
Nanometer Scale Patterning and Processing

Spring 2016

Lecture 39

Nanoimprint Lithography (NIL) – NIL Tools

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- Section 8

NIL TOOLS

Limitations of solid parallel plate (SPP) press



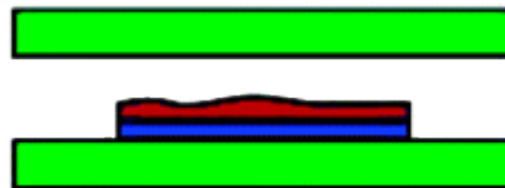
(a)

(a) ideal SPP



(b)

(b) imperfect plate surfaces



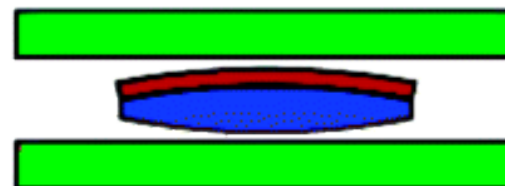
(c)

(c) uneven mold/substrate backside



(d)

(d) Non-parallelism between plates

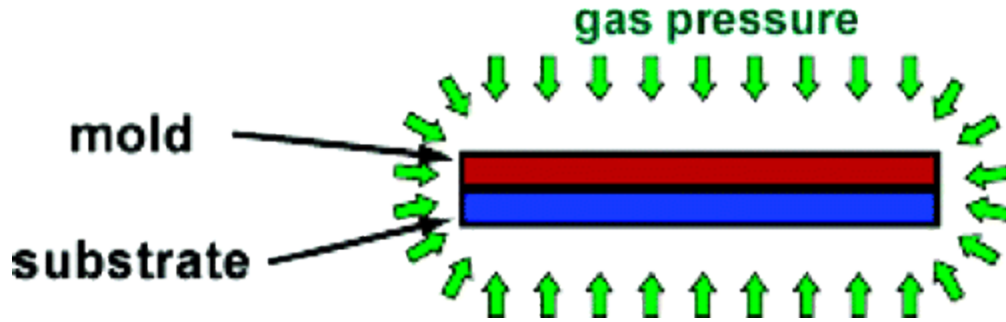


(e)

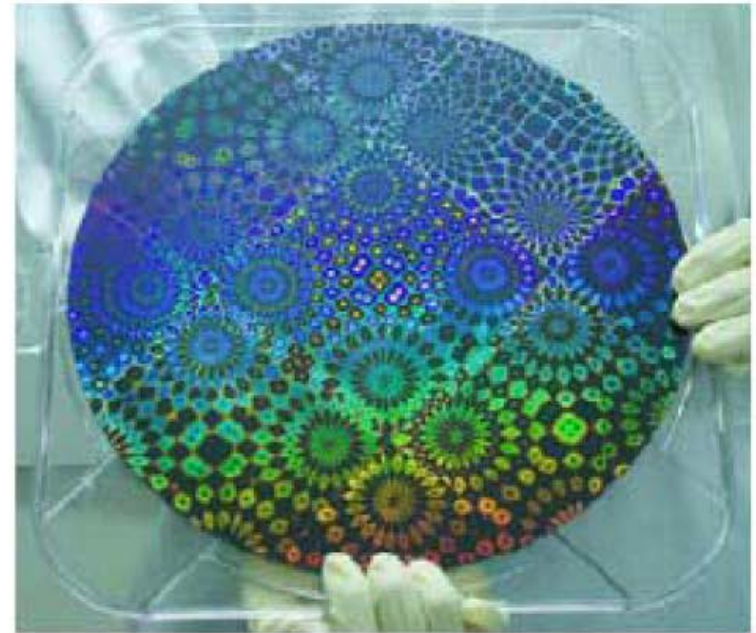
(e) curved sample surfaces

Fortunately, most of the problems can be solved by putting a piece of clean room paper, plastics, or graphite sheet above/below mold/substrate.

