EE669: VLSI Technology

Etching

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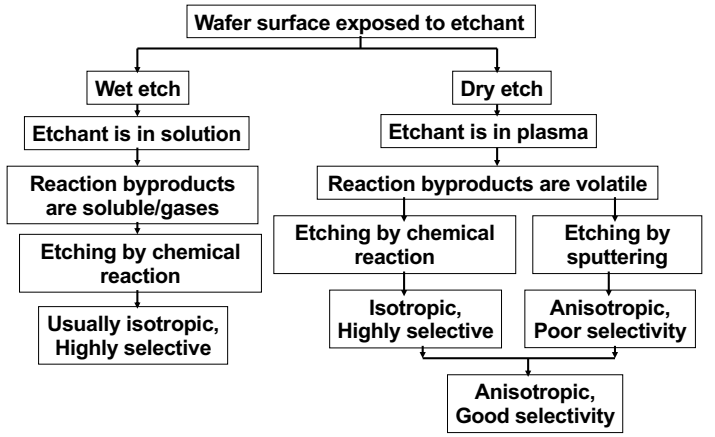
Taxonomy of Etch Processes



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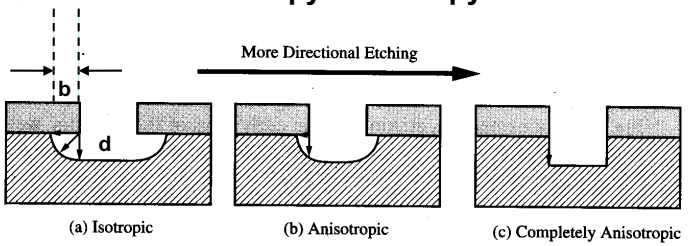
Isotropy/Anisotropy



$$A_f = 1 - \frac{r_{lat}}{r_{ver}} = 1 - \frac{b}{d}$$

Silicon VLSI Technology, J. D. Plummer, M. D. Deal, P. B. Griffin

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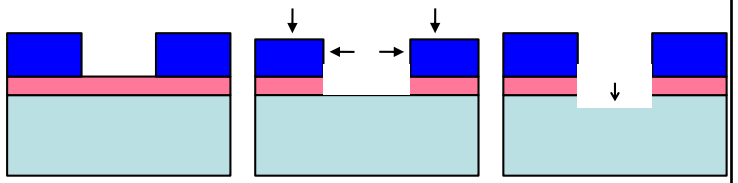
Etch Selectivity



$$S = \frac{r_1}{r_2}$$

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Etch Processes: Wet etch

Etch rate and selectivity:

- **Concentration**
- **Temperature**
- **Stirring of solution**

Williams et al., IEEE Journal of MEMS, Dec. 1996 & Dec. 2003

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SiO_2 etch using HF solutions

- **Overall reaction**
  - $SiO_2 + 6HF \rightarrow H_2SiF_6 + 2H_2O$
- **Various concentrations used: 49%, 10%, 2%, ……**
- **Etch rate and selectivity depends on the concentration**
- **Selective to Si**
- **Selective to Si_3N_4 at low concentration and if Si_3N_4 contains low concentrations of H and O**
- **BHF (HF: NH_4F = 1:5) for etching SiO_2 selective to photo resist and Si**

Williams et al., IEEE Journal of MEMS, Dec. 1996 & Dec. 2003

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Isotropic Silicon Etch

- **$HF:HNO_3:CH_3COOH$**
  - **Typical mixing ratio is 1:60:6**
  - **Exothermic reaction**
- **The overall reaction**

  $18HF + 4HNO_3 + 3Si \rightarrow 3H_2SiF_{6\,(aq)} + 4NO_{(g)} + 8H_2O$
- **CH_3COOH is used for uniform etching with smooth surfaces (c-Si)**
- **NH_4F can be used instead of HF for a longer lasting solution**
- **Selective to Si_3N_4 and SiO_2**

Williams et al., IEEE Journal of MEMS, Dec. 1996 & Dec. 2003

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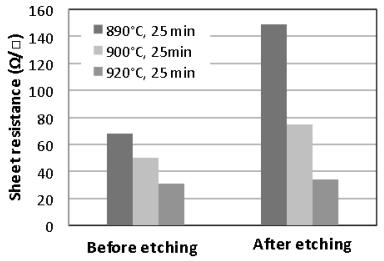
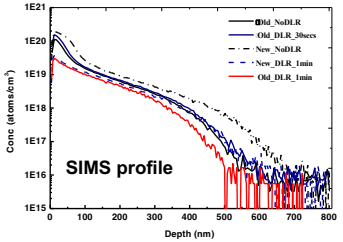
Isotropic Silicon Etch for Dead Layer after Phosphorous Diffusion

Phosphorous diffused in Si using a solid source



Dead layer removal (DLR) in $HF:HNO_3:CH_3COOH$ 1:60:6



Exercise: determine the thickness of dead layer in the New_DLR_1 min. Reference profile before DLR is New_NoDLR.

Gaudhaman Jeevanandam & Ketan Warikoo, NCPRE

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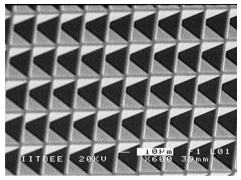
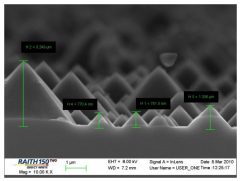
Anisotropic Si etch: KOH or NaOH or $N(CH_3)_4OH$

KOH etch selectivities ➔ (110):(100):(111) of 400:200:1

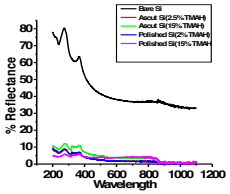
$Si + 2\ OH^- + H_2O$ ➔ $SiO_2(OH)_2^{2-} + 2H_2$



Inverted pyramids, 25 µm X 25 µm squares with 5 µm gap. TMAH 2.5%



Random texturization, 2.5 % TMAH, 85 – 90 C, 3.3 µm.



Reflectance of random textured wafers.

Sandeep S. S., NCPRE

Self Study

All wet etch processes described in

1. Kirt R. Williams and Richard S. Muller, Etch Rates for Micromachining Processing, IEEE JOURNAL OF MICROELECTROMECHANICAL SYSTEMS, VOL. 5, NO. 4, pp. 256-269, DECEMBER 1996
2. Kirt R. Williams, Kishan Gupta, and Matthew Wasilik, Etch Rates for Micromachining Processing – Part II, IEEE JOURNAL OF MICROELECTROMECHANICAL SYSTEMS, VOL. 12, NO. 6, pp DECEMBER 2003