Principles of Micro- and Nanofabrication for Electronic and Photonic Devices

Etching 刻蚀
Part I: Overview

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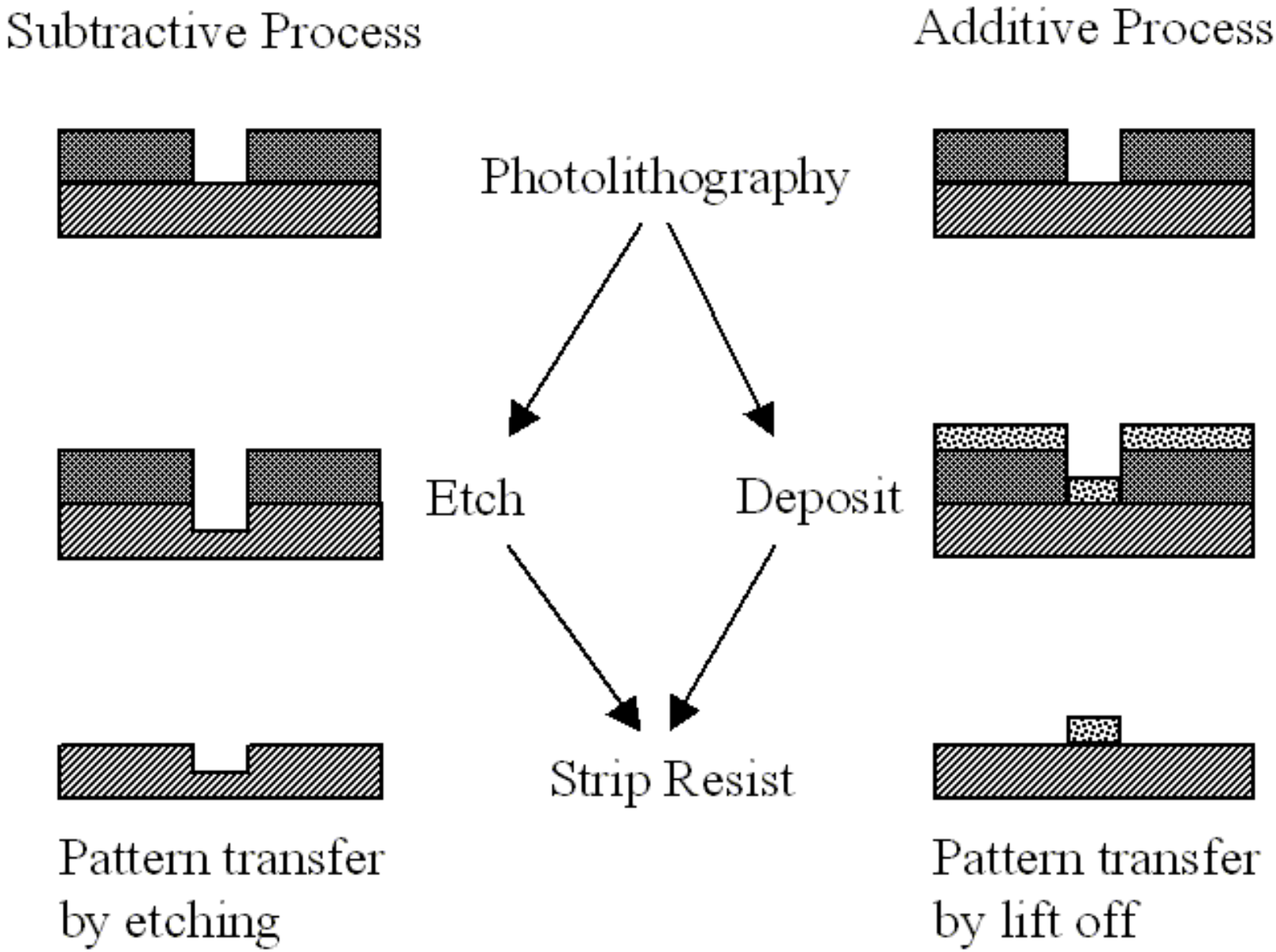
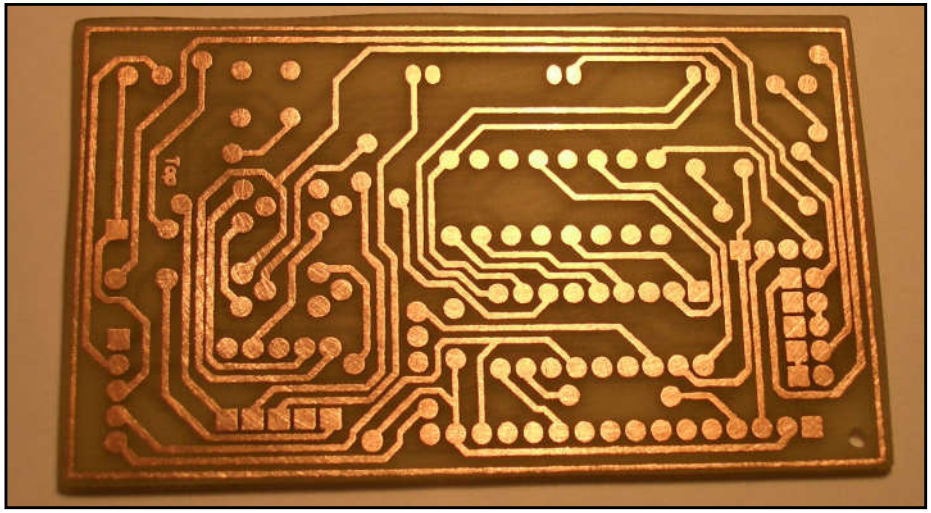
Pattern Formation



