Non traditional manufacturing processes (2)

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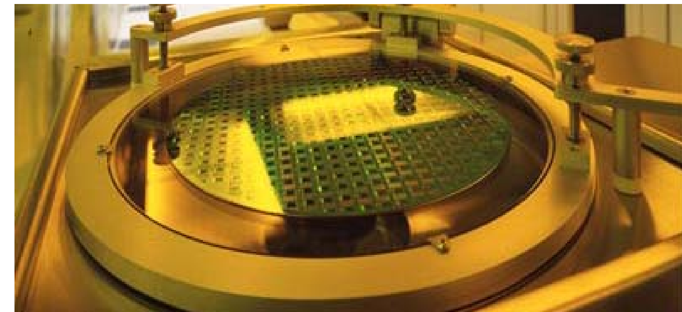
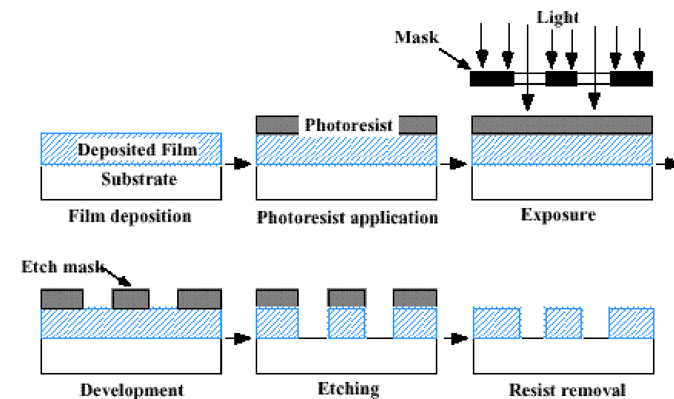
Photolithography

- Uses light radiation to expose a coating of photoresist on the surface of the wafer
  - Common light source in wafer processing is ultraviolet light, due to its short wavelength
- A *mask* containing the required geometric pattern for each layer separates the light source from the wafer, so that only the portions of the photoresist not blocked by the mask are exposed





http://www.youtube.com/watch?v=aCOyq4YzBtY&feature=related

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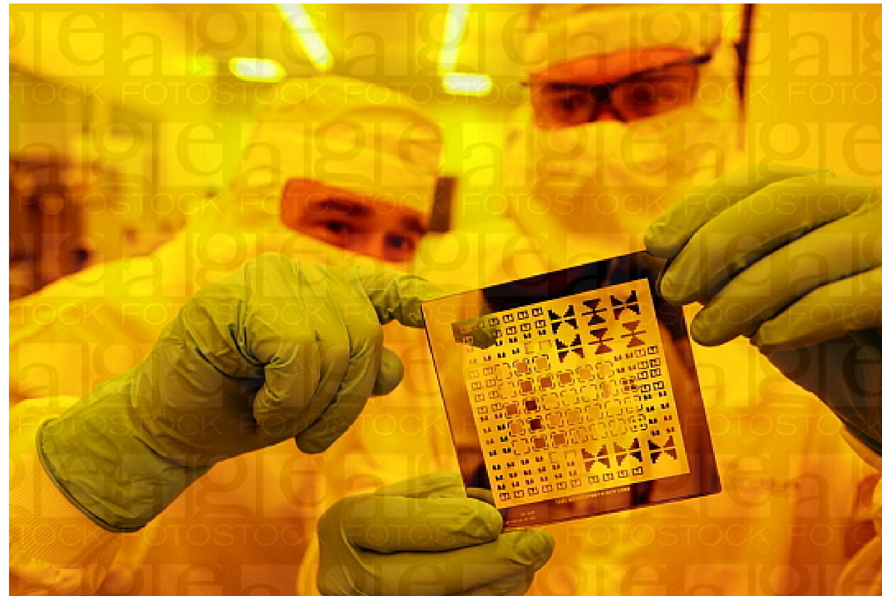
Photolithography Mask

- Flat plate of transparent glass onto which a thin film of an opaque substance has been deposited in certain areas to form the desired pattern
- The mask itself is fabricated by lithography, the pattern being based on circuit design data, usually in the form of digital output from the CAD system used by circuit designer



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Photoresist

- Organic polymer that is sensitive to light radiation in a certain wavelength range
- Sensitivity causes either increase or decrease in solubility of the polymer to certain chemicals
- Typical practice in semiconductor processing is to use photoresists sensitive to UV light
  - UV light has a short wavelength compared to visible light, permitting sharper imaging of circuit details on wafer surface
- Also permits fabrication areas in plant to be illuminated at low light levels outside UV band

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Photoresist Spin Coating

- Wafer is held on a spinner chuck by vacuum and resist is coated to uniform thickness by spin coating.
- Typically 3000-6000 rpm for 15-30 seconds.
- Resist thickness is set by:
  - primarily resist viscosity
  - secondarily spinner rotational speed
- Resist thickness is given by $t = kp^2/w^{1/2}$, where
  - k = spinner constant, typically 80-100
  - p = resist solids content in percent
  - w = spinner rotational speed in rpm/1000
- Most resist thicknesses are 1-2 μm for commercial Si processes

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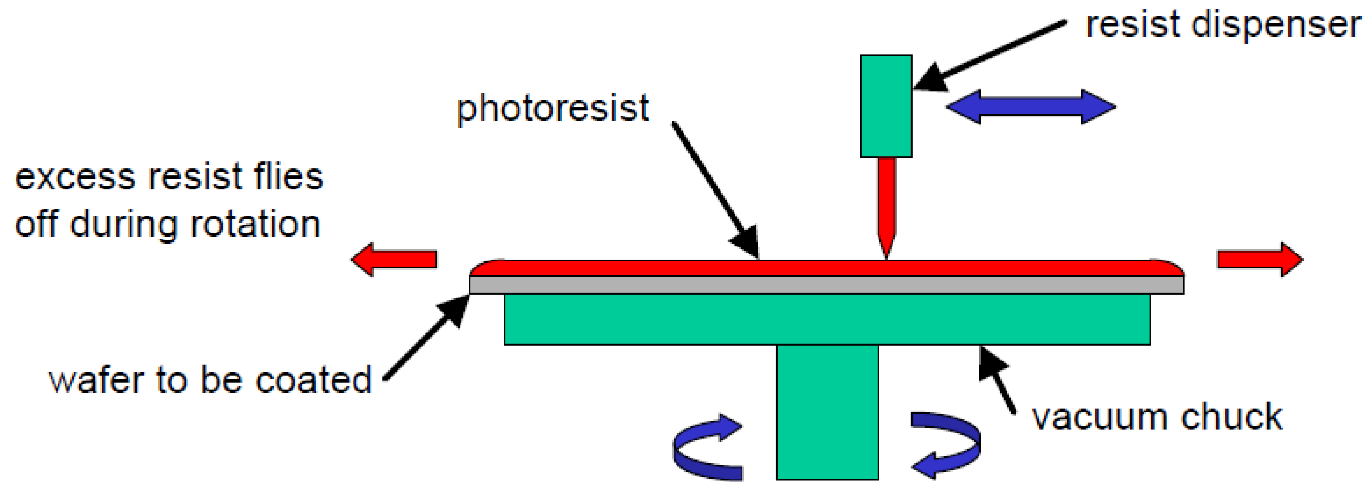
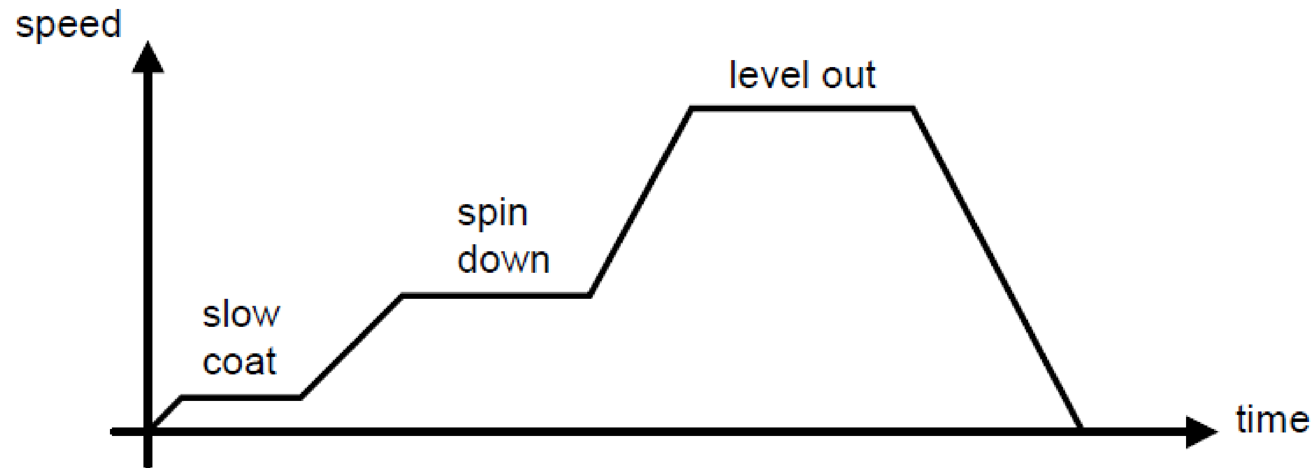
Photoresist Spin Coating





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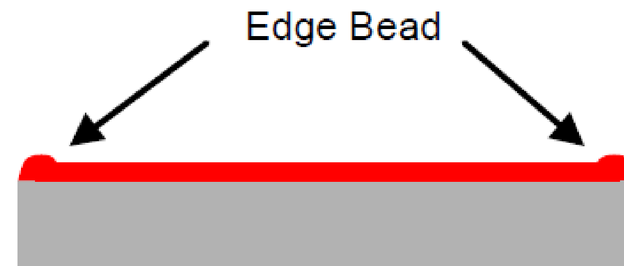
Stages of Resist Coating

1. EQUILIBRIUM STAGE
(stopped)

2. WAVE-FORMATION STAGE
(~ 2 revolutions)

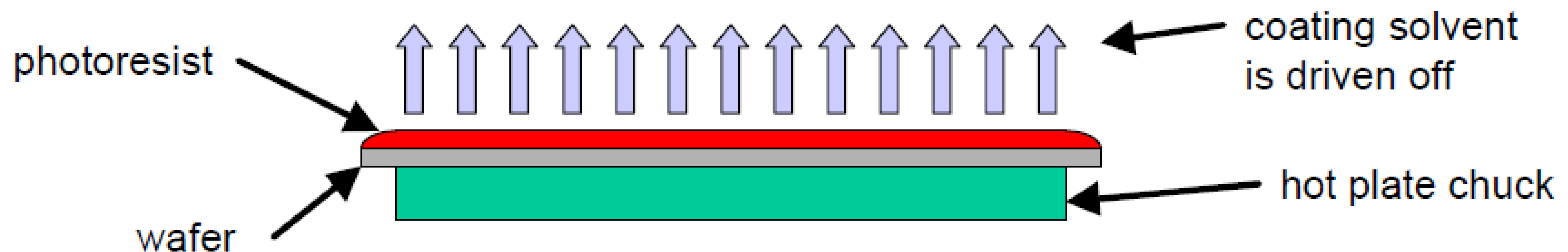
3. CORONA STAGE
(~ 30 revolutions)



4. SPIRAL STAGE
(~ 1000 revolutions)

Prebake (Soft Bake)

- Used to evaporate the coating solvent and to densify the resist after spin coating.
- Typical thermal cycles:
  - 90-100°C for 20 min. in a convection oven
  - 75-85°C for 45 sec. on a hot plate
- Commercially, microwave heating or IR lamps are also used in production lines.
- Hot plating the resist is usually faster, more controllable, and does not trap solvent like convection oven baking.



