Abstract Submitted
for the DFD16 Meeting of
The American Physical Society

Effect of meniscus curvature on thermal transport in microchannels with ridged walls TOBY KIRK, SIMON GAME, Imperial College London, MARC HODES, Tufts University, ERIC KEAVENY, DEMETRIOS PAPAGEORGIOU, Imperial College London — It is well known that textured surfaces can reduce flow resistance in microchannels, but their effect on thermal transport in, e.g., direct liquid cooling of microprocessors, has only recently been considered. We investigate thermal transport in Poiseuille flow through a channel textured with periodic longitudinal ridges that are held at constant heat flux. We assume the liquid only makes contact with the tips of the ridges, reducing drag but also the area for heat transfer. Accounting for curvature of the interfaces (menisci) that bridge each cavity, we consider two asymptotic limits: (i) small meniscus deflection from flat, using boundary perturbation; (ii) channel height large compared to ridge period, using matched asymptotics. In limit (i), the problem is reduced to dual series equations. If limit (ii) is also taken, we find explicit expressions for the effective slip length and Nusselt number. A remarkable finding is that the simple slip length expressions have exponentially small errors and so are accurate even for channel heights as low as half a ridge period. Finally, limit (i) is compared against direct numerical computations using Chebyshev collocation, and the effect of arbitrary curvature on the Nusselt number is presented for the full range of channel geometries.

Toby Kirk
Imperial College London

Date submitted: 30 Jul 2016 Electronic form version 1.4