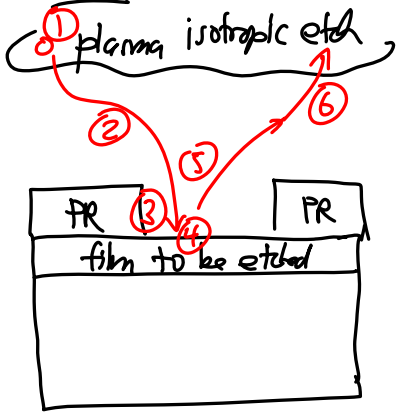
Lecture 15: Etching II

- Announcements:
- Need volunteers for Cal Day (April 17):
  - Alumni & prospective students visit Cal
  - If interested, sign up with your lab TA
- HW#6:
  - Add problem 5.2 and 5.4 from Jaegar
  - HW#6 due next Tuesday, 3/16/10
- Midterm Exam: coming Thursday, March 18
  - It'll be during lecture
  - Review Session Time: Tu 6-8? 20 votes
- ---
- Lecture Topics:
  - Etching
    - Anisotropy
    - Selectivity
    - Wet Etching
    - Dry Etching
      - Ion Milling
      - Plasma Etching
      - Reactive Ion Etching (RIE)
      - Deep Reactive Ion Etching (DRIE)
      - Chemical Mechanical Polishing (CMP)
  - Ion Implantation
    - Gaussian Distribution
    - Range, Straggle, & Lateral Straggle
    - Masking
    - Junction Depth
- ---

- Last Time: Plasma Etching

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

⇒ Result: much better selectivity, but got 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 ↑ the gas stream. MOST IMPORTANT STEP!

Ex. Polysilicon Etching w/ CF_4 and O_2

$CF_4 \xrightarrow{\text{plasma}} CF_4^+ + CF_3^+ + CF_2^+ + CF^+ + F^+ + F^0 + \dots$

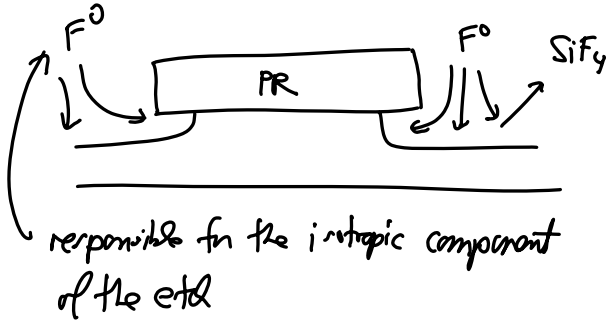
neutral radical (highly reactive!)

$e^- + CF_4 \rightarrow CF_3 + F^0 + e^-$

Si

$SiCF_6, SiF_4$ ← both volatile ∴ dry etching is possible

⇒ F^0 is the dominant reactant
↳ but it can't be given a direction
∴ get isotropic etch!



responsible for the isotropic component of the etch

Problems:
① isotropic etching
② formation of polymer, because of C in CF_4
↳ Soln: add O_2 to remove polymer
(but note this reduces S poly/PR)

Soln: use

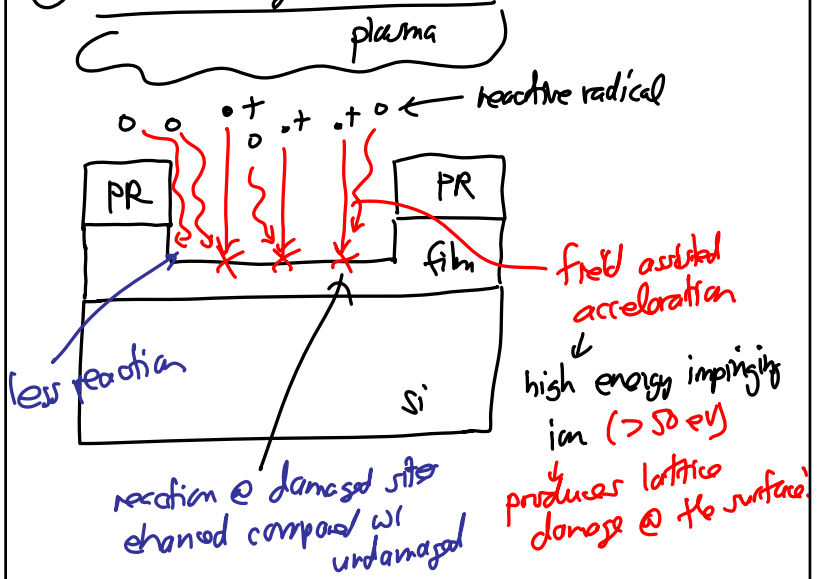
Reactive Ion Etching (RIE)

⇒ use ion bombardment to aid & enhance reactive etching in a particular direction
↳ Result: directional, anisotropic etching!