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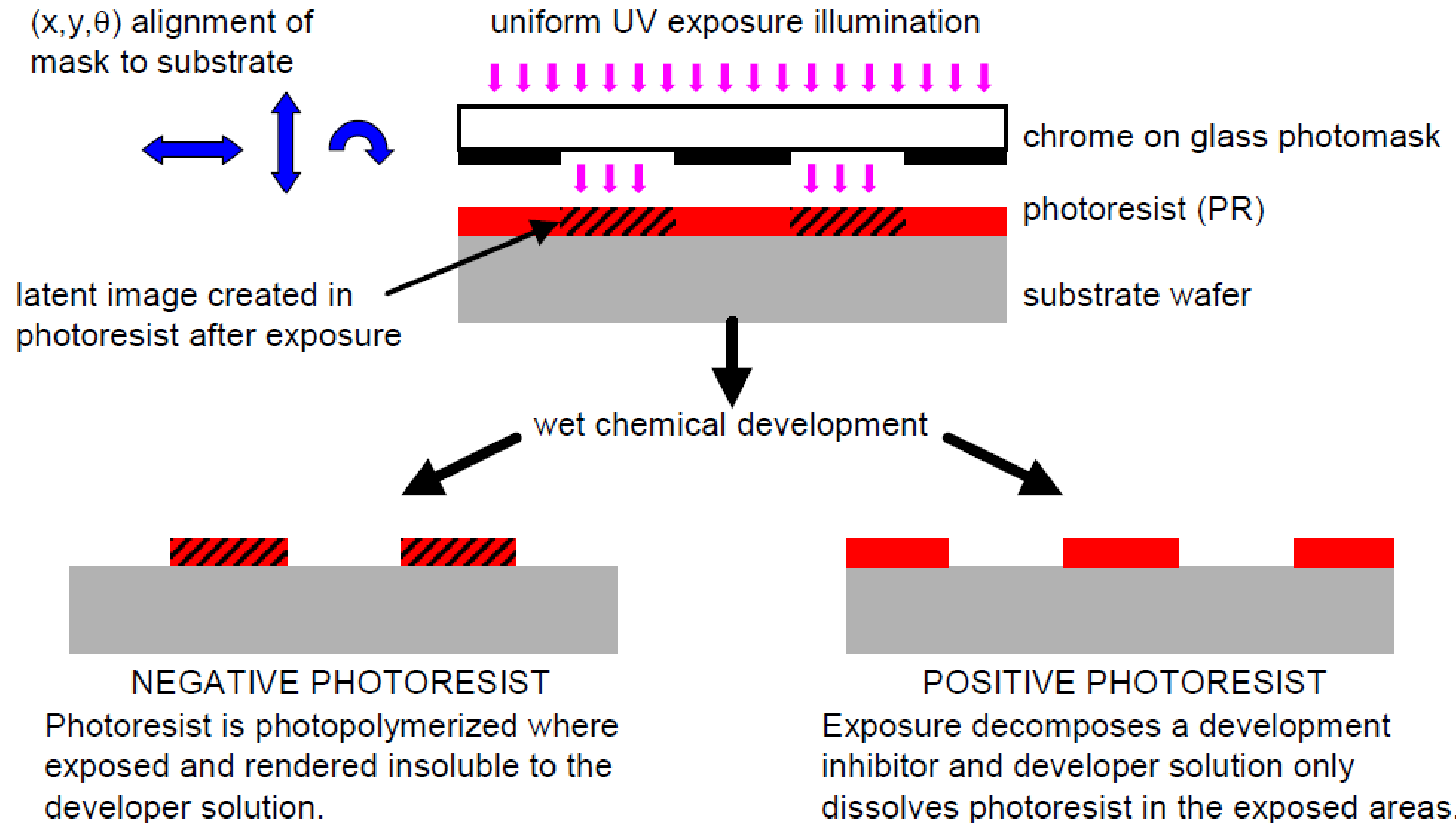
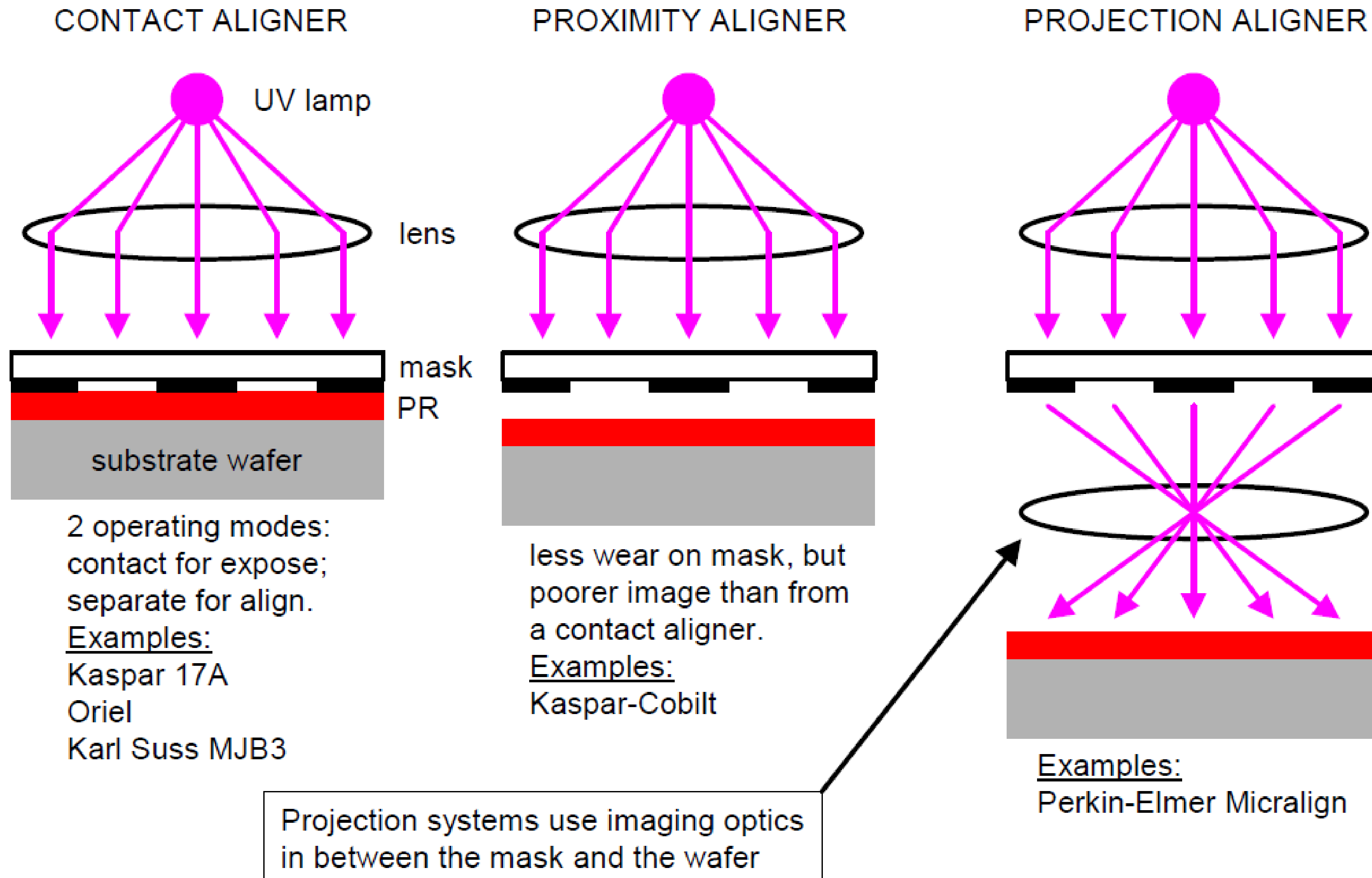
Overview of Align/Expose/Develop Steps



Alignment and Exposure Hardware



http://www.youtube.com/watch?v=9uJ09p_KG_U&feature=fvsr

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Postbake (Hard Bake)

- Used to stabilize and harden the developed photoresist prior to processing steps that the resist will mask.
- Main parameter is the plastic flow or glass transition temperature.
- Postbake removes any remaining traces of the coating solvent or developer.
- This eliminates the solvent burst effects in vacuum processing.
- Postbake introduces some stress into the photoresist.
- Some shrinkage of the photoresist may occur.
- Longer or hotter postbake makes resist removal much more difficult.

http://www.youtube.com/watch?v=9x3Lh1ZfggM

http://www.youtube.com/watch?v=63SPa0Lx9-c

Photoresist Removal (Stripping)

- Want to remove the photoresist and any of its residues.
- Simple solvents are generally sufficient for non-postbaked photoresists:
  - Positive photoresists:
    - acetone
    - trichloroethylene (TCE)
    - phenol-based strippers (Indus-Ri-Chem J-100)
  - Negative photoresists:
    - methyl ethyl ketone (MEK), $CH_3COC_2H_5$
    - methyl isobutyl ketone (MIBK), $CH_3COC_4H_9$
- Plasma etching with O_2 (ashing) is also effective for removing organic polymer debris.

