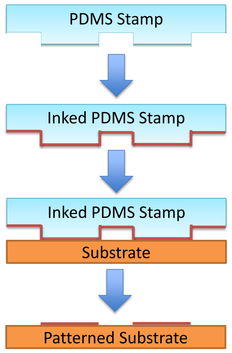
Printing Two Inks Simultaneously via Microcontact

David Moore, Ravi Saraf

Microcontact Printing

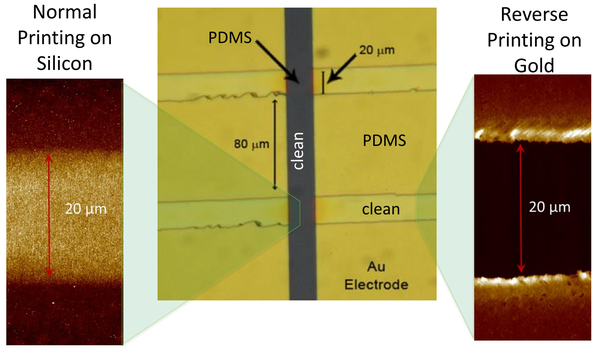
Microcontact printing deposits a pattern on a substrate by “inking” a stamp which is then applied to the surface. The ink will only go where the stamp touches, and this allows for very fine features.

Stamps are typically made of Polydimethylsiloxane (PDMS).



Negative Space Printing

We discovered that, under the right circumstances, PDMS will deposit on gold, but not silicon ,where the stamp is *not* in contact. Below are AFM images which confirmed this.



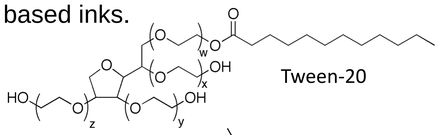
This mean that, on gold, we could possibly print two polymers simultaneously. Doing so might enable sensors to be printed on a large electrode while fully passivating the bare gold.

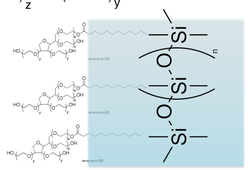
Challenges

- The PDMS needed to be in the right state of curedness. Too well-cured and it won’t deposit, too uncured and it won’t hold it’s shape.
- The PDMS needed to be hydrophilic for the polymer of interest: polyallylamine HCl (PAH)
- Most modifications of PDMS to make it hydrophilic ruin the negative space printing.

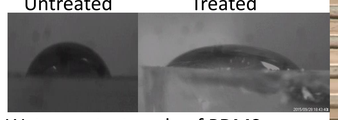
Method

To solve the hydophobicity problem, we opted to use a Tween-20 surface modification. Tween-20 is an emulsifier; it’s alkane tail will stick to PDMS while it’s hydroxyl-rich head will allow water-based inks.

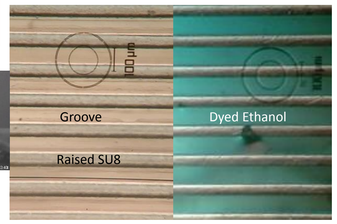


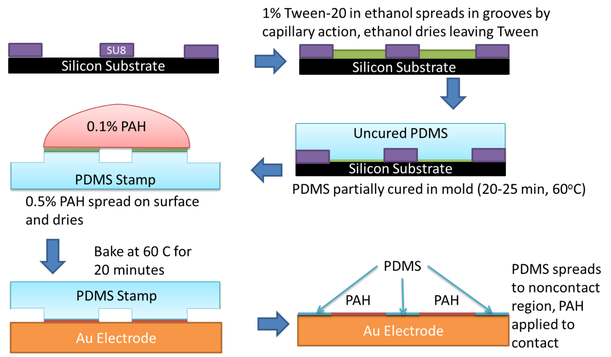


Capillary action carries Polysorbate-20 into groves in 1% ethanol (dyed for visual)