Etching vs. Corrosion

Etching (刻蚀)



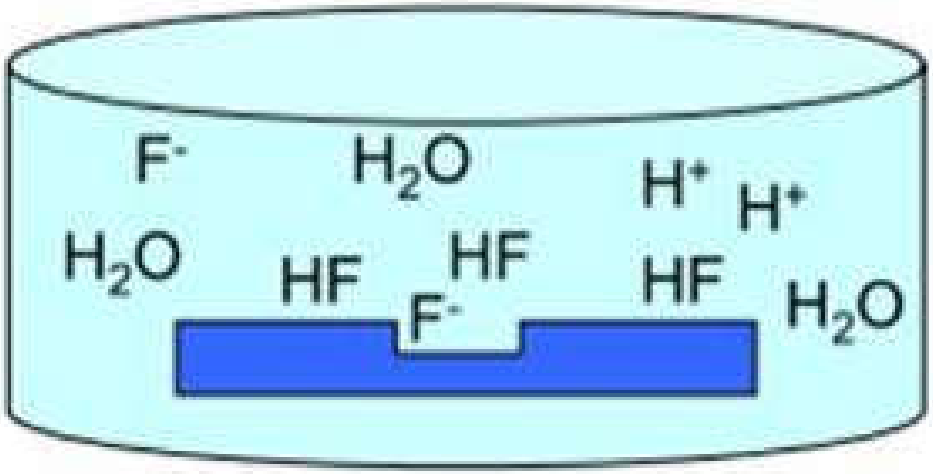
wanted

Corrosion (腐蚀)

