Particle Assembly And Transfer

Laurent Malaquin[1], Tobias Kraus[1,2], Emmanuel Delamarche[1], Heinz Schmid[1], Nicholas D. Spencer[2], Heiko Wolf1[1]

IBM Research GmbH, Zurich Research Laboratory, Säumerstrasse 4, 8803 Rüschlikon, SWITZERLAND
[2]Laboratory for Surface Science and Technology, Department of Materials, Swiss Federal Institute of Technology, ETH-Hönggerberg, Wolfgang-Pauli-Strasse 10, 8093 Zürich, SWITZERLAND
hwo@zurich.ibm.com

Soft Lithography and Self-Assembly are major topics in the **NaPa** (Emerging Nano-patterning Methods) integrated project. They pave the way to low cost, large area patterning down to the nanometer scale. The Soft Lithography & Self-Assembly (SLASA) subproject is aimed at developing and optimizing these techniques towards industrial applicability. The main goals and achievements of the SLASA subproject in NaPa will be briefly reviewed.

Self-Assembly is especially useful as a parallel technique for the formation of well ordered arrays of particles [1]. Significant progress has been made in the synthesis of particles with controllable shape, structure and size. Such particles can provide diverse properties that make them potential building blocks of novel micro- and nanosystems [2]. However, many devices in microelectronics and micromechanics, as well as many sensors require the integration of these particles on their surfaces to provide the desired functionality such as electrical connection, spacing, biological or chemical activity, or light emission. We investigated two complementary principles to create particle assemblies ranging from full layers to sparse arrays, starting from colloidal suspensions of gold and polystyrene particles between 60 nm and 500 nm in diameter (Figure 1):

(i) Crystalline mono- or multilayers were fabricated by convective assembly [3] on hydrophilic substrates using convective flow of nanoparticles induced by evaporation at the contact edge of the solution.

(ii) Sparse arrays were fabricated by capillary assembly using capillary forces to trap

and organize particles in the recessed regions of a template. A dedicated setup was developed to provide control over all relevant process parameters, including the suspension temperature which we found to be critical for efficient and precise particle alignment. Microscopic observation of the assembly process revealed different regimes depending on the temperature and evaporation rate. For different particle sizes, assembly patterns, and contact angles we demonstrate that the range of structures accessible strongly depends on temperature. The optimized process is compatible with almost arbitrary particle arrangements and even allows reversing the particle assembly to remove misaligned parts while maintaining the overall order.

In a further step, the particles can be transferred from the assembly template to another substrate, thus separating the actual integration from the assembly step (Figures 2,3) [4]. This becomes important when nanoparticles are to be integrated into existing devices which are usually not compatible with the topographical or chemical patterning required in self-assembly processes.

References:

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Figures:

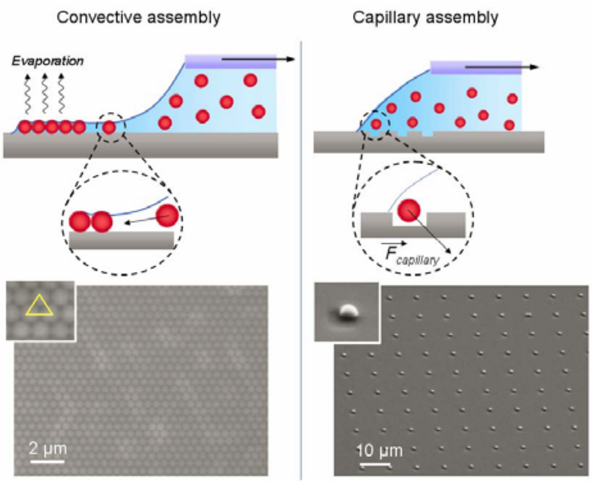

Figure 1 Polystyrene beads with 500 nm diameter were assembled from aqueous suspension in a densely packed layer onto a flat silicone elastomer surface by convective assembly (left) and as a sparse array on a patterned silicone elastomer template (right).

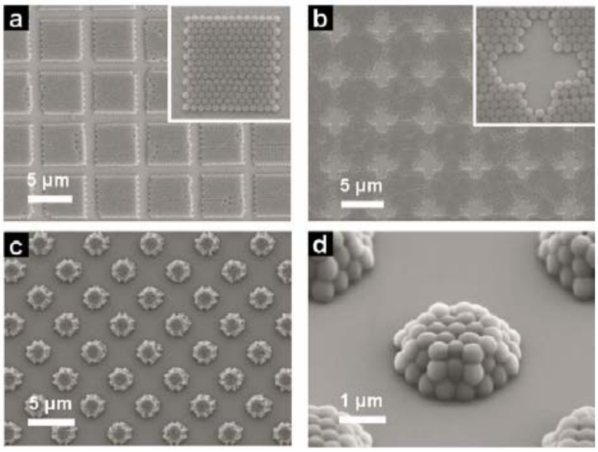

Figure 2
SEM images of polystyrene particles (500 nm) assembled in 2D and 3D structures and transferred onto silicone substrates in a single step.

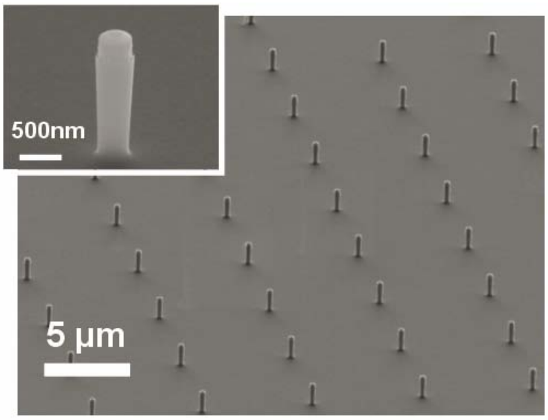

Figure 3 Array of silicon pillars produced by a reactive ion etch with printed polystyrene particles (500 nm) used as a resist.