

Lecture 5: Process Module Overview II

- Announcements:
  - ↳ These are prepared notes
- Lecture Topics:
  - ↳ Finish Materials Handout (from last lecture)
  - ↳ Process Modules
    - Photolithography
    - Etching
    - Oxidation
    - Film Deposition
- Finish Materials Lecture from last time

Process Modules

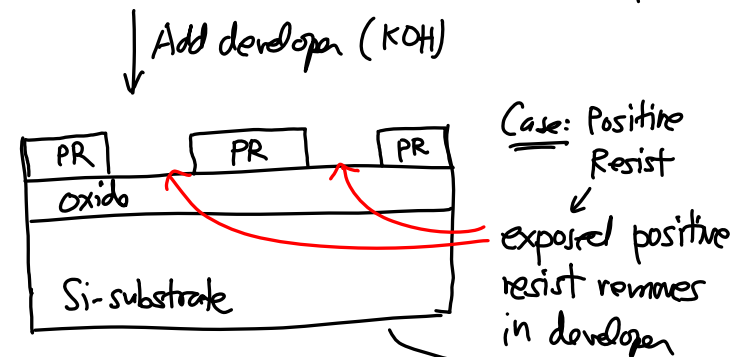
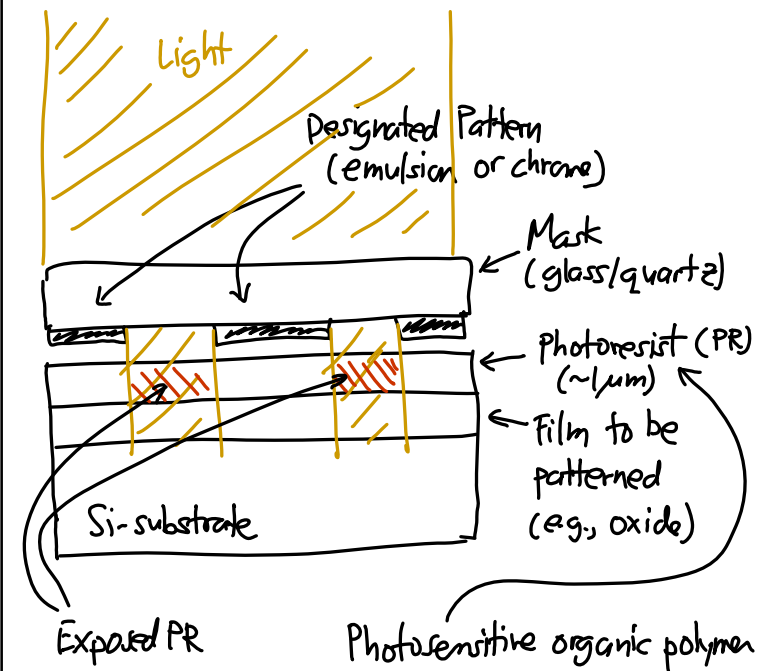
⇒ there are actually only a few basic modules used for processing

↓  
Combination of these in the correct sequence yields an integrated circuit technology that provides transistors, MEMS, nanodevices, etc.

