Surface Engineering Introduction:

Why surface treatment is important?

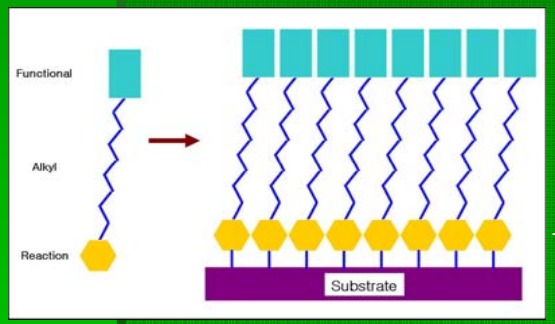
- Soft lithography, microfluidics, thin film coating, semiconductor cleaning process, etc.
- Surface properties: wettability, adhesion, biocompatibility

What kinds of methods can be used?

- Chemical methods
  - SAM: surface modification: hydrophilic vs hydrophobic
  - Piranha solution: surface cleaning (strong acid or base)
- Physical methods
  - Plasma
  - UV or UVO

1. Surface modification by using SAMs

- **Various functionalities**
- **Without damage to sensitive device structures**



→ Functional group

→ Alkyl chain

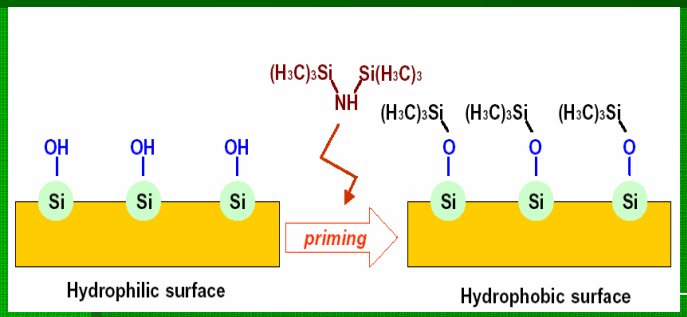
→ Reaction group

Hydrophobic: $-CH_3$, $-CF_3$, $-Phenyl(C_6H_5)$
Hydrophilic: $-OH$, $-COOH$, $-SH$, $-NH_2$

$-SH$, $-SiCl_3$, $-Si(OR)_3$

Au, Ag, Pd, Pt

Si, SiO_2, glass, Cu, Ni, ITO



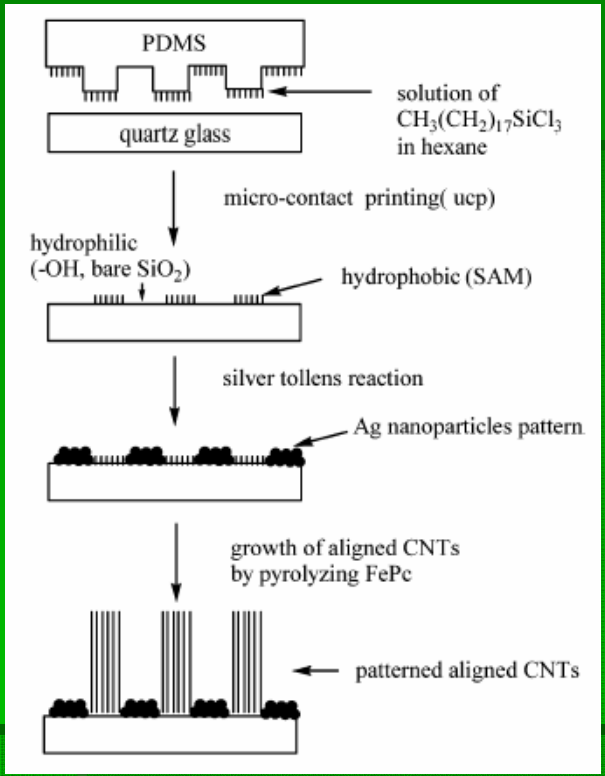
→ 반도체 공정에서 실리콘옥사이드 기판위에 PR의 접착력 증가를 위해서 (HMDS)

Classification of surfaces

nonstick	(+)attracting	(−)attracting	sticky
CH_3−	H−terminated Si (Si−H)	NMe_3+ terminated SAM	Bare
CF_3−	$COOH^-$terminated SAM	$C(NH_2)_2$+ terminated SAM	Gold
	PO_3H^- terminated SAM	NH_3+ terminated SAM	
	Oxidized Si (Si−O^-)	NMe_3H+ terminated SAM	
	Hexaethylene glycol−SAM		

