On chip synthesis and characterisation of nanostructures in- and outside TEM

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Microfabricated chips with incorporated heater structures allow micro-CVD synthesis of carbon nanotubes and epitaxial silicon nanowires, as well as synthesis insitu TEM. The microheater approach readily gives the experimenter access to high temperatures, fast response times and temperature gradients, which is challenging in any conventional setup. I will overview some of the possibilities that microchip heaters have to offer for studying thermally induced processes such as growth, catalyst roughening and annealing. Resistively heated chips were used to make a linear temperature ramp, which in a single experiment gives a picture of the carbon nanotube growth rate in a continuous range of temperatures. The temperatures were calibrated by micro Raman thermometry and finite element modeling [1]. By using heated single crystalline silicon chips in an environmental TEM, the growth of epitaxial silicon nanowires was tracked in-situ, giving insight in the shape and behavior of the gold catalyst as well as into non-equilibrium effects when hot nanowires form contact to opposing cold silicon walls [2]. Finally, I will point out some of the possibilities for rapid (20 minutes) D.I.Y. fabrication of electron-transparent in-situ TEM heater devices with custom electrode layout by focused ion beam milling of template membrane chips [3], show how this may be used to monitor catalyst surface dynamics directly in TEM, and discuss what else such chips could be used for.

[1] C. Kallesoe, Cheng-Yen Wen. K. Molhave, P. Boggild and F. Ross, Small, DOI: 10.11002/smll.200902187 (2010)
[2] D. S. Engstrom, N. L. Rupesinghe, K. B. K. Teo, W. I. Milne, P. Boggild, J. Micromech. Microeng., 21, 015004 (2011)
[3] A. Lei, D. H. Petersen, T. Booth, L. V. Homann, C. Kallesoe, O. Sardan Sukas, Y. Gyrsting, K. Molhave, P. Boggild, Nanotechnology, 21, 40, 405304 (2010); L. Homann, T. Booth, A. Lei, D. H. Petersen, Z. D. Davis, P. Boggild, J. of Microelectromech. Systems, 1074-1080, 2011