unwanted

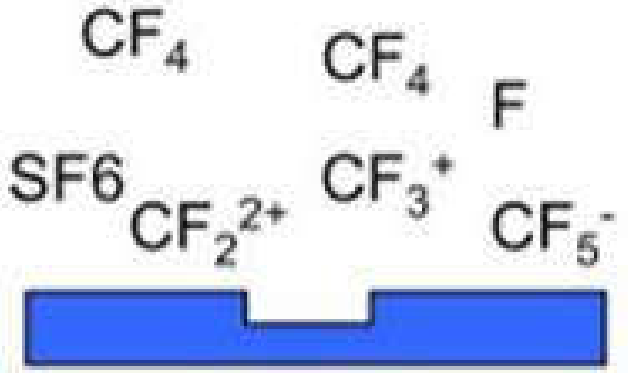
Wet vs. Dry

liquid source



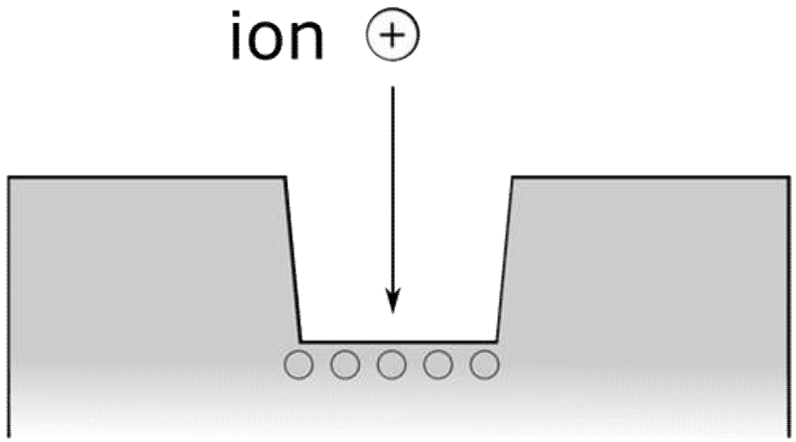
Wet Etch

gas source

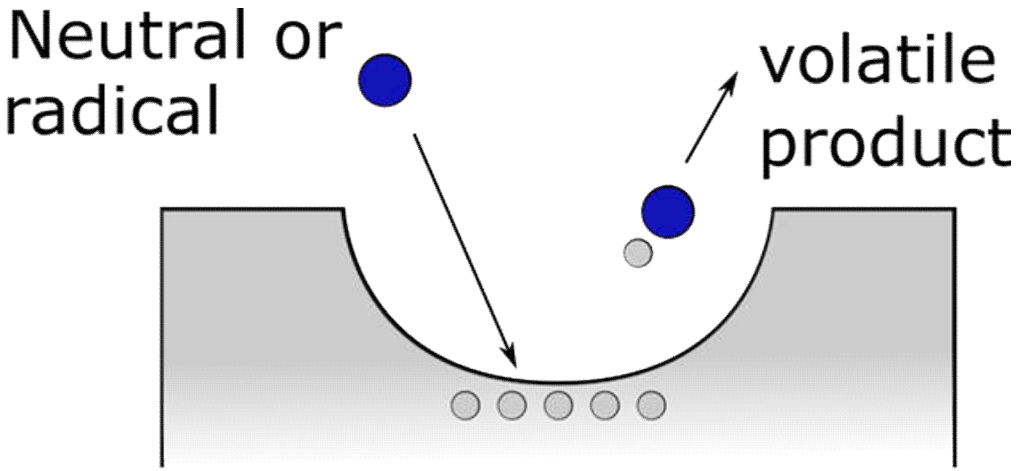


Dry Etch

Physical vs. Chemical



Physical etching
(sputtering)