Air cushion press (ACP) nanoimprint



8-in. pressure indicating papers (gas pressure= 5kg/cm²). Uniform color means uniform pressure.



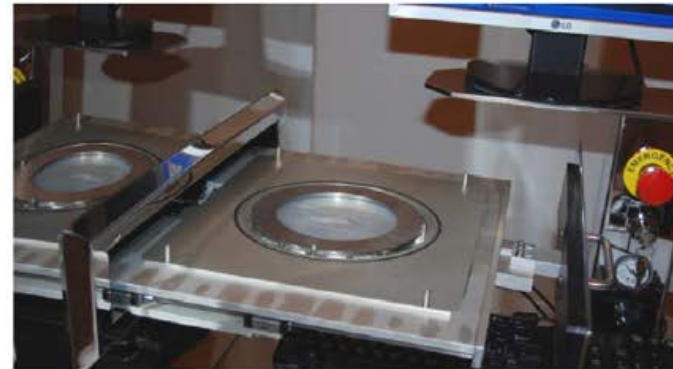
A 12-inch imprinted wafer

One can get similar imprint result using solid plate press, but needs higher pressure to make sure the pressure is high enough everywhere across the wafer.

NIL tools: air-press

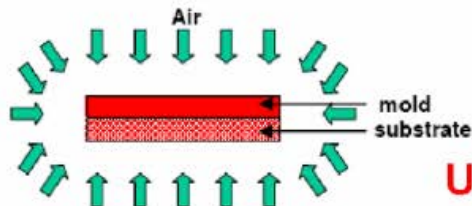


$P_{\max} = 500 \text{ PSI (34 bars)}$
 $T_{\max} = 220 \text{ }^\circ\text{C}$
UV : 200 W, 320-390 nm



- * Full-wafer (up to 4") nanoimprinting tool
- * Sub-micron overlay alignment accuracy

