

Characterization of the Wettability of Nanostructured Porous Films

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Heat pipes using conventional porous membrane wicks offer limited heat transfer rates for a given thickness. This could be addressed through wick nanostructuring, which promises high capillary pressure and precise control of local porosity. Past characterization of the wettability of nanostructured porous media have used the transient weight methodology [1] and samples much thicker than 1 micron. This approach is not well suited for ultrathin nanostructured films [2], for which relative weight changes with wetting for practical sample geometries are small. External contact angle (ECA) measurements of the liquid phase at the surface of bulk samples [3] are strongly influenced by surface morphology and do not yield the required internal contact angle (ICA).

The present work develops a high-speed camera tracking methodology to measure ICA in hydrophobic and hydrophilic silicon and copper nanowire films (SiNW, CuNW) with respect to water. The SiNWs are fabricated with a modified Vapor-Liquid-Solid growth methodology [4], which uses plasma treatments to control nanowire wetting characteristics [5]. The CuNWs are produced with rapid flame synthesis, using flame temperature and UV treatment to control wettability. In the fluid tracking methodology a modified Lucas-Washburn model extracts ICA from the data without neglecting gravity effects. In the case of hydrophobic materials, water wettability is quantified indirectly with the use of the Owens-Wendt two-parameter model. Additionally, these models incorporate the effect of evaporation on measurements, which for ultrathin nanostructured films is expected to be significant. Lastly, we present results of ICA and ECA measurements on films with varying nanowire geometry in order to reveal quantitative effects of size and surface roughness on wettability.

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