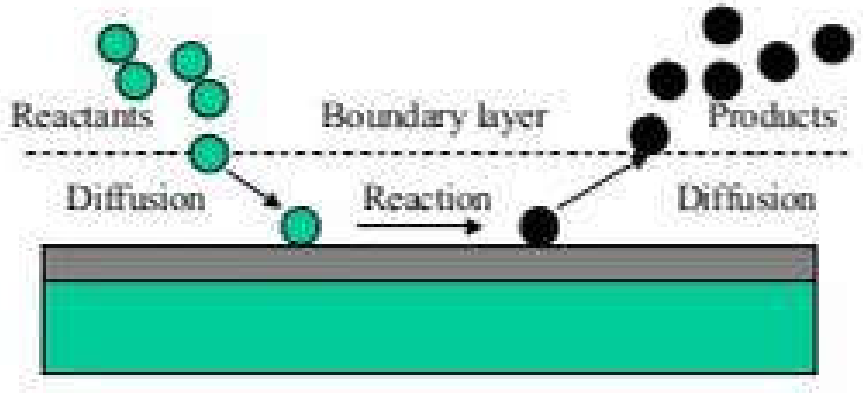


Chemical Etching

Etching

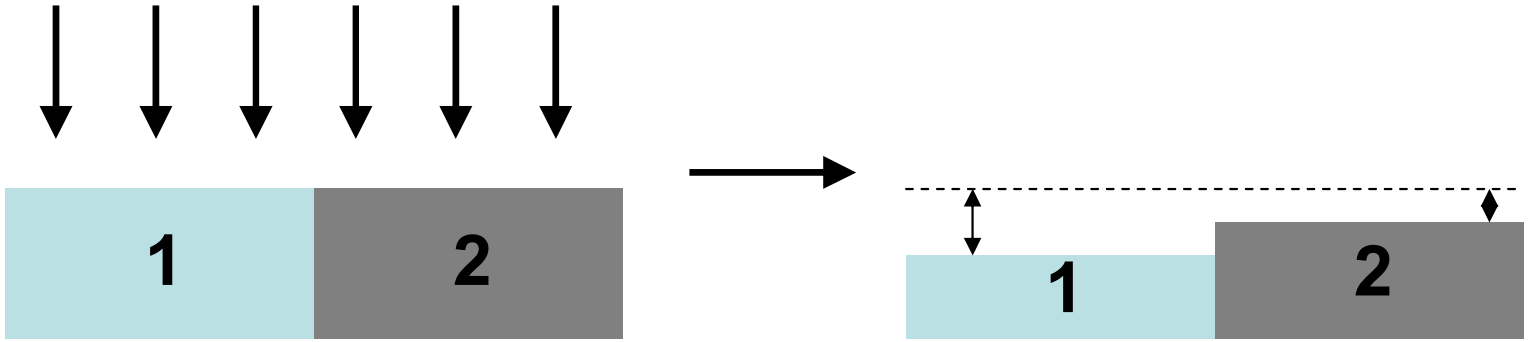
- **Process Parameters**
  - Time
  - Temperature
  - Etchant type
  - Etchant concentration
  - Mask type
  - ...
- **Control Parameters**
  - Etch rate
  - Selectivity
  - Anisotropy
  - Uniformity
  - ...

