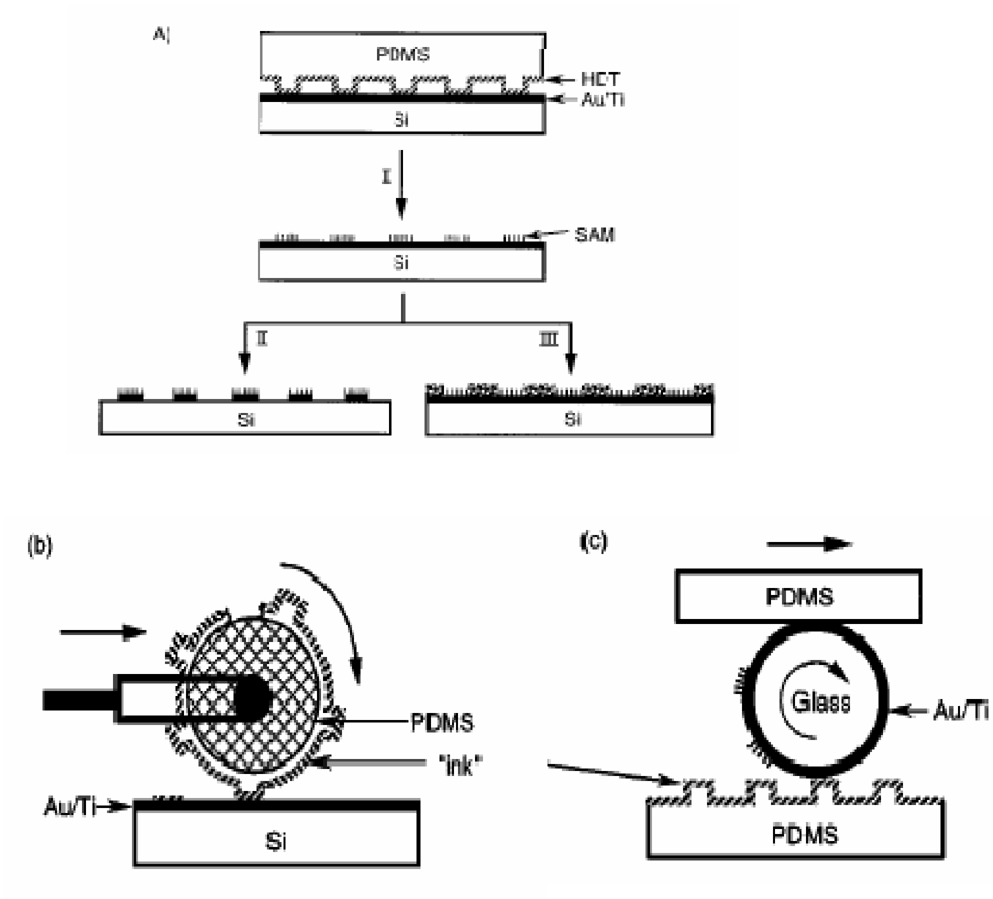
한국기계연구원 최대근

Soft lithography

Whitesides group의 논문을 포함한 PDMS를
이용한 패터닝 방법 및 응용에 관한 논문 소개

Microcontact Printing (μCP)



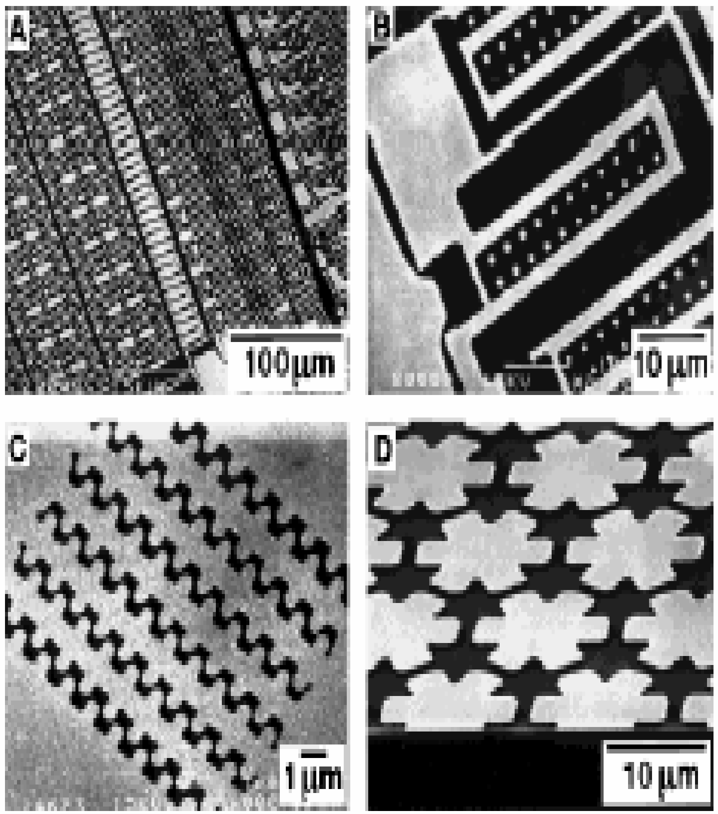
(a) Printing on a planarsurface with a planar stamp

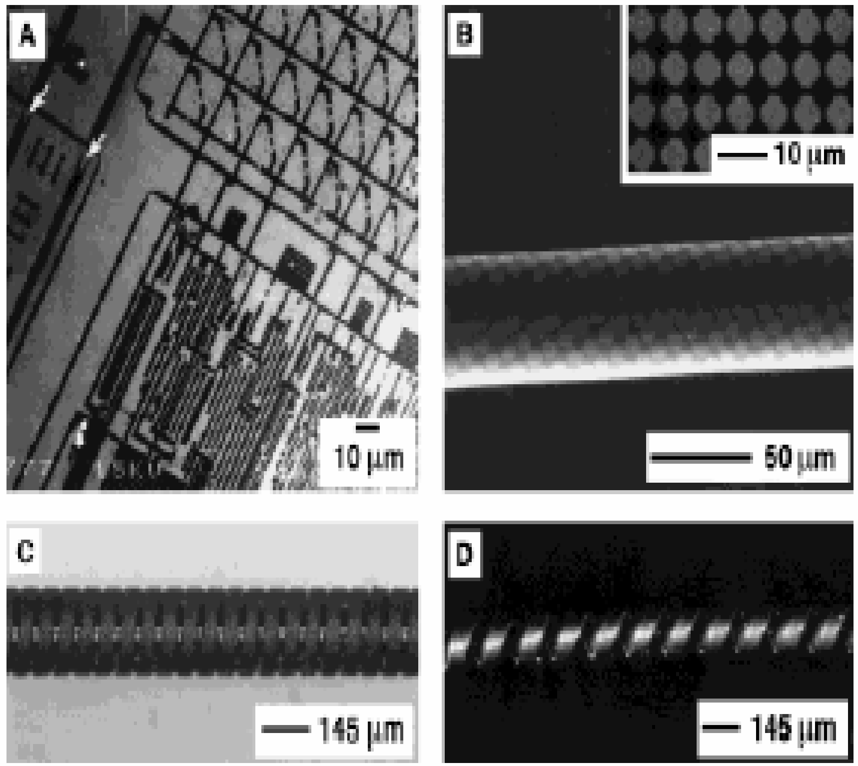
(b) large-area printing on a planar surface with a rolling stamp

(c) printing on a nonplanar surface with a planar stamp

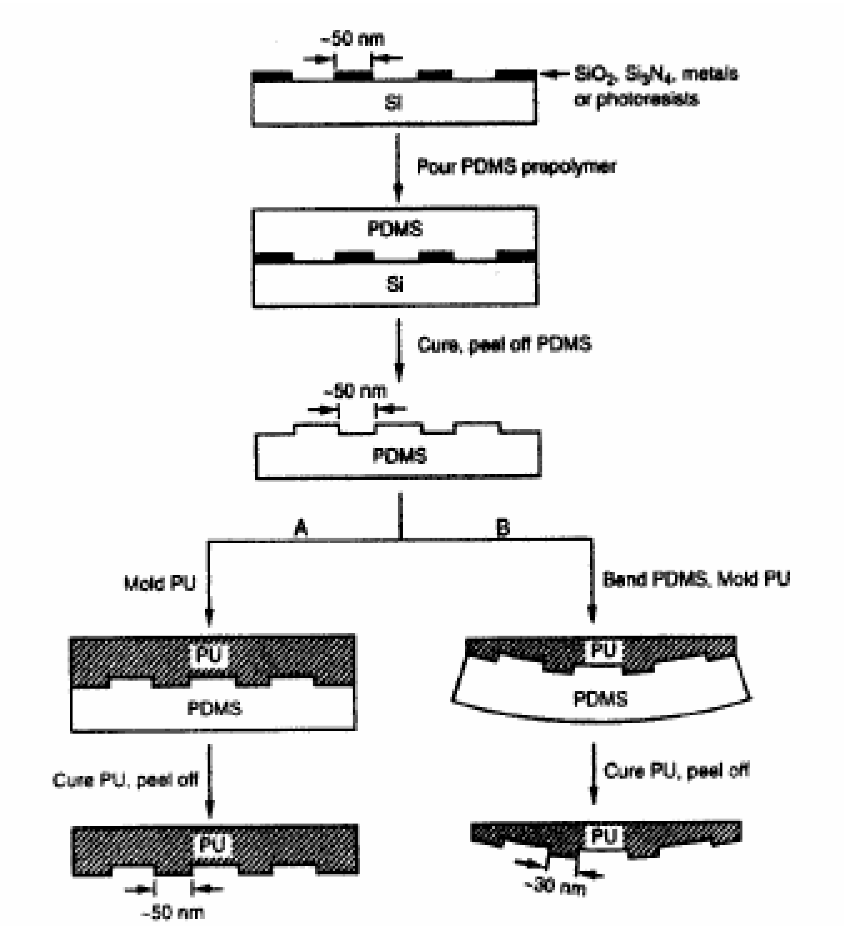
Angew. Chem. Int. Ed, 37, 550-575 (1998)