Air Cushion Press™ (ACP)
for ultimate nanoimprint uniformity

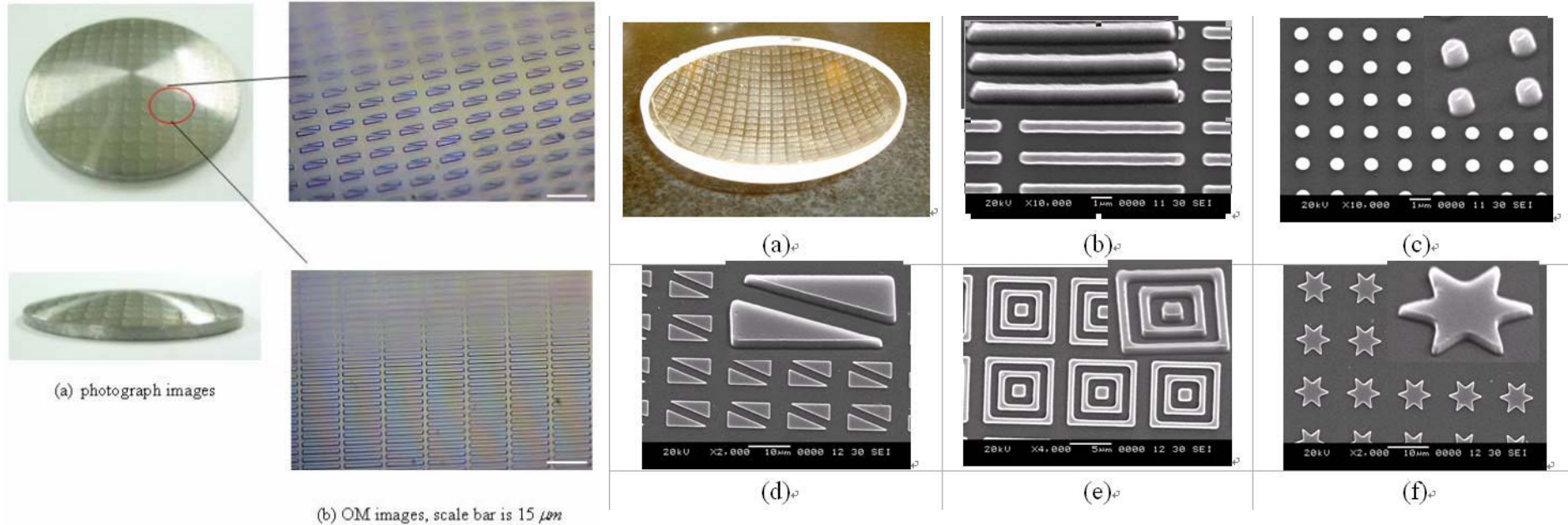


Uniform pressure applied by the 2 membranes



Air press has uniform pressure, but for most applications parallel plate press can also achieve good result (may need something soft like a paper for more uniform pressure).

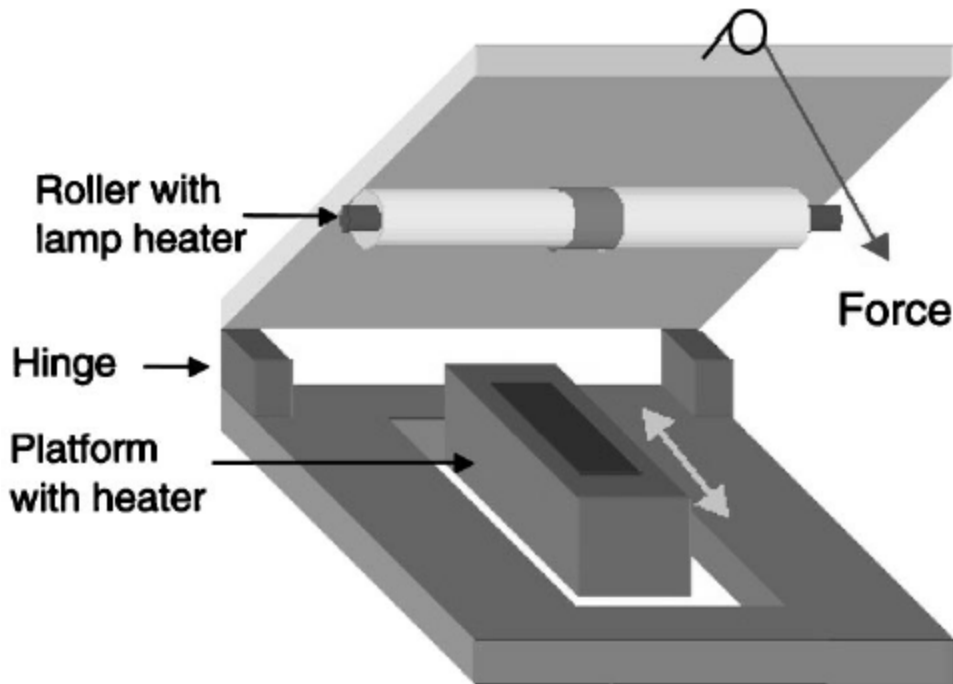
NIL onto curved surface



- Imprinted patterns on 2-inch convex surface.
- Using flexible PDMS mold and uniform gas pressure, the patterns can be transferred onto curved surface successfully.

