Artificial trees to investigate nanoscale capillary effects

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Trees evolved efficient ways to transport water (sap) from their roots to their leaves, based on passive transpiration at the leaf level. The driving force for the flow is the capillary (negative) pressure associated with confined, curved liquid-vapor interfaces and can reach massive magnitudes due to the nanoscale character of the confinement.

Inspired by plants, we developed silicon-based microplatforms able to generate tunable capillary pressures down to approximately -100MPa, which we used to study a variety of nanoscale capillary phenomena, including cavitation [1], drying-induced flows [2], capillary condensation and spontaneous imbibition flows [3].

In this presentation, I will show that the analysis of these dynamic responses to large capillary stresses allows to get precise measurements of the behavior of highly confined liquids and can be used both as tool for the study of nanoscale fluid physics and as a method to handle liquids in a controlled way for lab-on-chip applications. I will also discuss flow enhancement possibilities based on ideas from the vascular anatomy of plants.

[1] O. Vincent, D.A. Sessoms, E.J. Huber, J. Guioth, A.D. Stroock, Drying by cavitation and poroelastic relaxations in porous media with macroscopic pores connected by nanoscale throats, Physical Review Letters **113**, 134501 (2014)

[2] O. Vincent, A. Szenicer and A.D. Stroock, Capillarity-driven flows at the continuum limit, Soft Matter **12**, 6656-6661 (2016)

[3] O. Vincent, B. Marguet and A.D. Stroock, Imbibition triggered by capillary condensation in nanopores, Langmuir **33**, 7, 1655-1661 (2017)