SEM Images of Patterns by μCP

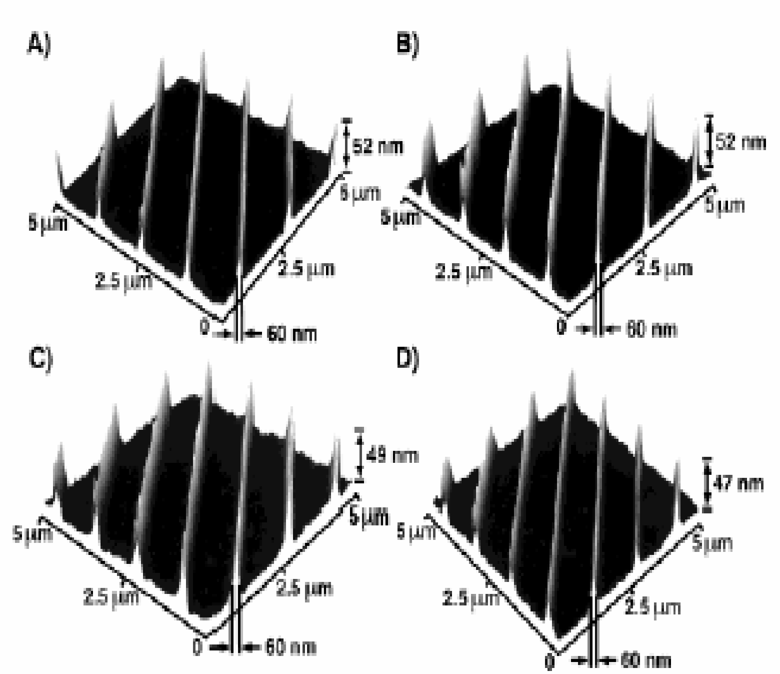




REM(Replica Molding)

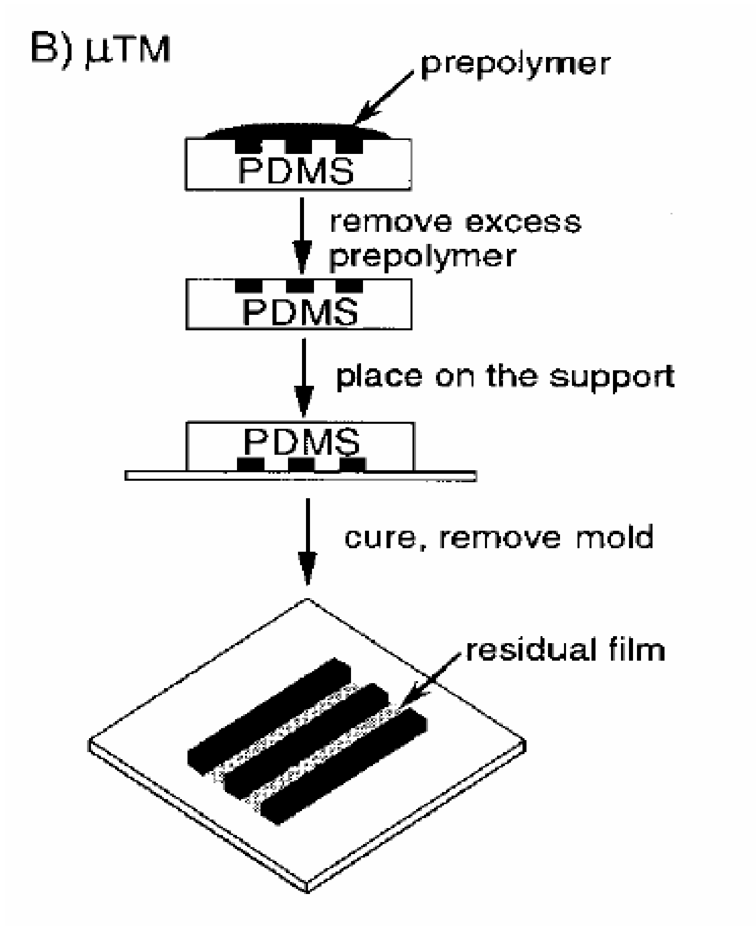


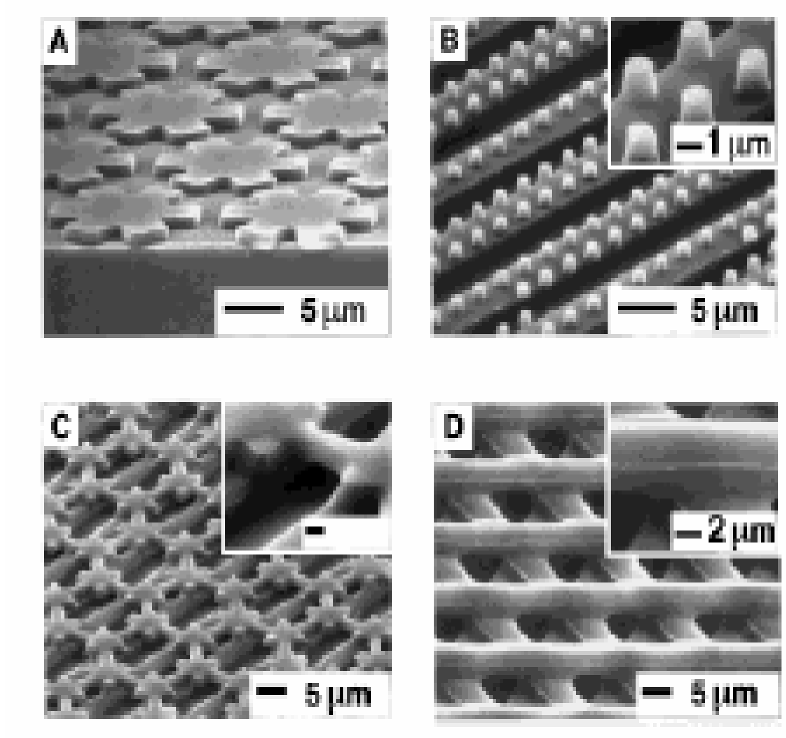
J.Mater.Chem. 1997,7(7),1071



Angew. Chem. Int. Ed, 37, 550-575 (1998)

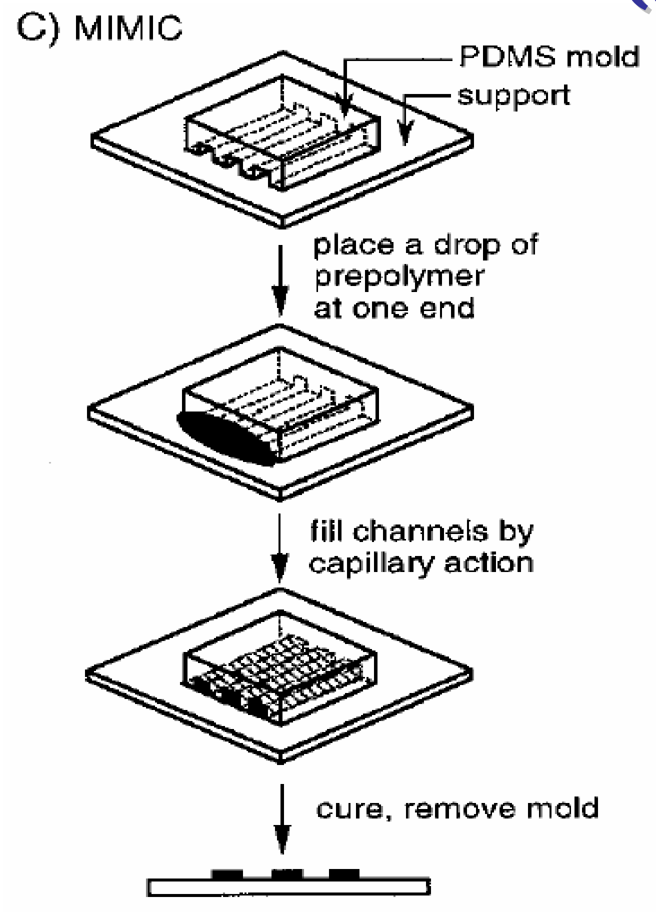
Microtransfer Molding(μTM)





Angew. Chem. Int. Ed, 37, 550-575 (1998)

