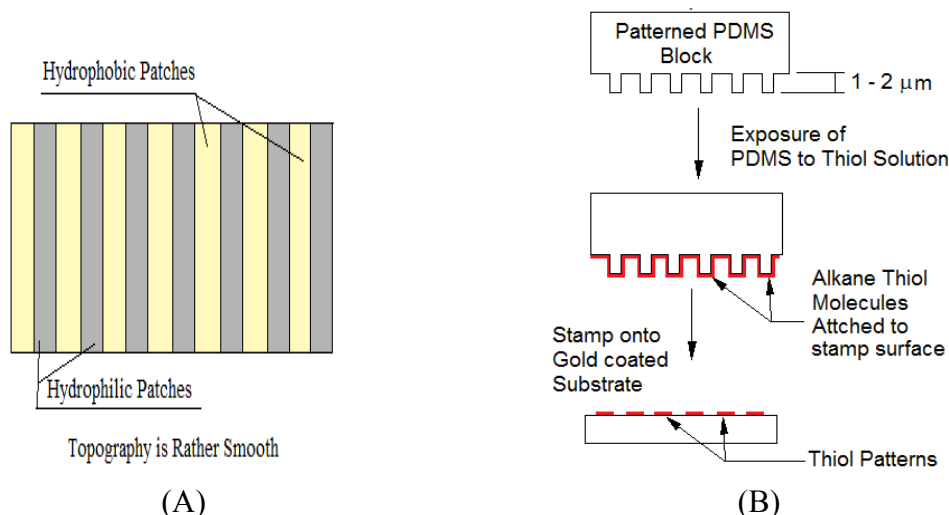


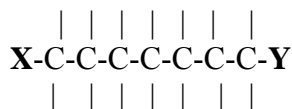
Lecture-16-21 Soft lithography

16.1. Discuss a Soft Lithography method that allows the fabrication of chemical patterns.

Ans: Micro contact printing (μCp) is a technique which allows fabrication of Chemical Patterns on a surface. By chemical patterns, we mean a surface which has ordered array of different wettability domains (refer to figure A).



Micro contact printing (Schematic shown in figure B) helps in producing chemical patterns on the surface. It uses surface active molecules (e.g. ligands) and the substrate is dipped into the ligand solution. This is known as silanisation. Along the contours of the surface only a monolayer of silane molecules are formed. There are two end chain groups along the linear carbon chain structure.



Y determines the level of hydrophobicity or hydrophilicity of the patterns. Depending on whether **X** is hydrophobic or hydrophilic, a silanized surface will also be hydrophobic or hydrophilic.

X determines the preferential reaction affinity towards the surface taken.

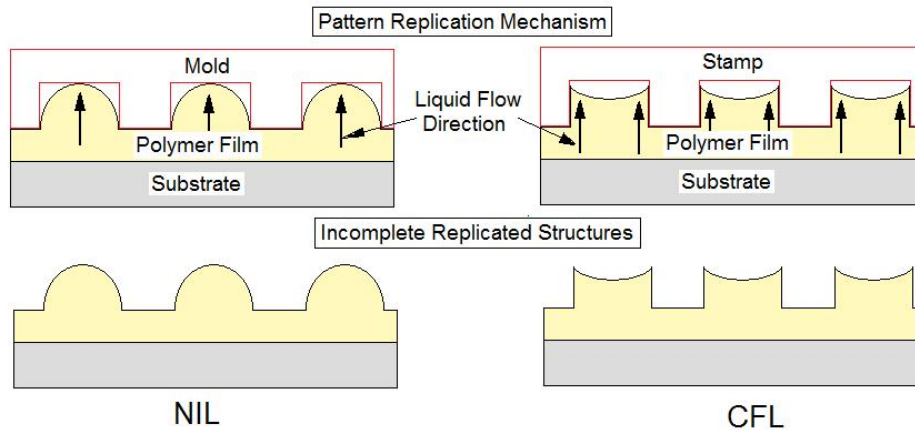
16.2. Give examples of Soft Lithography methods where pattern replication relies on Capillary driven flow? Compare the relative merits and demerits of the methods.

Ans: Both Micro molding in Capillaries (MIMIC) and Capillary Force Lithography (CFL) rely on Capillary driven flow. However, MIMIC relies on the flow of a dilute solution polymer solution inside micro channels formed due to conformal contact between the stamp and the flat, bare substrate. This protocol allows fabricating structures made of colloidal particles by MIMIC. In contrast, CFL requires a previously coated thin polymer film.

Pattern replication might be a problem in MIMIC over a wide area, as the capillary driving force progressively reduces as the meniscus progresses inside the channel. Also, as the solvent content in MIMIC is high, the extent of shrinkage is also higher. In contrast, CFL is capable of producing high fidelity patterns with virtually zero shrinkage, as it relies on capillary driven flow of a molten/ softened polymer layer

(rather than a dilute polymer solution). However, as a pre coated film is necessary in CFL, it is not possible to obtain structures with colloidal particles by this method.

