Wet Etching Fundamentals

Matthew Duty & Phillip Sandborn

ENEE416

9/29/2011

Wet Etch

- Etch: removal of material from wafer (e.g. removal silicon dioxide)
- Wet Etch: removal by liquid-phase etchant
- Dry Etch: removal by plasma-phase etchant

Advantages/Disadvantages

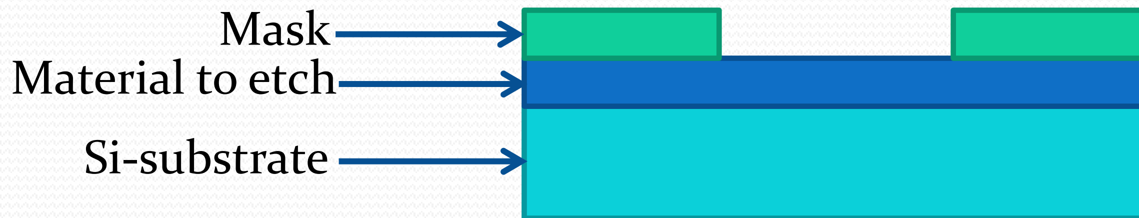
- + Selectivity
- + Inexpensive
- + Speed
- + Batch process

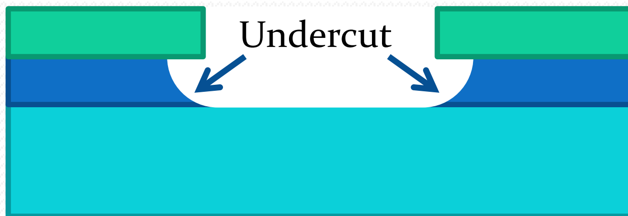
- - Isotropic (undercutting)
- - Temperature sensitivity
- - Safety
- - Chemical Waste

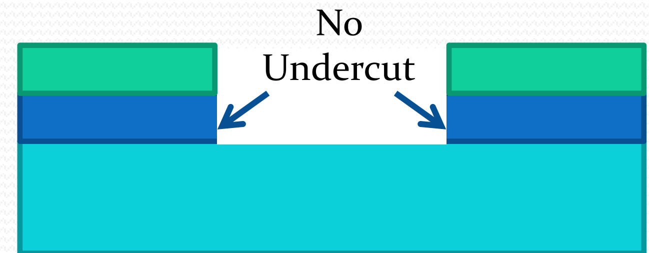
Selectivity

- Ability to etch one material but not another (e.g. silicon dioxide but not silicon)
- Different etch rates for each material
- Different etch rates for certain crystal orientations
  - Allows *anisotropic* etch