diffusion - reaction - diffusion

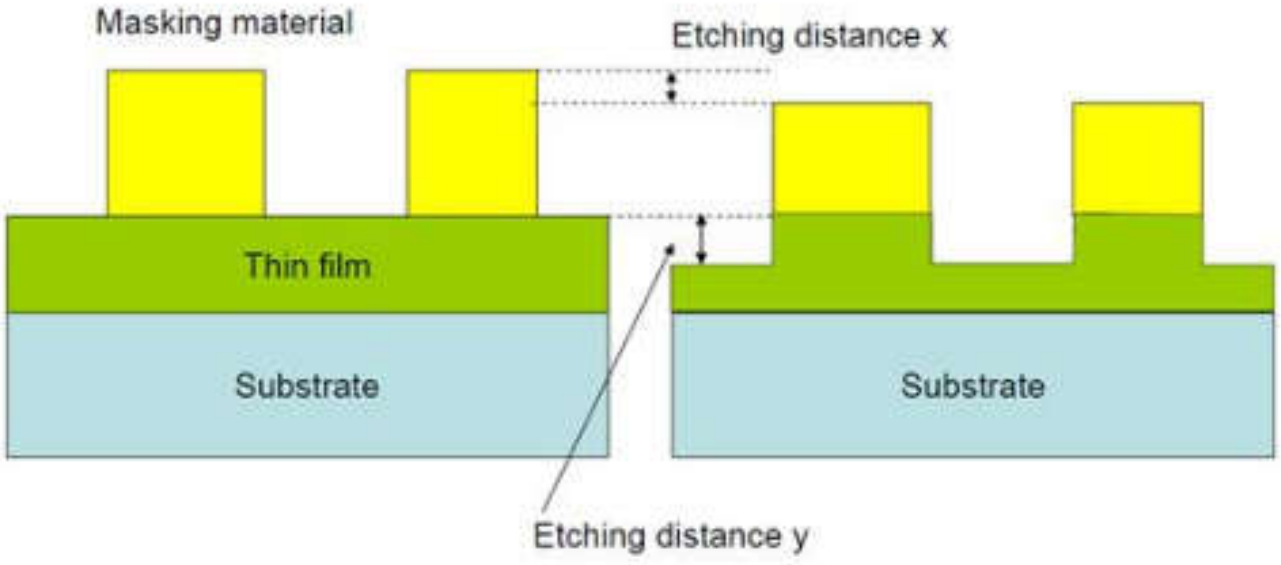


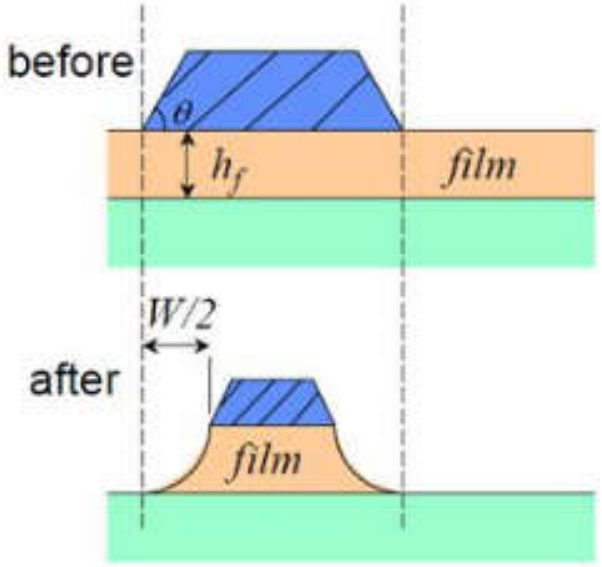
- chemical reactions occur
- products should be disposable

