3D Micro and nano engineering of fragile materials

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The manufacturing of silicon micro systems is well advanced because the devices for many societal applications can be fabricated with established methods from IC industry. Polymer-based MEMS have a great potential for flexible electronics and biomedical applications. But we must admit that up to now the techniques to engineer functional polymers into reliable 3D microsystems for daily use are still at their beginning. One reason is that a standardized fabrication platform with the appropriate tools and processes does not yet exist.

This talk will provide an overview of recent achievements in advanced manufacturing at the micro/nanoscale than can be applied in particular to fragile materials, where harsh process steps using charged beams and etch chemistry can be harmful. I will in particular review briefly **nanostencilling** [1] that keeps offering novel opportunities for direct, in-vacuum patterning in particular for organic electronic applications. I will then show a new combination of **3D & inkjet printing** for creation and precise filling of micro-containers [2]. **Local thermal processing** [3] of silk [4] is introduced as a new, water-solvable resist. Finally, **capillary based self-assembly** [5] of nanoparticles is shown to form metallic dimer structures with controlled nano-gabs. All these techniques form part of the gentle toolbox for future micro/nano-manufacturing of fragile material systems, combining top-down and bottom-up techniques. One of the open challenges is to define mix-and-match strategies using the individual techniques.

References

[1] O. Vazquez-Mena, et al. Microelectronic Engineering, 132 (2015) 236-254
[2] F. Zheng et al. IEEE-NEMS 2020
[3] S. Howell et al. Microsystems & Nanoengineering (2020)
[4] S. Howell et al. (manuscript in prep)
[5] V. Flauraud et al. Nature Nanotechnology (2017)

Figures

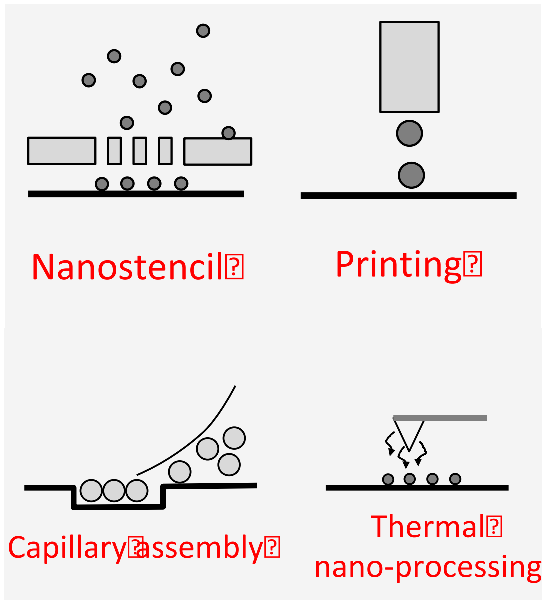

Figure 1: Schematic of 4 key techniques enabling patterning fragile material systems.

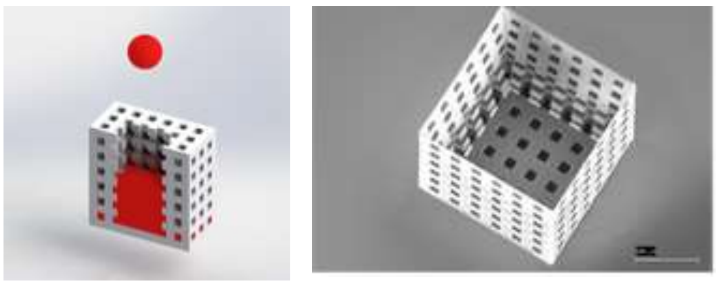

Figure 2: Schematic (left) of 3D printed scaffold ~250 micrometer side length to be filled with inkjetted drug and SEM image (right) of 3D printed scaffold before filling