

# Etching

Etching is to remove any material layer not protected by hardened photoresist after photolithography. It uses the reaction between the chemical (wet etching) or ionized gas (dry or plasma etching) with the material.

- High degree of selectivity is required so that etchant will remove material layer more rapidly than photoresist.

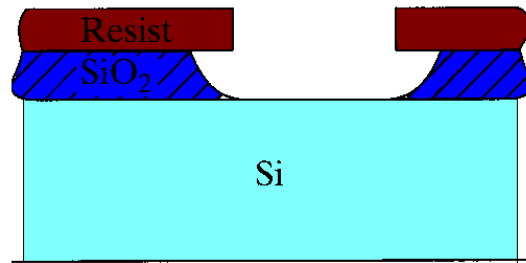
There are 2 techniques of etching:

- Wet etching (also known as chemical etching)
- Dry etching (also known as plasma etching)

# Wet Etching

Use chemicals for example diluted HF acid also known as Buffered oxide etch (BOE) to etch silicon dioxide.

- More hazardous.
- Simple & less costly system.
- Isotropic process, etching equally in all direction causing undercut.



Wet Isotropic Etch

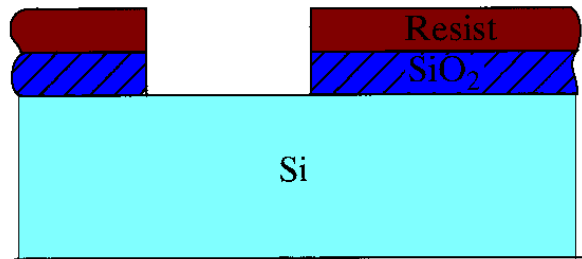


Automated Acid Etch  
(SEZ)

# Dry Etching

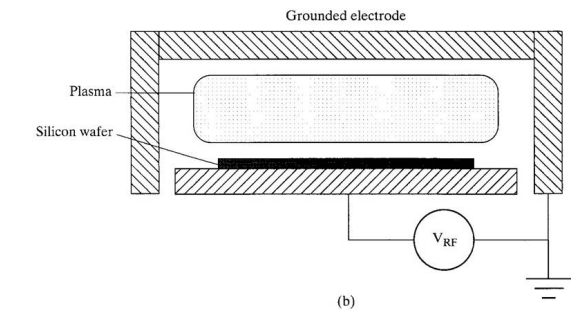
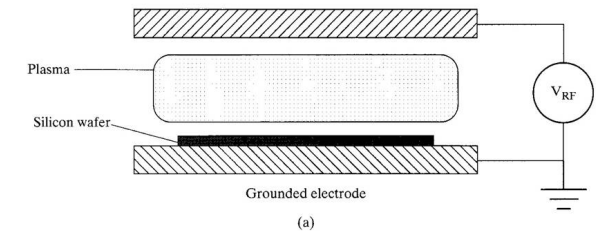
Use RF excitation to ionize the gas (plasma) in a vacuum system for example  $\text{CF}_4$  gas to etch silicon dioxide.

- Less hazardous.
- Complex & more costly system.
- Anisotropic process, without causing undercut.



Wet Isotropic Etch

Plasma-Etching Sources	
Material	Source Gases
Organic Materials	$\text{O}_2, \text{SF}_6, \text{CF}_4$
Polysilicon	$\text{CCl}_4, \text{CF}_4, \text{NF}_3, \text{SF}_6$
Silicon Dioxide	$\text{CF}_4, \text{C}_2\text{F}_6, \text{C}_3\text{F}_8, \text{CHF}_3$
Silicon Nitride	$\text{CF}_4, \text{C}_2\text{F}_6, \text{CHF}_3, \text{SF}_6$
Aluminum	$\text{CCl}_4, \text{Cl}_2, \text{BCl}_3$
Titanium	$\text{C}_2\text{Cl}_2\text{F}_4, \text{CF}_4$
Tungsten	$\text{Cl}_2$