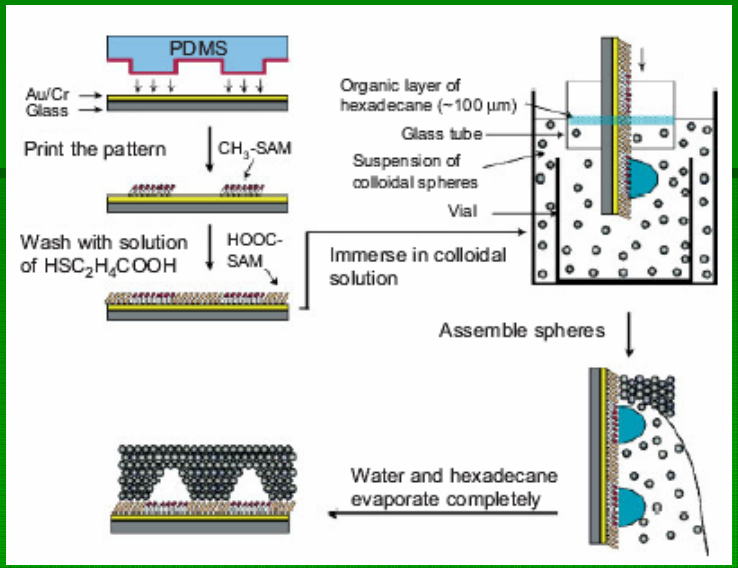
G.M. Whitsides et al, *Langmuir* **1997**, *13*, 5355

Selective Growth of CNT



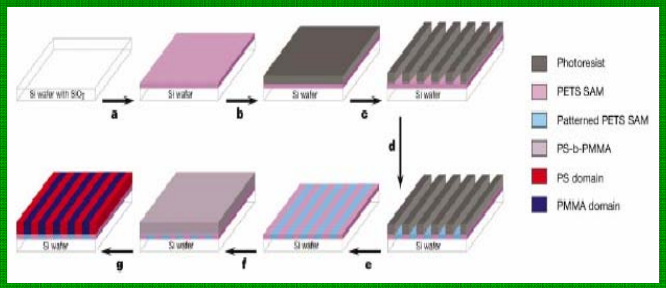
J. Phys. Chem. B, 2003, 3455

Patterned colloidal crystals



Adv. Mater. 2002, 1799

Epitaxial self-assembly pattern of BCs



Nature, 2003, 411

What's problem?

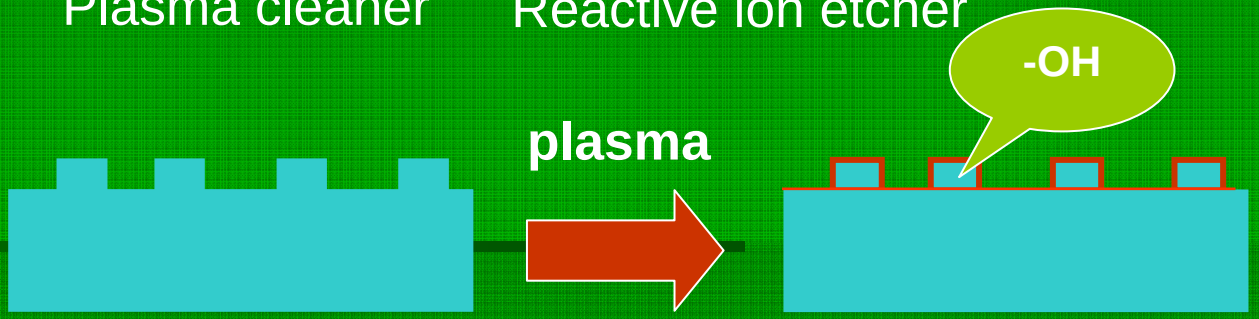
The use of chemicals?
-tricky
If surface reaction groups do not exist?

Convenient & Defect free method?