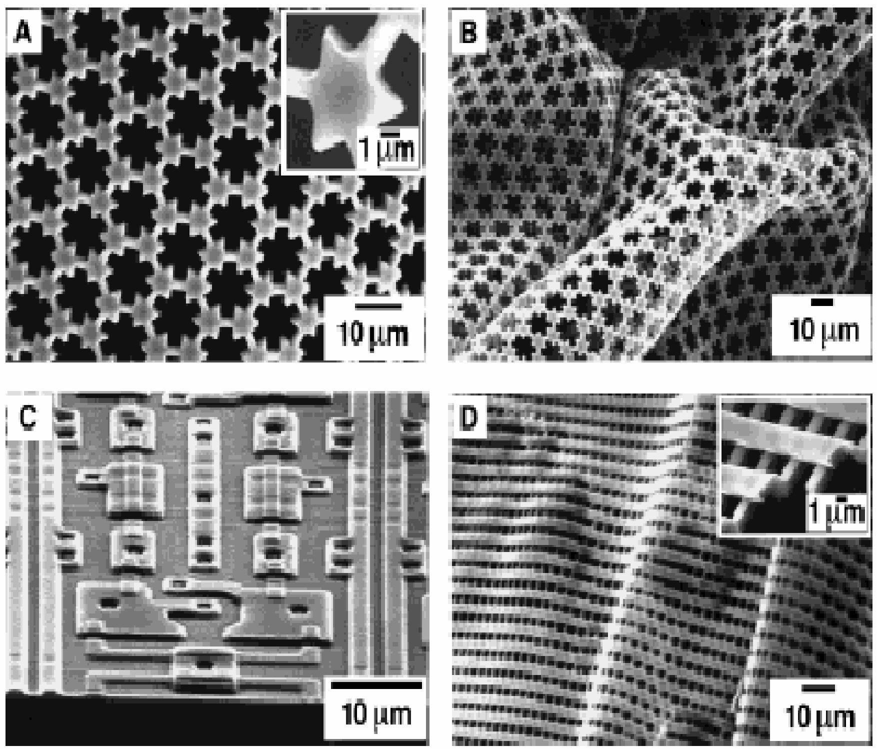
Micromolding in Capillaries (MIMIC)

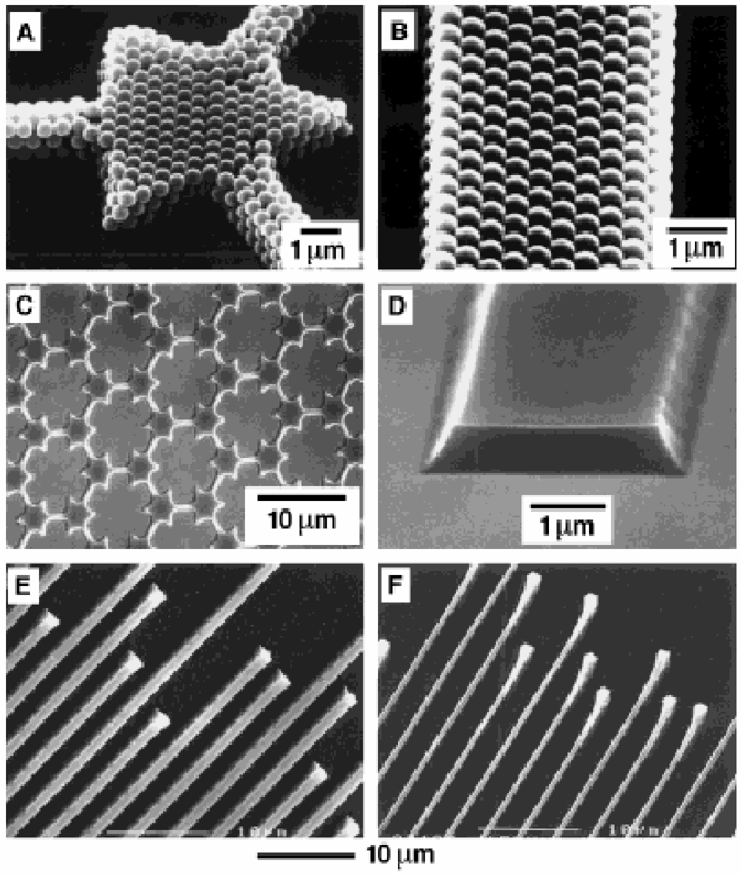


- PDMS mold is placed on the surface of a substrate
- The relief structure in the mold forms a network of empty channels
- Liquid prepolymer used here should have low-viscosity
- The liquid spontaneously fills the channels by capillary action.

Angew. Chem. Int. Ed, 37, 550-575 (1998)

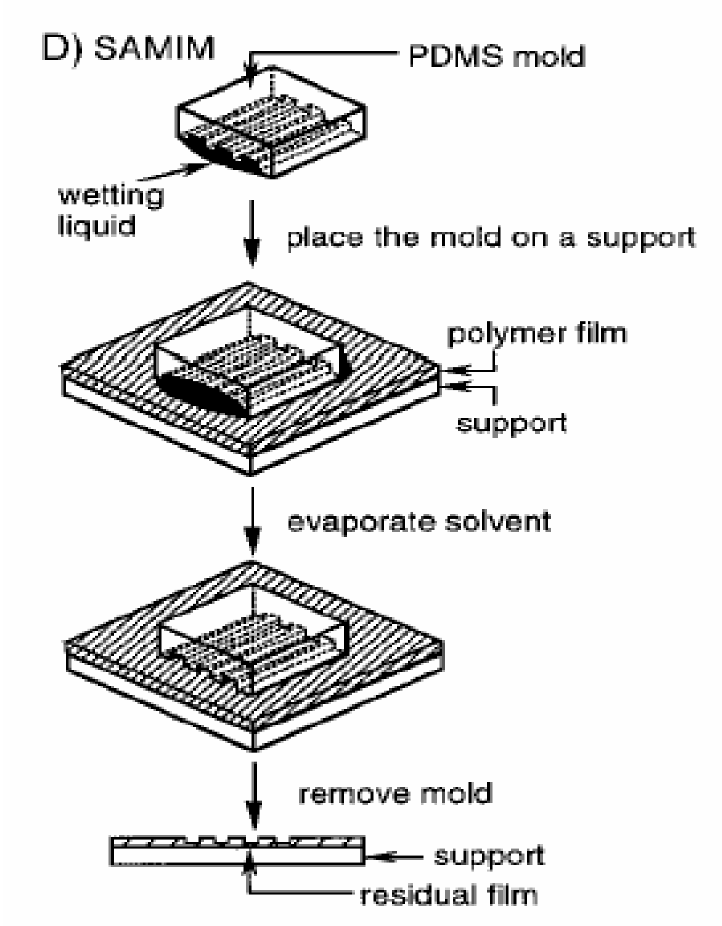
MIMIC of Systems with and without solvents





Angew. Chem. Int. Ed, 37, 550-575 (1998)

Solvent-Assisted Micromolding(SAMIM)



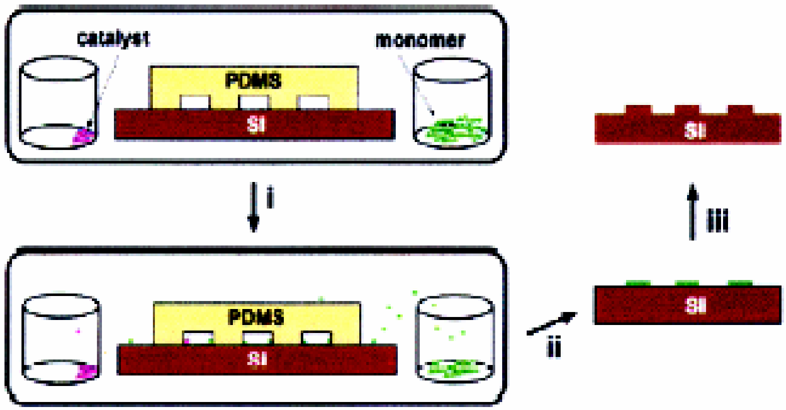
- Elastomeric rather than a rigid mold
- Solvent instead of high temperatures
- Much faster than the time consuming capillary fillings of MIMIC

Angew. Chem. Int. Ed, 37, 550-575 (1998)

Solventless Polymerization

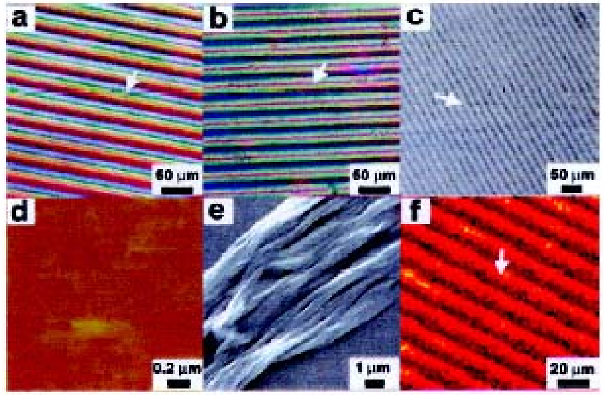
Hongwei Gu et al., *JACS*, 2003, 125, 9256

Experimental

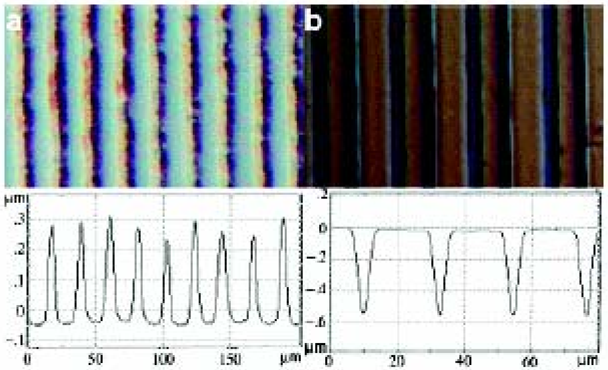


- Spatial migration of a catalyst
- Complementary alternative to spin coating, layer-by-layer deposition
- Grubbs's catalyst and poly norbonene
- Selectivity of wet etching and RIE etching