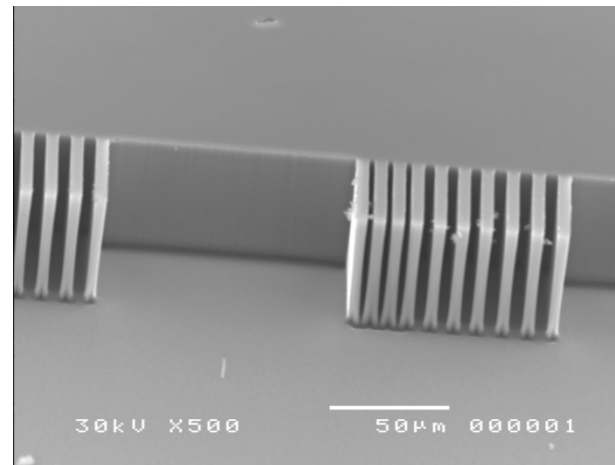
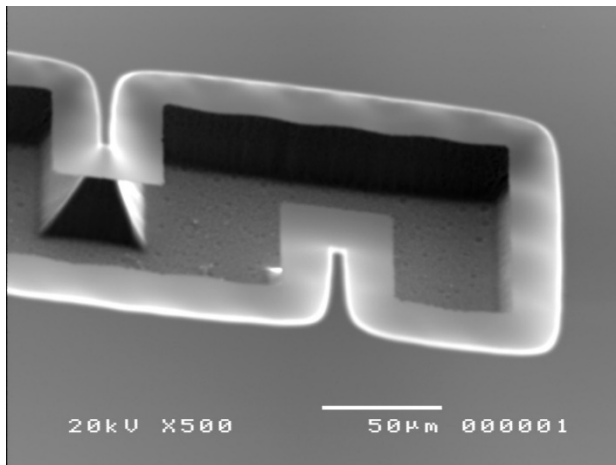


(a) Concept of a parallel plate plasma etcher (b) Asymmetrical reactive ion etching (RIE) system

# Reactive Ion Etching (RIE)

Reactive-ion etching (RIE) combines the plasma etching and sputtering action (covered in thin film deposition) of the ionized gas (plasma). It is used for cutting deep trenches especially for MEMS application & fabrication.

- Highly anisotropic



Isotropic & highly Anisotropic etching in MEMS fabrication

# Photoresist Removal

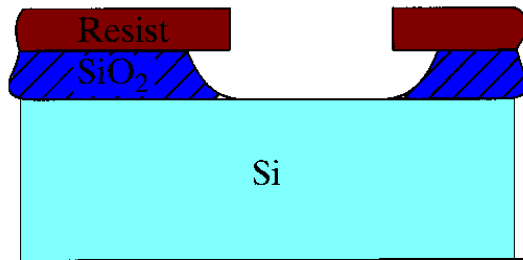
Although strictly speaking, this is not part of etching but it is always done after etching. After etching, photoresist is removed leaving behind the un-etched material layer (pattern of the mask used in photolithography)

- Typically uses resist stripper or acetone after wet etching.
- Oxygen plasma is used after dry etching, also known as photoresist ashing

# Summary

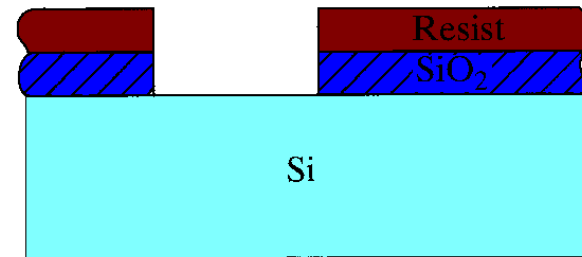
## Wet Etching

- Requires disposal of relative large amounts of liquid chemical waste (Hazardous)
- Simple & less costly system
  - Isotropic



