

Self-Assembly of Lithographically-Designed Colloidal Particles on Templated Surfaces



McIntosh Bonthera

Chemical Engineering, New Jersey Institute of Technology

NNIN REU Site: Cornell NanoScale Science & Technology Facility, Cornell University

NNIN REU Principal Investigator: Prof. Abraham Stroock, Chemical Engineering, Cornell University

NNIN REU Mentor: Stephane Badaire, Chemical Engineering, Cornell University

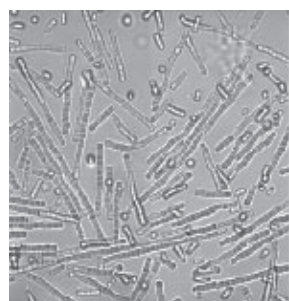
Contact: mb265@njit.edu, ads10@cornell.edu

Abstract:

The formation of a diversity of structures via the assembly of colloidal particles is hindered by the scarcity of available particles, the difficulty of attaining mono-dispersed samples, and the lack of tunable and selective interactions. With the aid of depletion interactions, we have been able to induce and control structure in systems of photolithographically designed cylindrical particles. The structures that have been formed thus far consist of isolated columns of cylinders that do not present order on a larger scale. Our aim is to self-assemble these building blocks on a patterned surface to have better control of the structure. Preliminary experiments have shown that the particles adhere to the patterned surfaces as envisioned however, replication of the process is necessary.

Introduction:

The general challenge that is faced by the industry is the fact that at the microscale, researchers typically deal with spherical particles. Armed with a limited diversity of shapes, the result was a limited diversity of structure. We believe that through the use of lithography, we can utilize the diversity of these building blocks and ultimately gain a more mechanistic insight into the formation of structure. This project served as a means to answer the question— can we in fact have some form of power on formation and structure? By templating a glass surface, we hoped we could demonstrate selective self-assembly of the particles on a patterned surface.



Optical Micrograph

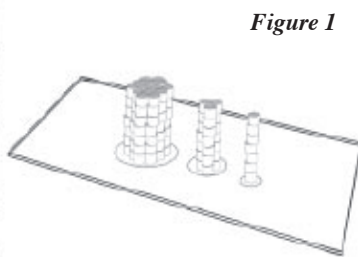


Figure 1

Templating

Experimental Procedure:

Experimental Procedure for Glass Coverslips:

1. Plasma clean (about 11 glass coverslips approx. 140 μm in thickness).
2. Spin 1 μm layer of SU-8 2002 (6000 rpm, 40 sec).
3. Soft bake for 2 min. at 65°C and 3 min. at 95°C (to remove solvents).
4. Use contact mask aligner (EV620) to expose pattern onto glass coverslip (exposure time of 5 sec. in top side soft contact setting).
5. Post bake for 1 min. at 65°C and 2 min. at 95°C (to crosslink SU-8 2002).
6. Develop SU-8 2002 by dipping and agitating for 2 min. in SU-8 developer solution, 1 min. in another solution of SU-8 developer solution, and 1 min. in isopropanol solution.
7. Final wash with bottle of isopropanol solution and dry with nitrogen gas.
8. Place in coverslip holder and store.

Surface Chemistry:

We templated a glass surface with shapes made of SU-8. Our goal was to graft an amino silane (positively charged once in water) on the glass surface, and then use

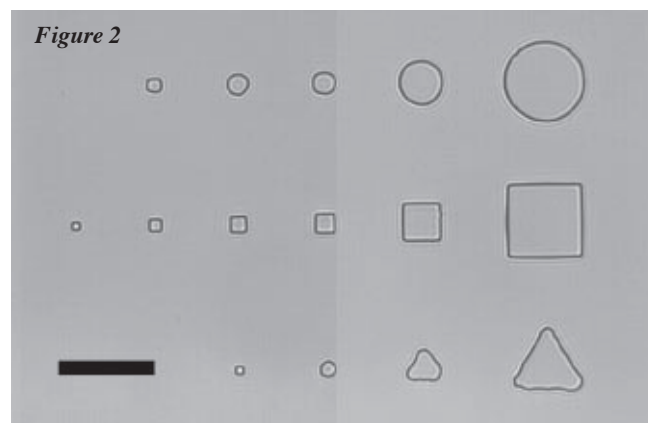


Figure 2

Optical microscopy picture (scale bar = 20 microns)

this highly positive surface to adsorb a strongly negative polymer, dextran sulfate. The main idea was to make the glass surface strongly negative so that the cylinders would “stick” to SU-8 first, due to the depletion effect. During the surface chemistry trials, it appeared that one coverslip presented a surface activity corresponding to what we were searching for, but we still have to investigate the surface chemistry process to be able to reproduce that result.

Results and Conclusions:

The cylinders adhered to the SU-8 patterns like originally dreamt in a nice hexagonal ordered array. Hopefully when placed on a rotating stage, the Brownian cylinders will fall off the glass surface and stack up onto the SU-8 patterns and progressively build themselves. We are currently trying to replicate this phenomenon which is no easy task. It would seem parameters beyond our understanding are involved. This result is a testament that our original goal is attainable and has revitalized our thirst to continue this project and one day build novel structures.

Future Work:

When our coating process is excellent, we plan to explore the consequences of differing concentrations of salts and depletants, confinement effects meaning size and shape variation, and observe if the use of complimentary shapes can affect structure that is formed.

Acknowledgements:

I would like to thank my principal investigator, Professor Abraham Stroock, my mentor, Dr. Stephane Badaire, the Stroock Group for having me, Intel Foundation for sponsoring me, the National Nanotechnology Infrastructure Network Research Experience for Undergraduates Program (NNIN REU) and National Science Foundation (NSF) for funding, Ms. Melanie-Claire Mallison and Dr. Lynn Rathbun, CNF staff, for their aid, and all who have contributed to this effort.

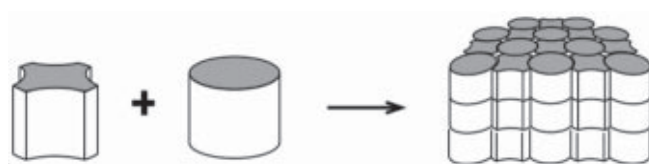
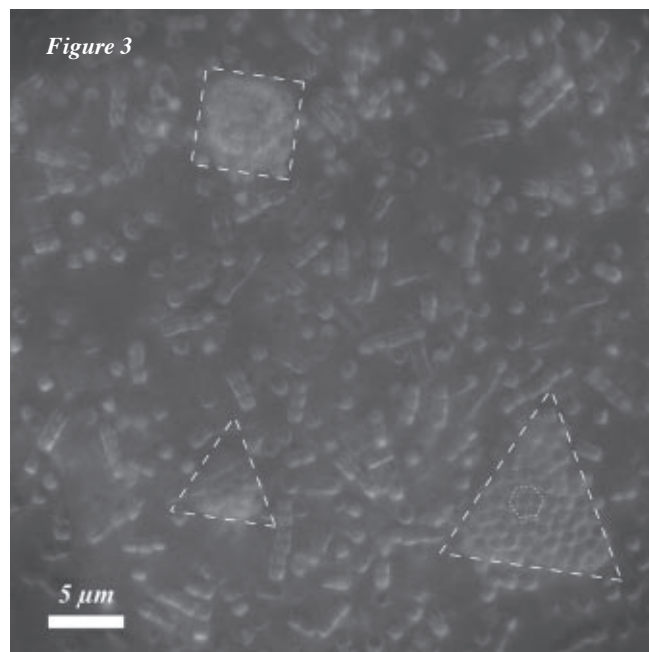


Figure 4