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Basics of Photolithography for Processing

- Microfabrication processes:
  - Additive → deposition
  - Subtractive → etching
  - Modifying → doping, annealing, or curing
- Two primary techniques for patterning additive and subtractive processes:
  - Etch-back:
    - photoresist is applied overtop of the layer to be patterned
    - unwanted material is etched away
  - Lift-off:
    - patterned layer is deposited over top of the photoresist
    - unwanted material is lifted off when resist is removed

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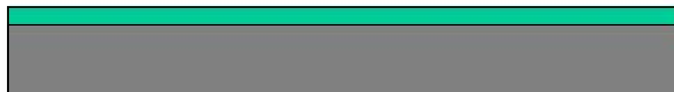
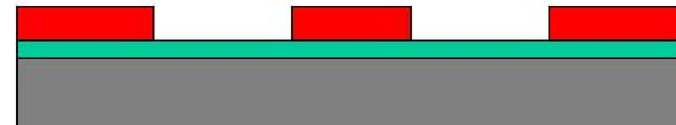
Etch-back

1



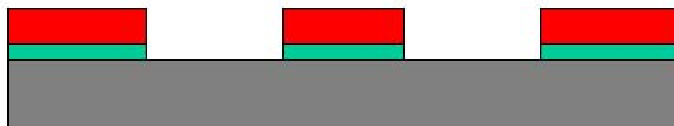
deposit thin film of desired material

2



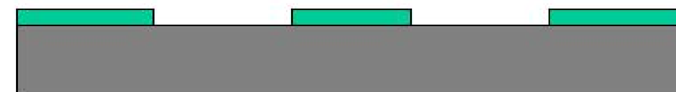
coat and pattern photoresist

3



etch film using photoresist as mask

4



remove photoresist

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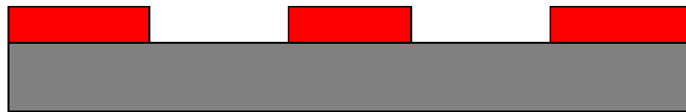
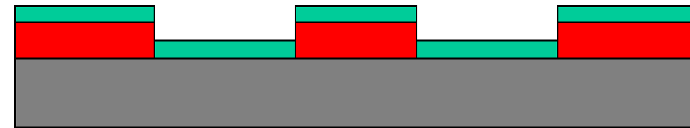
Lift-off

1



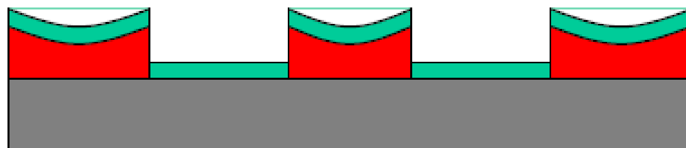
coat and pattern photoresist

2



deposit thin film of desired material

3



swell photoresist with a solvent

4

remove photoresist and thin film above it

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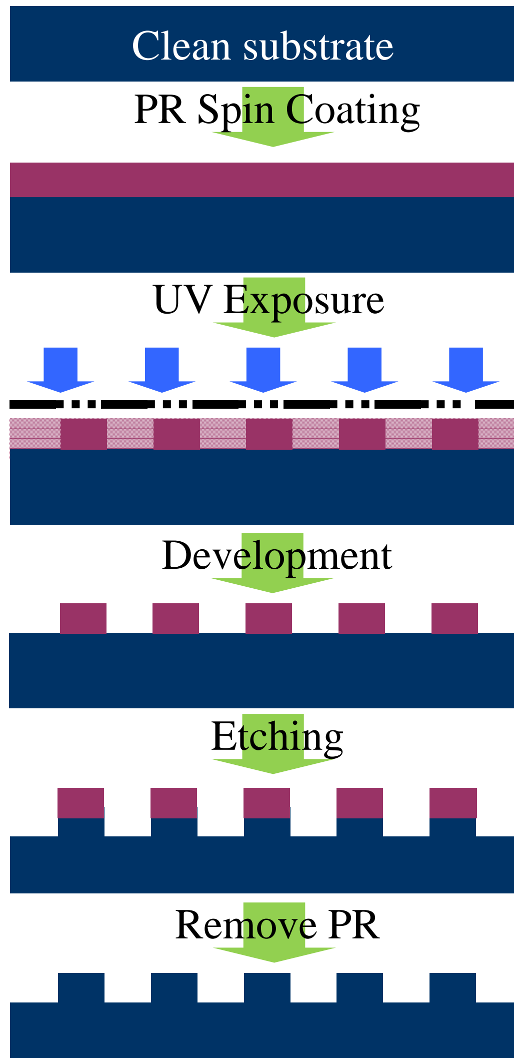
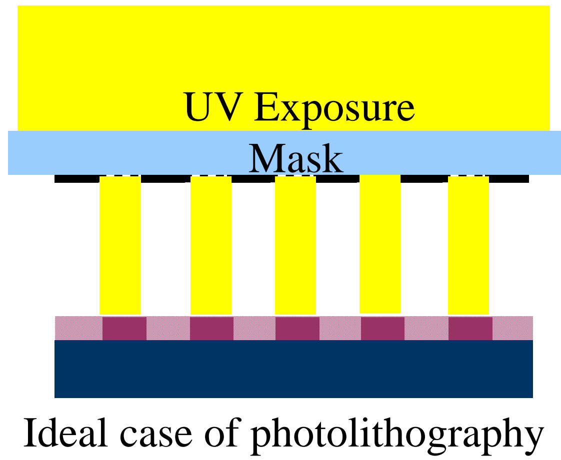
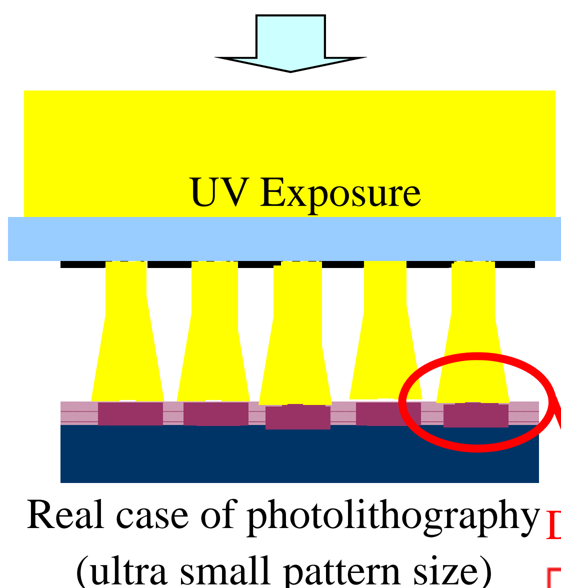
Photolithography process and limitation





Ideal case of photolithography



Real case of photolithography
(ultra small pattern size)

Diffraction effect

회절로 인해 같은 조건의
촬영 시 위와 같은 상이한
결과를 초래
(Image blur 현상 발생)

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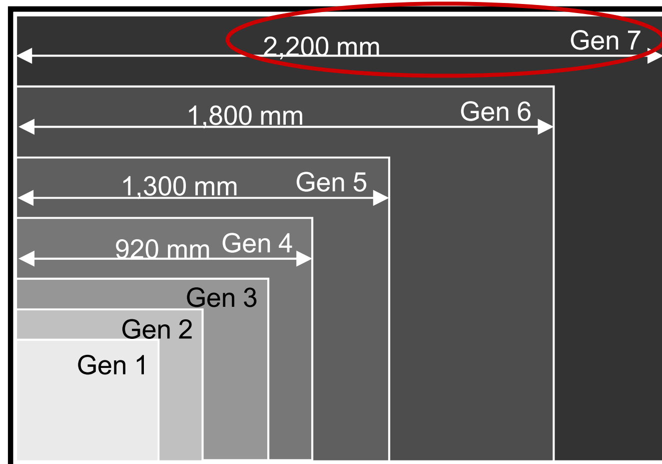
Limitation of Photolitho. In Display

- Increase of demands for nano/micro scale patterns with large pattern area
- Large-size substrate in digital display

[100" LCD]

[Glass size 1950 X 2250mm]

[Glass substrate generation]



• Accomplishment of 7th generation display above 40”

→ Requirement for replication of large area pattern

• Limitation in conventional micro/nano technology

- Expensive lithography system for large area pattering

- Expensive process

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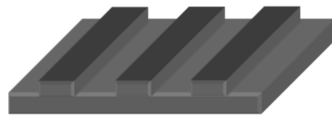
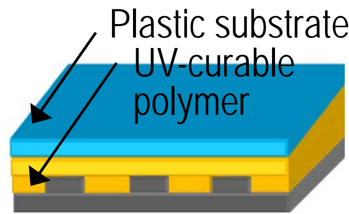
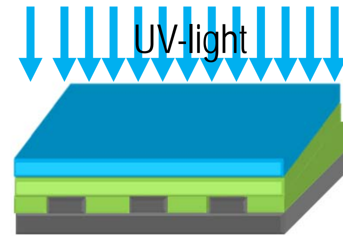
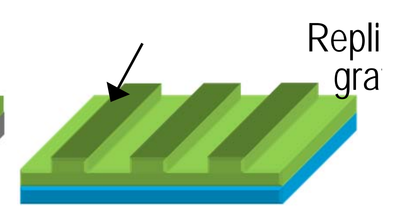
Nano-replication

틀 준비 | 기름칠하기 | 반죽 붓기 | 구워주기 | 완성(떼어내기)









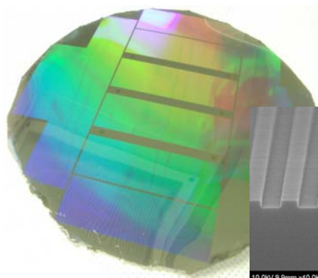
Mold preparation (Photolitho. Etching, Electroforming, etc)

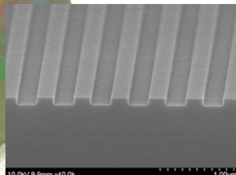
SAM Surface treatment

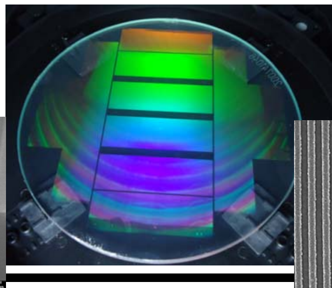
Material coating

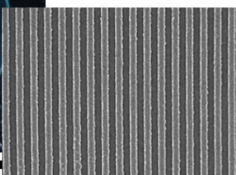
Curing

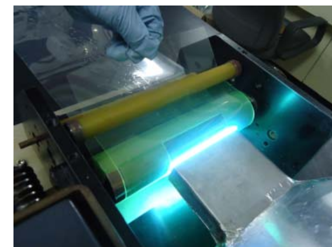
Releasing

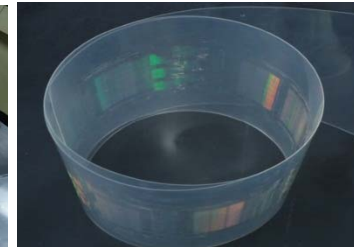












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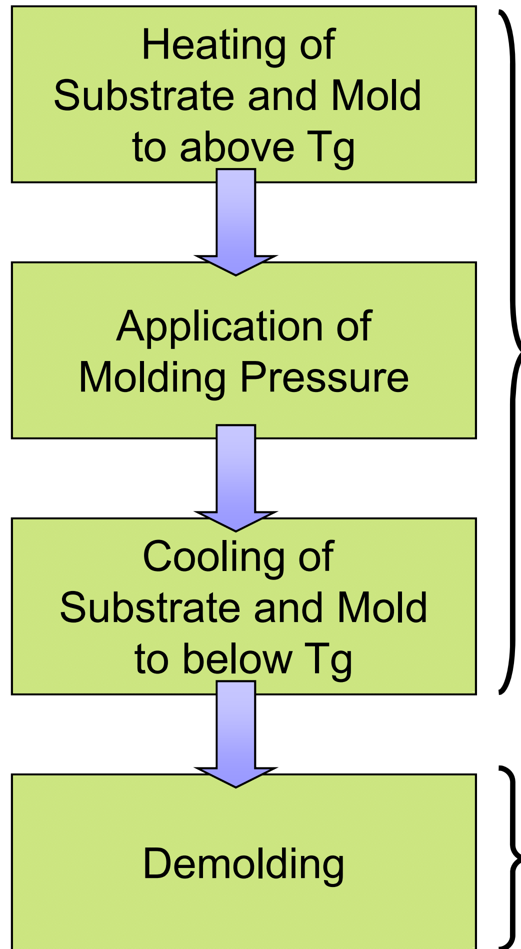
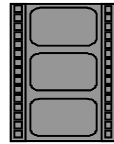
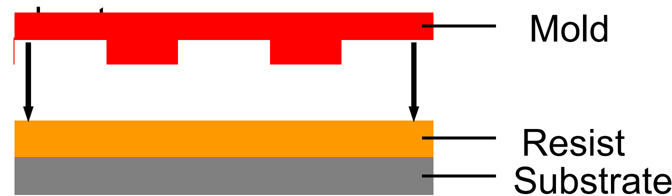
Thermal nano-imprinting

