

# Capillarity effects in silicon based nanochannels

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Using silicon based micromachining we have developed different techniques to create 1D and 2D confined nanochannels, with a characteristic diameter down to 5 nm. A short introduction to these techniques will be given. Capillary action in channels of this small size is a strong effect. The capillary suction in nanochannels can easily exceed 1 bar in magnitude. For an ambient pressure of 1 bar this implies that the liquid is at a negative pressure (tension). We show experiments in which the elastocapillary deformation of the nanochannels is used to quantify the negative pressure in the liquid. The dynamics of capillary filling has been characterized using dedicated chips containing arrays of nanochannels. The filling dynamics in 1D-nanochannels with heights in the range of 10 – 100 nm are qualitatively well described by the Washburn model. However, for filling with water we find quantitative deviations which can be attributed to apparent as well as real viscosity effects. Two important devices employing capillarity at the nanoscale will be discussed: a nano-emitter electrospray source and the nanofountain pen.

## References:

- J.W. van Honschoten, M. Escalante, N.R. Tas, M. Elwenspoek, Formation of Liquid Menisci in Flexible Nanochannels, *Journal of Colloid and Interface Science* 329 (2009), 133 – 139.
- Haneveld, J., Tas, N.R., Brunets, N., Jansen, H.V., Elwenspoek, M., Capillary filling of sub- 10 nm nanochannels, *Journal of Applied Physics* 104 (2008) 014309.
- J.W. van Honschoten, M. Escalante, N.R. Tas, H.V. jansen, M. Elwenspoek, Elastocapillary filling of deformable nanochannels, *Journal of Applied Physics* 101 (2007), 094310.
- S. Deladi, N.R. Tas, J.W. Berenschot, G.J.M. Krijnen, M.J. De Boer, J.H. De Boer, M. Peter, M.C. Elwenspoek, Micromachined fountain pen for atomic force microscope-based nanopatterning, *Applied Physics Letters* 85 (2004) 5361-5363.
- N.R. Tas, J. Haneveld, H.V. Jansen, M. Elwenspoek, A. Van Den Berg, Capillary filling speed of water in nanochannels, *Applied Physics Letters* 85 (2004) 3274-3276.
- N.R. Tas, P. Mela, T. Kramer, J.W. Berenschot, A. Van Den Berg, Capillarity Induced Negative Pressure of Water Plugs in Nanochannels, *Nano Letters* 3 (2003), 1537-1540.
- N.R. Tas, J.W. Berenschot, P. Mela, H.V. Jansen, M. Elwenspoek, A. Van den Berg, 2D-Confined Nanochannels Fabricated by Conventional Micromachining, *Nano Letters* 2 (2002), 1031-1032.