Soft lithography is a form of nanolithography, which constitutes a set of various non-photolithographic techniques centered on the principle of self-assembly and replication (or imprinting). The term “soft” in soft lithography is derived from the physical nature of the mold used (i.e., soft) for fabricating structures, where the soft mold itself is prepared from rigid templates. Rigid templates, also termed as master patterns, are reusable patterned substrates that are usually prepared by photolithography, EBL, or micromachining on materials like silicon and silica. The master pattern is first subjected to cast molding to form its replica on an elastomeric material like polydimethylsiloxane (PDMS) to prepare the soft mold or stamp, which is then used to generate structures or patterns by various techniques that are collectively termed as soft lithography. Over the years, soft lithography has evolved into one of the most economical and most convenient nanolithography techniques where features as small as sub-10 nm size scale have been successfully fabricated by many research groups. Several review articles have also been communicated from time to time focusing on key developments in soft lithography techniques all over the world. Some commonly used soft lithography techniques are: replica molding (REM), microtransfer molding (μTM), micromolding in capillaries (MIMIC), solvent-assisted micromolding (SAMIM), and microcontact printing (μCP).

- **Replica molding (REM)**: REM is a simple and single-step replication technique used to create micro/nanoscale features by curing prepolymer cast into PDMS molds. UV or thermally curable prepolymer without any solvent and low shrinkage (typically less than 3% on curing) are used for REM. Polyurethane (PU) is an example of a UV curable prepolymer used extensively for replica molding. REM has also been employed against rigid molds for mass production of a variety of materials including
compact discs (CDs), diffraction gratings, holograms, and micro-tools.

- **Microtransfer molding (µTM):** In a µTM process, a liquid prepolymer is first applied to the surface of a PDMS mold and the excess is removed by scraping, or blowing by passing a stream of gas, and then the liquid prepolymer filled mold is placed on the surface of a substrate. The prepolymer is thermally or UV cured to become solid and attached to the substrate after which the PDMS mold is delicately removed to leave behind the patterned structure on the substrate. Thermally curable epoxy resins and UV curable polyurethanes have been used as prepolymer for µTM.

- **Micromolding in capillaries (MIMIC):** MIMIC is a very versatile soft lithography method used to create micro/nanoscale features from a variety of materials, such as UV or thermally curable polymers with no solvents, functional polymer solutions, glassy carbon or ceramic forming precursor polymers, inorganic salts, sol-gel materials, colloidal solutions, polymer beads, and biologically functional macromolecules. In this method, a PDMS mold with channels is first placed on a substrate and then a low-viscosity prepolymer is placed at the open ends of the channels. The prepolymer fills up the channels by capillary action, which is then solidified by curing. The PDMS mold is then slowly removed from the substrate to create patterned features of the polymer.
• **Solvent-assisted micromolding (SAMIM):** SAMIM is the only soft lithography method which utilizes polymer films to create nanostructures on their surface from PDMS molds. However, only those polymer films can be used whose solvents do not affect the PDMS mold during micromolding. In this method, the surface of the PDMS mold is first wetted with a solvent that can dissolve (or soften) the polymer whose nanostructures are to be created. The PDMS mold with the solvent is then brought in contact with the polymer film held on a substrate. The solvent dissolves (or softens) a thin layer of the polymer and forms a gel that fills the patterns in the mold. When the solvent evaporates the gel inside the patterns freezes into solid polymer and forms polymer nanostructures on the substrate. A schematic of the SAMIM process is shown in the figure below.

• **Microcontact printing (μCP):** μCP was originally developed by George M. Whitesides at the Harvard University. It is essentially a printing process in which a soft mold like PDMS is covered with a chemical solution called *ink* and then brought into physical contact with a substrate after the ink has dried. A commonly used ink is a thiol solution, such as hexadecanethiol. Upon physical contact with the substrate, the thiol is transferred to the surface of the substrate resulting in the reproduction of the mold pattern. The three known configurations to transfer the ink, based on the geometry of the mold and the substrate, are: i) planar mold onto a planar substrate; ii) nonplanar mold onto a planar substrate; and, iii) planar mold onto a nonplanar substrate. Figure below shows the schematics of these three configurations. A derivative of μCP called
nanocontact printing (NCP) is reported to pattern sub-50 nm features. μCP (and NCP) have been investigated for applications in micromachining (where the ink acts as a resist for an etching process) and biological engineering (by patterning cells, DNA, and proteins).
Schematics of some commonly used soft lithography techniques: (A) replica molding (REM); (B) microtransfer molding (μTM); (C) micromolding in capillaries (MIMIC); (D) solvent-assisted micromolding (SAMIM); and, (E) microcontact printing (μCP) in three different configurations: i) planar mold - planar substrate, ii) rolling mold - planar substrate, and iii) rolling substrate - planar mold. [Reference]