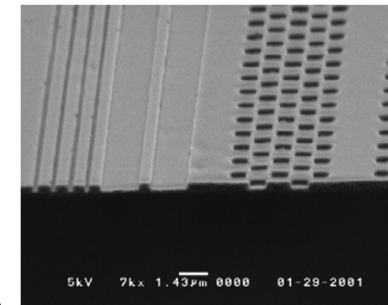
- Procedures





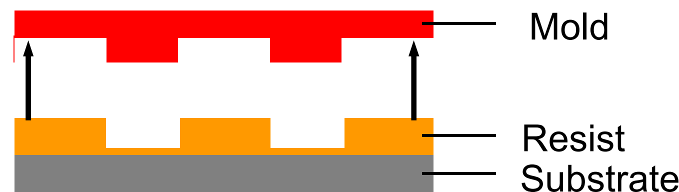
1. Press mold with

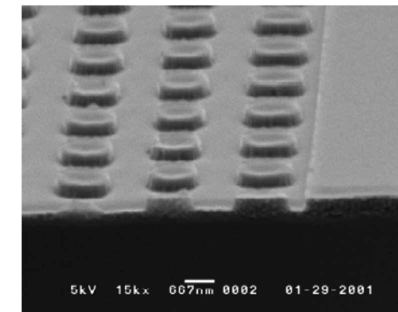




< Mold >

2. Remove mold



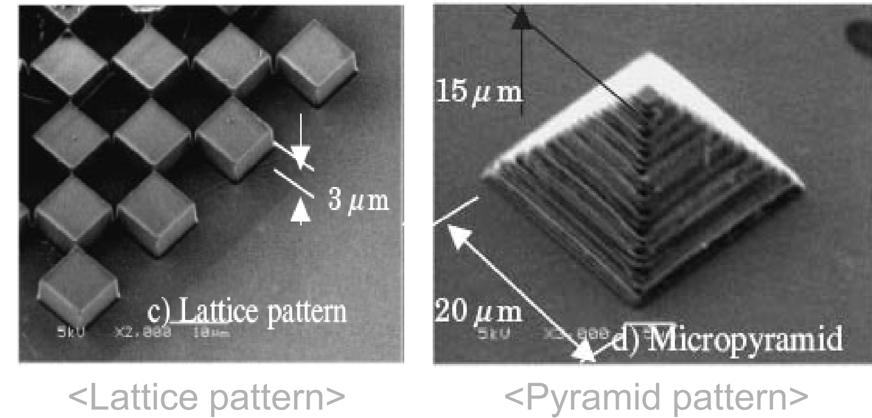


< Imprinted resist >

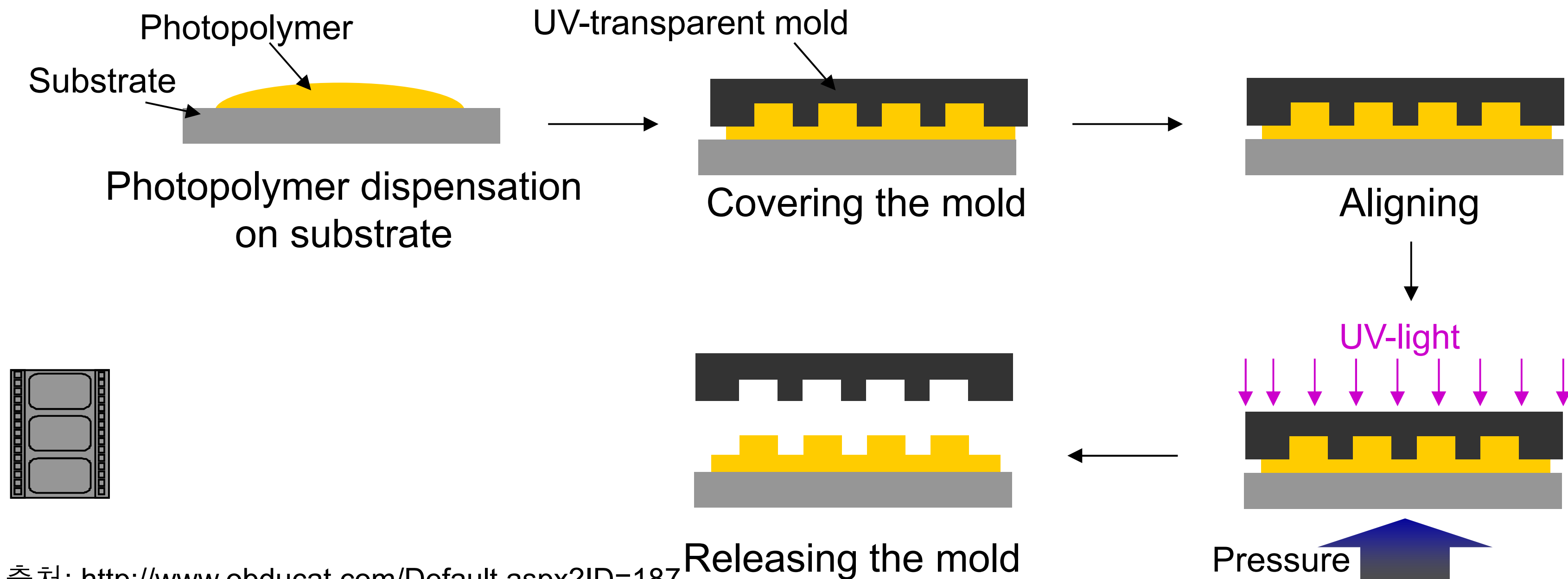
자료출처: http://www.obducat.com/Default.aspx?ID=187

UV nano-imprinting

- UV nano-imprinting
  - Material: UV-curable photopolymer
  - Processing condition: room temp. & low pressure
  - No fluidity problem
- Procedures



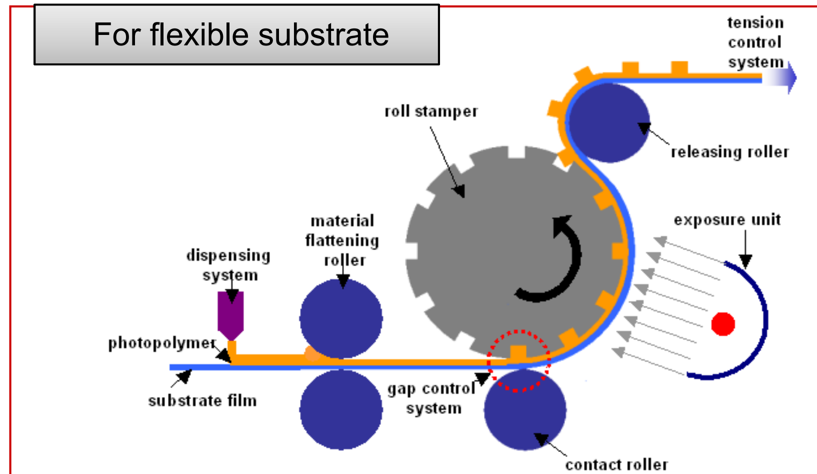
<Lattice pattern> <Pyramid pattern>

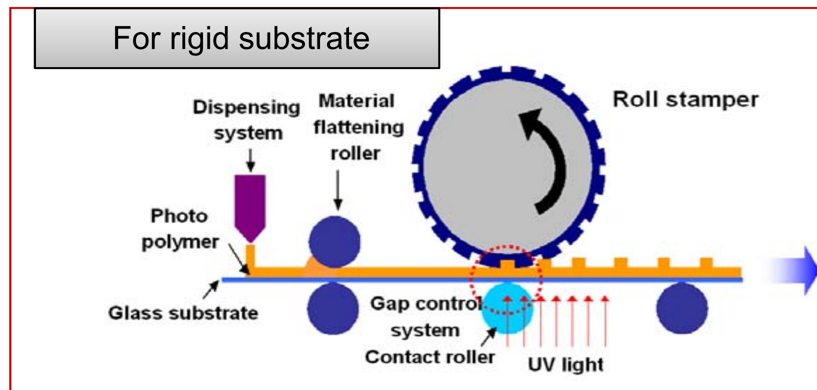


자료출처: http://www.obducat.com/Default.aspx?ID=187
JJAP, vol. 44, No. 7B, pp. 5600, 2005

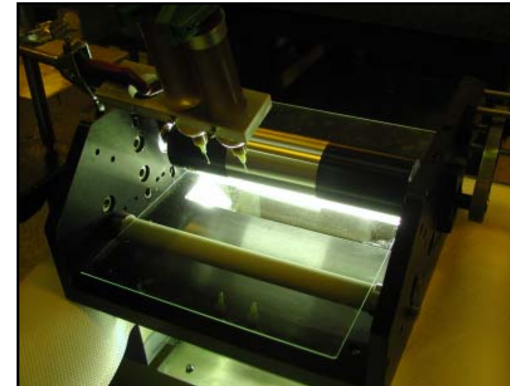
Continuous UV nano-imprinting

- Design and construction of continuous UV nano imprinting system

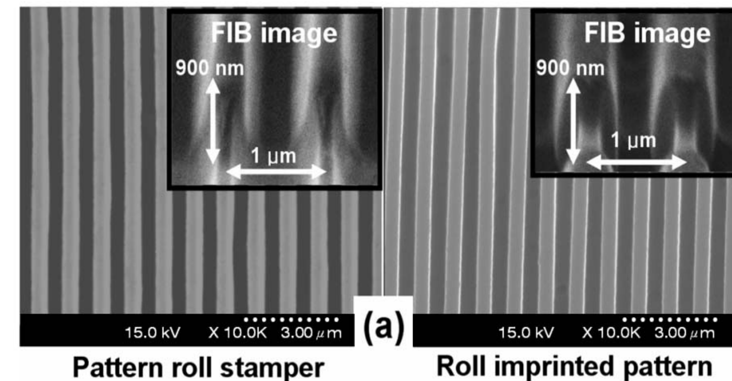




- Continuous UV nano-imprinting system



- Fabrication results



1. Can replicate nano patterns of large area with high precision

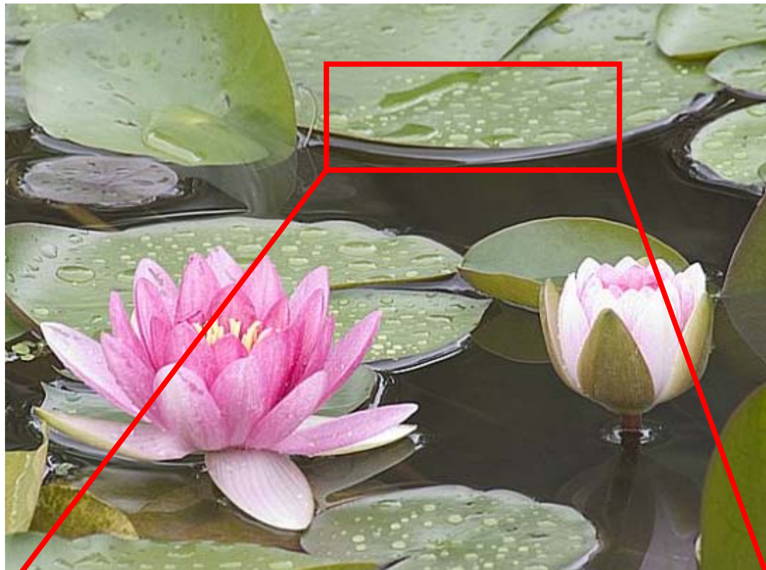
2. Can replace conventional lithography process

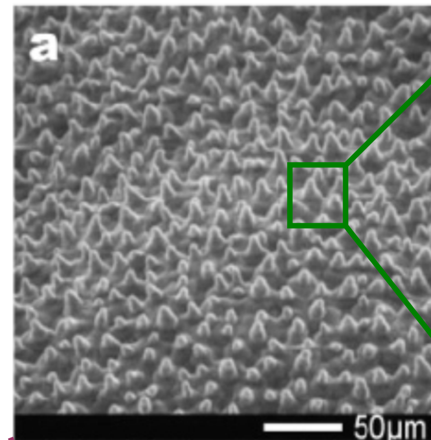
Nano-Imprinting 기술의 응용분야 1.

