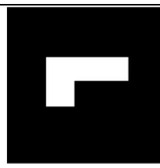
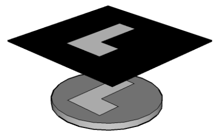
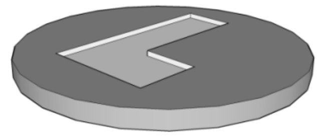
EE C245 Discussion 3 Ilya Gurin 9/22/2008

I: Examples

1. Lithography

Going from mask to features: how do we determine the polarity of the features?

Mask (dark-field)	Expose photoresist	Develop photoresist (positive)
		

What if we want a feature with the opposite polarity? (remove all PR *except* in the L-shaped area)?

Use a *clear-field* mask (dark feature on a clear background).

Negative PR is also possible, but more difficult.

2. Doping: limited-source diffusion

Say we have a bare silicon wafer with a certain dose Q of boron predeposited on the surface.

We diffuse it with a diffusion constant $= 10^{-11}\,\frac{\text{cm}^2}{\text{s}}$ for time $:\ 17\ \text{min} = 1000\ \text{s}$. (How would we find the diffusion constant?) **How deep does it go?**

As an approximate measure, find the characteristic diffusion length:

$$l_c = 2\sqrt{D\,t} = 2\ \mu\text{m}$$

But what's the actual junction depth? This is a limited-source diffusion (Gaussian profile).

First, we need the surface concentration . We would find it by setting the integral of the the Gaussian distribution equal to the dose. Let's say we've found that $= 10^{16}\ \text{cm}^{-3}$. Now, we know that:

$$x_j = 2\sqrt{D\,t\ln N_0/N_B}$$

Try some numbers:

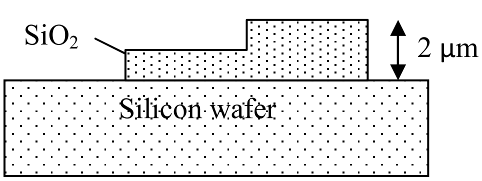
$$N_B = 10^{15}\ \text{cm}^{-2} \rightarrow x_j = 3\ \mu\text{m}$$
$$N_B = 10^{13}\ \text{cm}^{-2} \rightarrow x_j = 5.25\ \mu\text{m}$$

Sidenote: when calculating the sheet resistance, need to keep track of the electrical activity limit

3. Etching: anisotropic etch

Perfectly anisotropic etch. SiO_2: 1 μm/min; Si: 0.5 μm/min

Initial profile:

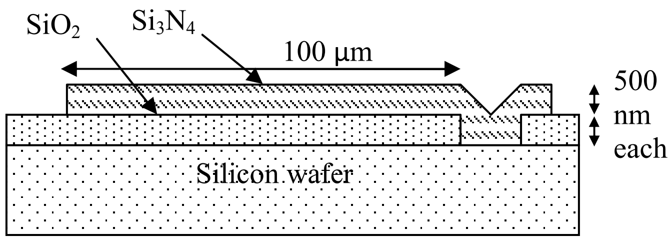


Final profile:

4. Etching: isotropic release etch

Perfectly isotropic etch (HF). SiO_2: 1 µm/min; Si_3N_4: 1 nm/min

Initial profile:



Final profile:

II: Tradeoffs in fabrication

1. Lithography

Benefits	Technology choice	Benefits
Depth of focus	**Exposure system** Contact Proximity ⟷ Projection	Resolution Quality of alignment Die-to-die uniformity Avoids mask contamination
Depth of focus Behavior in developer Resolution Easier to work with	**Photoresist** Thin (< 2 µm) ⟷ Thick (~ 10 µm possible)	Topography coverage Uniform exposure over topography Ability to etch thick layers

2. Etching

Benefits	Technology choice	Benefits
Selectivity Etch rate Throughput	**Etch type** Wet ⟷ Dry	Uniformity Anisotropy possible Repeatability
Allows lower selectivities to underlying layer and PR Avoids PR "burning"	**Overetch** Short ⟷ Long	Removal of stringers Mitigates nonuniformity
Process simplicity	**Masking layer** Photoresist only ⟷ PR + "hardmask"	Allows lower selectivity to photoresist Vertical sidewalls