TIES BETWEEN MICROSYSTEM TECHNOLOGY AND NANO-ENGINEERING

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The continuous improvements in conventional lithography methods for integrated circuit hardware allow further device shrinkage deep into the sub-micron dimensions. Two major drawbacks of these high-end patterning methods based on photoresist technologies are i) their high process costs and ii) their limited process versatility. Increased flexibility, however, becomes important for the engineering of advanced nano/micro-electro-mechanical systems (NEMS/MEMS), such as ultra-thin solid-state membrane or cantilever devices, polymer-based devices, micro/nanofluidics, and bio-analytical systems. Often standard lithography methods cannot be applied on unconventional materials, because the surfaces to be structured are either mechanically unstable and/or (bio-) chemically functionalized. Bottom-up methods relying on self-assembling strategies are making tremendous progress to form ordered structures with nanometer precision, but they still lack control on a larger scale. The key aspect in the near future is to find new ways to tie *top-down* and *bottom-up* methods together, and to connect structures across the *nano/micro gap* so that the improved effects relying on nanometer dimensions can be efficiently scaled-up.

Recently, a series of new, alternative surface patterning methods related to MEMS technology have been developed, such as molecule delivery via DipPen/NADIS lithography or soft-lithography, thermo-mechanical indentation by Nanoimprint lithography, or local deposition via nanostencils. Due to their versatility and multiple length-scale capabilities they have great potential to form bridges between nano and micro-world.

We will present some examples of our contribution to the field of MEMS and Nanotechnology, such as large area nanostencil based on a DUV/MEMS membrane [1], NEMS devices [2], functional SAM layers for MEMS [3, 4], self-assembled nanowire sensors, nanoscale Hall-probe on surface released polymer cantilevers, and focused ion beam (FIB) and focused electron beam (FEB) nanofabrication. Some of these examples are presented in detail during TNT'04.

[1] M.A.F. van den Boogaart et al., DUV-MEMS stencils for high-throughput resistless patterning of mesoscopic structures, JVST B (in press)
[2] G.M. Kim et al., Nanomechanical structures with 91 MHz resonance frequency fabricated by local deposition and dry etching, JVST B (in press)
[3] M. Koelbel et al., Self-assembled monolayer coatings on nanostencils for the reduction of materials adhesion, Advanced Functional Materials, 13(3), pp.219-224 (2003)
[4] G.M. Kim et al., Surface modification with self-assembled monolayers for nanoscale replication of photoplastic MEMS, IEEE Journal of Microelectromechanical Systems, 11(3), pp.175-181 (2002)

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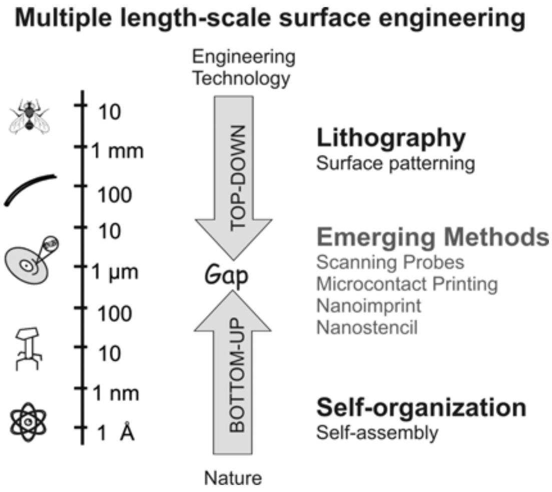

Fig. 1: Methods to bridge the nano-micro gap

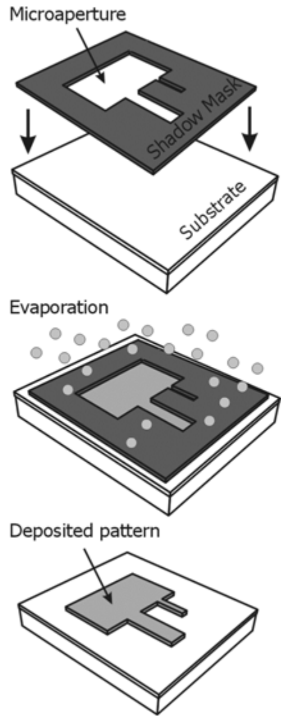

Fig. 2: Schematic view of the nanostencil method

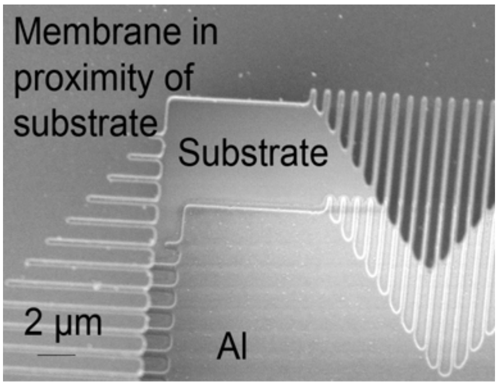

Fig. 3: SEM image showing the gap between nanostencil and substrate after Al deposition

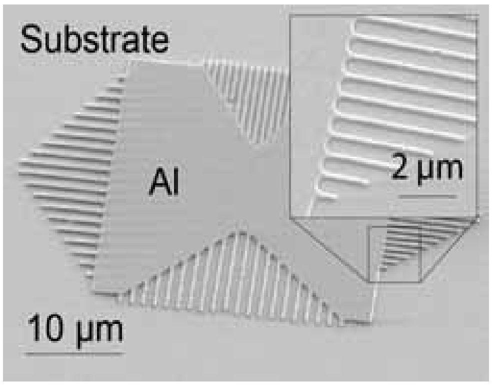

Fig. 4: Array of Al nanopatterns fabricated by a full-wafer DUV/MEMS nanostencil

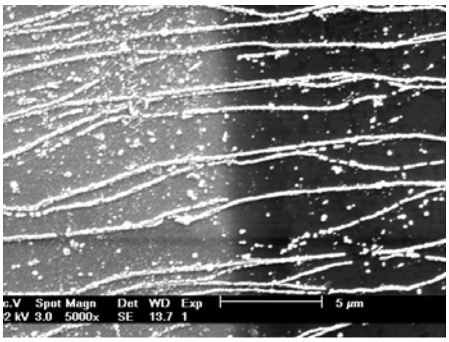

Fig. 5: SEM image of HOPG with electro-deposited Pd (60 nm) nanowires and nanostenciled Al connection pad

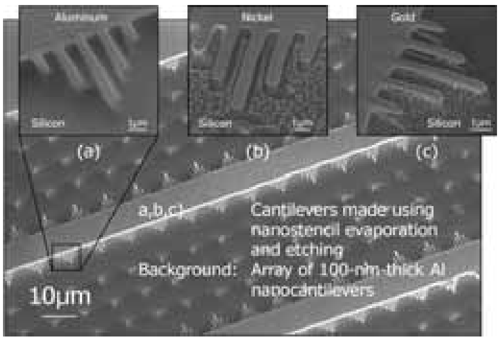

Fig. 6: NEMS cantilever array in different materials (Al, Ni, Au) made by nanostencil (cf. Fig. 4) and dry release etching