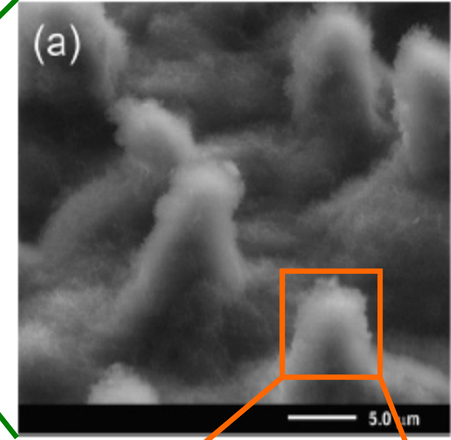
특수한 기능을 가진 자연물의 모사

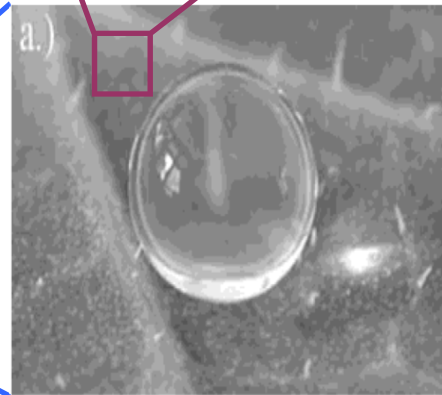
물에 젖지 않는 자연물들 (1)

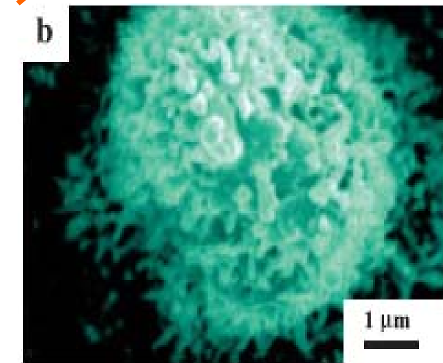
■ 연꽃 잎







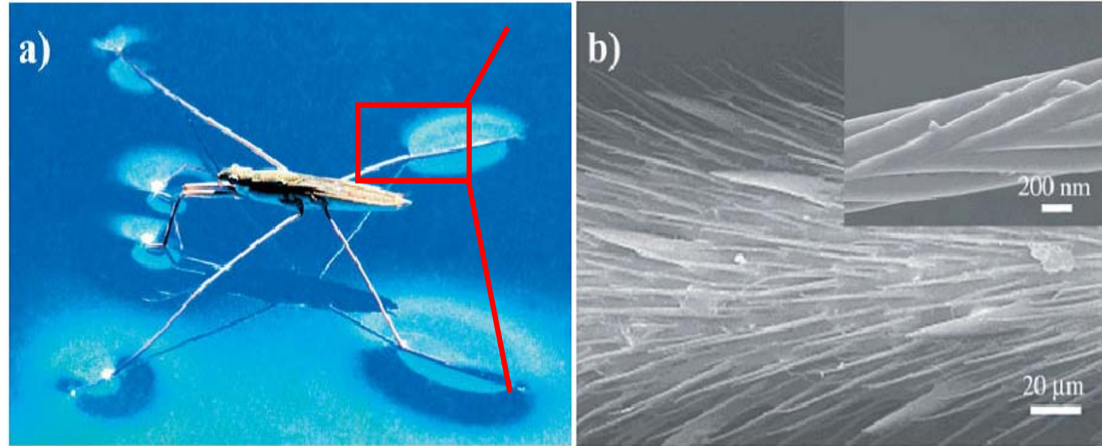




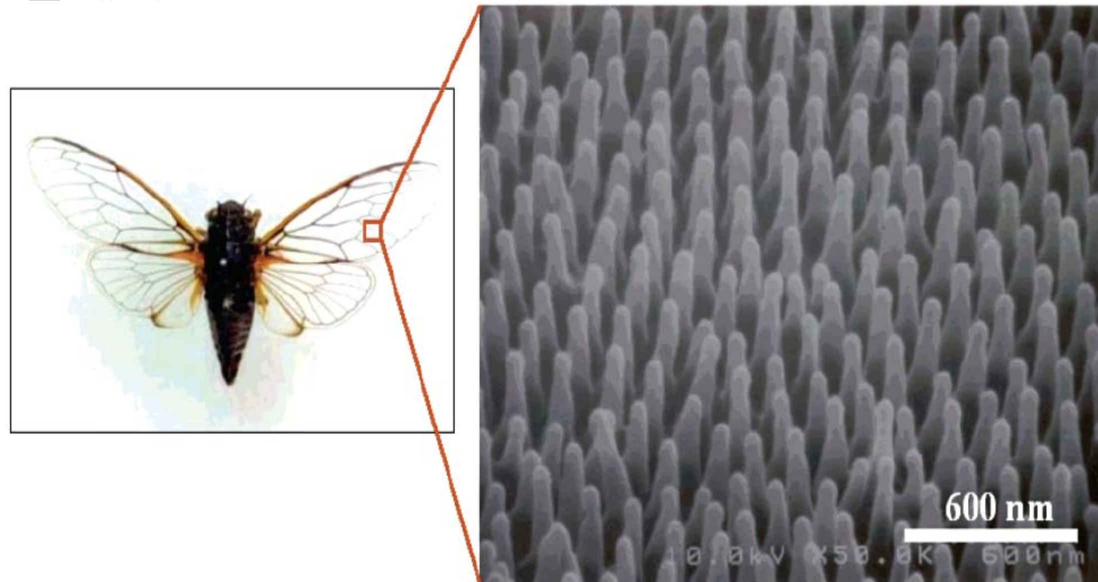
자료출처: http://blog.empas.com/hl1vgt/, Manhui Sun, Langmuir, Vol.21, pp.8978, 2005
L. Feng, Advanced Material,Vol.14, pp.1857, 2002
Alexander Otten, Langmuir, Vol.20, pp.2405, 2004

물에 젖지 않는 자연물들 (2)

■ 소금쟁이



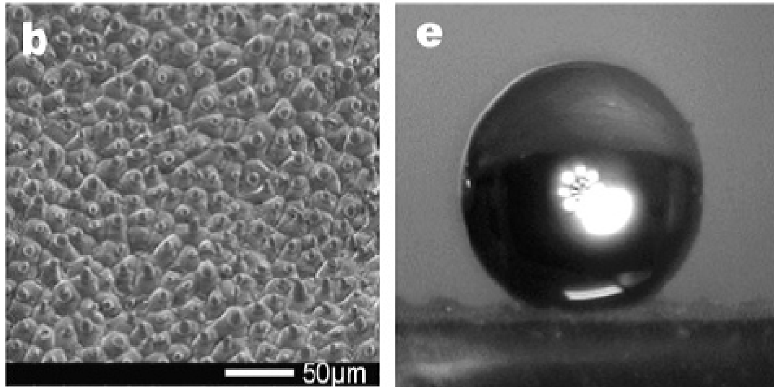
■ 매미



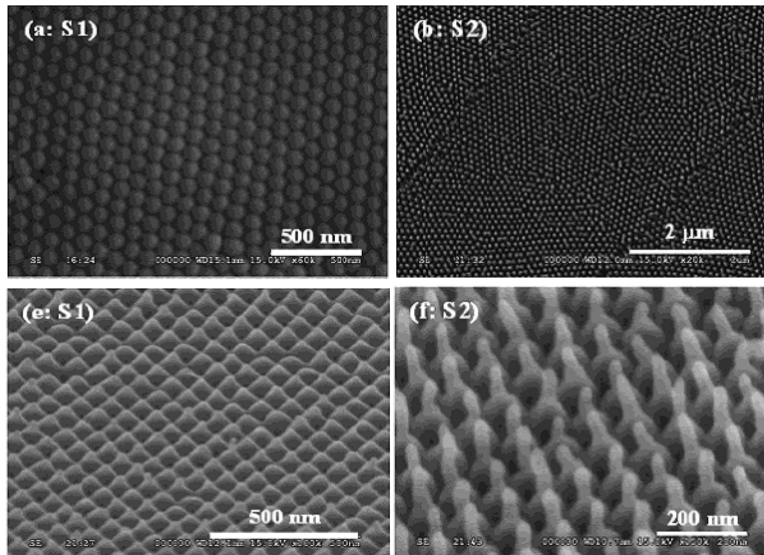
자료출처: Woo Lee et at al., Langmuir, Vol.20, pp.7665, 2004
Xuefeng Gao et at al., Nature, Vol.432, pp. 36, 2004

