NDnano Undergraduate Research Fellowship (NURF)
2013 Project Summary

1) Student name: Patrick Jung
2) Faculty mentor name: Prof. Marya Lieberman, Dr. Valerie Goss
3) Project title: Microcontact Printing of DNA Origami onto Silicon Substrates

4) Briefly describe any new skills you acquired during your summer research

During my research, I developed the skills required to handle and clean very small silicon substrates. I also learned how to use the Mann 3600F photomask pattern generator in order to make the masters for my stamps. In order to characterize the data and surfaces, I used the atomic force microscope to take images of my samples.

5) Please briefly share a practical application/end use of your research:

As the demand for better and smaller electronic components increases, so does the demand for new techniques on how to pattern electronic features onto silicon circuits. Currently size limits in features made by photolithography techniques are being reached. DNA origami has potential applications as a scaffold for molecular electronics because of the small distance between individual base pairs and its ability to selectively bind functional ligands. Microcontact printing with PDMS stamps is flexible, durable, and unreactive and therefore may have potential applications in flexible electronics and chemically sensitive materials.

We worked on developing microcontact printing methods to localize DNA nanostructures on modified silicon substrates. We started out by making poly(dimethylsiloxane) PDMS stamps that were cast off of laster-printed masters and then used them to make rough patterns of thiols on silver. This allowed us to develop and test PDMS curing techniques and optimize contact time. The pattern design was made with the Mann 3600F photomask pattern generator and consisted of 2.0 micrometer ovals formed in an array with two micrometer spacing. The pattern was etched into a 100 nm layer of chromium on a 4" glass mask. The ratio of height to width of the pattern was 1:20 as advised in the literature to avoid sagging and pairing of the relief structures on the stamp. Since DNA cannot normally bind to silicon, a monolayer of aminopropyltriethoxysilane (APTES) was applied to modify the substrate.

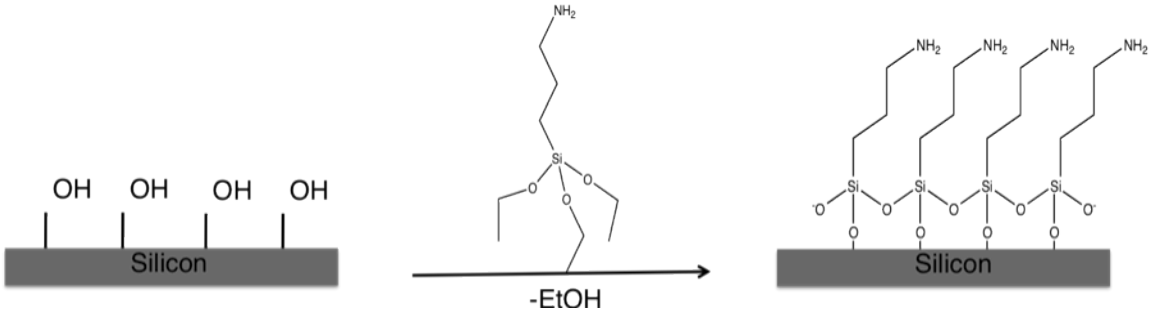
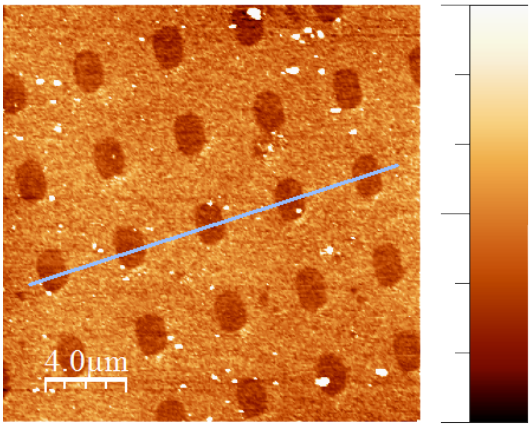


Fig. 1 APTES modified silicon surface

The PDMS was mixed at a ratio of 1:10 curing agent to base and then poured over the chromium master. After curing the stamp, a 1% (v/v) APTES solution in water was applied to the patterned surface of the stamp. Once the APTES had sufficiently adsorbed to the PDMS stamp, it was brought in contact with a cleaned piece of silicon.



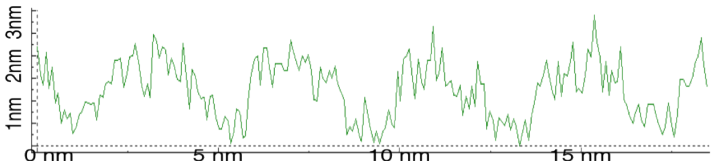


Fig. 2 This an atomic force microscopy scan of the APTES modified silicon along with a height graph. The average height difference inside the oval wells was about 1.5nm. This corresponds with the length of one APTES molecule.

We made DNA origami following a rectangle design without the edges by Paul Rothemund. In order to check if the DNA had annealed properly, we deposited the DNA origami onto a mica substrate and characterized it with AFM. The DNA origami was then deposited onto the APTES modified silicon surface. Because the APTES surface was not completely uniform, the shape of the DNA origami was not as evident as it was when viewed on a mica substrate. The height scale in the image is from 0 to 5 nm.

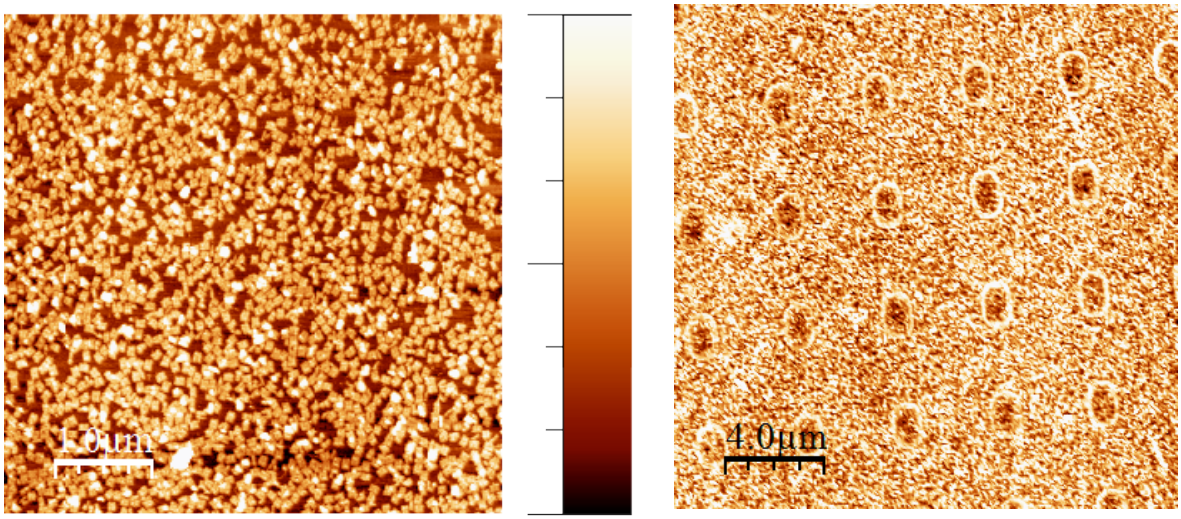


Fig. 3 On the left is an AFM scan of properly formed DNA origami on a mica substrate. On the right is the DNA origami deposited onto the APTES modified silicon substrate. The height scale in the image is from 0 to 5 nm.

Publications:
Poster at the Summer Undergraduate Research Sympsium 2013
“Microcontact Printing of DNA Origami onto Silicon Substrates”