Isotropy



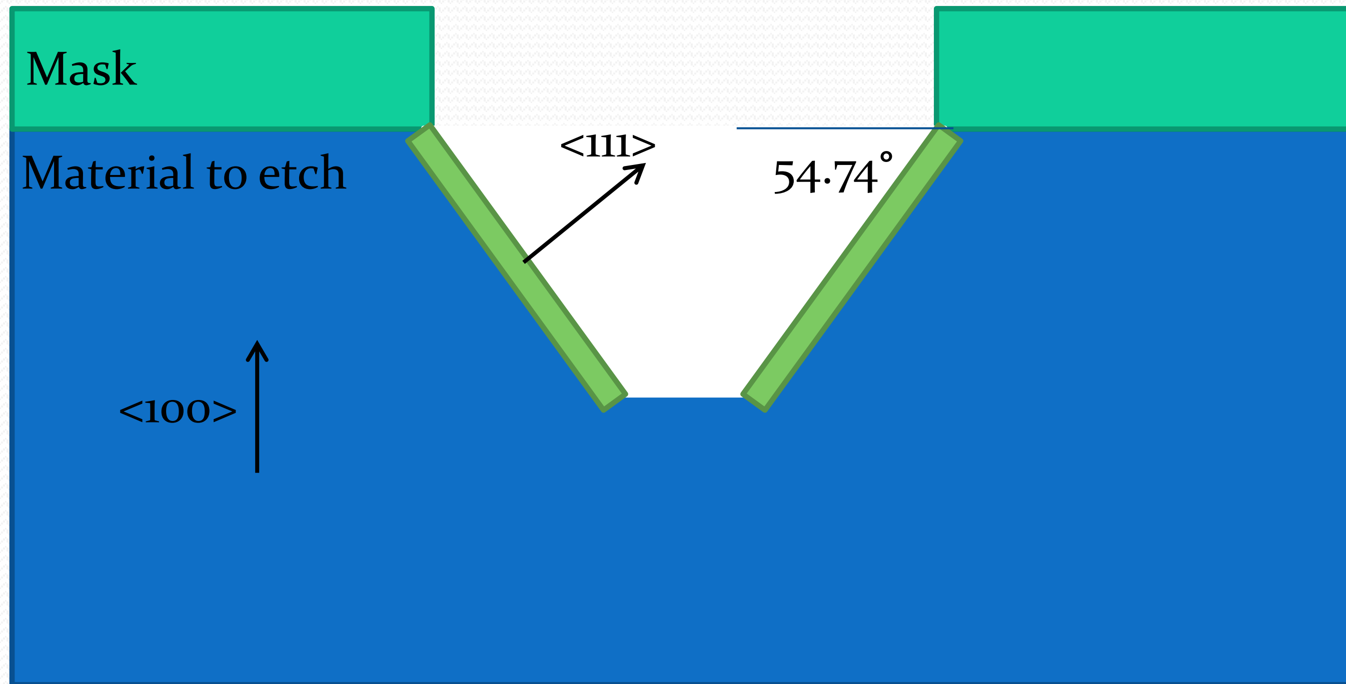




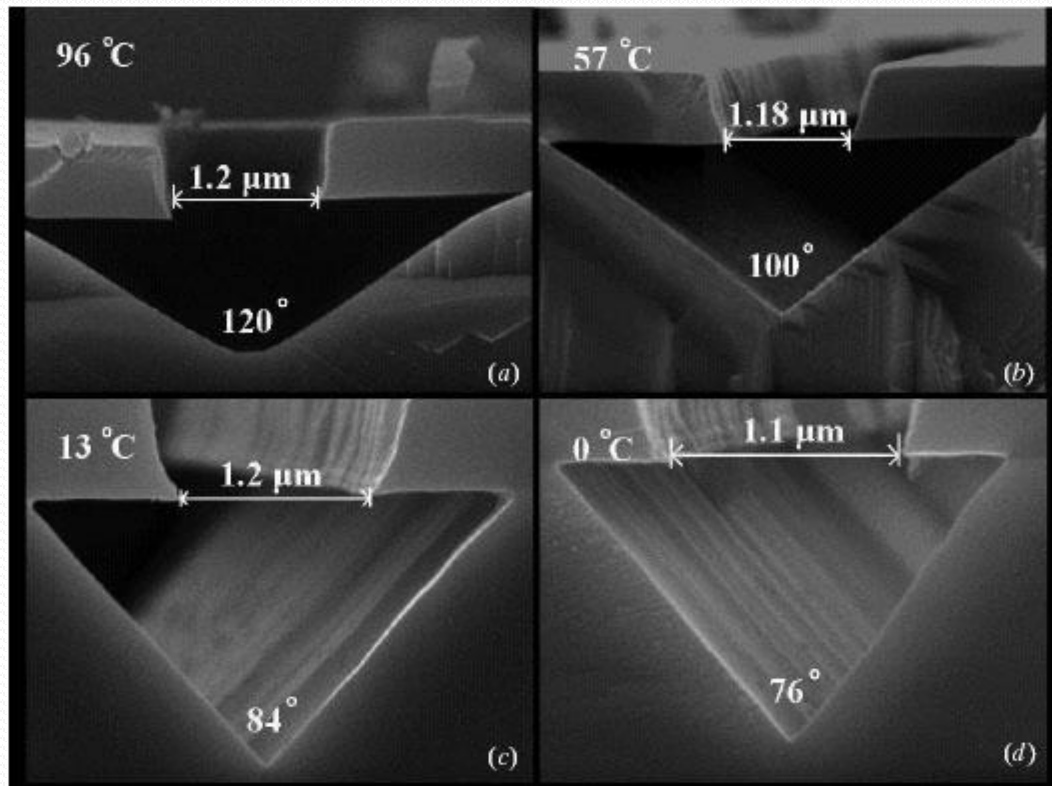
Isotropic: etches equally in all directions

