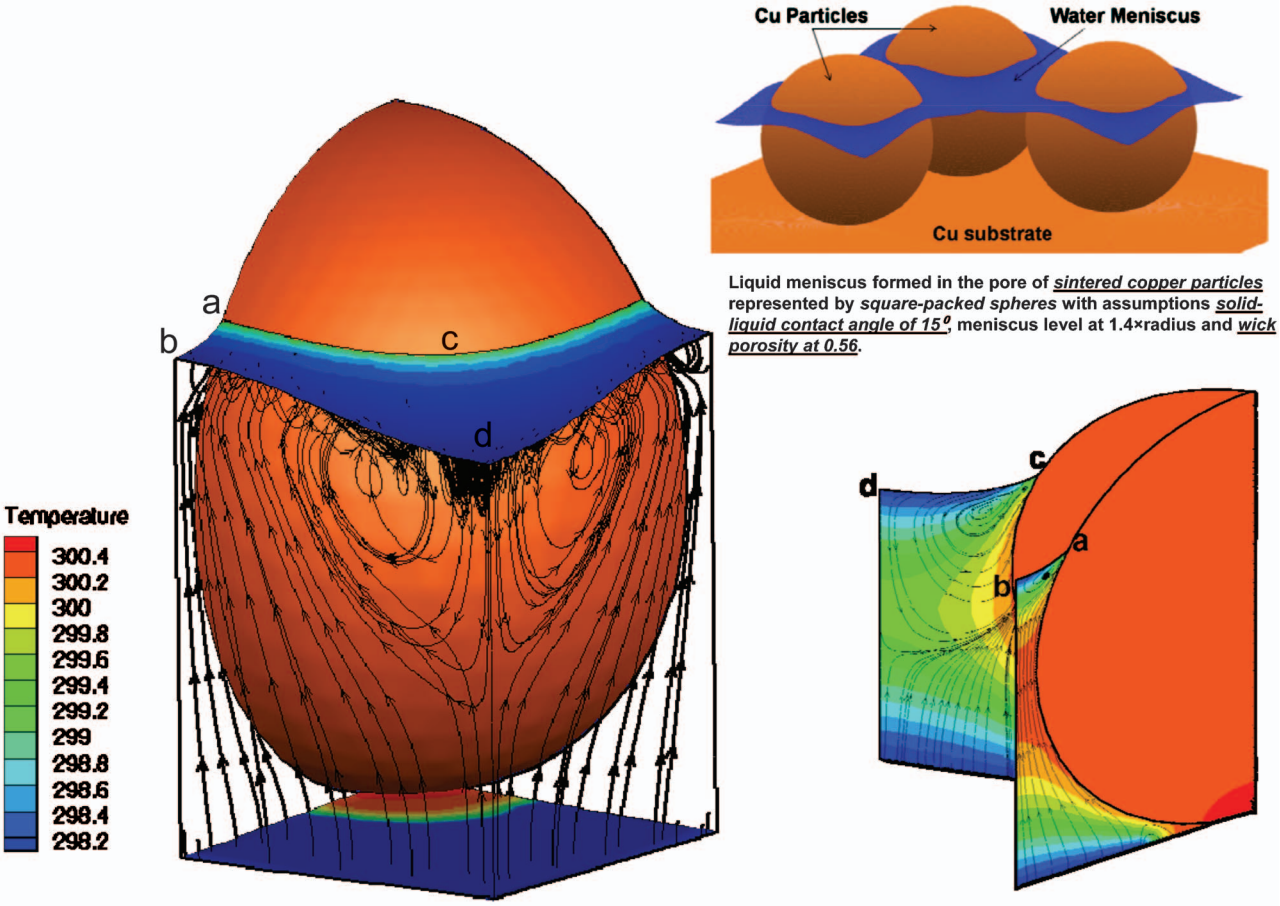

Liquid meniscus formed in the pore of *sintered copper particles* represented by *square-packed spheres* with assumptions *solid-liquid contact angle of 15°*, meniscus level at 1.4×radius and *wick porosity at 0.56*.

Complex-shaped toroidal vortex due to Marangoni convection observed in the wick pore during evaporation of water from sintered copper particles; temperature contours shown on the interface, liquid inlet and particle surface for solid wall temperature = 300.5 K and vapor temperature = 298 K.

Marangoni vortices shown in the central (c-d) and narrow (a-b) planes in liquid region; vortex diameter is a maximum in the central plane and a minimum in the narrow plane.

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An evaporating liquid meniscus is modeled under saturated vapor conditions in wick microstructures. The liquid-vapor interface shape is assumed to be static during evaporation. Liquid-vapor interface shapes in different wick geometries are obtained by solving the Young-Laplace equation using Surface Evolver. Mass, momentum and energy equations are solved numerically in the liquid domain. Evaporation at the interface is modeled using kinetic theory. Owing to non-isothermal evaporation from liquid-vapor interface, complex Marangoni convection vortices are observed below liquid-vapor interface in the pores of sintered particle wicks. More than 80% of total evaporation heat transfer from the meniscus occurs from 20% of the total meniscus area, identified as the thin-film area. Marangoni convection has less than a 5% effect in enhancing evaporation from the liquid-vapor interface for superheats < 5K (pertinent to heat pipes).

