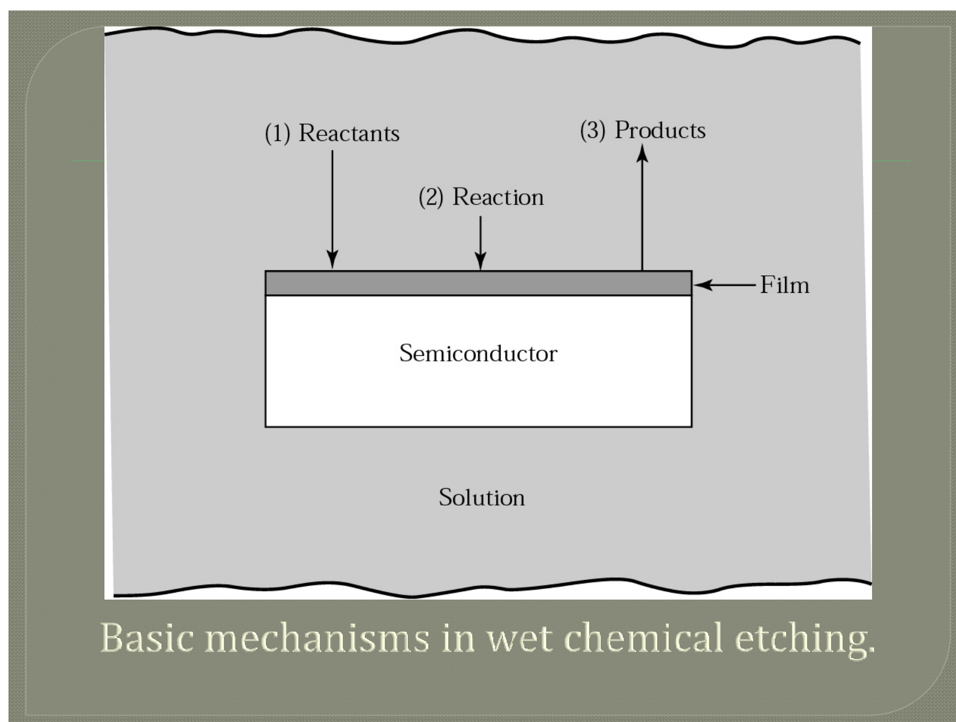
Etching

Etching

- To produce circuit features, the resist patterns (made be lithography) must be transferred into the underlying layers comprising the device.
- The pattern transfer is accomplished by an etching process that selectively removes unmasked portions of a layer.
- Etching categories:
  - Dry etching
  - Wet etching

Wet Etching

- Wet chemical etching is used extensively in semiconductor processing. Starting from semiconductor wafers sliced from an ingot, chemical etchants are used for lapping and polishing to give an optically flat damage free surface. Prior to thermal oxidation or epitaxial growth, semiconductor wafers are chemically cleaned to remove contamination that results from handling and storing. Wet chemical etching is especially suitable for blanket etches (i.e. Over the hole wafer surface) of polysilicon oxide, nitride metals. and III -V compounds.
- The mechanisms for wet chemical etching involve three essential steps:
  - The reactants are transported by diffusion to the reacting surface
  - chemical reactions occur at the surface
  - the products from the surface are removed by diffusion.
- Both agitation and the temperature of the etchant solution influence the etch rate, which is the amount of film removed by etching per unit time