J. Vac. Sci. Technol. B, Vol. 24, No. 4, Jul/Aug, pp. 1724-1727, Nov. 2006.

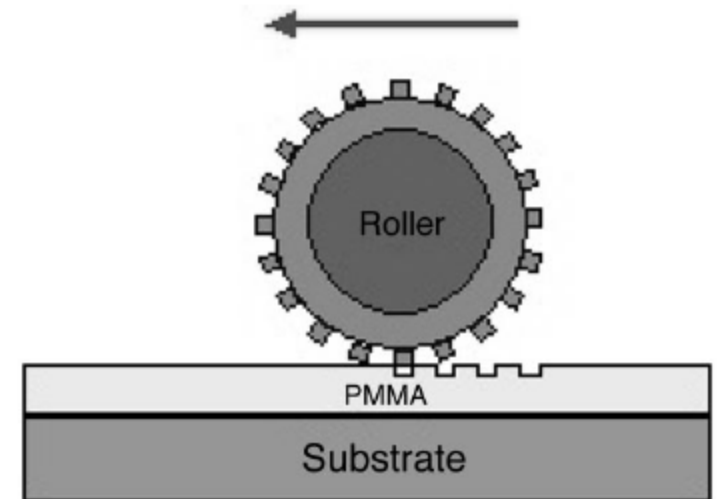
Roller NIL



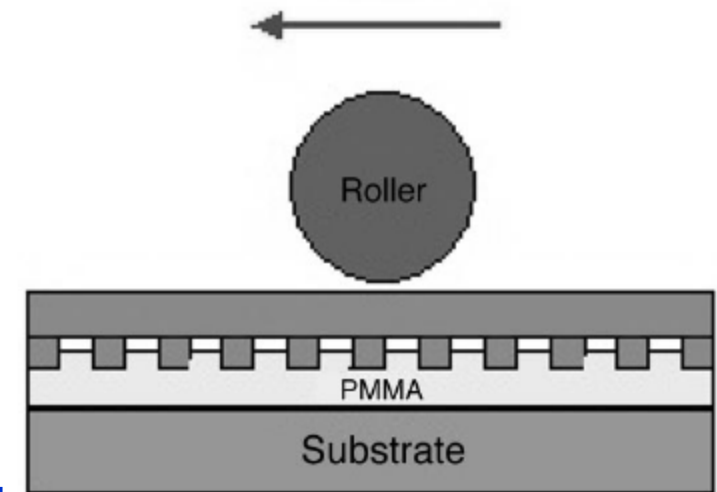
(a) imprints using a cylinder mold.

(b) imprints using a flat mold: putting the mold directly on the substrate, and rotating the roller on top of the mold.

- For schema (a), infinitely large surface area can be imprinted using one (small) mold.
- For schema (b), NIL can be done at very low force.