물에 젖지 않는 표면의 제작

■ 연꽃 잎의 모사

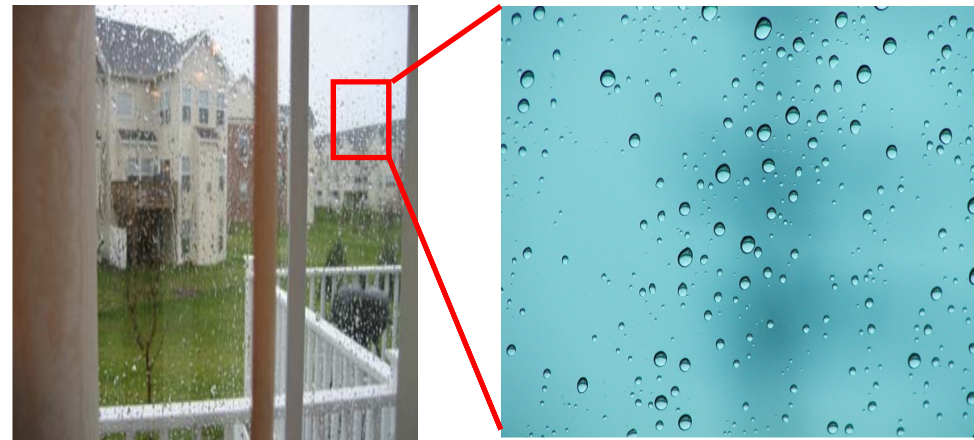


■ 매미 날개의 모사



■ 응용 분야

<자동차>

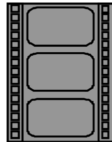


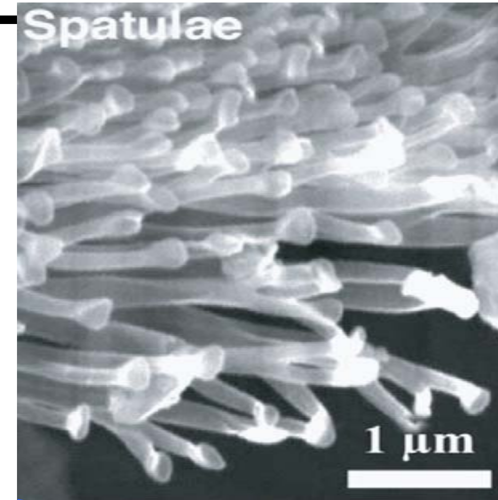
<유리창>

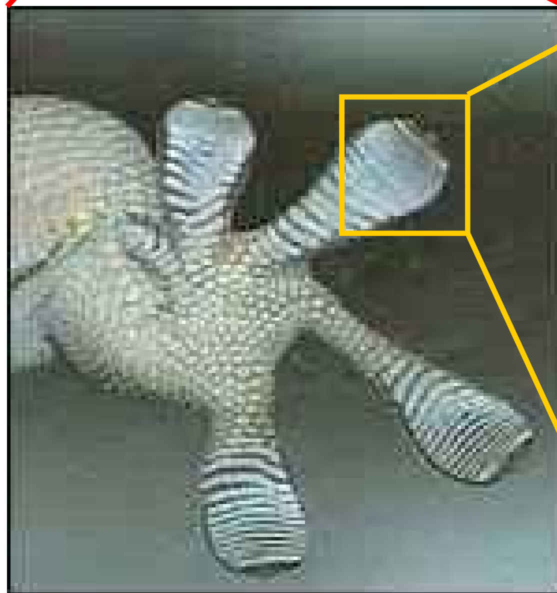
자료출처: Manhui Sun et at al.,langmuir, vol.21, pp.8978, 2005
Woo Lee et at al., Langmuir, Vol.20, pp.7665, 2004
http://www.dumitrup.com/blog/

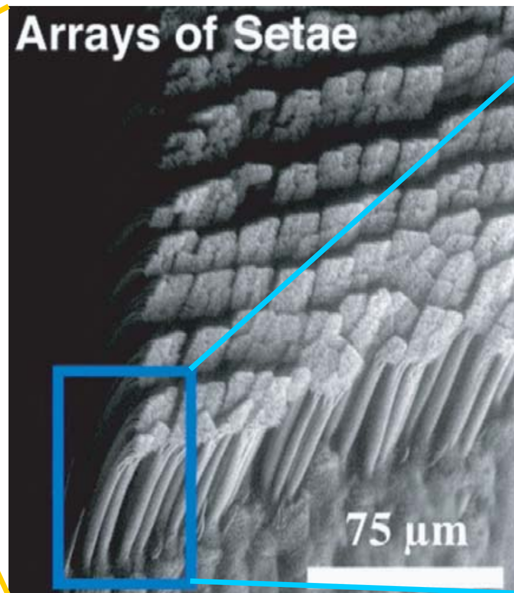
어떤 곳이든지 붙을 수 있는 발바닥

■게코 도마뱀의 발





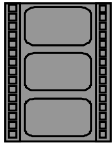


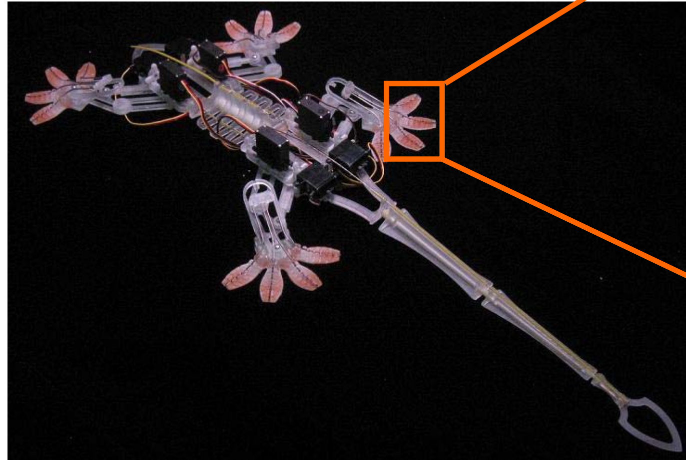


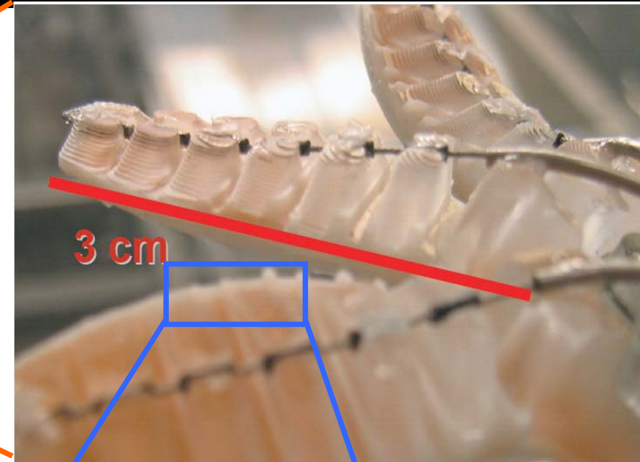
자료출처:
http://news.bbc.co.uk/2/hi/science/nature/781611.stm

어떤 곳이든지 붙을 수 있는 표면의 제작

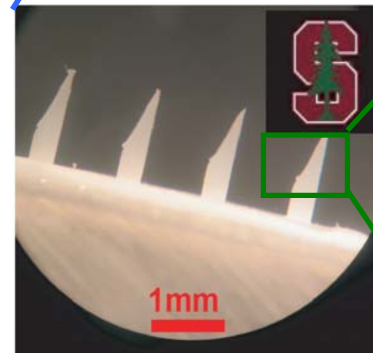
- Stickybot

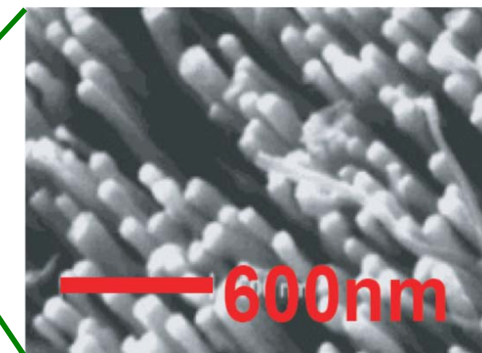






Vs.