2. Plasma-enhanced surface modification

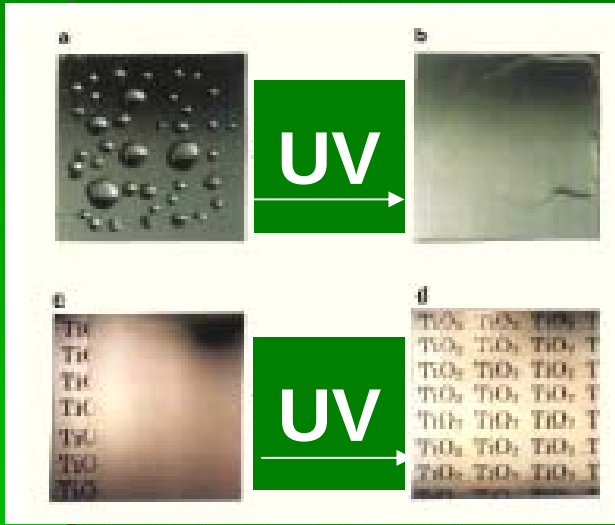
Plasma cleaner

Reactive ion etcher



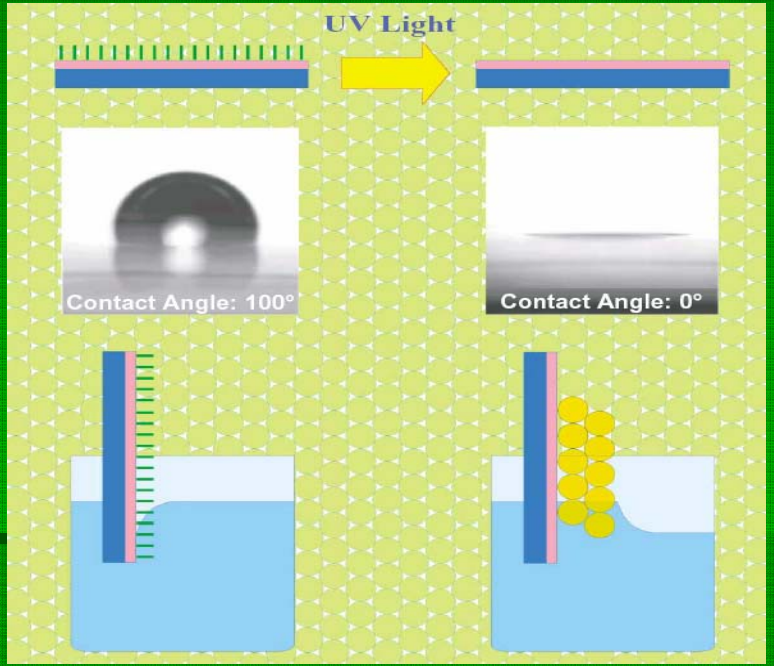
- Sometimes, Plasma (O_2) can cause damage (to the microstructure of polymer surface including PDMS.

3. UV/UVO assisted surface modification

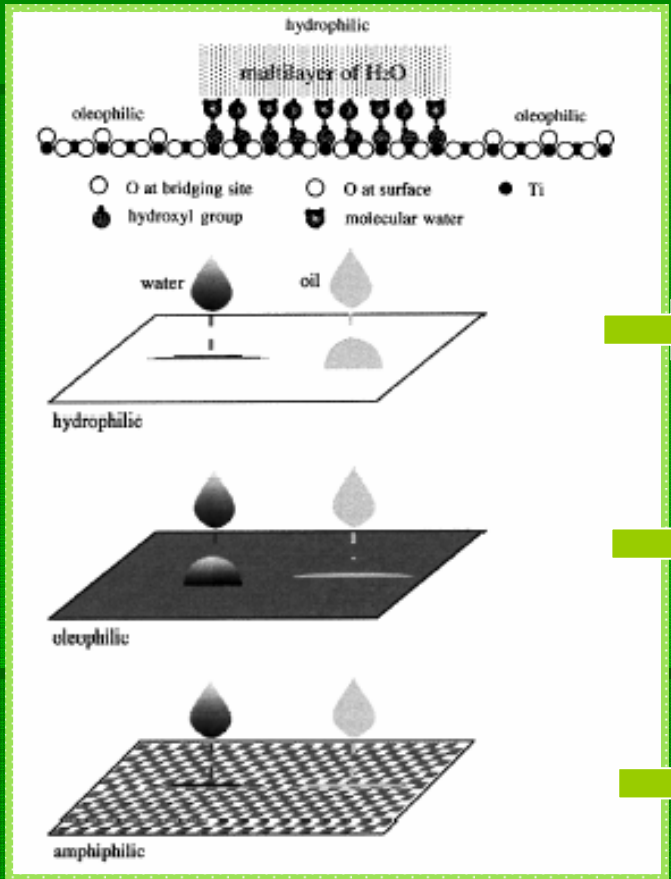


a: Hydrophobic b: hydrophilic
c: fog d: antifogging

Nature, 1998, 431



Angew. Chem. Int. Ed. 2002, 2067



Hydrophilic (After UV irradiation)