Anisotropic: etches at different rates in different directions

Anisotropic Etching



Anisotropic Etching



Etchants – HNA

- Hydrofluoric acid; Nitric acid; Acetic acid
  - Redox reaction oxidizes Si; Si^{2+} reacts to form SiO_2 (reaction with nitric acid)
  - SiO_2 dissolved by HF acid to become soluble in acetic acid
- Isotropic
- Etch rate = 1-3um/min
- Mask: Si_3N_4 (not SiO_2!)
- Low cost
- Simple
- Process not easily repeatable

Etchants – KOH

- Potassium hydroxide
- Anisotropic (Si plane selectivity: <110>:<100>:<111> = 600:400:1)
- Etch rate = 2um/min
- Mask: Si_3N_4 or SiO_2 (SiO_2 will etch quicker, though)
- Not CMOS-compatible (Ions contaminate gate oxide)
  - Not allowed in some IC cleanrooms

Etchants – EDP

- Ethylene Diamine, Pyrochatechol, and water
- Anisotropic (Si plane selectivity: <100>:<111> = 35:1)
- Etch rate = 1um/min
- Mask: SiO_2
- Not CMOS-compatible (Ions contaminate gate oxide)
  - Not allowed in some IC cleanrooms
- Dangerous

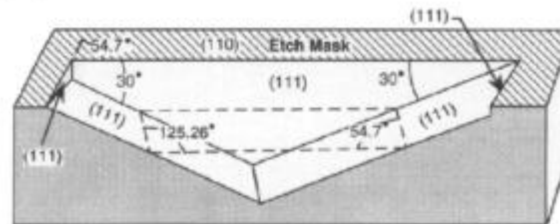
Etchants – TMAH

- Tetramethylammonium hydroxide
- No alkali ions (CMOS-compatible)
- Anisotropic (Si plane selectivity: <100>:<111> = 10-35:1)
- Mask: SiO_2

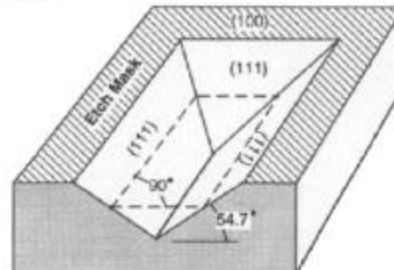
Stops – Controlling Etch Depth

- Photolithography
- Anisotropy
- Heavily-doped etch stops

(110) Silicon



(100) Silicon



References

- http://www.mrsec.harvard.edu/education/ap298r2004/Erli%20chen%20Fabrication%20III%20-%20Etching.pdf
- http://en.wikipedia.org/wiki/Etching_%28microfabrication%29
- Jaeger, Richard C. (2002). "Lithography". *Introduction to Microelectronic Fabrication*. Upper Saddle River: Prentice Hall
- Schwartz, B., and Robbins, H. "Chemical Etching of Silicon" *Journal of the Electrochemical Society*, 123 (12), pp. 1903-1909
- Collins, Scott D. "Etch Stop Techniques for Micromachining." *Journal of the Electrochemical Society* 144.6 (1997): 2242-262.