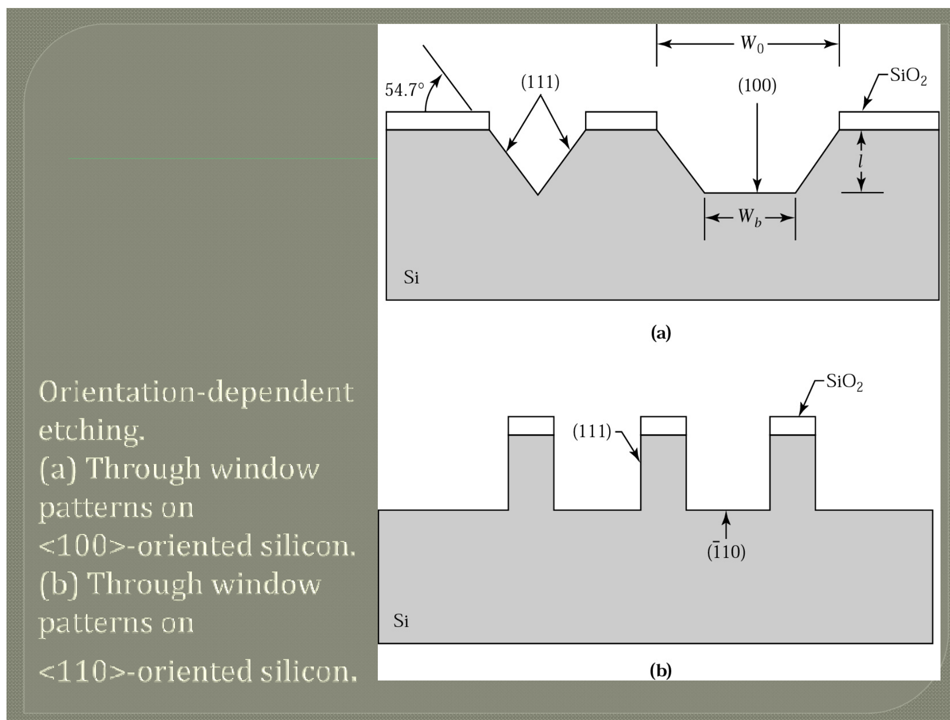


Basic mechanisms in wet chemical etching.

Silicon Etching

- For semiconductor materials wet chemical etching usually proceeds by oxidation, followed by the dissolution or the oxide by a chemical reaction.
- For silicon the most commonly used etchants arc mixtures or nitric acid (HNO_3) and hydrofluoric acid (HF) in water or acetic acid (CH_3COOH).

- HF is used to dissolve the SiO_2 layer:



Orientation-dependent etching.
(a) Through window patterns on <100>-oriented silicon.
(b) Through window patterns on <110>-oriented silicon.

Silicon Etching (Cont.)

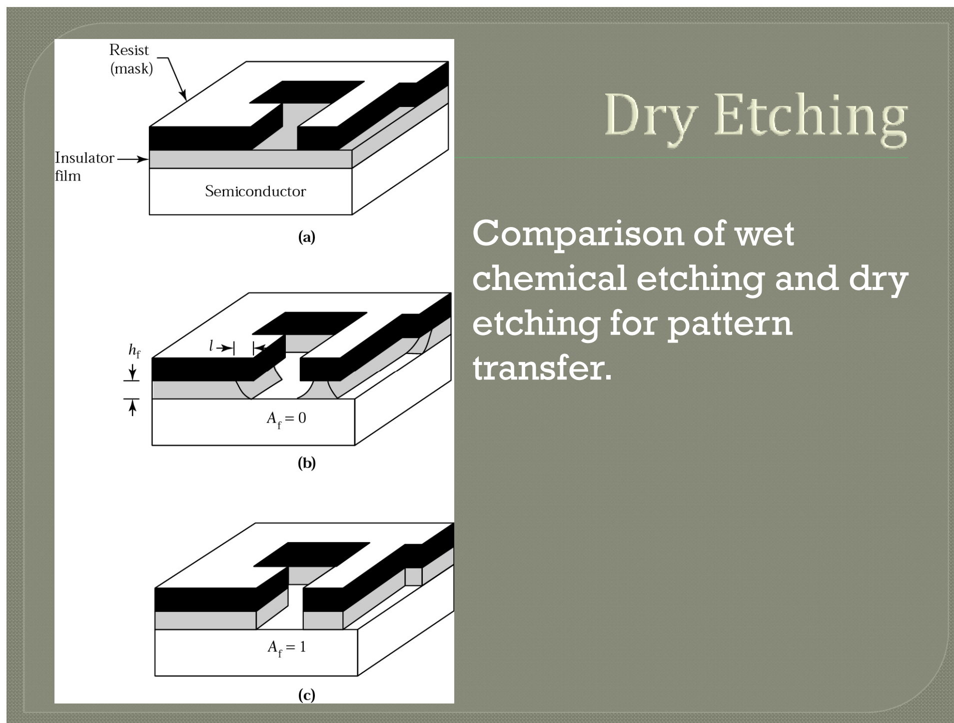
- For <111> planes the etching rate is slower.
- For <100> plane:

$$W_b=W_o-2l\cos 54.7=W_o+2^{1/2}l$$

<100> 0.6 um/min
<110> 0.1 um/min
<111> 0.006 um/min
<100>:<110>:<111> 100:16:1 80 C

TABLE 5.1 Etchants for Insulators and Conductors

Material	Etchant Composition	Etch Rate (nm/min)
SiO_2	28 ml HF, 170 ml HF, 113 g NH_4F (Buffered HF)	100
	15 ml HF, 10 ml HNO_3, 300 ml H_2O (P etch)	12
Si_3N_4	Buffered HF	0.5
Al	H_3PO_4	10
	4 ml HNO_3, 3.5 ml CH_3COOH, 73 ml H_3PO_4, 19.5 ml H_2O	30
Au	4 g KI	1000


Resist
(mask)
Insulator
film
Semiconductor
(a)
h_f
l
$A_f = 0$
(b)
$A_f = 1$
(c)
Dry Etching
Comparison of wet chemical etching and dry etching for pattern transfer.