Oleophilic

Amphiphilic

Adv. Mater., 1998,135

A Simple method for the attachment of polymer films on solid substrates

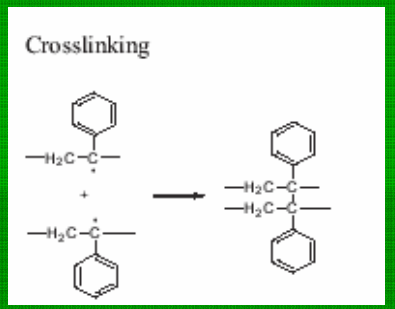
Spin coating
(physisorbtion)

Solvent washing

Easily removed
by rinsing with a
solvent

Spin coating & UV
(crosslinking)

Strongly attached
to the surface



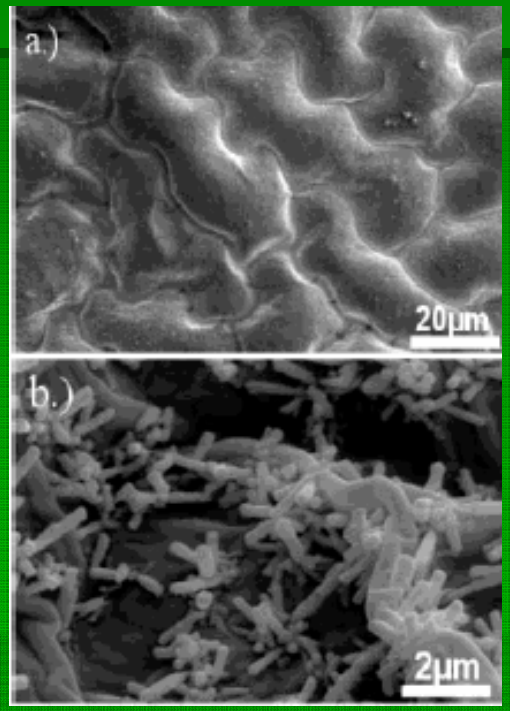
Adv. Mater., 2003, 244

UVO (UV and Ozone)

UVO cleaning method
-Photosensitized oxidation process
-The contaminants are excited and dissociated by the absorption of short-wavelength UV radiation

- Applications
  - Substrate cleaning prior to thin film deposition
  - Cleaning of silicon wafers, lenses, solar panels, and GaAs wafers
  - Etching Teflon and other organic materials
  - Improve adhesion of coatings on plastics
  - Increase hydrophilicity of surface

4. Lotus effect

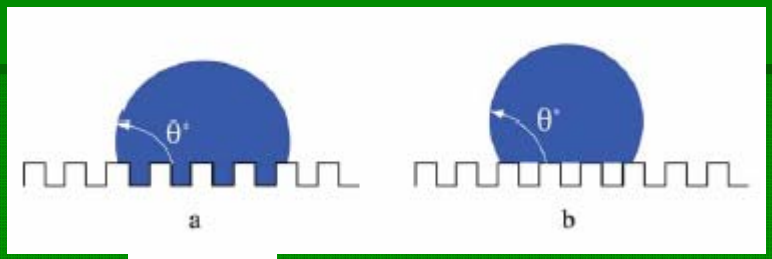


Langmuir **2004**, *20*, 2405−2408

Surperhydrophobic

초소수성 조건

1. 접촉면이 작아야 한다.
2. Aspect ratio 가 크면 유리.
3. 표면에너지가 낮아야 한다.
4. 마이크로/나노 복합구조.