Selectivity



$$S_{12} = \frac{R_1}{R_2}$$





Etching with mask erosion

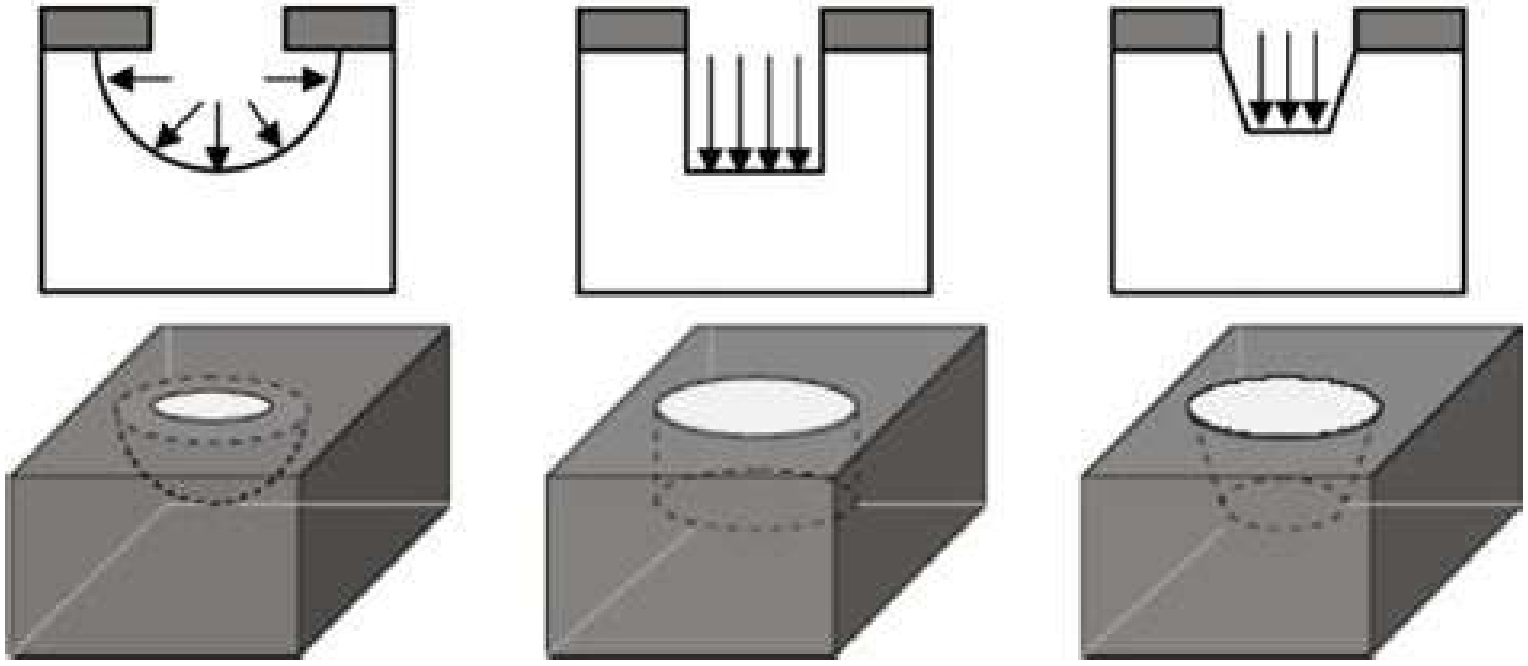
Selectivity - Example

- SiO_2 / Si wet etch by HF solution
  - very large selectivity $S_{SiO2/Si}$ ~ infinity
- SiO_2 / Si dry etch by CF_4 plasma
  - selectivity $S_{SiO2/Si}$ ~ 10

Anisotropy (各向异性)