Result 1



Result 2

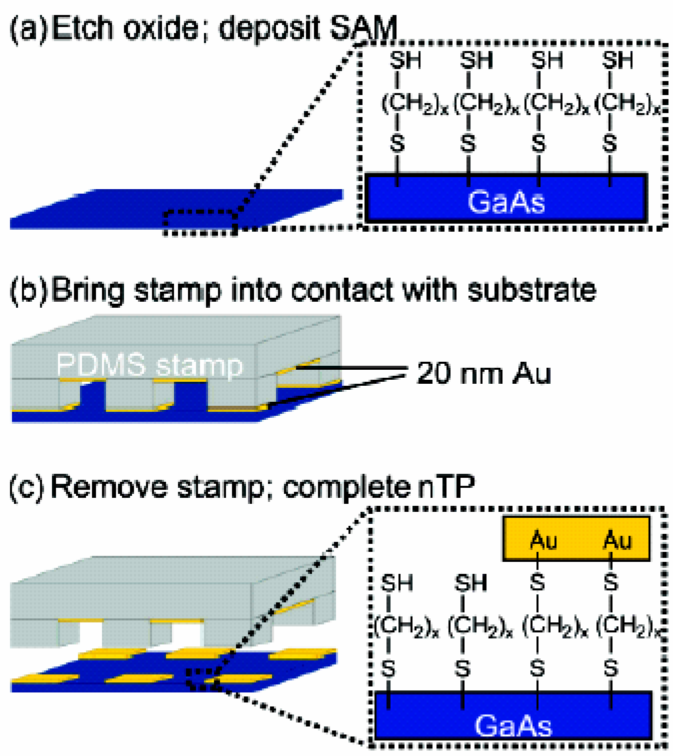


Wet etching Reactive ion etching

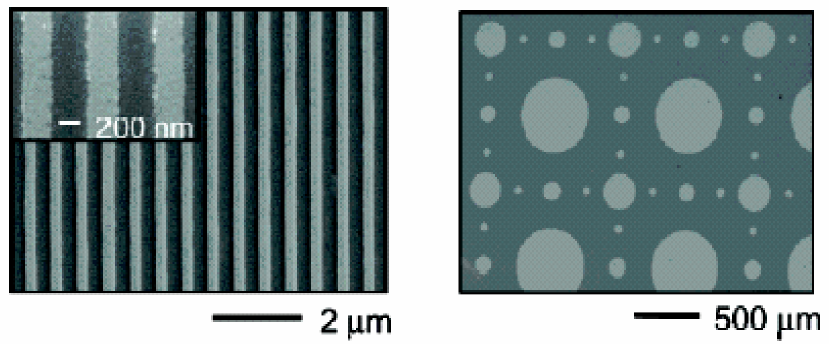
Molecular Layers by Nanotransfer Printing

Yueh-Lin Loo et al., Nano Lett., 2003, 3(7), 913

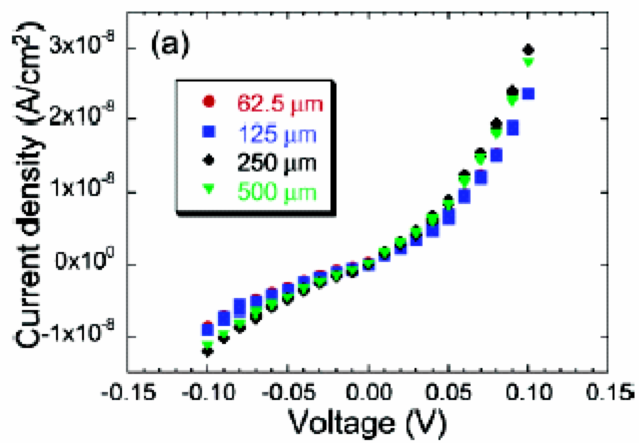
Experimental



SEM images



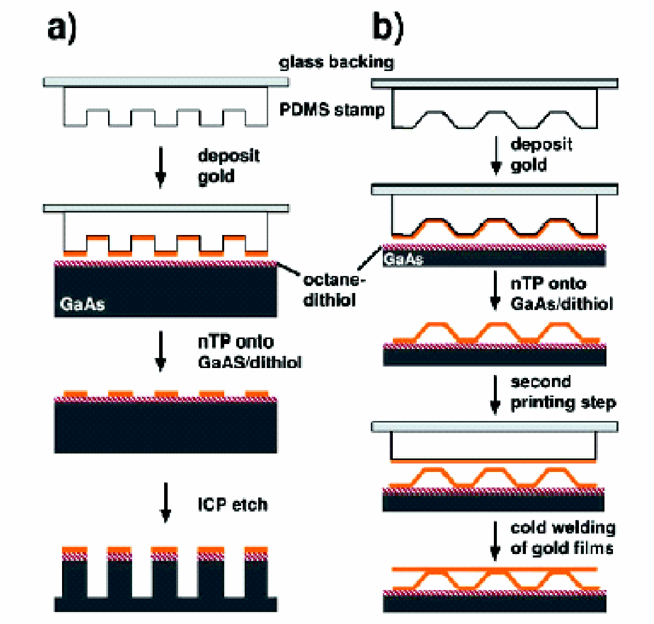
I-V properties



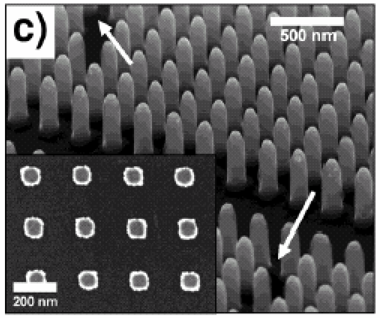
Nanotransfer Printing (3-D and Multilayer Nanostructure)

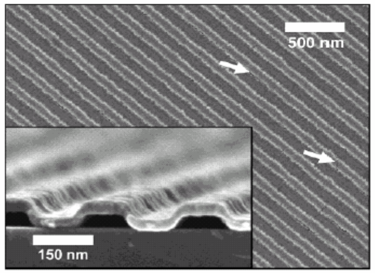
Jana Zaumseil et al. Nano Lett. ASAP (2003)

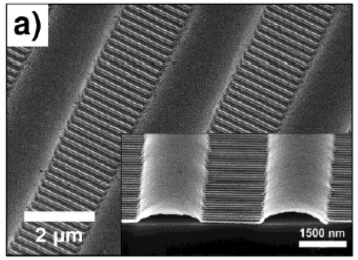
Experimental

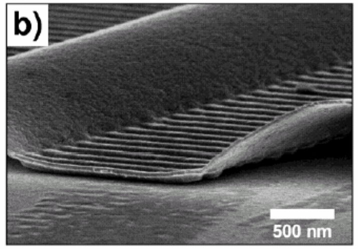


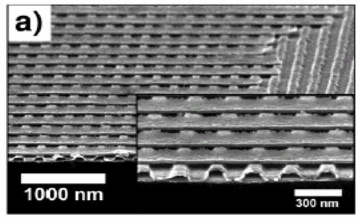
Results

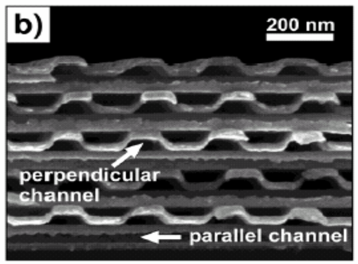










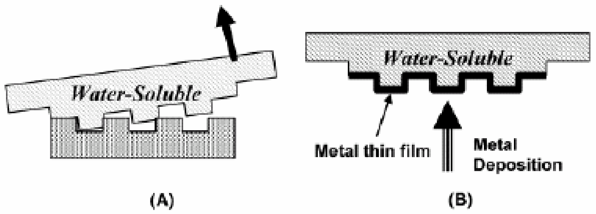


Pattern Transfer (from Water-Soluble Polymer Templates)

C. D. Schaper, Nano Lett., ASAP

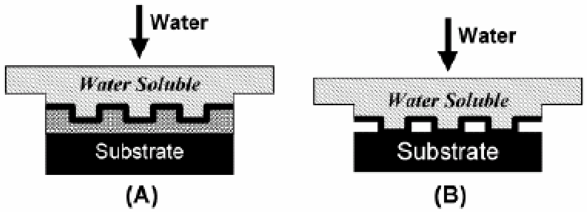
Experimental

Scheme 1. Procedure to Replicate Surface Topography in the Form of Metallized Water-Soluble Templates[a]



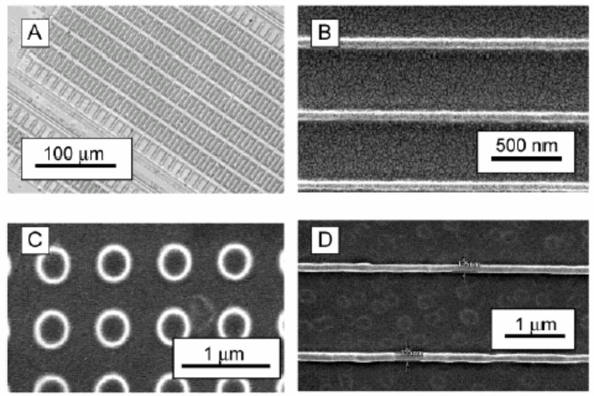
[a] (A) Procedure begins with spin-casting a poly(vinyl alcohol) (PVA) film-forming solution onto a master pattern, the binding of solid PVA sheet, and the removal from the master pattern to form a water-soluble template, followed by (B) deposition of a metal thin film.