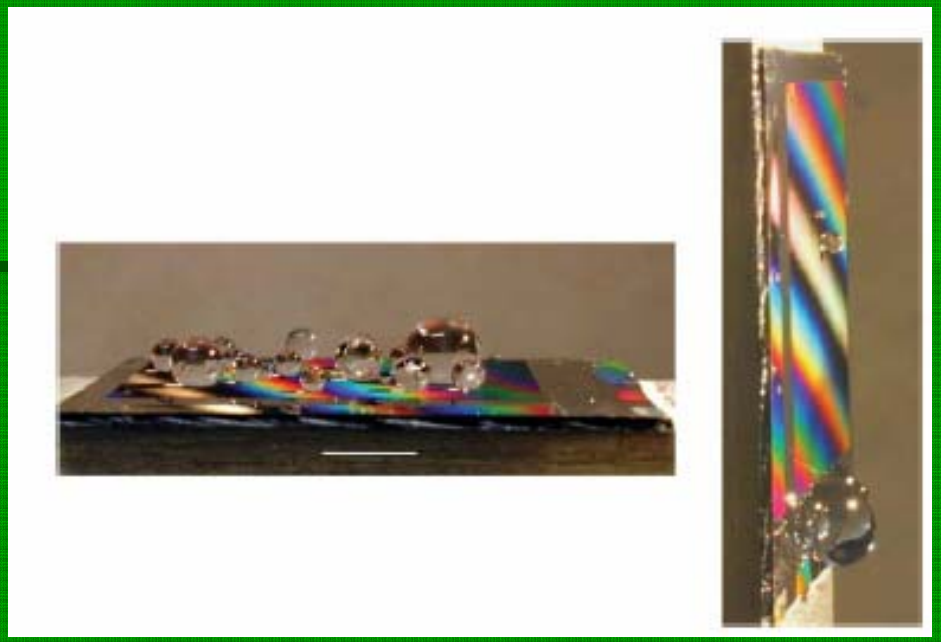


Wenzel state

$$\cos\theta^* = r\cos\theta$$

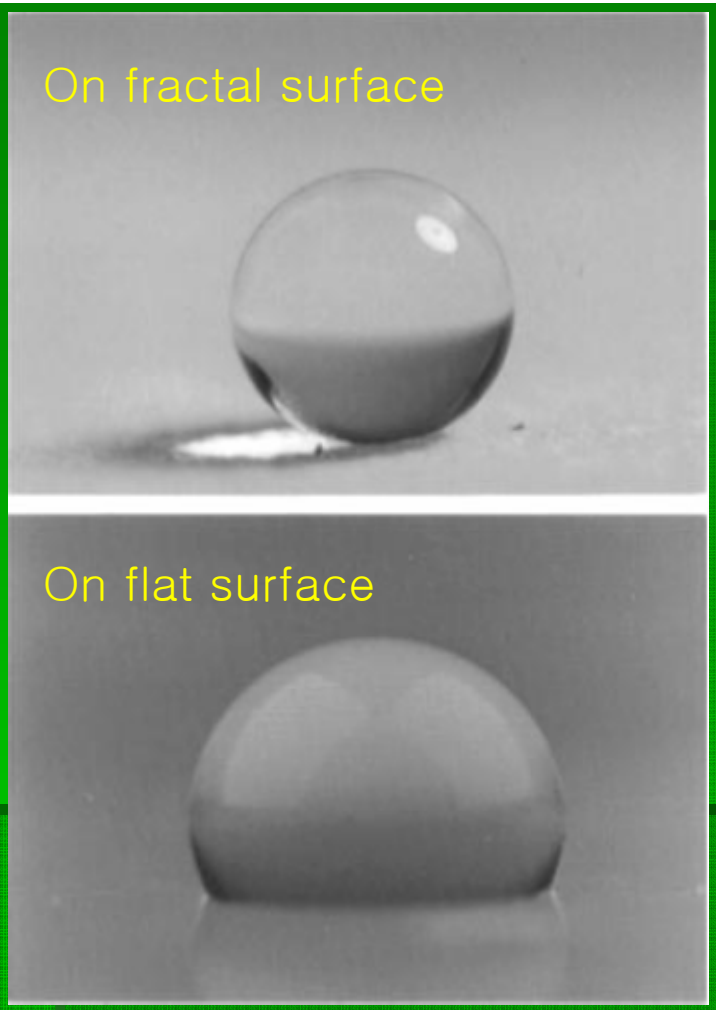
Cassie state

$$\cos\theta^* = -1 + \phi_s(\cos\theta + 1)$$



Super-Water-Repellent Fractal Surfaces

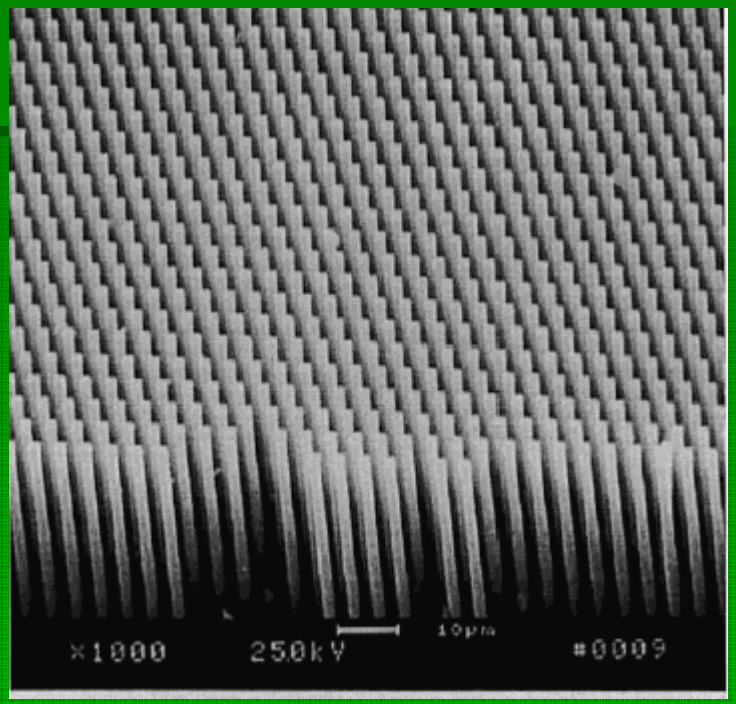
T. Onda,*,† S. Shibuichi,† N. Satoh,‡ and K. Tsujii†



Langmuir **2000**, *16*, 7777−7782

Ultrahydrophobic Surfaces. Effects of Topography Length Scales on Wettability