degree of anisotropy

$$A = 1 - \frac{R_{lateral}}{R_{vertical}}$$



isotropic
A = 0

fully anisotropic
A = 1

anisotropic
0 < A < 1

Isotropic vs. Anisotropic

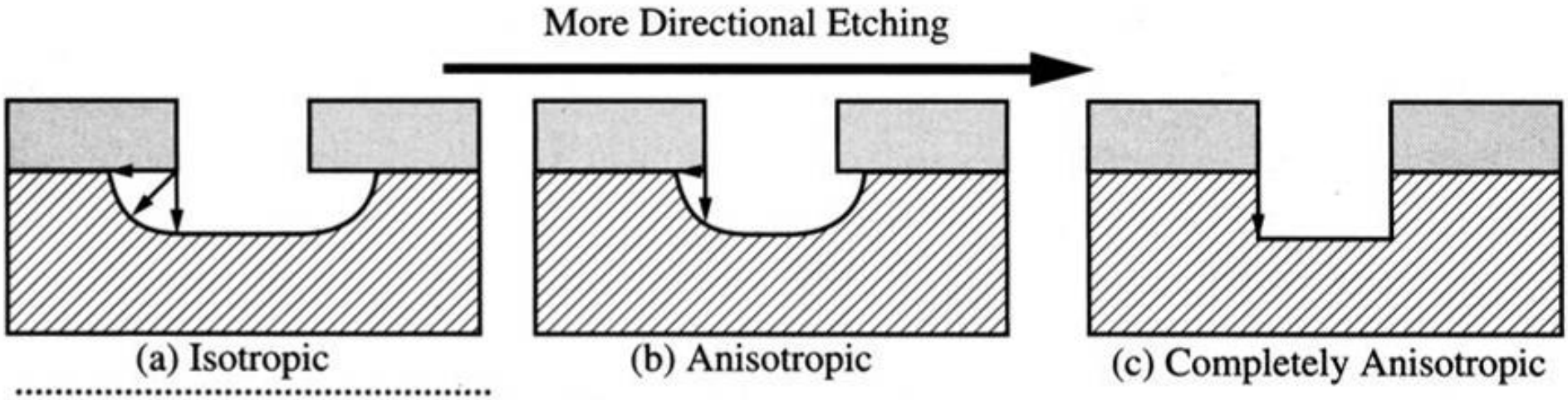
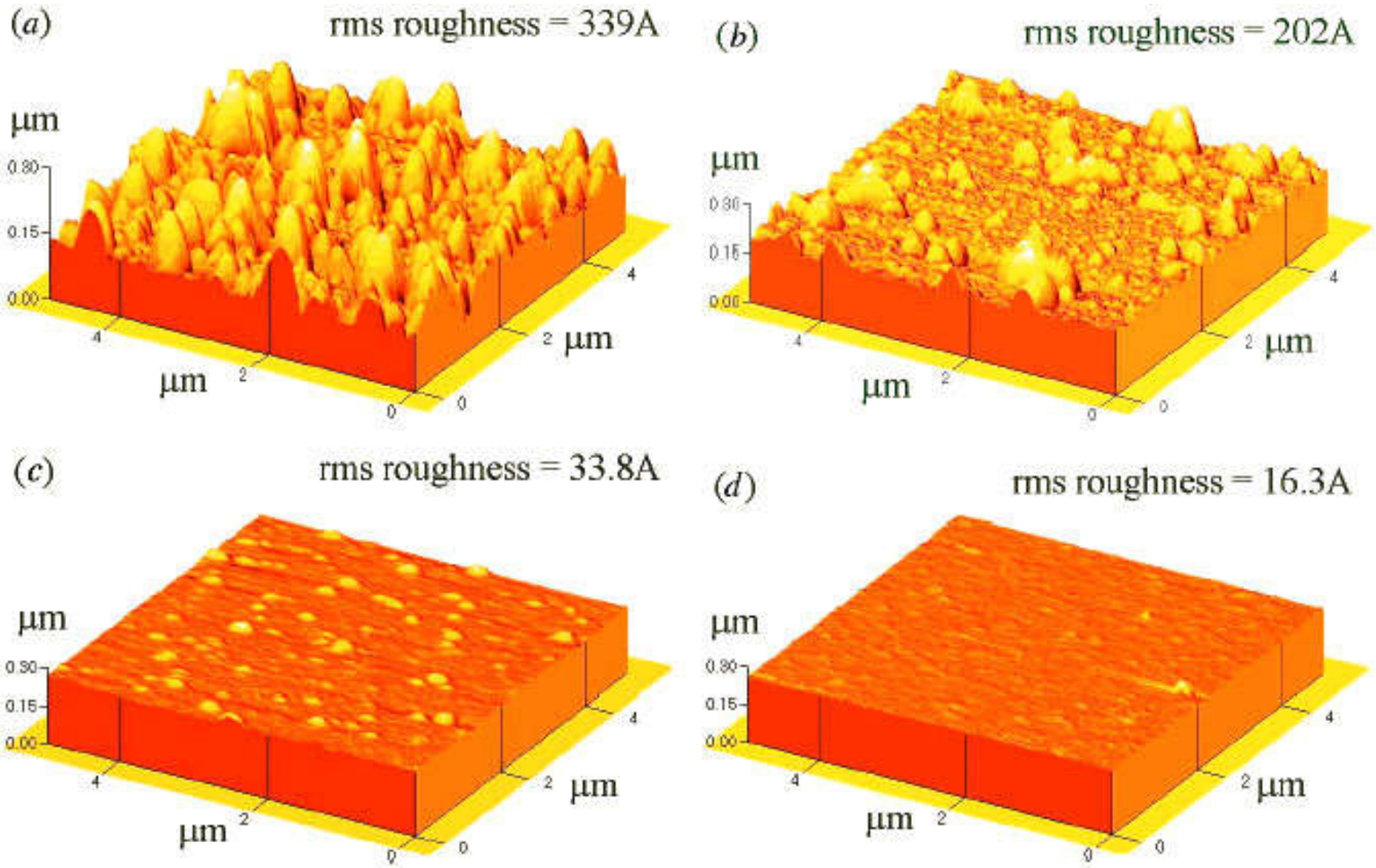