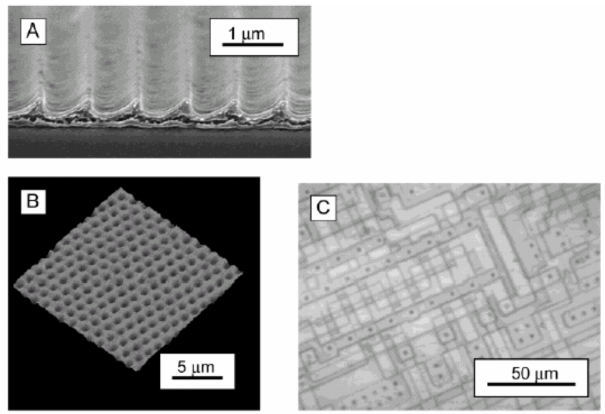
Scheme 2. Methods of Metal Thin Film Pattern Transfer[a]



[a] (A) Liquid adhesive is coated on the surface of the substrate, and then a water-soluble template is placed into liquid, followed by bonding through UV or two-part reactive schemes. Water is then used to dissolve the template, leaving the metal thin film bonded to the substrate surface. (B) Direct bonding of the patterned thin film to the substrate in the absence of an intervening liquid adhesive. After the soluble template has been bonded to the surface, it is dissolved with water, leaving the metal thin film adhered to the substrate.

Results





Fabrication of Metal Nanowires using mCP

M. Geissler et al., *Langmuir*, 2003, 19, 6301

Experimental

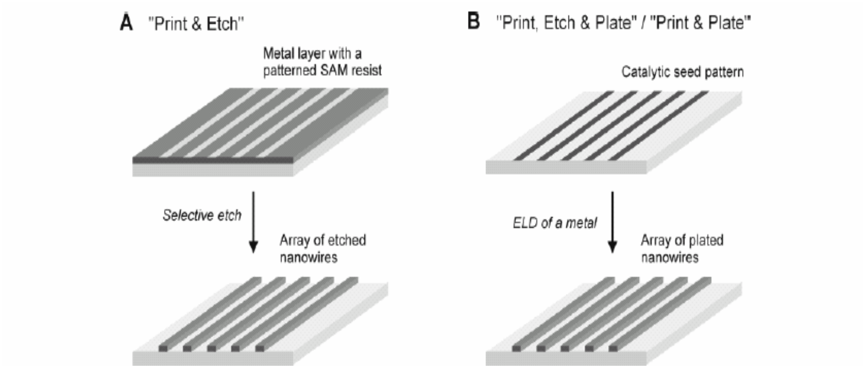
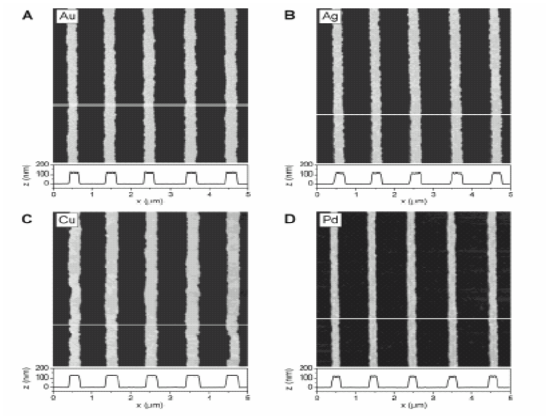
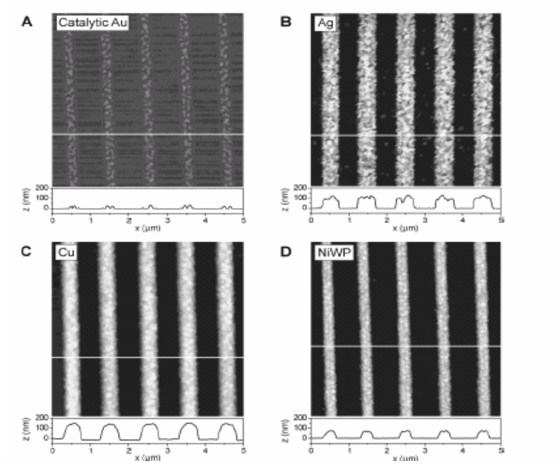


Figure 1. There are two direct patterning strategies to fabricate arrays of metal nanowires using μCP. In the first one, (A) "print & etch", a resist (usually a self-assembled monolayer) is printed on a metallic layer, and the pattern is transferred into the substrate by an etch process. The second concept (B) is additive, and relies in this case on the selective electroless deposition of a metal (or alloy) onto a catalytic seed pattern on a substrate. One variant of this approach, "print, etch & plate", relies on patterning a seed layer using the concept shown in part A. The other variant, "print & plate", entails the direct printing of a catalyst onto a substrate to activate those regions where ELD should occur.

Results





NIL for Hybrid Plastic Electronics

M.C.Mc Alpine et al. Nano Lett., 3(4), 2003, 443

Experimental

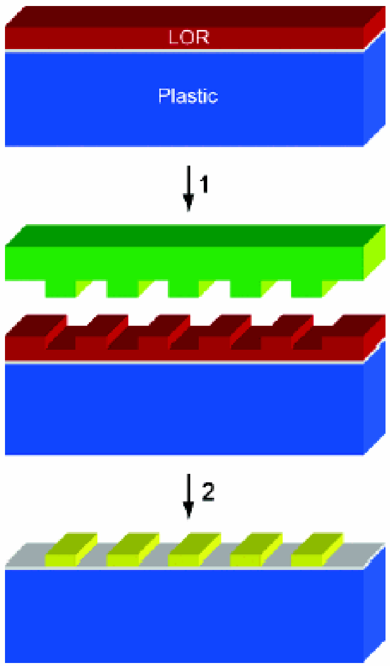
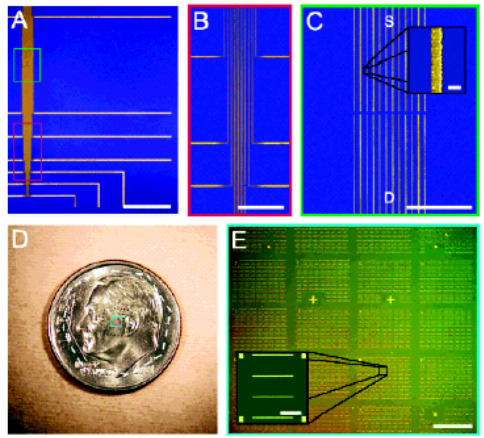
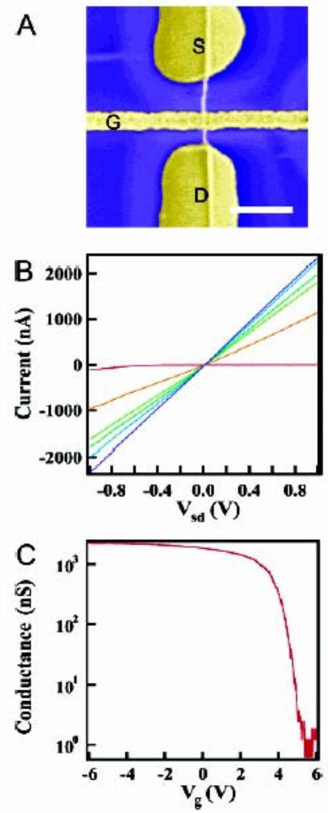


Figure 1. Schematic of the nanoimprint process on plastic substrates. Plastic substrates (blue) coated with SiO_2 (gray) and LOR (red) were imprinted (1) using a Si/SiO_2 stamp (green). The NIL pattern was transferred to the substrate in successive RIE, metal deposition, and lift-off steps (2).

Results





Biomimetic Nanostructure Fabrication: Nonlithographic Lateral Patterning and Self-Assembly of Functional Bacterial S-Layers at Silicon Supports

Erika S. Györvary,*,† Alan O'Riordan,‡ Aidan J. Quinn,‡ Gareth Redmond,‡
Dietmar Pum,† and Uwe B. Sleytr†

Nano Lett. 2003, 3(3). 315

Experimental

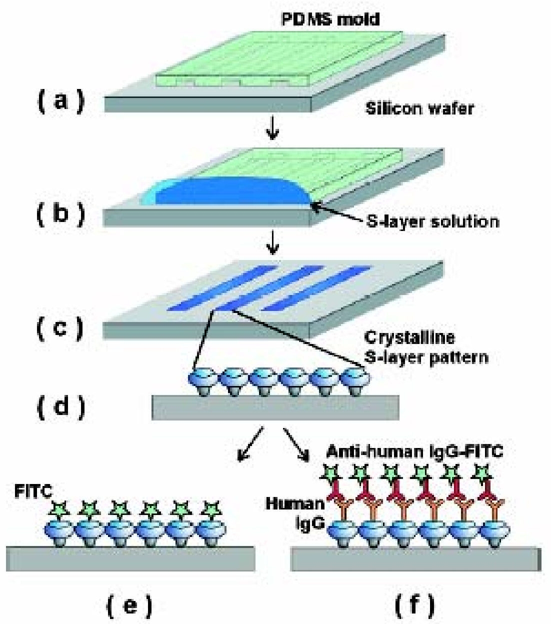


Figure 1. Schematic representation of S-layer protein patterning and assembly by MIMIC. (a) Channels are formed when a PDMS mold contacts a silicon wafer support. (b) Channels are filled with a protein solution by capillary forces. (c−d) Following mold removal, crystalline protein patterns are observed on the support surface. (e) S-layer patterns may be labeled with a fluorescence marker or (f) used as substrates for an antibody−antigen immunoassay.