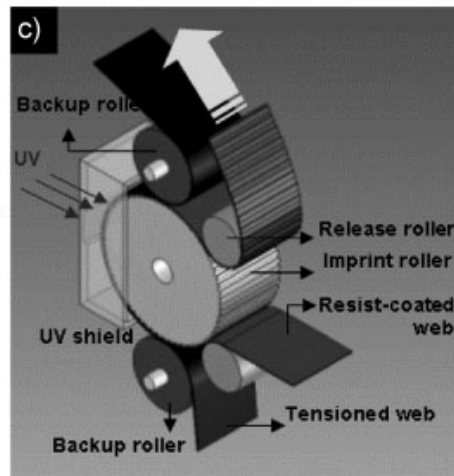
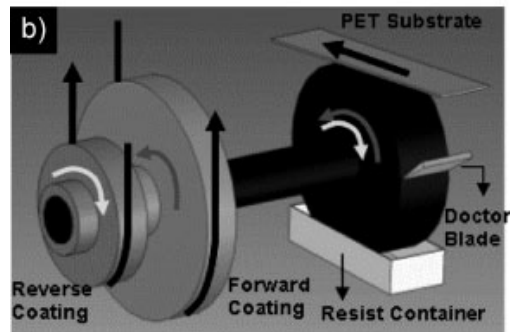
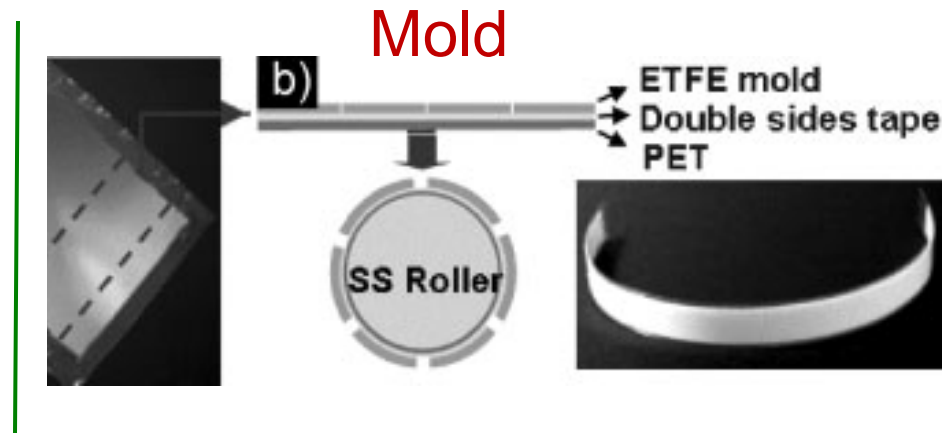
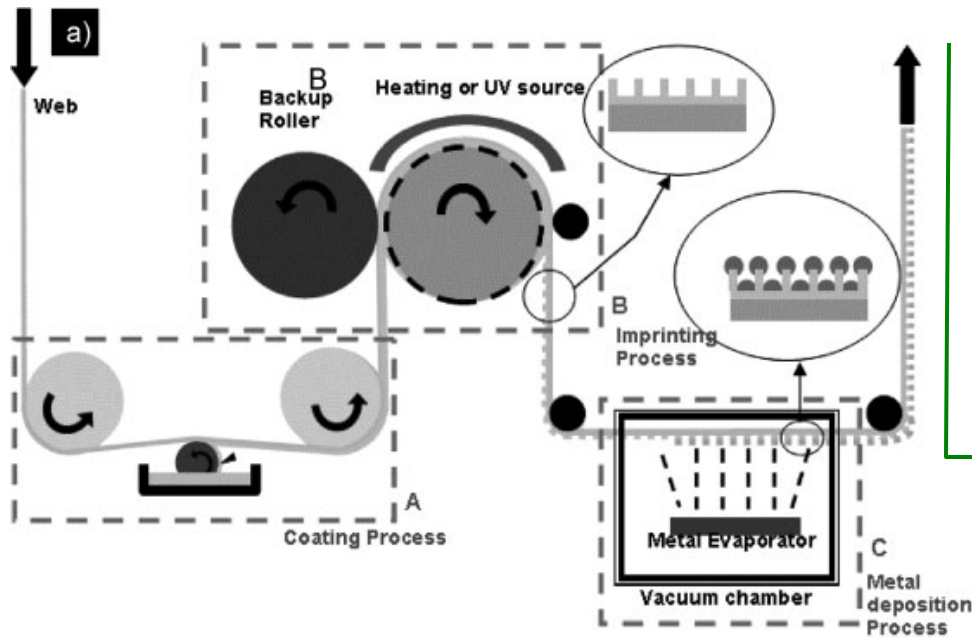


(a)



(b)

Roll-to-roll nanoimprint lithography system



(a) Schematic of the R2R-NIL process, and the continuous fabrication of a metal wire-grid polarizer as one of its applications.

(b) The coating unit.