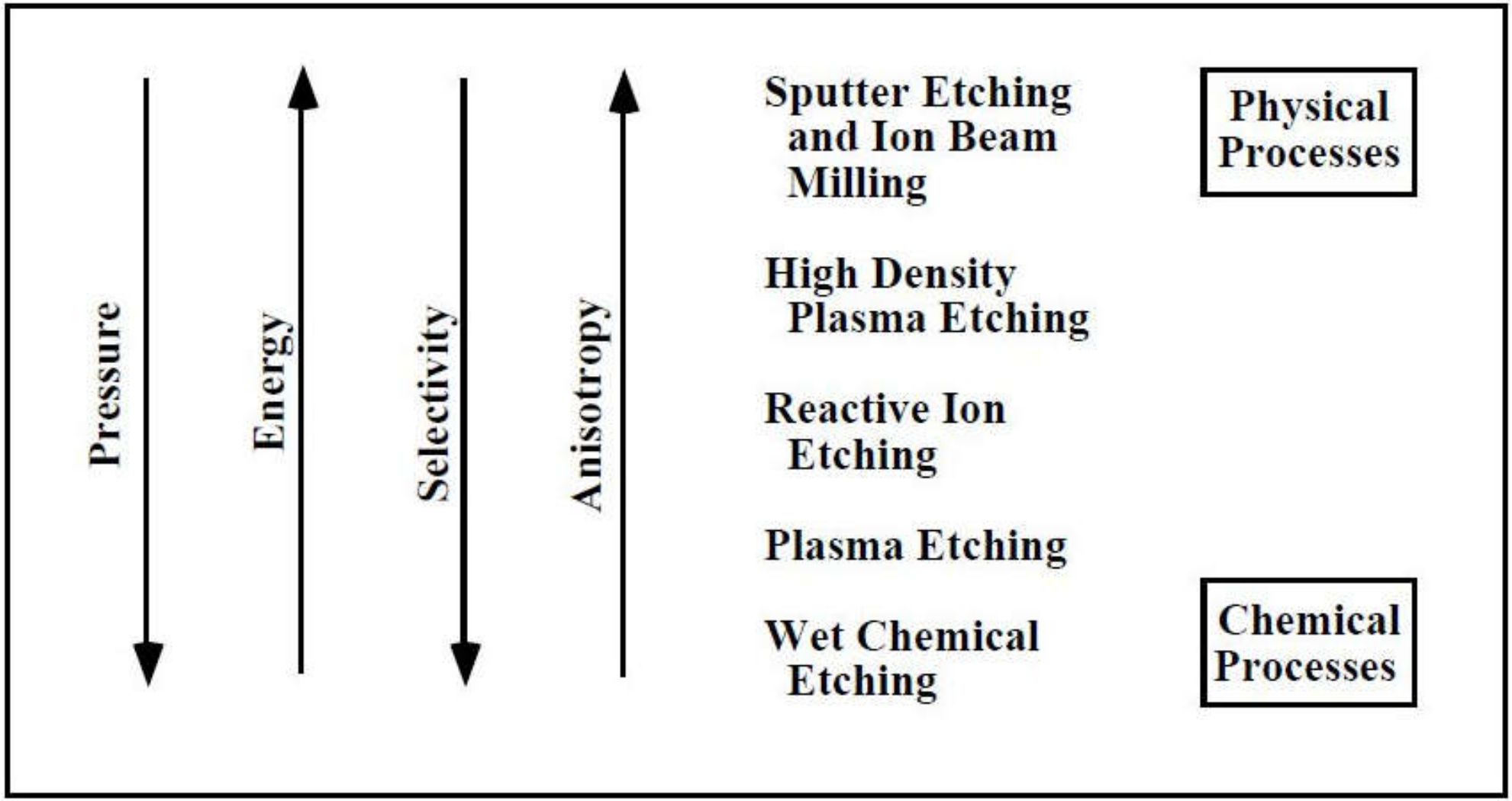
Figure 10–3 Etch profiles for different degrees of anisotropic, or directional, etching: (a) purely isotropic etching; (b) anisotropic etching; (c) completely anisotropic etching.

chemical → **physical**

Uniformity


(a)
rms roughness = 339A
(b)
rms roughness = 202A
(c)
rms roughness = 33.8A
(d)
rms roughness = 16.3A
μm
0.30
0.15
0.00
4
2
0
μm

Trends of Etching



Etching Methods

- Wet Etching 湿法刻蚀
- Dry Etching 干法刻蚀
- CMP and other methods