Results

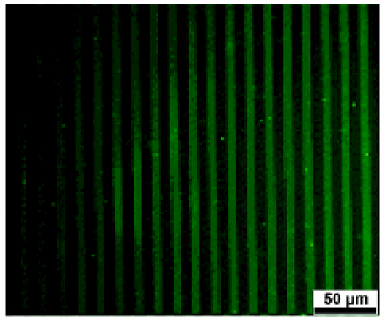


Figure 2. Fluorescence image of 6 µm wide FITC-labeled S-layer protein tracks patterned at a plasma-treated native silicon oxide support. S-layer protein: SbpA of *B. sphaericus* CCM 2177.

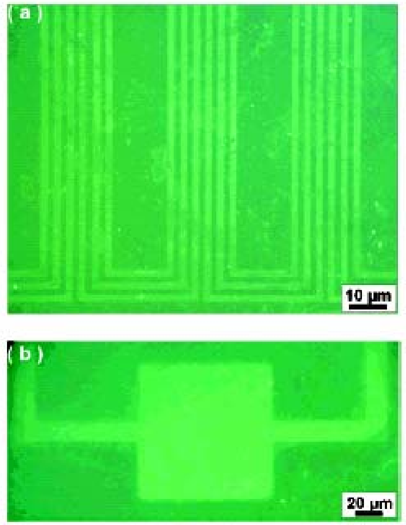


Figure 5. Fluorescence images of a SbpA S-layer patterned using a "circuit-like" PDMS mold. Following layer recrystallization and mold removal, human IgG was covalently attached to active carboxylate groups on the S-layer track surface. Subsequent binding of FITC-labeled antihuman IgG enabled fluorescence imaging of the modified S-layer and verified the functional integrity of the patterned layer.

Constructive Microlithography: Electrochemical Printing of Monolayer Template Patterns Extends Constructive Nanolithography to the Micrometer–Millimeter Dimension Ranc

Stephanie Hoeppener, Rivka Maoz, and Jacob Sagiv*

Nano Lett. 2003, 3(6). 761

Experimental

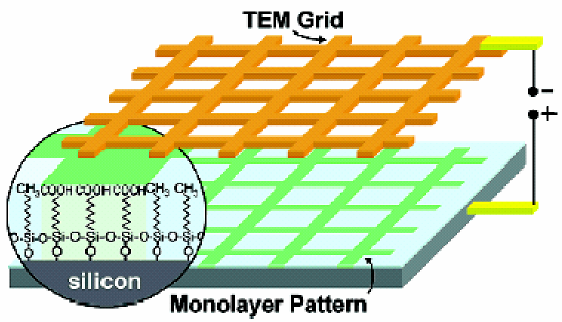


Figure 1. Schematic view of the pattern printing experiments: Rigid metal stamps consisting of TEM copper grids (SPI Supplies, West Chester, PA) mounted in a special Teflon holder were cleaned by ~1 h Soxhlet extraction with toluene, followed by exposure to HNO_3 vapor (twice 1 min on each side), sonication for several minutes in ultrapure water (Barnstead Nanopure system), and finally drying in a stream of clean nitrogen. A freshly cleaned grid attached to a piece of Scotch tape was placed for ~15 s above a beaker filled with hot water and then pressed manually against a self-assembled OTS/Si monolayer specimen (prepared as described before)[1,3] while applying (for ~45 s) a voltage bias of 20 V between the grid (negative) and the silicon wafer substrate (positive). Electrical contact with the grid was realized through a wire lead immobilized together with the grid on the same piece of Scotch tape. Typical currents in the range of 150−300 μA were measured during the printing of the patterns.

Results

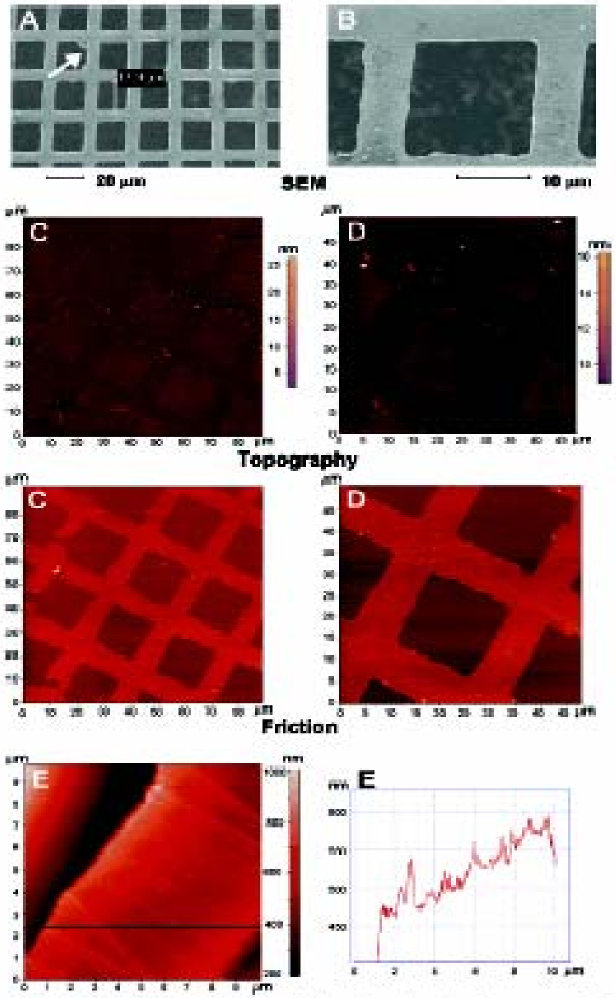


Figure 3. (A, B) Scanning electron micrographs of portions of the dimbar grid (mesh 1000) acquired on an E-SEM Philips XL30 instrument (without any additional coating on the specimen). (C, D) Topography and friction contact mode AFM images (acquired as in Figure 2,A) of printed monolayer patterns produced with the grid from which the SEM pictures shown in A and B were taken. (E) Semicontact mode AFM topographic image (acquired as in Figure 2, B) of a portion of the smoother (shiny) side of a bar from the same mesh 1000 grid and (right side) distance−height profile along the marked line in the image.

한국기계연구원 최대근

Direct Patterning of NiB on Glass Substrates Using Microcontact Printing and Electroless Deposition

Langmuir **2003**, *19*, 6283−6296

Matthias Geissler, Hannes Kind, Patrick Schmidt-Winkel, Bruno Michel, and Emmanuel Delamarche*

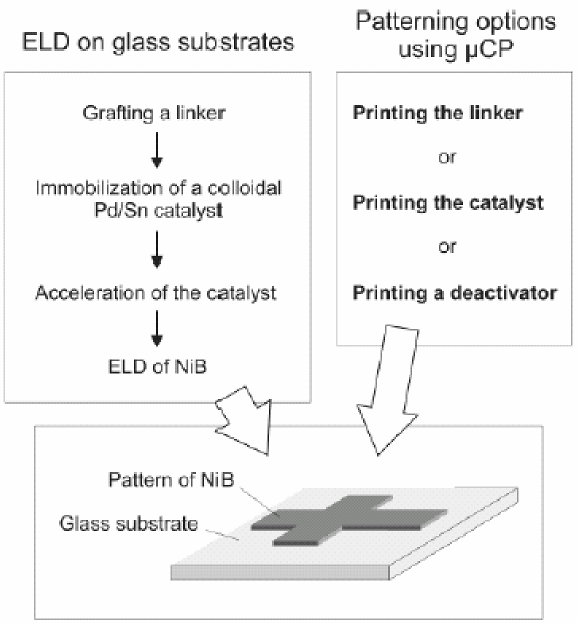


Figure 1. Three methods based on μCP can direct the ELD of NiB on a glass substrate. The ELD of a blanket film of NiB itself comprises several processing steps, which are all performed in solution. As ELD initiates only if a catalyst is present on the substrate, patterning the NiB layer is possible by either microcontact-printing a linker between the catalyst and the glass, the catalyst itself, or a catalyst deactivator. These three methods are collectively called "print & plate" and are described in detail in this article.

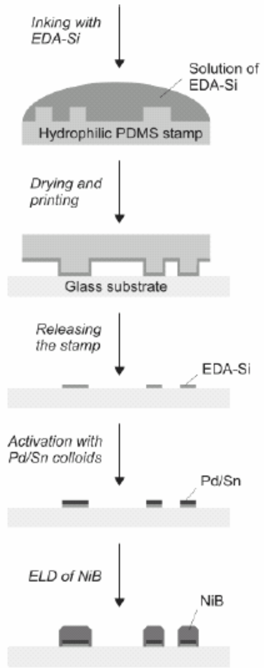


Figure 2. Procedure for the selective ELD of NiB using microcontact printing of EDA-Si onto a glass substrate. EDA-Si is inked onto a hydrophilized PDMS stamp and then microcontact-printed onto a glass substrate to act as a linker between a colloidal Pd/Sn catalyst deposited from solution and the substrate. The pattern of EDA-Si on the surface, ideally, defines the electroless-deposited NiB patterns.