Didem Öner and Thomas J. McCarthy*

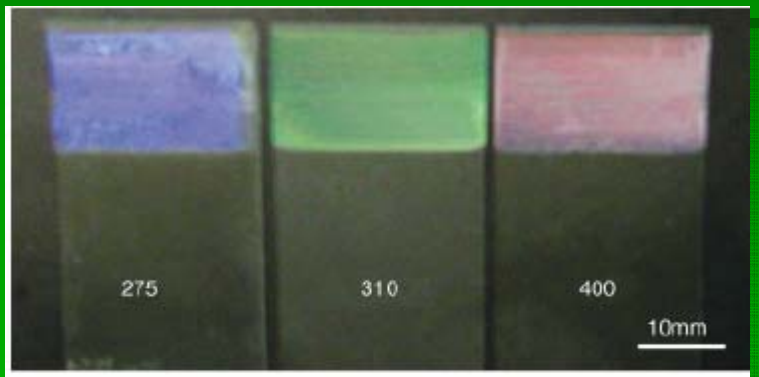


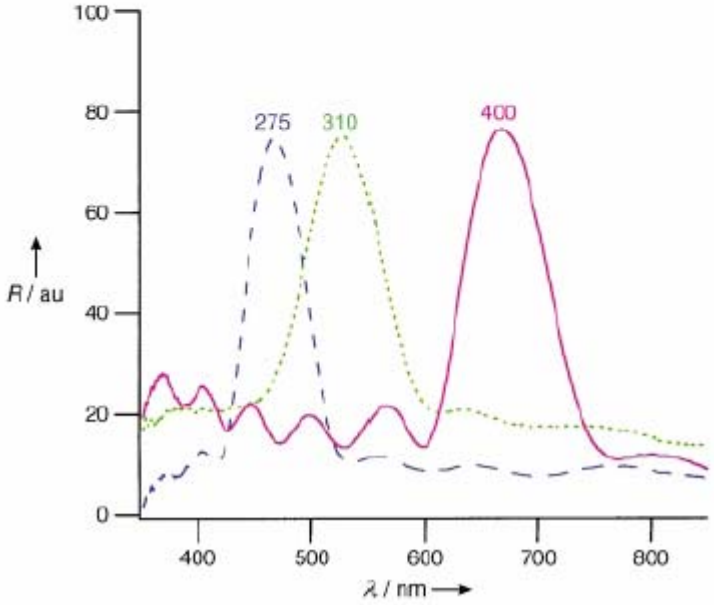
silicon surface	DMDCS-modified		ODMCS-modified		FDDCS-modified	
	θ_A (deg)	θ_R (deg)	θ_A (deg)	θ_R (deg)	θ_A (deg)	θ_R (deg)
smooth	107	102	102	94	119	110
2μmSP40μm	176	141	174	141	170	146
8μmSP40μm	173	134	173	139	170	140
16μmSP40μm	171	144	174	134	168	145
32μmSP40μm	168	142	170	132	170	146
64μmSP40μm	139	81	114	65	149	100
128μmSP40μm	116	80	95	58	131	93