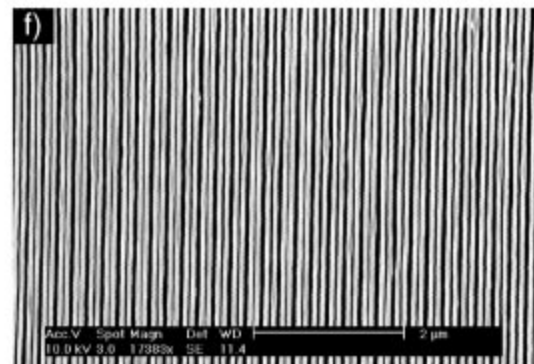
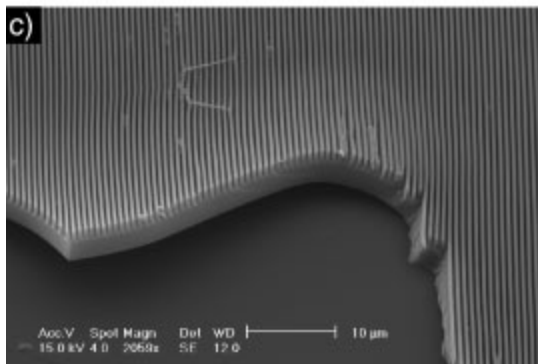
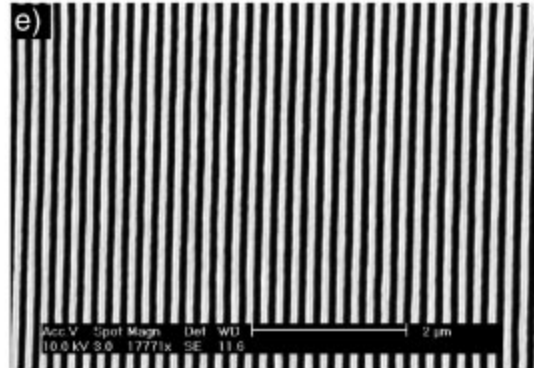
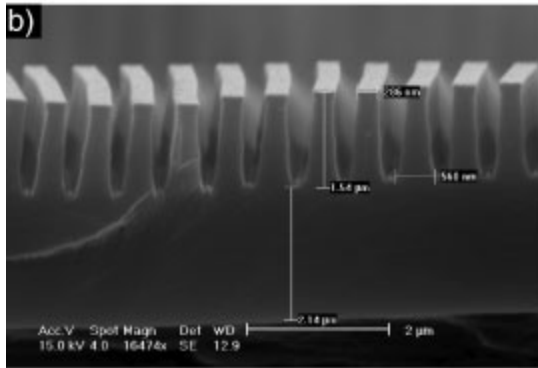
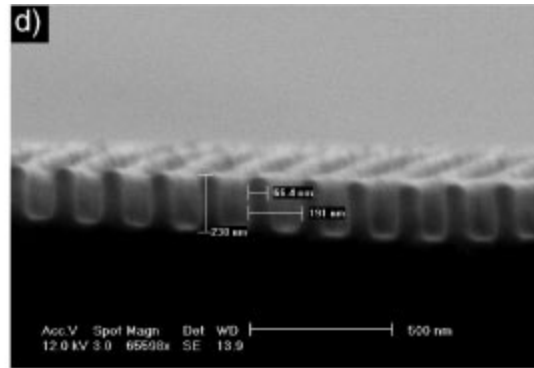
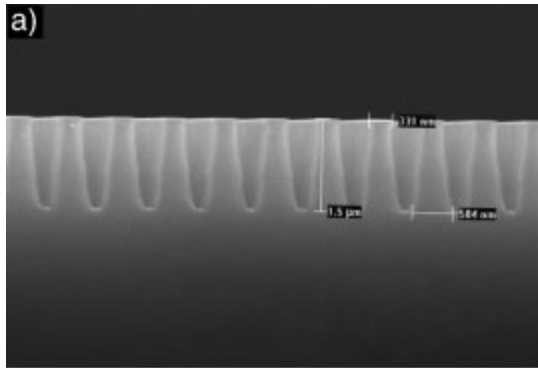
(c) The Imprint unit of the R2R-NIL apparatus.

Application: large area electronics or optical devices (with nano-features) on flexible plastic substrates.

“High-Speed Roll-to-Roll Nanoimprint Lithography on Flexible Plastic Substrates”, Guo, Adv. Mater. 2008.