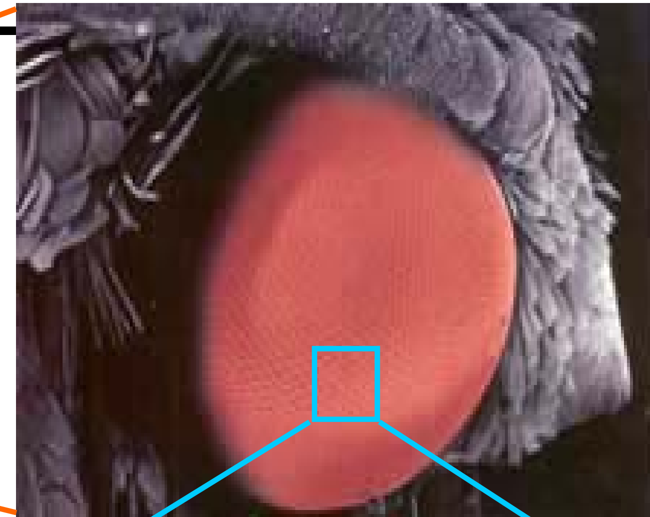




자료출처:
http://bdml.stanford.edu/twiki/bin/view/Main/StickyBot

빛이 반사하지 않는 표면

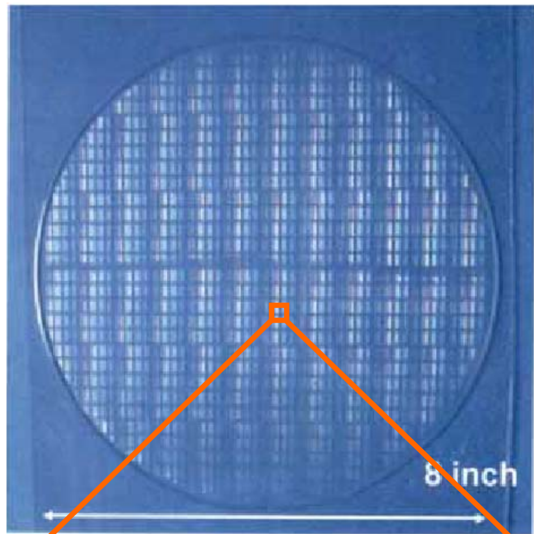
■나방의 눈

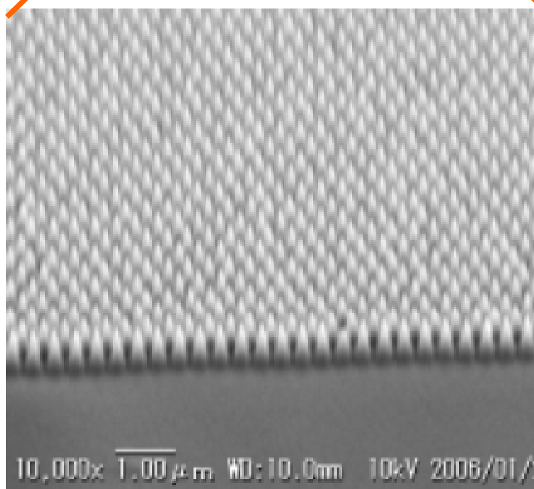


자료출처: http://www.motheye.com/
http://blog.empas.com/squirrel1226/

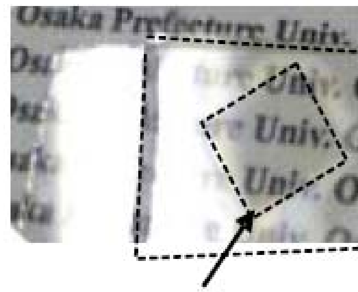
빛이 반사하지 않는 표면의 제작

■나방 눈의 모사 패턴





■ 무반사면의 응용



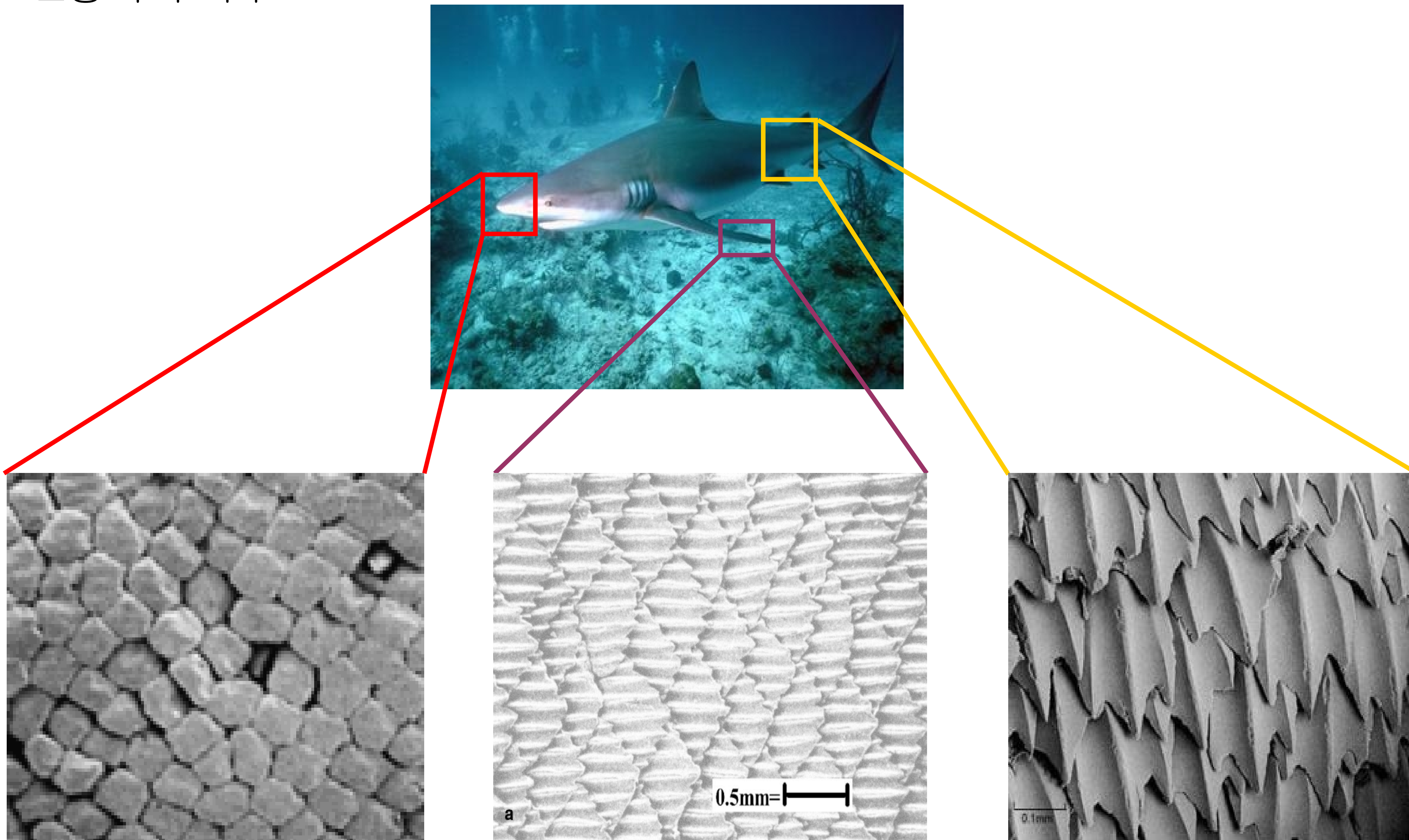
Anti -reflective area
(5 mm square)

Before

After Motheye

유체의 저항을 줄이는 표면

■상어의 피부



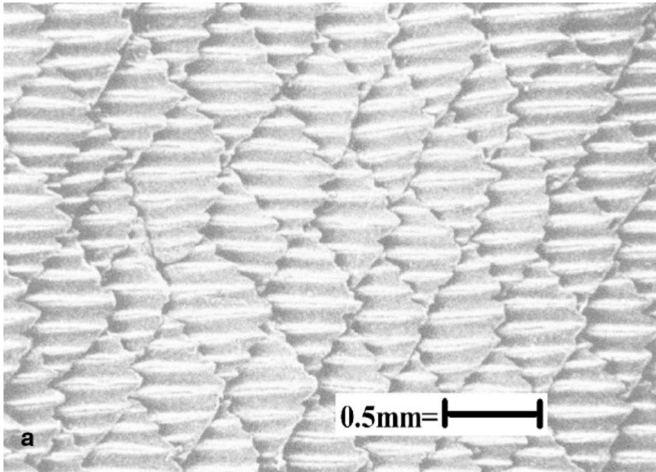
자료출처: http://news.softpedia.com/news/The-Shark-Coating-42520.shtml

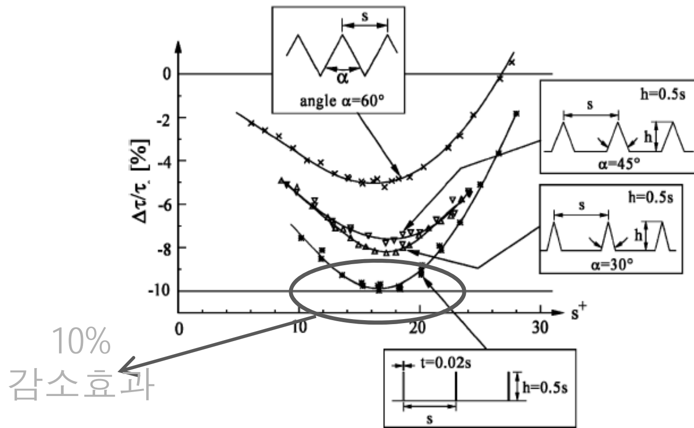
D. W. Bechert, Naturwissenschaften, Vol. 87, pp.157, 2004

Chung-Ang University Mechanical Engineering

유체 저항을 줄이는 표면의 제작

■상어 피부



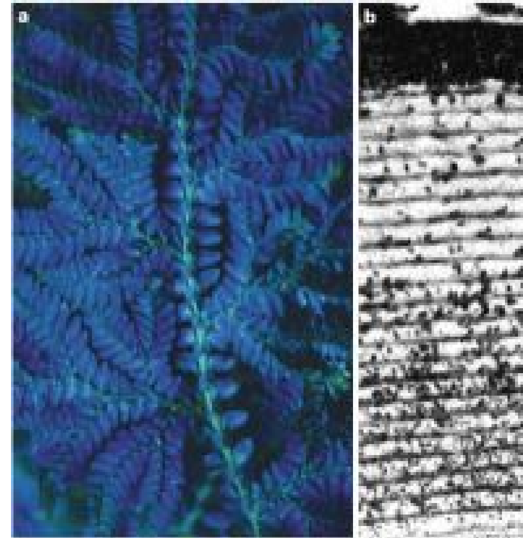


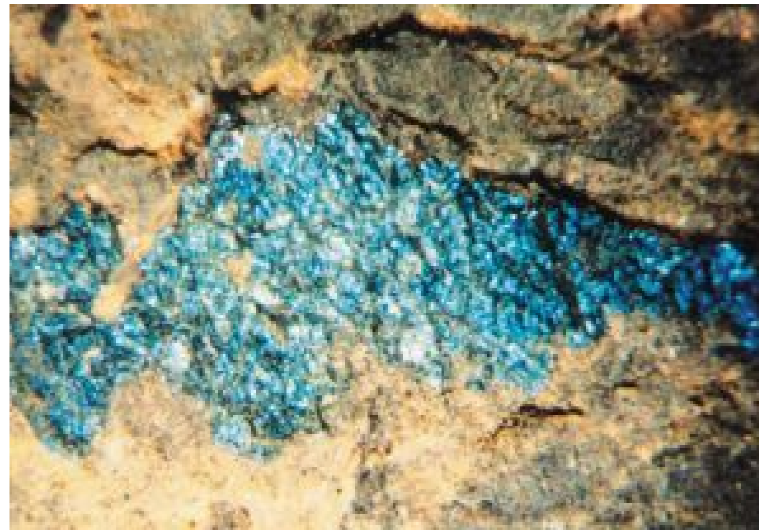
<Drag reduction of surface>

■상어 피부 형상의 응용 - 수영복

<Speedo Fastskin II>

특정 파장의 빛을 반사하는 표면

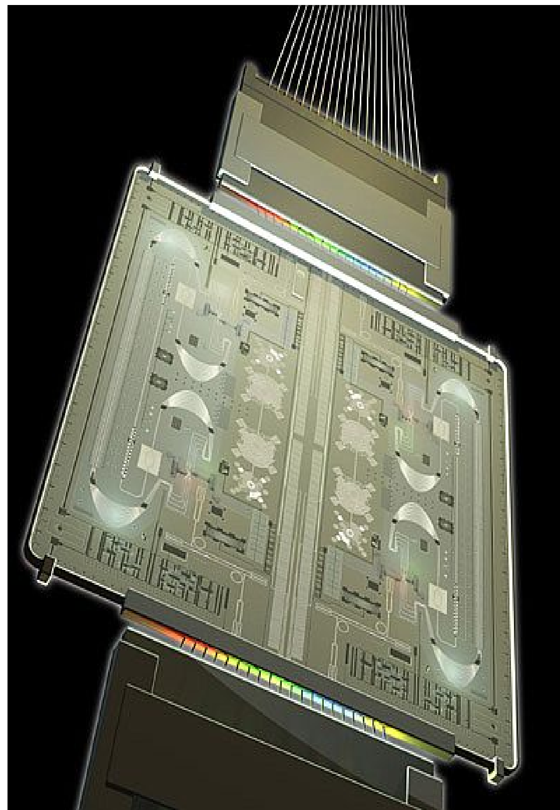


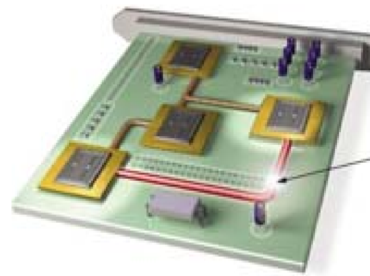


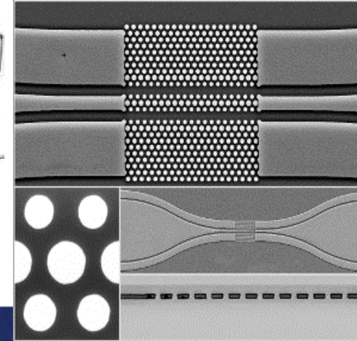
Nano-Imprinting 기술의 응용분야 2.