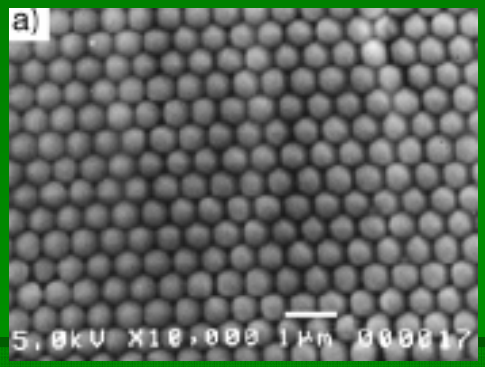
Surface Effects from Nanostructure

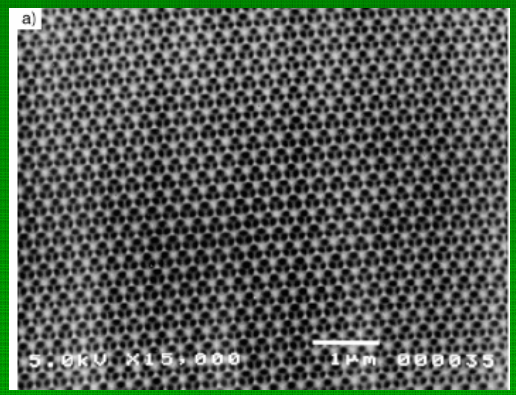
Structural Color and the Lotus Effect**

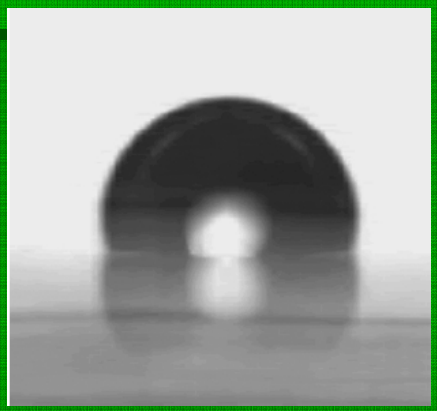
*Zhong-Ze Gu, Hiroshi Uetsuka, Kazuyuki Takahashi, Rie Nakajima, Hiroshi Onishi, Akira Fujishima, and Osamu Sato**