Water contact angle of PDMS before and after treatment



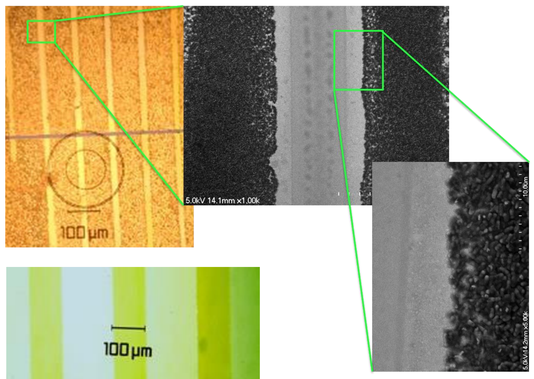


Method:

1. Make stamp mold
2. Pretreat mold with Tween solution
3. Fill mold with PDMS
4. Cure mold until right consistency
5. Dry ink on mold under vacuum
6. Apply stamp to substrate
7. Bake for 20 minutes at 60ºC

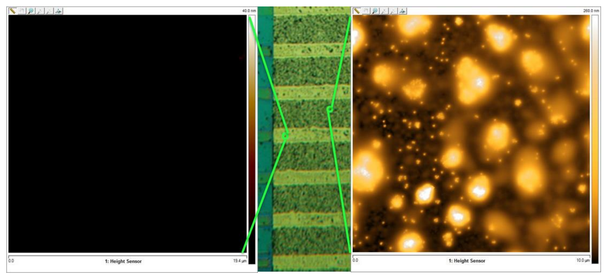
Confirming Ink and PDMS Transfer

The PAH pattern was tagged with E. coli

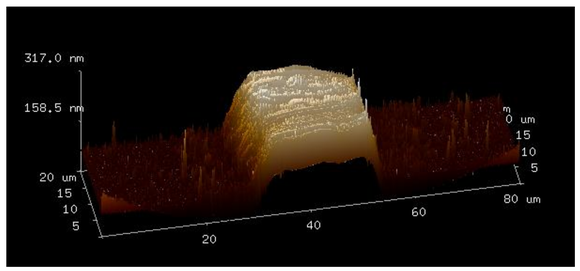


We dyed larger features with an amine-reactive red dye to see the PAH transfer (smaller features were ruined by this process.

The PAH pattern attracted nanoparticle clumps that did not show in the PDMS region.

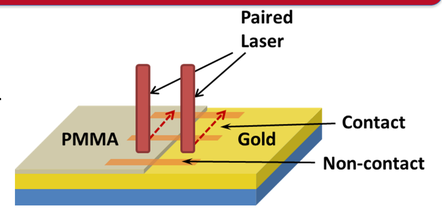


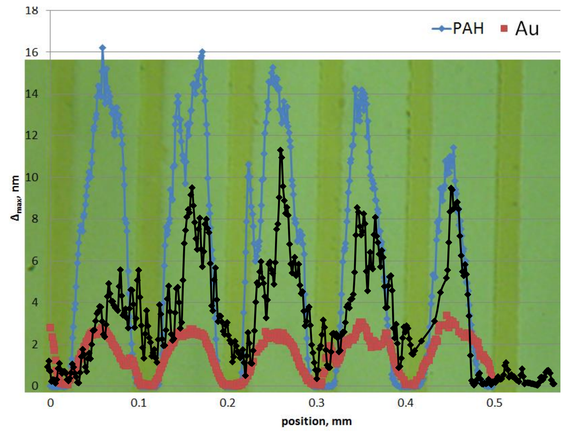
We imaged the combination with AFM. The PDMS region was much thicker (as expected)



Sensing the Film

Simply imaging the PAH transfer does not tell us if the PDMS has become active due to PAH contamination. We use a home-built device called a Scanning Electrometer for Electrical Double-layer (SEED) to see if the PDMS region is truly passive. This process involves scanning the lines with a laser interferometer that is sensitive to surface activity in saline.





The PAH enhanced signal (blue) over bare gold (red) and was fully passivated in the PDMS region. Similar scans on using ferricyanide-impregnated PAH detected Dopamine (black) which will not happen on pure gold.

Conclusions

We successfully printed a pattern of fine features (as small as 10 microns) on a gold substrate using a combination of negative-space printing and traditional microcontact printing. This was demonstrated in several ways

Future work could involve trying new inks and new stamp materials, as well as testing post-processing methods such as plasma-activating the PDMS.

University of Nebraska Lincoln | Nebraska Center for Energy Sciences Research

University of Nebraska Lincoln