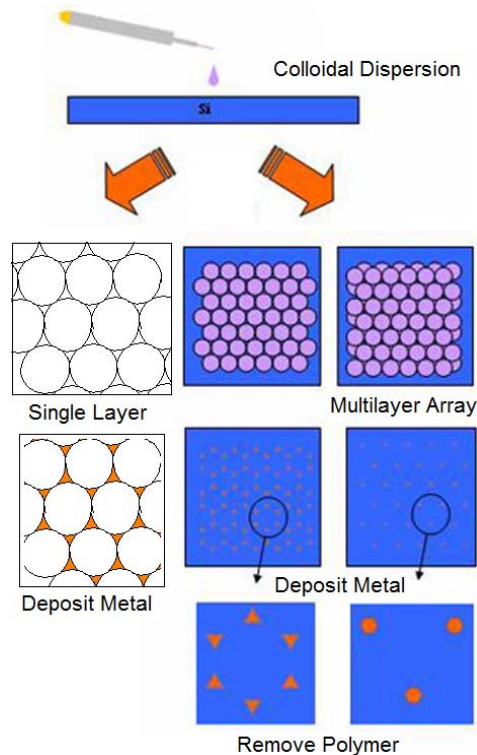
- 16.3. You are performing NIL as well as CFL. However you do not allow the processes to continue for the desired duration and stop the pattern transfer process at an intermediate stage itself. Please draw the likely profile of the incomplete replicated structures, assuming that imprinting was done using a stripe patterned stamp.



- Ans: The above figure shows the likely profile in the two cases. The difference in morphology is due to the pattern replication mechanism, which is also shown in the figure. While the liquid rises through the central part of a mold groove in case of NIL, it rises along the stamp walls in case of CFL, which leads to the difference in the morphology, in case pattern replication remains incomplete. In case pattern replication is allowed to proceed to completion, in both case a perfect negative replica of the stamp pattern will result.

- 16.4. What is nanosphere lithography?

- Ans: [Nanosphere lithography](#) uses [self-assembled monolayers/multilayers](#) of spheres (typically made of polymers like PS) as evaporation masks. This method has been used to fabricate arrays of nanodots with precisely controlled spacing. The array of the colloidal particle can be used as a mask for subsequent deposition metals, as can be seen in the adjoining figure.



16.5. What is swelling of a polymer film?

Ans: When a dry bulk polymer is exposed to a solvent, the solvent molecules enter into the porous structure of the polymer and diffuse into all accessible volume. This phenomenon is commonly referred as mass uptake, since the solvent molecules at this stage are physically or chemically adsorbed on the surface as well as are absorbed into the pores and the available free volume. If however the polymer is soluble in the solvent, there is a strong attractive interaction between the polymer and the solvent, and the net interaction between the polymer segments is repulsive. As a result, the coiled chains start to swell as soon as they are in contact with the solvent molecules

16.6. What is the advantage of using a soft/elastic stamp over a rigid stamp?

Ans: There are several advantages of using a flexible stamp (majority of the cases, an elastomeric stamp) over a rigid stamp (as used in Nano Imprint Lithography).

A flexible stamp can simply be peeled off from one side with hand or a tweezer, after the pattern replication is over. This is a major advantage over a rigid stamp, where stamp release agents are required.

A flexible stamp comes in conformal contact with major part of a film, even if there are some minor defects. In case there are some defects on the film surface in NIL (rigid stamp), the defects act as spacers and does not allow the mold to come in contact with the film. In some cases, application of external pressure against a defect (a dust particle) may lead to complete disintegration and breakage of the stamp.

The use of a flexible stamp allows films coated on non planar surfaces to be patterned.

A flexible stamp is much cheaper as compared to a rigid silicon mold.

16.7. Describe a soft lithography method that is capable of fabricating 3 – D structures.

Ans: Micro transfer molding (μTm) is a Soft Lithography method that is capable of generating 3 – D meso scale structures.

16.8. What is the concept of “Beyond the Master Patterning”.

Ans: Majority of the Soft Lithography (including NIL) methods produce a perfect negative replica of the stamp pattern. Thus, a new stamp/ mould is necessary for fabricating structures with every new design or geometry. This makes most soft lithography methods indirectly dependent on other lithography methods such as photo lithography or electron beam lithography for the fabrication of stamp.

To overcome this limitation, state of art research is now oriented at exploring possibilities if ordered structures of different morphologies/ dimension/ geometry can be created from a single stamp. Some examples of such approaches are LISA (Lithographically Induced Self Assembly). Electrohydrodynamic Lithography. Elastic Contact Lithography etc.