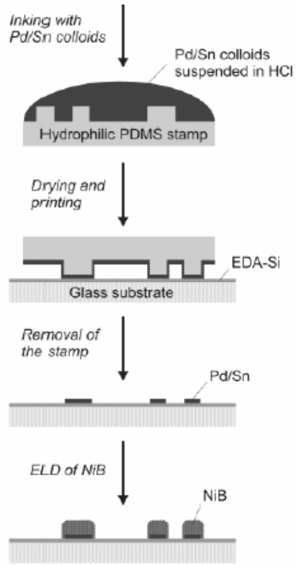


Figure 5. Microcontact-printing catalysts on an insulating glass substrate provides a method for selective ELD of metals. One method explored here in depth starts by hydrophilizing a PDMS stamp, treating it with a polyelectrolyte such as Cartaretin, and inking it with an acidic solution of Pd/Sn colloids. The colloids on the stamp are accelerated before the printing step. The catalytic colloids transfer from the stamp to a glass surface derivatized with EDA-Si during the printing step. ELD of NiB proceeds in those areas of the glass substrate where the Pd/Sn catalyst has been printed.

한국기계연구원 최대근

Micropatterns of Chemisorbed Cell Adhesion-Repellent Films Using Oxygen Plasma Etching and Elastomeric Masks

Langmuir 2003, *19*, 4754–4764

Anna Tourovskaia,[†] Thomas Barber,[‡] Bronwyn T. Wickes,[§] Danny Hirdes,[†] Boris Grin,[†] David G. Castner,[†,§] Kevin E. Healy,[‡] and Albert Folch*,[†]

1.

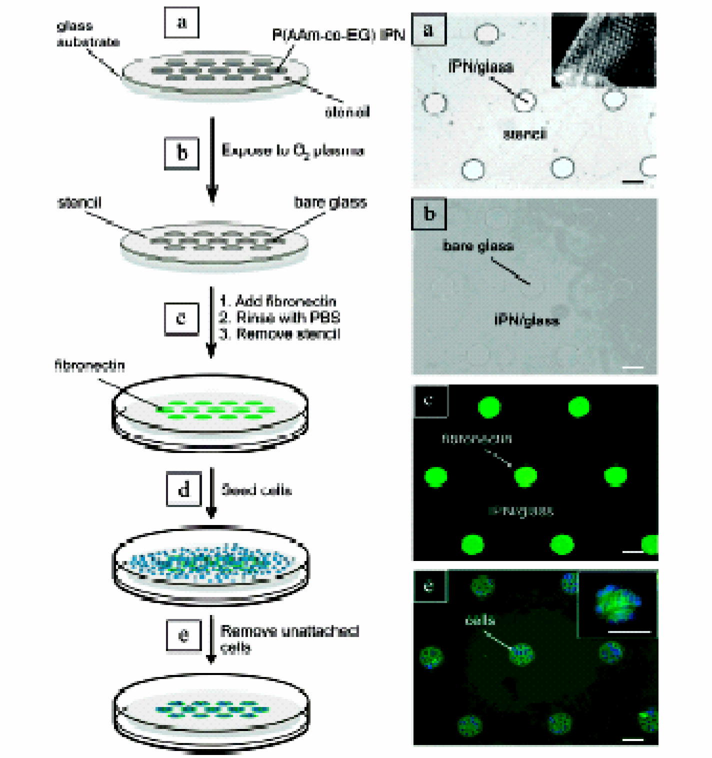


Figure 1. Schematic illustration (left column) and demonstration (right column) of the procedure for cellular micropatterning based on the use of PDMS stencils. (a) The stencil is placed onto a glass substrate homogeneously grafted with the IPN. A picture of the stencil before (inset) and after application onto the surface is shown on the right. (b) The stencil serves as a mask for selective etching of the IPN in an oxygen plasma. The etching leaves islands of IPN-free glass surrounded by IPN (as shown in the corresponding phase-contrast image on the right). (c) Fluorescently tagged fibronectin (Fn) is adsorbed onto the plasma-etched islands of glass, and the stencil is removed. (d) The fibronectin/IPN patterned substrate is incubated with a cell suspension. (e) Unattached cells are removed by exchanging the medium. The inset shows a fluorescence image of C2C12 myoblasts (blue) attached to the fibronectin islands (green). Scale bars are 100 μm.

2.

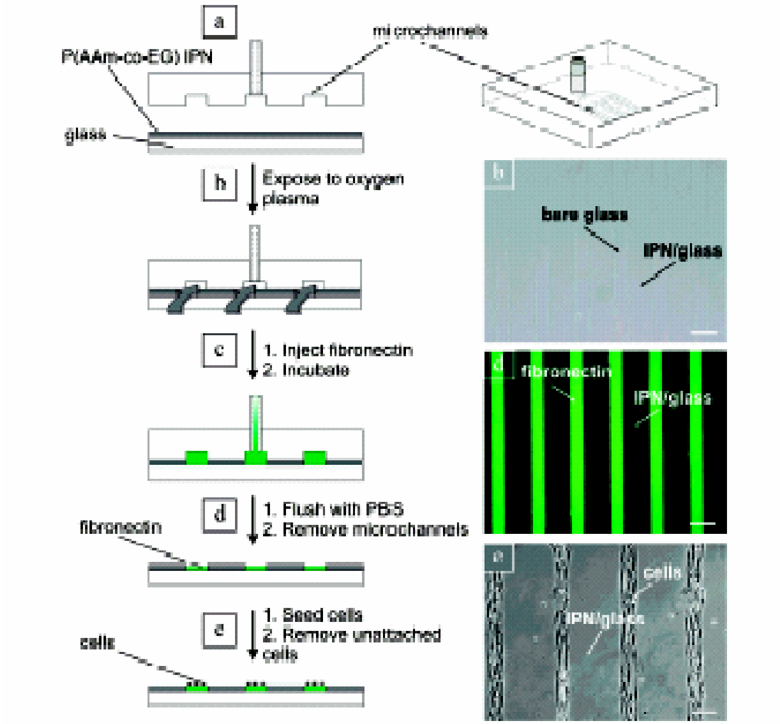


Figure 2. Schematic illustration (left column) and demonstration (right column) of the procedure for cellular micropatterning based on the use of PDMS microchannels. (a) The PDMS mold is placed onto a glass substrate homogeneously grafted with the IPN. (b) The IPN is selectively removed after exposure of the surface to oxygen plasma, which leaves lines of IPN-free glass surrounded by IPN (see phase-contrast image on the right). (c–d) Fluorescently tagged fibronectin is injected into the microchannel network. After flushing with PBS, the microchannels are removed, leaving lines of fibronectin surrounded by IPN (see fluorescence image of the adsorbed fibronectin on the right). (e) The fibronectin/IPN patterned substrate is incubated with a cell suspension and unattached cells are removed by exchanging the medium. Shown on the right is a phase-contrast image of C2C12 myoblasts attached to the lines of fibronectin. Scale bars are 100 μm.

한국기계연구원 최대근

Multilayer Line Micropatterning Using Convective Self-Assembly in Microfluidic Channels

Langmuir **2003**, *19*, 3094–3097

Hongseok Jang, Sangcheol Kim, and Kookheon Char*

Experimental

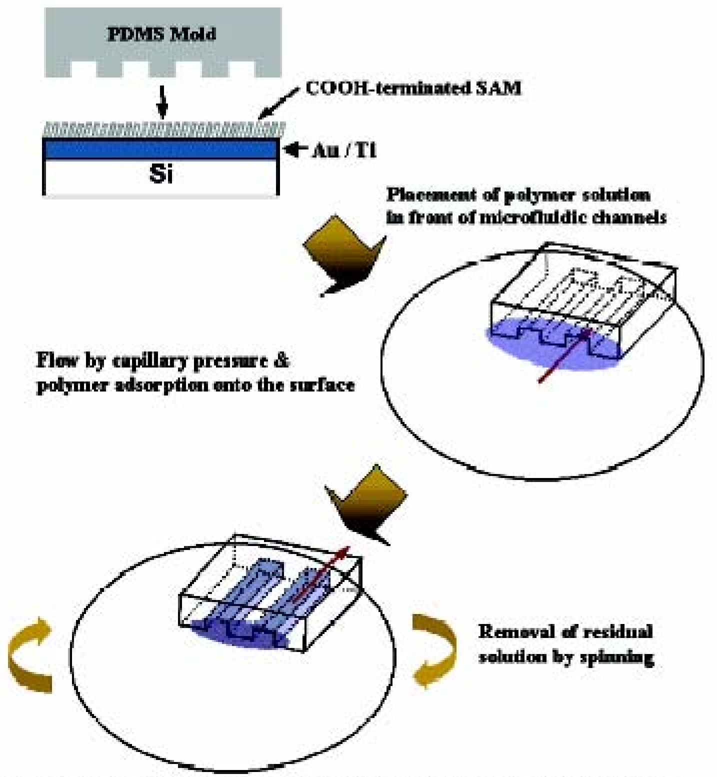


Figure 1. Schematic of micropatterning of multilayer films using the convective self-assembly process.