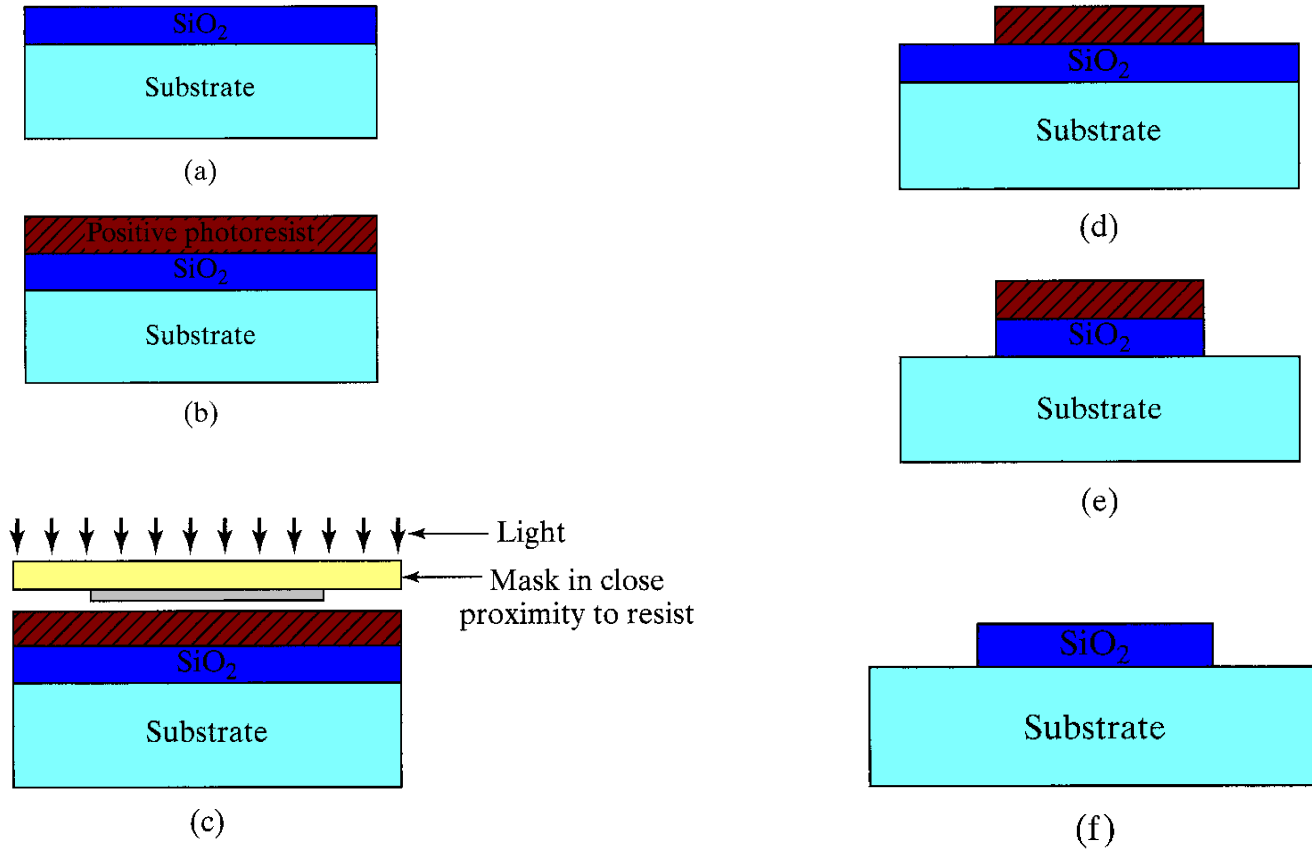
## Dry Etching

- Requires only small amount of reactant gas & exhausted safely (less Hazardous)
- Complex & more costly system
  - Generally anisotropic



# Summary

Material layer formation followed by Photolithography followed by Etching, also known as Lithography



- Today we are reaching the limits of optical lithography.
- The wavelength of light is too long to produce smaller features.