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Fabrication of 4" PDMS stamps and large area sub-µm µCP

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Presenter is Student / Post-Doc: Yes

Microcontact printing (µCP) is a simple and yet excellent method to functionalize surfaces by using a structured and "inked" stamp to transfer patterns of the desired substances directly onto the substrate surface. One of the key element in this process is quality of the stamp, which is the negative copy of a master.

In most cases the stamp is made by simply pouring liquid PDMS over a structured Si-master. This normally results in a considerable lateral thickness variation of the stamp which is unfavourable for the printing quality since it induces a variation of the printing pressure. Spin-casting can reduce the thickness variation problem but suffers from edge bead and thin stamps which are difficult to handle. We produced 4" PDMS-stamps directly on a transparent rigid back-plate, which supports the 900 µm thick PDMS layer and therefore ensures save handling and compatibility to the printing device. (figure 2).

Both master and stamp were evaluated using SEM and AFM. The suitability of these stamps for large area µCP was tested by microcontact printing alkanethiols, which form self assembled monolayers (SAMs) on a gold surface. These structured SAMs were used as etch mask to structure the gold surface with a thiourea solution.[1]-[2] (figure 1). The microcontact printing process itself was performed on a EVG®620 mask aligner under clean-room conditions. This guaranteed best possible control over important process parameter like, contact pressure, contact time, and uniformity of pressure. The etch results were investigated using AFM.

The resolution of the PDMS stamp is primarily limited by the resolution of the master. To overcome the resolution limitation of the conventional photolithographic fabrication process for the Si-master we additionally used Si-masters coated with a UV-curable polymer, which was structured using UV nanoimprint lithography (UV-NIL). An SEM image of this master is shown in figure 3 and the etch result in figure 4. The smallest feature size so far characterized is in the range of 700 – 900 nm.

There are numerous potential applications in life science for µCP regarding patterning substrates for cell culture [3] and printing of proteins [4]-[5].

[1] Annu. Rev. Mater. Sci. **1998**. 28:153–84, "Soft Lithography", Younan Xia and George M. Whitesides
[2] Small, **2005**, 1, No.10, 940- 945; "Sub-100nm, Centimeter-Scale, Parallel Dip-Pen Nanolithography" K. Salaita et. al.
[3] Experimental Cell Research **1997**, 235, 305–313, "Using µCP to Pattern the Attachment of Mammalian Cells to Self-Assembled Monolayers of Alkanethiolates on Transparent Films of Au and Ag"; Milan Mrksich
[4] Adv. Mat. **2000**, 12, No. 14, "Microcontact Printing of Proteins"; Andre Bernard et. al.
[5] Adv. Mat. **2004**, 16, No 7, "Soft Lithographic Patterning of Hyaluronic Acid on Hydrophilic Substrates Using Moulding and Printing", Kahp Y. Suh, et. al.

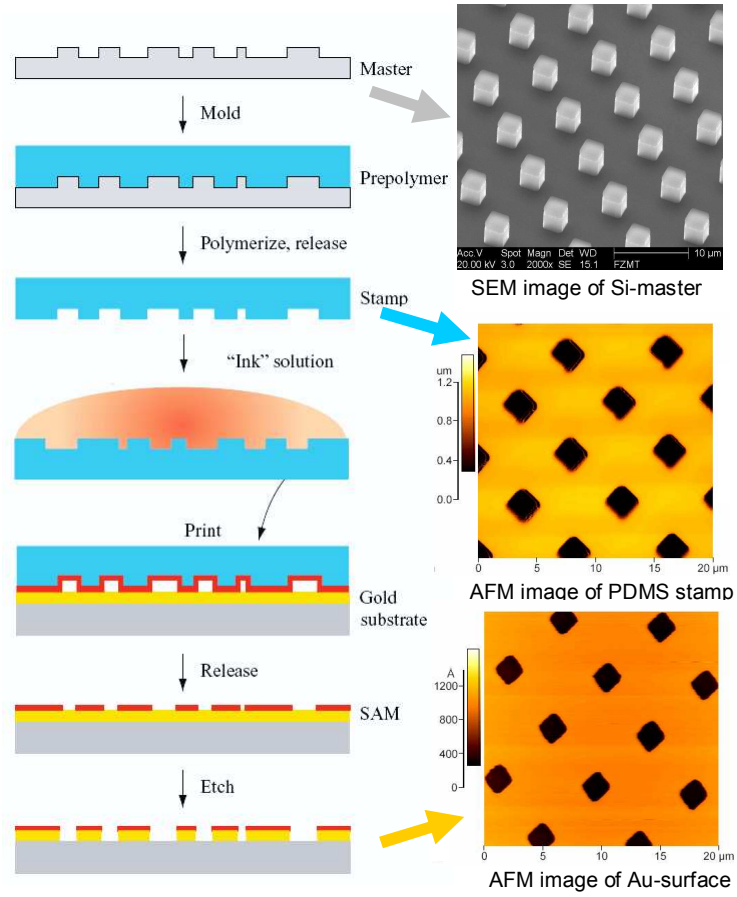

Figure 1 left: principle of micro contact printing of Thiol SAMs on Au and etching; right: SEM / AFM images of Si master, PDMS stamp and Au layer (from top to bottom).

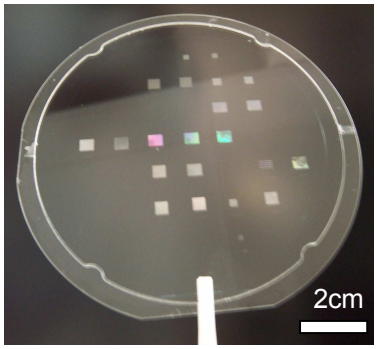

Figure 2 4" PDMS stamp. with glass back-plate

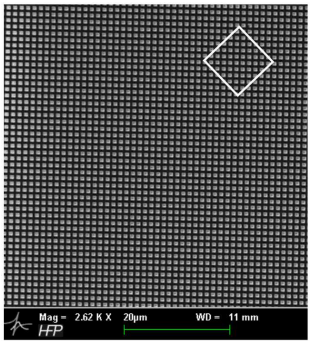

Figure 3 UV-NIL imprint, master for sub-µm µCP (white square indicates size of area in figure 4)

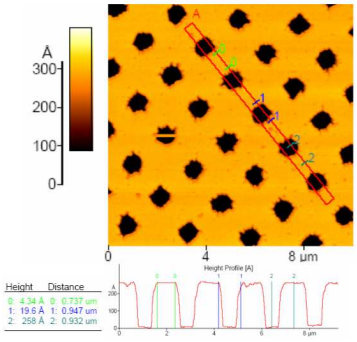

Figure 4 Structured gold surface, using a PDMS stamp cast from master given in figure 3, typical feature size is 900 nm.