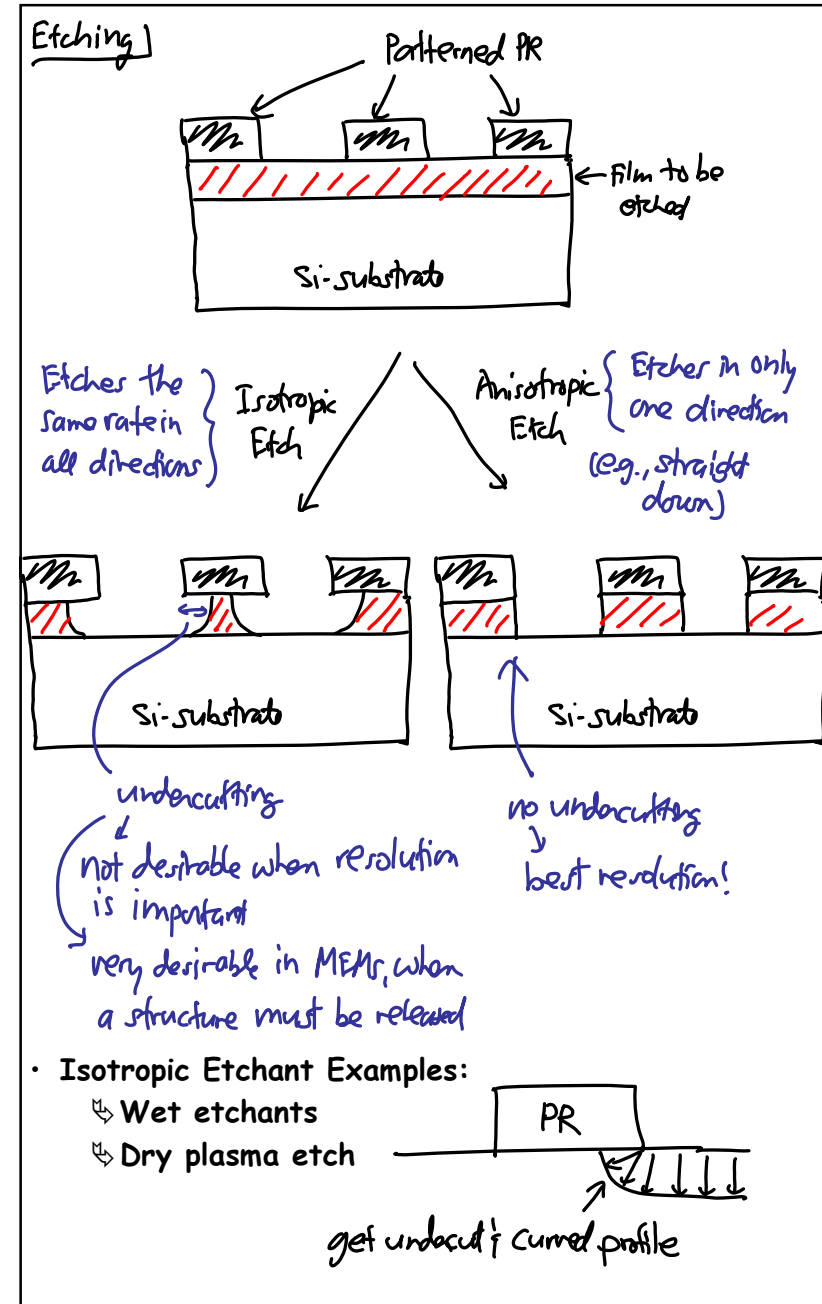
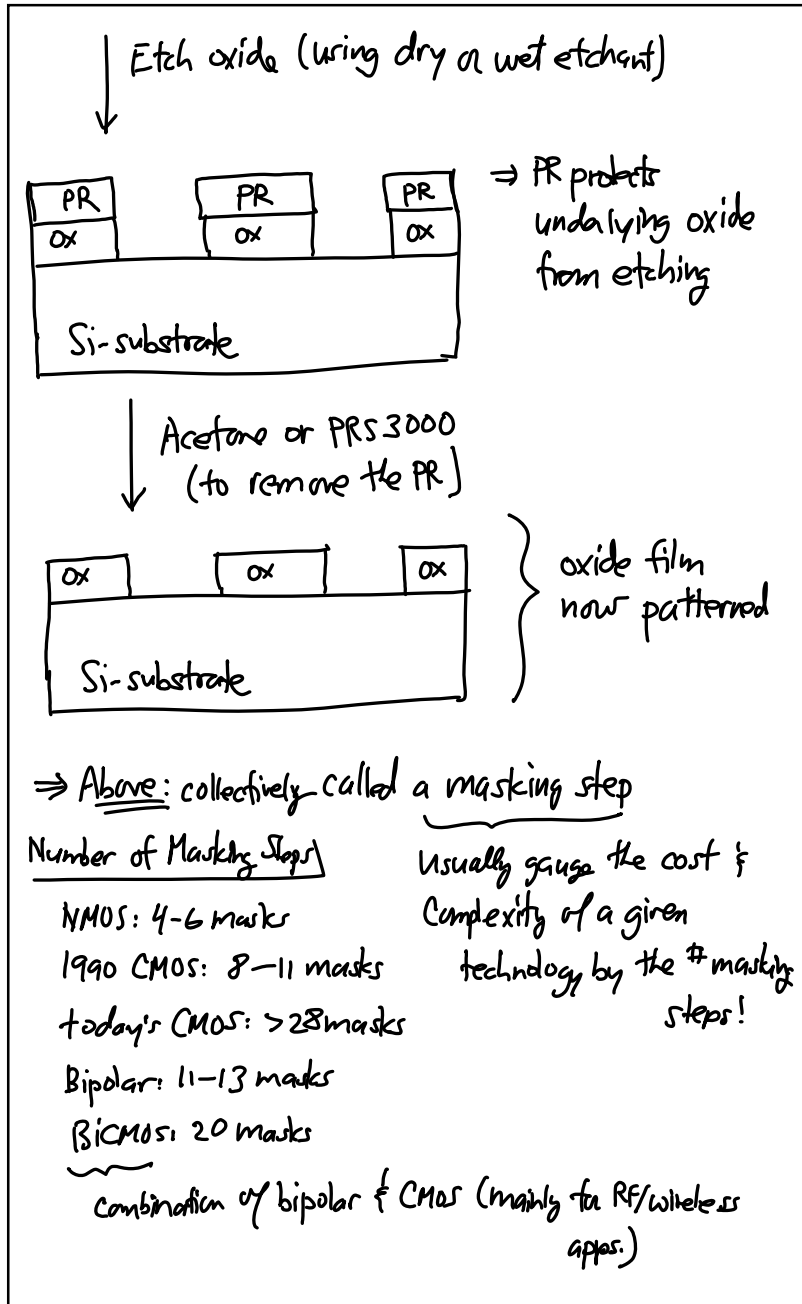
⇒ For each module, need to understand:

- ① Physics and engineering of each module in detail.
- ② Interactions between modules.
- ③ The effect of each module on the finished device.

Photolithography



⇒ Now, the PR is patterned  
⇒ Ready for the next step: Etching



• Anisotropic Etchant Examples:

- ↳ Reactive ion etch
  - ↳ Ion milling
- } Use ions under E-fields  
to give the etch  
more directionality.



square profile & no undercut

• Remarks:

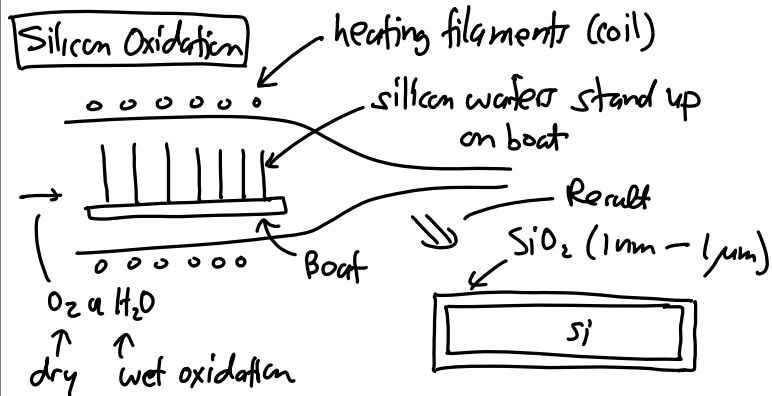
- ↳ Wet etching is fairly cheap
- ↳ Dry etching requires a plasma, so requires some expensive equipment
- ↳ Don't always want straight sidewalls



