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EE C247B – ME C218 Introduction to MEMS Design Spring 2019

Prof. Clark T.-C. Nguyen

Dept. of Electrical Engineering & Computer Sciences
University of California at Berkeley
Berkeley, CA 94720

Lecture Module 4: Lithography, Etching, & Doping

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Etching

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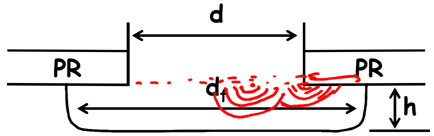
Etching Basics

- Removal of material over designated areas of the wafer
- Two important metrics:
  1. Anisotropy
  2. Selectivity

1. Anisotropy –
   a) Isotopic Etching (most wet etches)



If 100% isotropic: $d_f = d + 2h$
Define: $B = d_f - d$
If $B = 2h$ ⇨ isotropic

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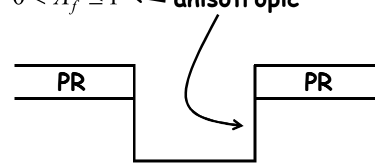
Etching Basics (cont.)

b) Partially Isotropic: $B < 2h$
(most dry etches, e.g., plasma etching)

Degree of Anisotropy: (definition)

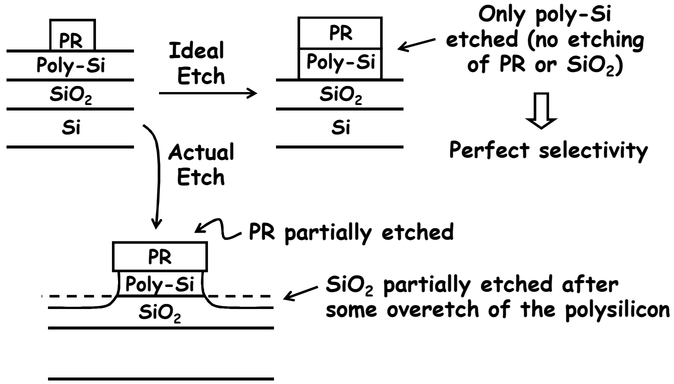
$$A_f = 1 - \frac{B}{2h} = 0 \quad \text{if 100\% isotropic}$$

$$0 < A_f \leq 1 \leftarrow \text{anisotropic}$$



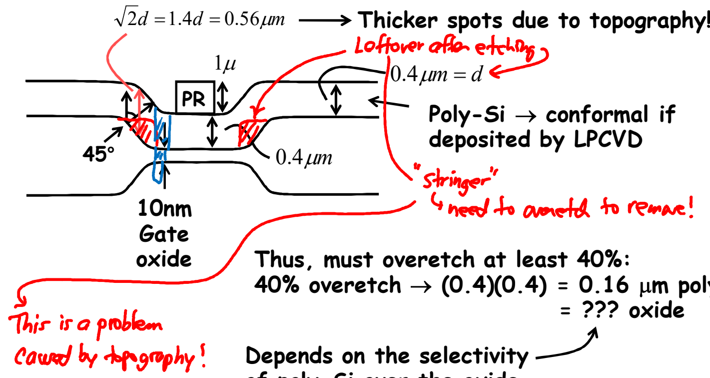
Etching Basics (cont.)

2. Selectivity –



Etching Basics (cont.)

Why overetch?



Thus, must overetch at least 40%:
40% overetch → (0.4)(0.4) = 0.16 μm poly
= ??? oxide

Depends on the selectivity of poly-Si over the oxide

Etching Basics (cont.)

Define selectivity of A over B:

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

← Etch rate of A
← Etch rate of B

Selectivity of A over B

e.g., wet poly etch (HNO_3 + NH_4 + 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 type of etcher)

$S_{poly/PR} = \frac{4}{1}$

ECR: 30:1
Bosch: 100:1 (or better)

Etching Basics (cont.)

If $S_{poly/SiO_2} = \frac{8}{1}$ ⟹ 40% overetch removes

$\frac{0.16}{8} = 20$ nm of oxide! ⟹ This will etch all poly over the thin oxide, etch thru the 10nm of oxide, then start etching into the silicon substrate → needless to say, this is bad!

with better selectivity:

e.g., $S_{poly/SiO_2} = \frac{30}{1}$

(Can attain with high density Cl plasma ECR etch!)

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

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Dry Etching

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Dry Etching

- Physical sputtering
- Plasma etching
- Reactive ion etching

All based upon plasma processes.