EE 143: Microfabrication Technology
Lecture 14c: Etching I

CTN 3/4/10

Lecture 14: Etching

- **Announcements**:
- Might need volunteers for Cal Day: if interested, sign up with your lab TA
- Midterm Exam: coming Thursday, March 18
  - Evening exam? 9 for different time; 14 for this period → so it'll be during lecture
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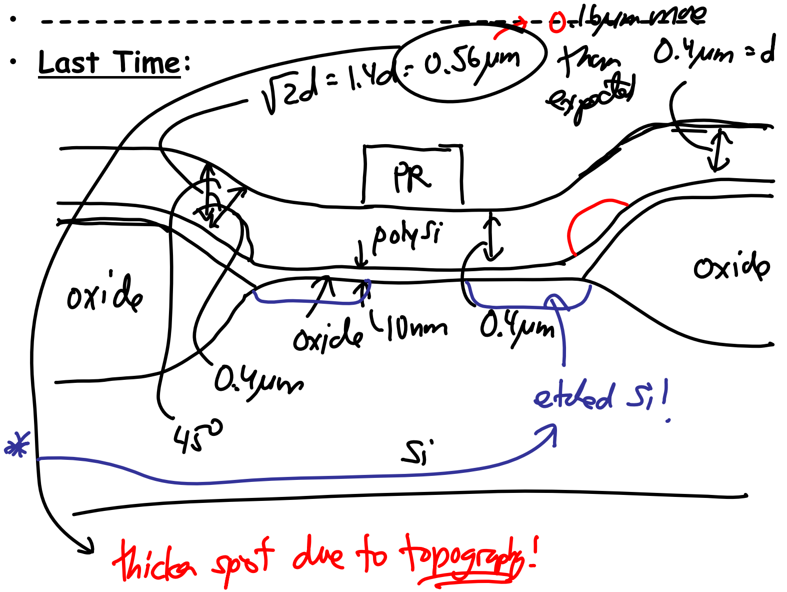
- **Lecture Topics**:
  - Etching
    - Anisotropy
    - Selectivity
      - Deep Reactive Ion Etching (DRIE)
    - Wet Etching
    - Dry Etching
      - Plasma Etching
      - Reactive Ion Etching (RIE)
- --
- **Last Time**:



Thus, must overetch by at least 40%:

40% overetch → $(0.4)(0.4) = 0.16\mu m$ poly Si

$= ???$ oxide

Depends upon the selectivity of the etchant to polysilicon versus oxide

Define selectivity to A over B:

$$S_{ab} = \frac{E.R._a}{E.R._b}$$

$E.R._a$ ← etch rate of A

$E.R._b$ ← etch rate of B

S_{ab} ← selectivity of a over b

e.g., wet polysilicon etch ($HNO_3 + NH_4F + H_2O$)

$S_{poly/SiO_2} = \frac{15}{1}$ (very good selectivity)

$S_{poly/PR}$ = very high

(but PR can still peel off after soaking for >30 min., so beware) e.g., polysilicon dry etch:

$S_{poly/SiO_2} = \frac{5-7}{1}$ ← regular RIE (but depends on the type of etcher)

very high density plasma → ECR: 30:1

Bosch: 100:1 (or better)

If $S_{poly/ox} = \frac{8}{1}$ ⟹ 40% overetch removes:

$\frac{0.16\mu}{8} = 20$ nm of oxide! — *

this will etch all the polySi over the SiO_2 in the active area; then etch all the SiO_2 (10nm); then start etching the S/D drain regions very fast! Bad