RIE ← a bit of a misnomer
↳ ions are not reacting; rather, they just enhance the reaction in a specific direction

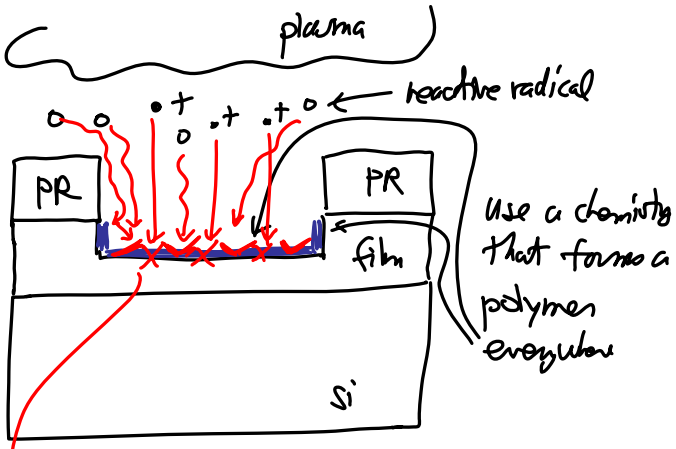
Two Principle Mechanisms Behind RIE:

① Surface Damage Mechanism –



Result: E.R. @ surface >> E.R. on sidewalls

② Surface Inhibitor Mechanism -

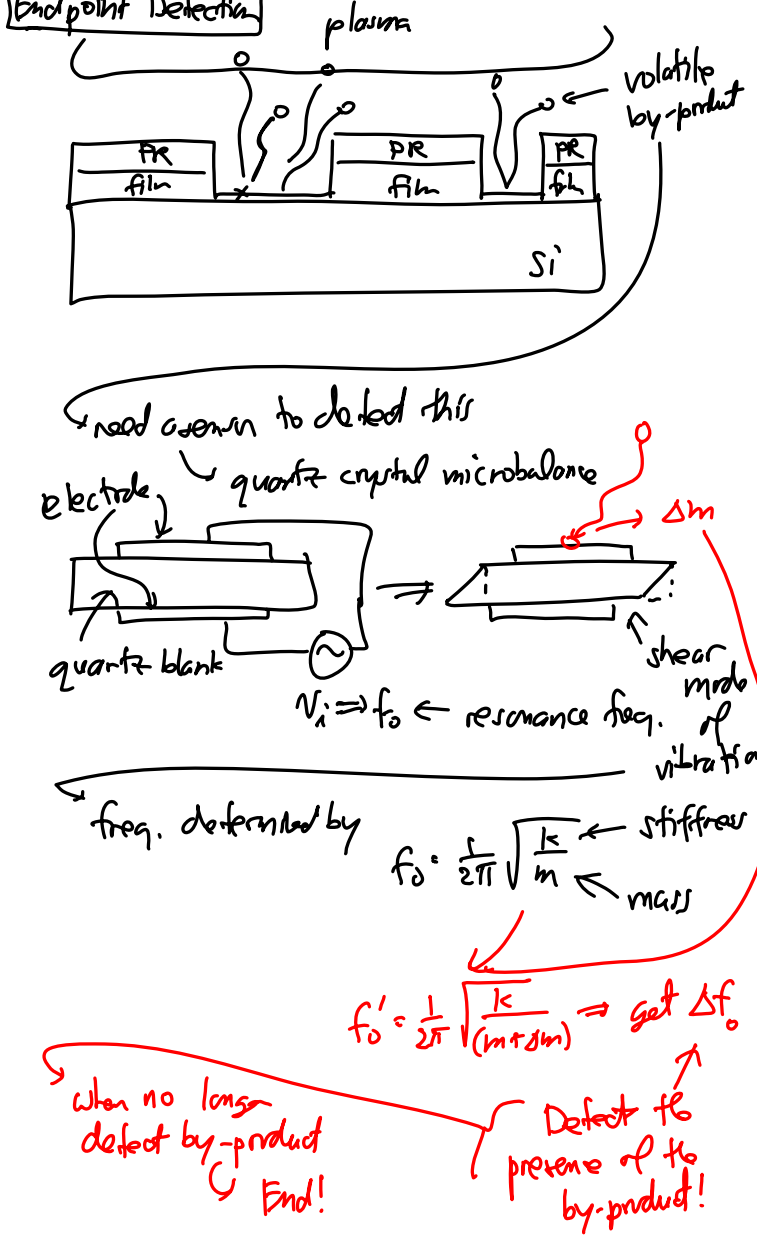


High energy ions impact the surface & break up the polymer! → get reaction w/ neutral radicals

Result: E.R. @ surface >> E.R. on sidewalls

Loading Effects in Etching

Endpoint Detection



Ion Implantation

⇒ method by which dopants can be introduced into Si (actually into anything) to form, e.g., pn-junctions, S/D junctions, & to set threshold voltages

The Basic Process: