

## Silicon Oxide Etch Process

To remove the areas of silicon dioxide unprotected by photoresist to remove  $\text{SiO}_2$  and expose the silicon underneath.

### Preparation and Precaution:

1. This operation should be started within 30 minutes of the completion of the hard bake of the photoresist.
2. Use Buffered Oxide Etch (BOE) solution (6 parts 40%  $\text{NH}_4\text{F}$  and 1 part 49%  $\text{HF}$ ). This reagent is found under the last acid fume hood in the Yellow Room.
  - 2.1 Always use plastic beakers and graduated cylinders for etchants containing  $\text{HF}$ ;  $\text{HF}$  WILL ETCH GLASS!
3. Know the oxide thickness on your substrate.

### Procedure:

1. Clean the substrate or wafer surface by rinsing with DI water; hold the sample with Teflon tweezers.
2. Before beginning the etching, calculate the time needed to etch through the oxide of known thickness using the known etch rate of the BOE solution; the etch rate at room temperature is  $\sim 700 \text{ \AA/min}$ .
3. Use a stop watch to time the etching process.
4. Etch the wafer for about half of the estimated time. Remove your sample, rinse with DI  $\text{H}_2\text{O}$ .
5. If the silicon dioxide has not been completely etched away, you will observe a film of the DI water wetting or sheeting across the whole surface of the wafer. If the layer of  $\text{SiO}_2$  has been etched off, the DI water will not adhere to the back, except for a few isolated drops, and the wafer will appear dry and dull gray. This happens because  $\text{SiO}_2$  is

hydrophilic as opposed to silicon which is hydrophobic. Observe the backside of the wafer to confirm this effect for a few seconds.

6. If the oxide is not thoroughly etched or removed, immerse the substrate or the wafer back into the BOE solution. Etch for an additional 30 seconds. Recheck back of wafer as mentioned in step 5 after the substrate has been rinsed with DI water.

7. Repeat step 6 until  $\text{SiO}_2$  is completely etched and removed.

8. If you are unsure of your ability with the above method or you are performing a critical step in your process and cannot tolerate much overetch, then use the method below. This should prevent any overetching and damage to the Si substrate surface.

8.1 Remove the substrate or the wafer from the BOE solution and rinse the wafer for two minutes in running DI water.

8.2 Dry the wafer with an  $\text{N}_2$  gun.

8.3 Check the color of the oxide under a light microscope using incident white light. The oxide thickness can be estimated from an oxide color chart; dark or light tan color indicates about 700 angstroms of oxide remain.

8.4 Etch in BOE solution for 30 seconds.

8.5 Repeat 8.1 through 8.4 till you observe the following:

8.5.1 Dark tan or light tan color. In this case about 700Å remain to be etched. Continue etching for 55 seconds and proceed to step 9.

8.5.2 White color. This indicates that silicon has shown up. Etch for 30 seconds and proceed to step 9.

NOTE: A very thin oxide layer is invisible since the last few hundred Angstroms of oxide do not show any color. So etch the oxide about 20 seconds longer than necessary.

9. After the exposed positions of  $\text{SiO}_2$  have been etched, rinse the wafer in running DI water for five minutes.

10. Dry the wafer with an  $\text{N}_2$  gun.

11. As a final check, view the etched areas of the wafer under the

microscope, you should not see oxide, which has colors, but instead silicon, which appears rather white under a high-power microscope with vertically incident white light.

**Buffered HF:** 6 parts  $\text{NH}_4\text{F}$  (40%) + 1 part HF (49%).

Etch rate of  $\text{SiO}_2$  at room temperature is  $\sim 700 \text{ \AA}/\text{min}$ .

**Dilute HF:** 25 parts  $\text{H}_2\text{O}$  + 1 part HF (49%) .

**P-Etch:** 300 parts  $\text{H}_2\text{O}$  + 10 parts  $\text{HNO}_3$  (70%) + 15 parts HF (49%).

**Polysilicon Etch:** 200 parts  $\text{H}_2\text{O}$  + 500 parts  $\text{HNO}_3$  (70%) + 15 parts BHF (1:6) .

Note: 30 seconds dip in BHF is necessary prior to etching with polysilicon etch.

### **Silicon Etch:**

50% solution by weight of potassium hydroxide (KOH), 100g  $\text{H}_2\text{O}$ , in 40g or 30ml of methyl alcohol at 50 - 60C. Etch speeds are dependent upon the orientation of the Si (7000A/min for 100 Si, 1400 A/min for 110 and 350A/sec for 111).

This should be done in a quartz glass or pyrex beaker using a glass cover glass and slow magnetic stirring on a hotplate to allow a reflow of the evaporating alcohol to occur. As the alcohol vapors reach the cooler surface of the watch glass they will condense and fall back into the solution. To prevent etching of the back surface of the substrates it may be necessary to coat it with a water insoluble protective lacquer. During the KOH etch, the areas where bare Si is present (no  $\text{SiO}_2$ ) small hydrogen bubbles will appear.

Silicon (single-crystal or poly-crystalline) may be wet-etched using a mixture of nitric acid ( $\text{HNO}_3$ ) and hydrofluoric acid (HF). The nitric acid consumes the silicon surface to form a layer of silicon dioxide, which in turn is dissolved away by the HF. The over-all reaction is as follows:  $\text{Si} + \text{HNO}_3 + 6 \text{HF} \rightarrow \text{H}_2\text{SiF}_6 + \text{HNO}_2 + \text{H}_2 + \text{H}_2\text{O}$ .

200 parts  $\text{H}_2\text{O}$  + 500 parts  $\text{HNO}_3$  (70%) + 150 parts BHF (1:6)