Results

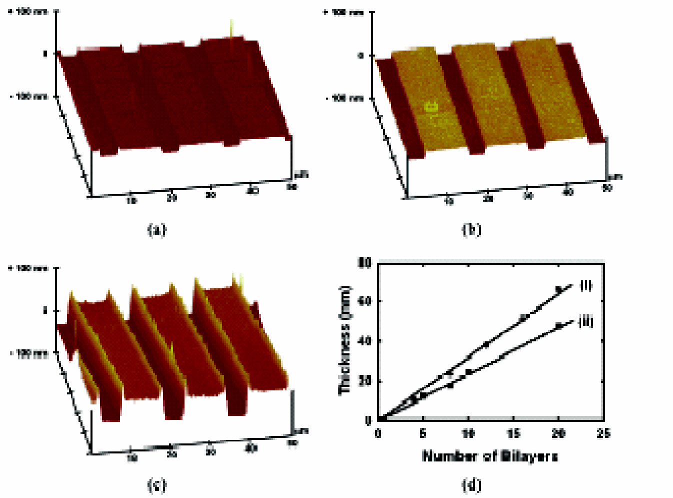


Figure 2. AFM images of patterned multilayer films of (a) (PVP/PAA)[illegible], (b) (PVP/PAA)[illegible], and (c) (PVP/PAA)[illegible] in micrometer scale. (d) Thickness as a function of the number of bilayers for (i) unpatterned films and (ii) patterned films.

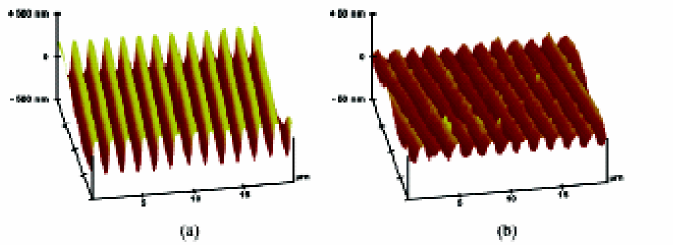


Figure 3. AFM images of (a) a PDMS mold used and (b) a patterned multilayer film of (PVP/PAA)[illegible] in submicrometer scale.

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Tailored Micropatterns through Weak Polyelectrolyte Stamping

Langmuir **2003**, *19*, 2231−2237

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Experimental

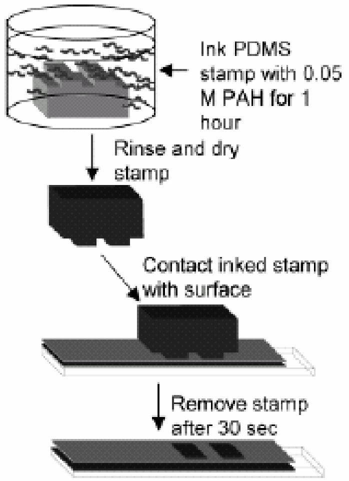

Figure 1. Diagram illustrating the polymer-on-polymer stamping process for PAH on a PAA/PAH multilayer platform.

Results

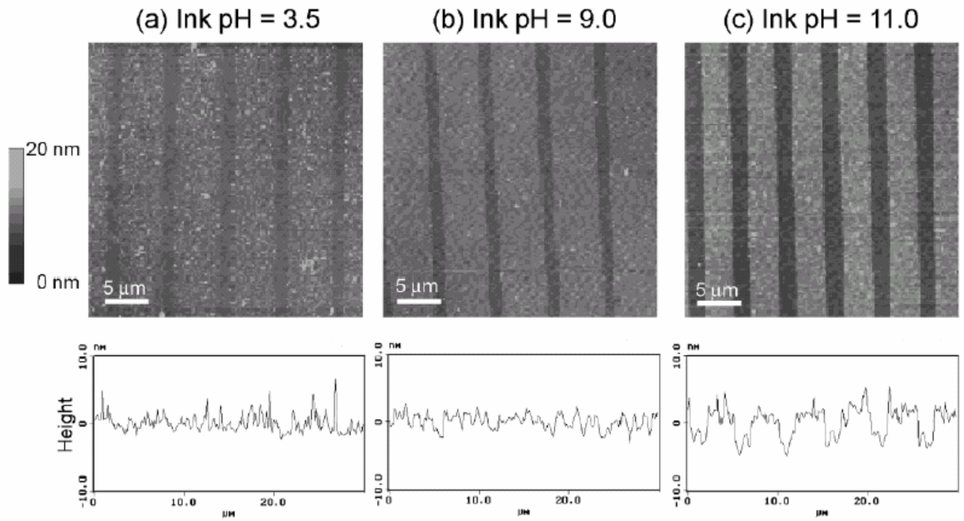

Figure 2. AFM height images and sectional analyses of 6.5/6.5 PAA/PAH multilayer platforms stamped with PAH at various ink pHs.

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Hot Microcontact Printing for Patterning ITO Surfaces. Methodology, Morphology, Microstructure, and OLED Charge Injection Barrier Imaging

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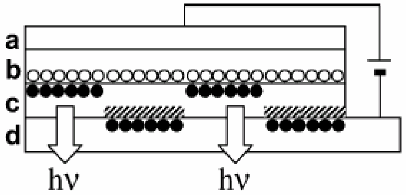
Experimental

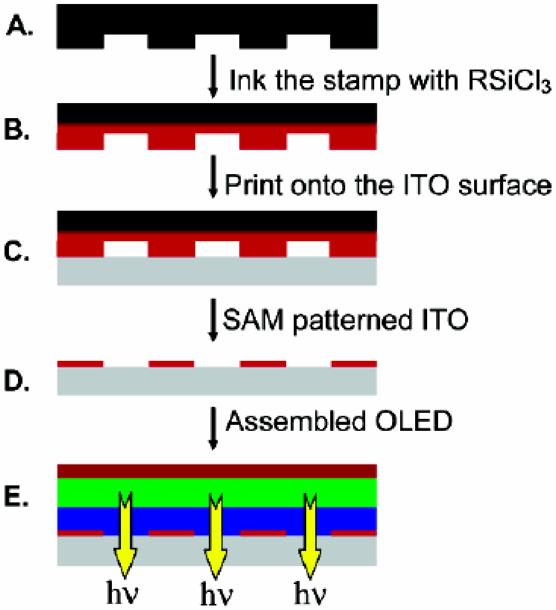
Scheme 1 Schematic Diagram of Patterned OLED Emission from an HμCP Patterned ITO Surface, Showing the Role of the DTS SAMs as the Hole Injection Blocking Layers



● hole
○ electron
DTS SAMs layer

a. Aluminum cathode layer (100 nm)
b. Tris(8-hydroxyquinolinate) aluminum electron transport/emission layer (60 nm)
c. N-N'-diphenyl-N-N' bis (3-methylphenyl)-[1-1'-biphenyl]-4-4'-diamine (TPD) hole transport layer (50 nm)
d. ITO coated glass

Scheme 2. Procedure for μCP ITO Surface Patterning[a]



[a] An elastomeric stamp (A) is impregnated with a DTS/hexane solution (B) and printed onto the ITO (C), forming a SAM pattern on the surface (D). A typical OLED device is fabricated by depositing TPD (E: blue), quinacridine doped Alq (E: green), and an aluminum cathode (E: brown), in this order.

Results

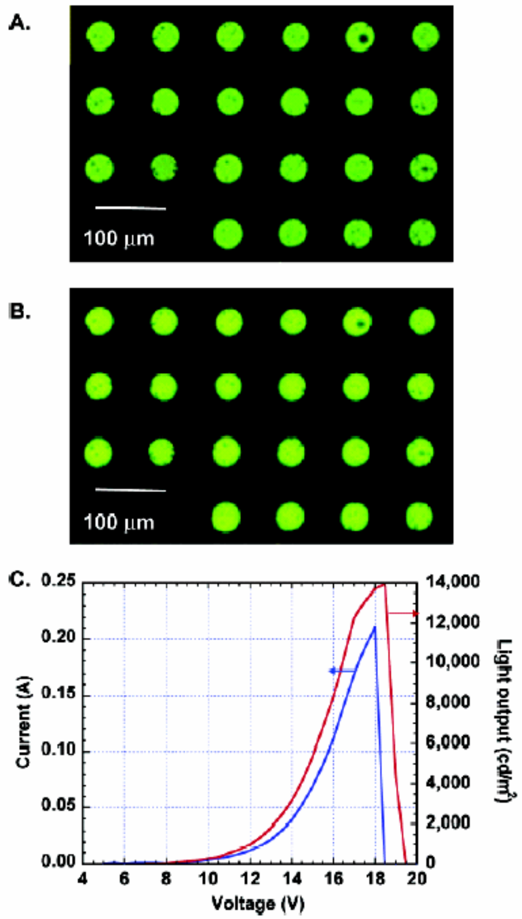


Figure 4. Optical images of the emitting surface of a HμCP (80 °C) patterned OLED device (ITO/TPD/5% QD doped Alq_3/Al) operated at different bias voltages: (A) at 12 V; (B) at 17 V. The contact time is 5 s. (C) Current−voltage and light output−voltage curves for the OLED device. The response is corrected for fill factor.