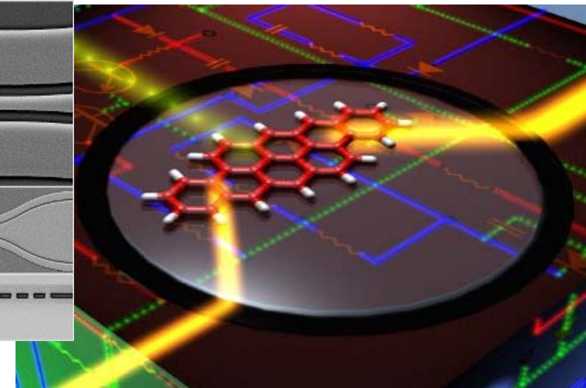
Electronics

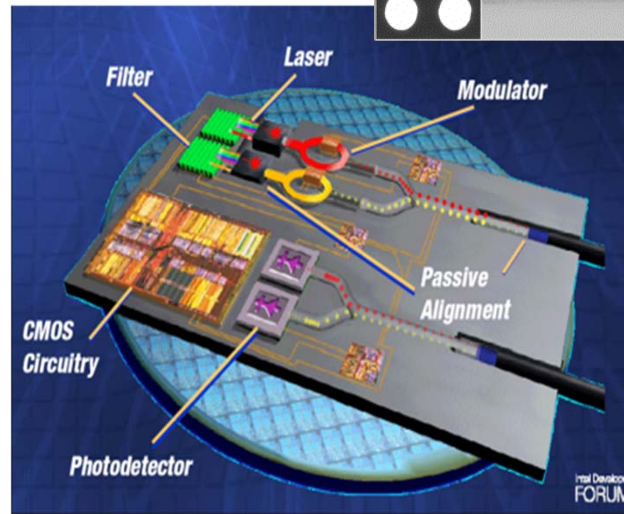
Photonic IC

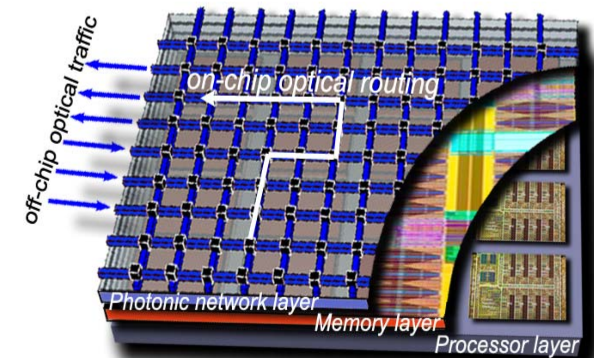








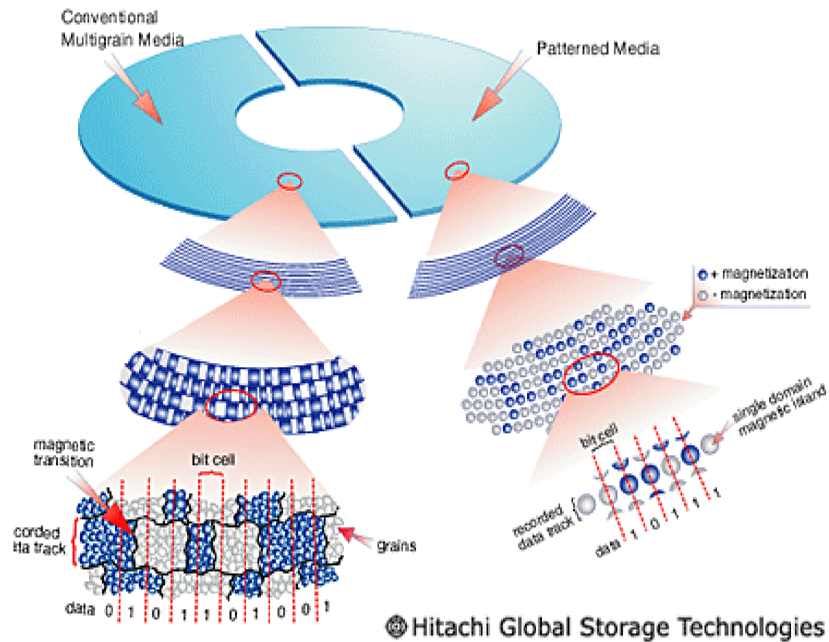


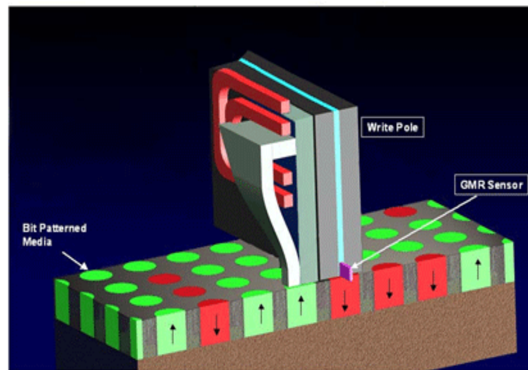


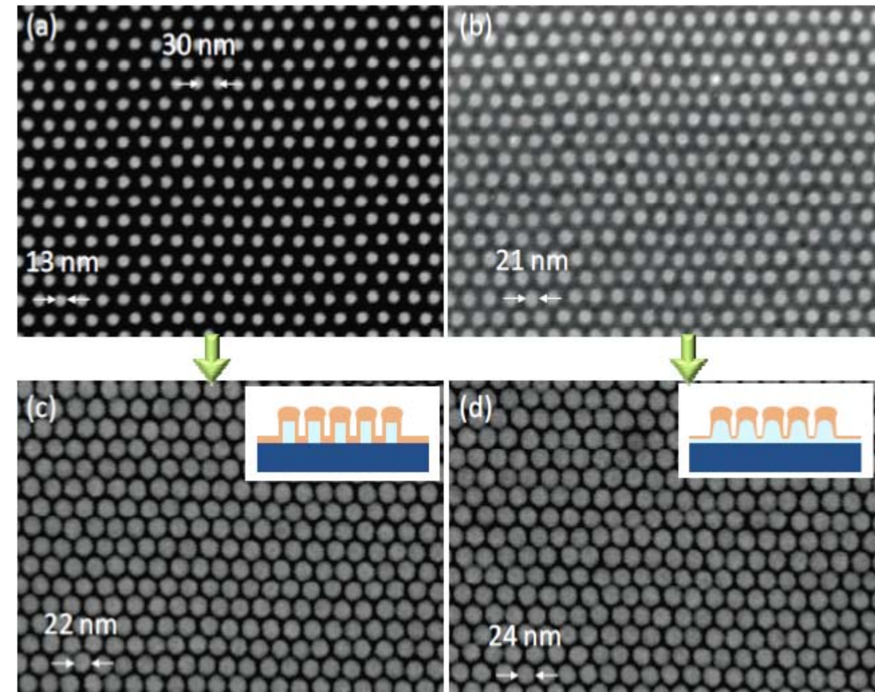
World's Fastest Optical Chip
wavelength division multiplexing (WDM)

Concept of photonic IC

Patterned Media





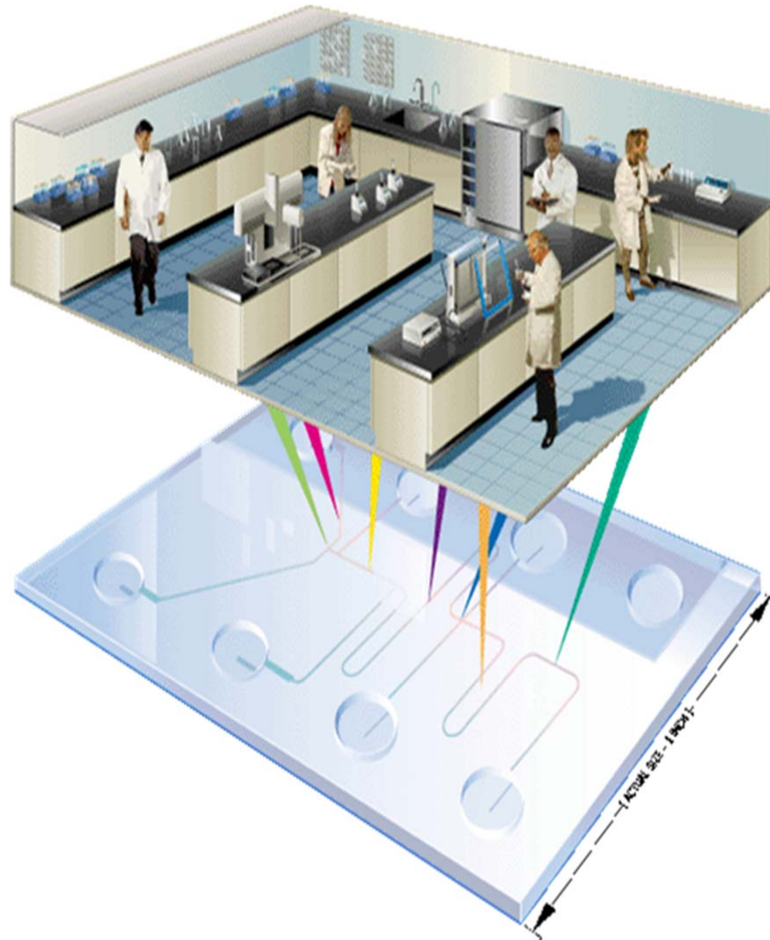


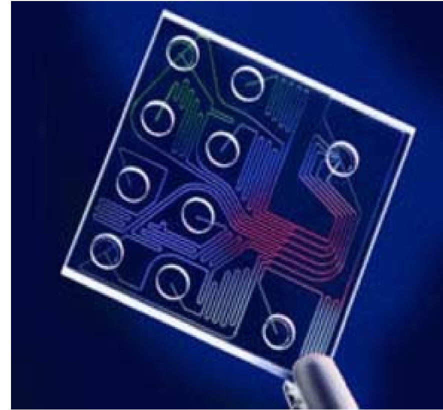
Department of Mechanical Engineering
Chung-Ang University

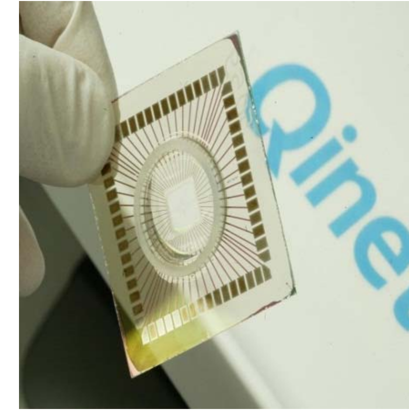
Nano-Imprinting 기술의 응용분야 3.

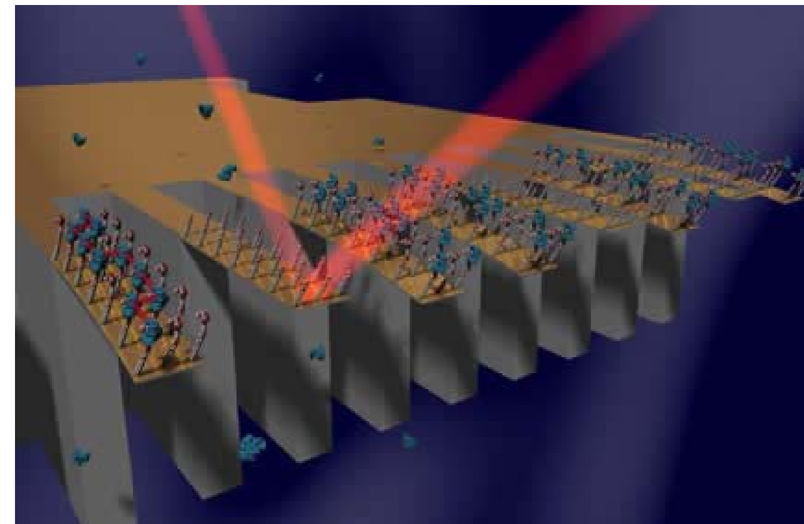
Bio Application

Lab on a chip & Bio sensor









Micro-Cantilever biosensor

Chung-Ang University Mechanical Engineering

Scaffold tissue engineering