w/ better selectivity,

e.g. $S_{polySi/ox} = \frac{30}{1}$ (ECR) ← high density plasma

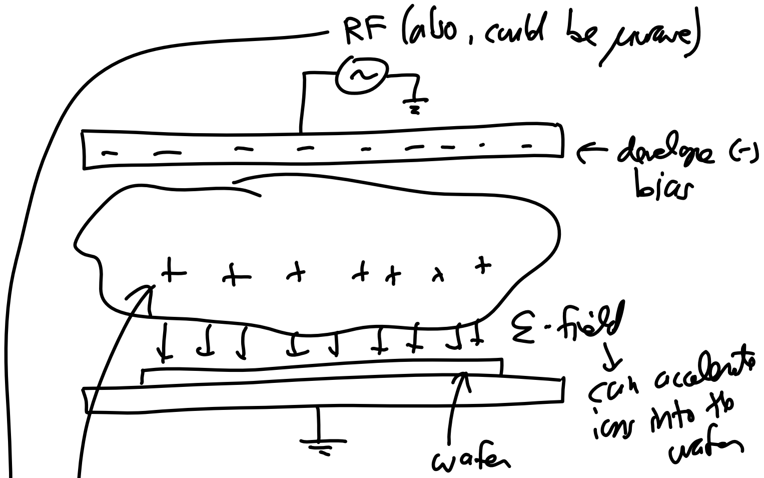
40% overetch removes $\frac{0.16}{30} = 5.3$nm (better)

Go through module on wet etching.

Dry Etching

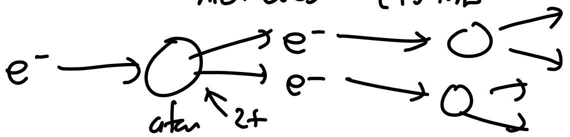
- Physical Sputtering
- Plasma Etching
- Reactive Ion Etching

} All based upon plasma processes!



plasma (partially ionized gas composed of ions, e⁻'s, and highly reactive neutral species)

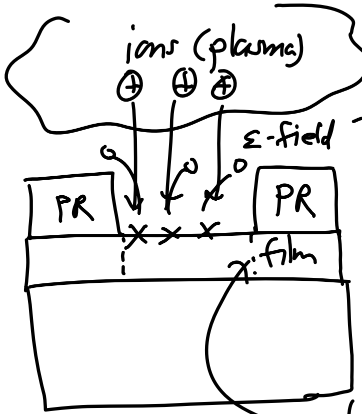
RF energy → inelastic collisions between e⁻'s & molecules → (+) ions



avalanche effect!

Physical Sputtering (ion milling)

⇒ bombard the substrate w/ energetic ions
↳ etching via physical momentum transfer

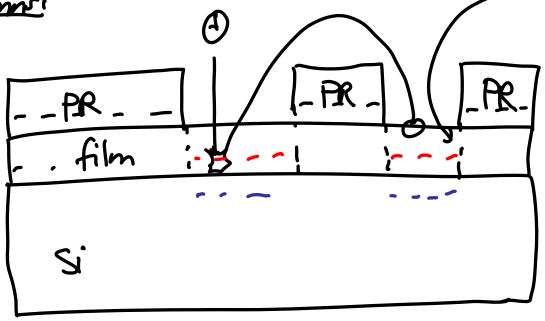


→ give the ions energy & directionality using E-fields

⇒ highly directional
⇒ very anisotropic

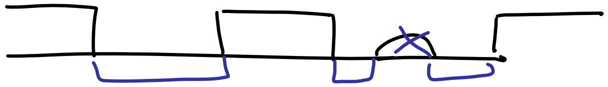
steep vertical wall

Problems:



① PR & other masking material etched at almost the same rate as the film to be etched (very poor selectivity!)

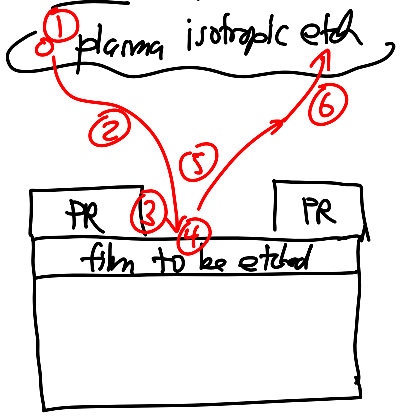
② Ejected species not inherently volatile
↳ get redeposition → non-uniform etch!



Plasma Etching

⇒ plasma (gas glow discharge) creates reactive species that chemically react w/ the film to be etched

⇒ Result: much better selectivity, but get an isotropic etch



Plasma Etching Mechanism

① Reactive species generated in a plasma.
② " " diffuse to the surface of the material to be etched
③ Species adsorbed on the surface.
④ Chemical reaction.

⑤ By-product desorbed from surface.

⑥ Desorbed species must diffuse into the gas stream.

MOST IMPORTANT STEP!
(determines whether plasma etching is possible or not)