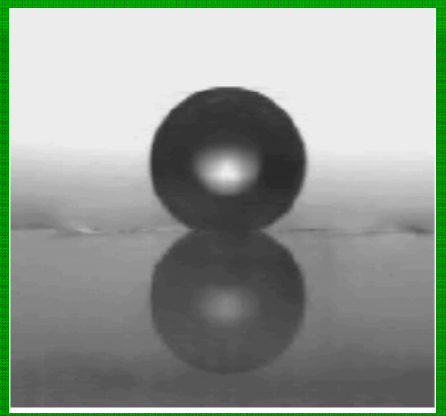






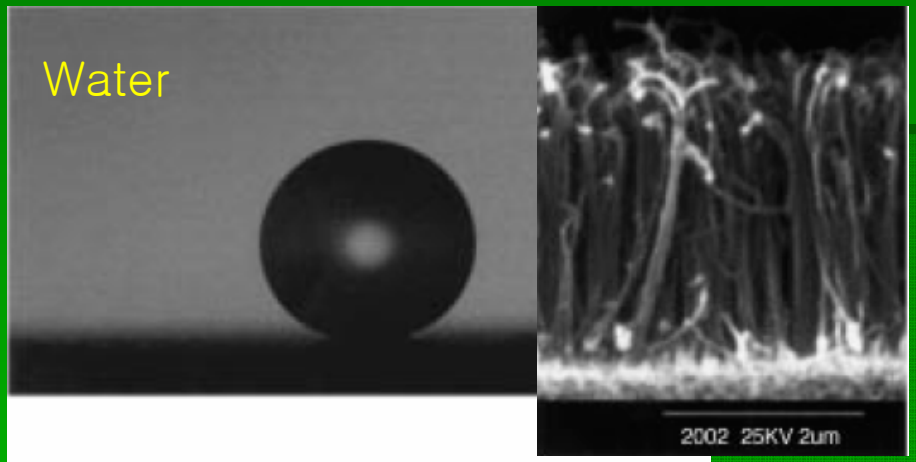


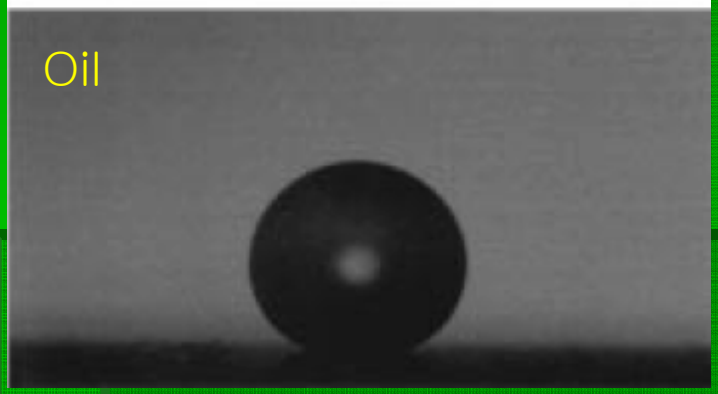




Super-"Amphiphobic" Aligned Carbon Nanotube Films**

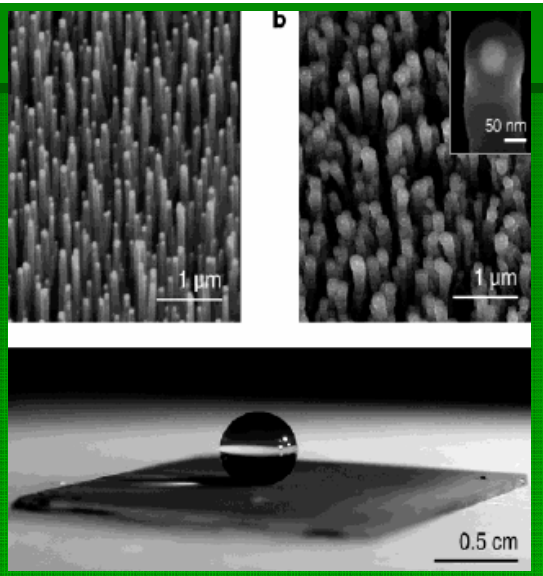
Huanjun Li, Xianbao Wang, Yanlin Song, Yunqi Liu, Qianshu Li, Lei Jiang,* and Daoben Zhu

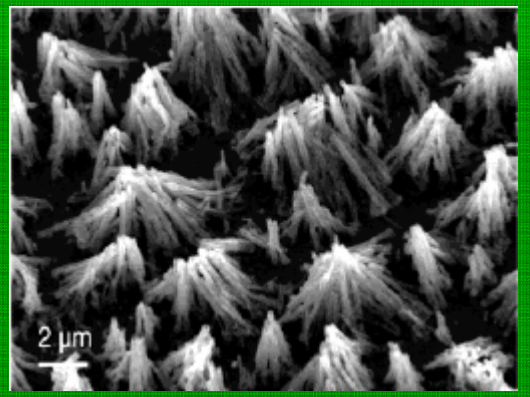




Superhydrophobic Carbon Nanotube Forests

Kenneth K. S. Lau,*,† José Bico,‡ Kenneth B. K. Teo,§ Manish Chhowalla,|| Gehan A. J. Amaratunga,§ William I. Milne,§ Gareth H. McKinley,‡ and Karen K. Gleason†





Reversible Super-hydrophobicity to Super-hydrophilicity Transition of Aligned ZnO Nanorod Films

Xinjian Feng, Lin Feng, Meihua Jin, Jin Zhai, Lei Jiang,* and Daoben Zhu