Anisotropic Etching Using KOH

GEORGE ALPHONSE
Isotropic vs Anisotropic Etching

Isotropic

1

Masking Layer (Photoresist)

Layer to be Removed (Si or SiO2)

Anisotropic

2
CyMOS Process - Buffered HF

- Isotropic wet etchant
- Reaction: $SiO_2 + 6HF \rightarrow H_2SiF_6 + 2H_2O$
  - Buffering agent: $NH_4F$ (ammonium fluoride)
- Etch Rate: 0.06 um/min (thermally grown oxide)
- Selectivity: Very large for $SiO_2 / Si$
Anisotropic Etching using KOH

- Orientation Dependent: Etch rate differs for different orientations
  - Etching rate is lower on more densely packed surface
- Reaction: \( Si + H_2 O + 2 KOH \rightarrow K_2 SiO_3 + 2 H_2 \)
- Etch Rate: depends on orientation, concentration, temperature
  - Silicon: \( \sim 100 \) um/hr
  - Silicon Dioxide: \( \sim 1 \) um/hr
  - Silicon Nitride: \( \sim 1 \) nm/hr
Anisotropic Etching using KOH

- Selectivity:
  - $\langle 110 \rangle / \langle 111 \rangle = 600:1$
  - $\langle 100 \rangle / \langle 111 \rangle = 400:1$

- $d = D - (2h / \tan (54.7^\circ))$
  - Where $d$ is floor width, $D$ is mask dimension, and $h$ is etch depth
Anisotropic Etching using KOH
Etch Rate of 100 Si vs Temp
Etch Rate of 110 Si vs Temp
Etch Rate of SiO2 vs Temp

KOH Etching of SiO2
20% KOH Solution
Etch Rate vs Solution Concentration

KOH ETCHING OF SI AT 90ºC

Si 100
Si 110
Advantages

- Low Cost
- Relatively safe
- Good selectivity and etch rate
- Orientation Dependent
- Controllable etch rates
Disadvantages

- KOH may introduce potassium ions into silicon dioxide
- Attacks aluminum structures on the wafer.

Not CMOS-compatible:

Undercutting is still a problem

\[ \delta = \frac{\sqrt{6}D}{S} = \frac{\sqrt{6}R_{100}T}{R_{100}/R_{111}} = \sqrt{6}TR_{111} \]

Etch rates varied by temperature and concentration
Questions?
Works Cited

https://cleanroom.byu.edu/KOH
http://ece.colorado.edu/~ecen4375/s10/secure/L4%20wet%20etching.pdf
http://nptel.ac.in/courses/113106062/Lec26.pdf
http://me.umn.edu/courses/me8254/attfiles/Lecture%2007%20Dry%20Etching_Full.pdf
Dry Etching - Plasma

**Advantages:**
- Small feature size (<100 nm)
- Less undercutting
- Highly anisotropic
- Eliminates handling of dangerous acids

**Disadvantages:**
- High cost
- Low throughput
- Poor selectivity