ECE 695 Nanometer Scale Patterning and Processing

Results of roll-to-roll imprint: micro-nanoscale



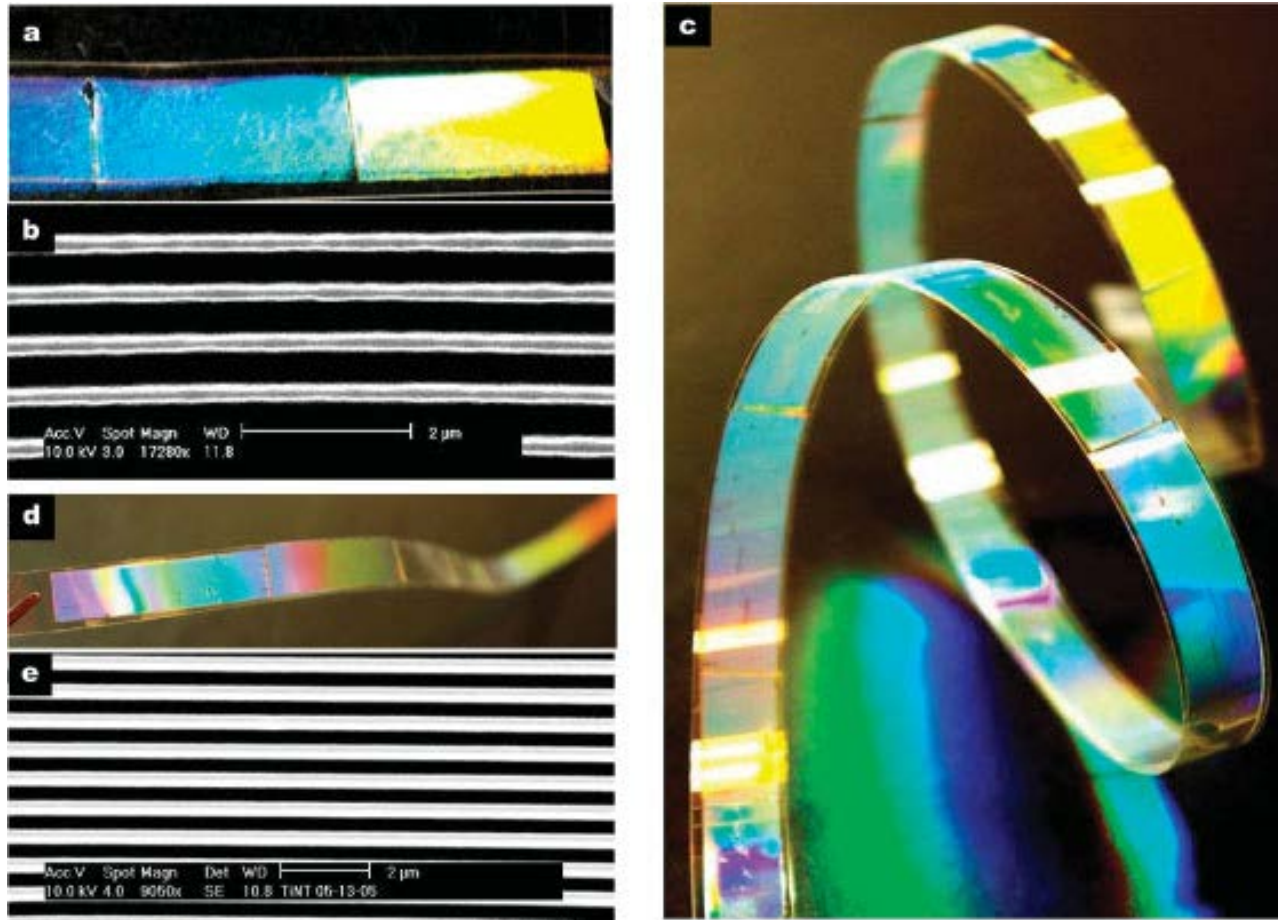
a) The original Si mold.

b-c) Epoxy-silicone gratings replicated from the ETFE mold.

d,e) SEM pictures of 200nm period 70nm line-width epoxy-silicone pattern.

f) 100nm period 70nm line-width epoxy-silicone pattern

Results of roll-to-roll imprint: large area



- Thermal R2R-NIL results: a-b) Photograph and SEM of a 700nm period 300nm line-width PDMS grating pattern imprinted on PET strip.
- UV R2R-NIL results: c-e) Photographs and SEM of 700nm period 300nm line-width epoxy-silicone grating pattern imprinted on PET strip, showing bright light diffraction. Total length is 570mm.