Too much topography  
↳ more difficult for  
subsequent films  
to conform



Sloped sidewalls  
allow better  
conformability



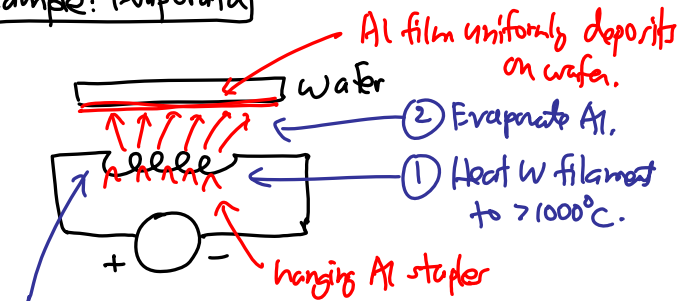
• Remarks:

- ↳ Uniformity can be better than 2% across the wafer from lot to lot
- ↳ Need to flow the  $\text{O}_2$  fairly fast in order to minimize reactant losses from the first boat to the last one

Thin-Film Deposition:

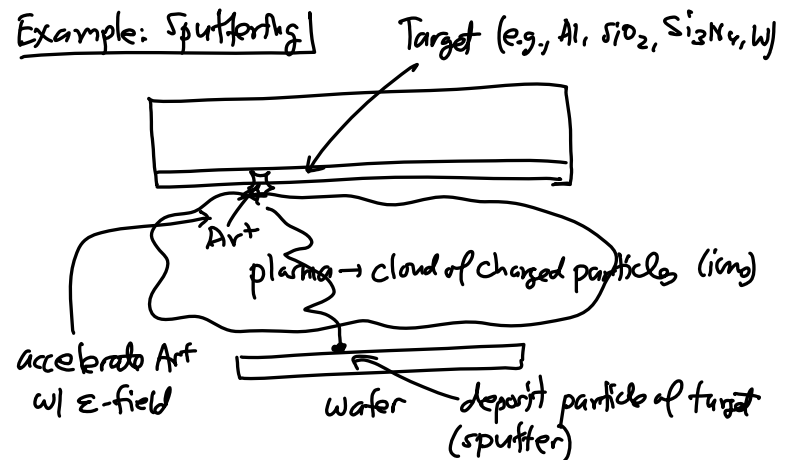
- For deposition of films like Al (and other metals),  $\text{SiO}_2$ ,  $\text{Si}_3\text{N}_4$ , and polysilicon
- Deposition, not thermal growth

Example: Evaporation

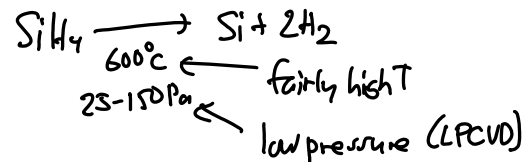
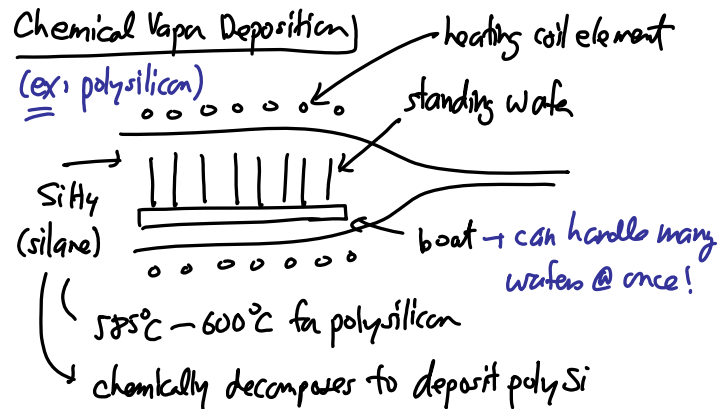


Tungsten (W) filament

Example: Sputtering



- Also, have chemical vapor deposition (CVD)
  - ↳ Chemical reaction involved in deposition of a given thin film
  - ↳ High temperature, but not nearly as high as often required for thermal growth



- Remarks:
  - ↳ Lot's of materials can be deposited in a similar manner: polysilicon, SiO<sub>2</sub>, Si<sub>3</sub>N<sub>4</sub>, tungsten
  - ↳ Compared to sputtering, CVD is less expensive since one can coat many wafers at once; sputtering generally does it one at a time
  - ↳ For higher temperature, CVD films are much more conformal than sputtered films

