Buffered Oxide Etch

STANDARD OPERATING PROCEDURE

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### 1. SUMMARY

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#### Description
Process for the removal of SiO\(_2\) (native oxide) on Silicon wafers for releasing microfabricated suspending structure, patterning wafer or in preparation for thermal oxidation.

#### Material used
Silicon wafer, 10:1 buffered hydrofluoric acid (HF), De-ionized water

#### Location
EE/CSE B025, EE Microfabrication Laboratory (EE-MFL), UoW

#### Contact
**Access**
Prof. Bruce Darling, Dept. of Electrical Engineering (206-543-4703, bdarling@ee.washington.edu).

**Technical**
Mr. Tai-Chang Chen, Dept. of Electrical Engineering, (tcchen@u.washington.edu)

**Emergency**
Mr. Tai-Chang Chen, Dept. of Electrical Engineering, (tcchen@u.washington.edu)

#### This Document
**Date** 1999-06-07  **Revision** 0  **Authors**
Leo L. Lam  Tai-Anh Lam  Young Mee Lee
2. INTRODUCTION

This Standard Operating Procedure (SOP) describes in detail the process flow of the Buffered Oxide Etch (BOE) of silicon dioxide on silicon wafers using buffered hydrofluoric acid. Due to the high health risk nature of the acid involved in this process, users are advised to heed the Material Safety Data Sheet carefully before carrying out the process. The MSDS are contained in a black folder located in the cupboard directly above the sink in the gowning area of B025.

Three main uses of BOE are:
1) To remove the underlying sacrificial oxide layer of suspending microstructures on silicon wafers.
2) To remove unwanted silicon dioxide on patterned silicon wafers.
3) To remove native parasitic silicon dioxide on silicon wafers in preparation for thermal oxidation.

While the removal of parasitic oxide is relatively straight forward, the timing issue in releasing microstructures can be critical and requires great care.

The BOE process is based on the complexing reaction:

\[
\text{SiO}_2 + 6\text{HF} \rightarrow \text{H}_2\text{SiF}_6 + 2\text{H}_2\text{O}
\]

where \( \text{H}_2\text{SiF}_6 \) is soluble in water.

This reaction is performed in a dilute solution of HF, buffered with NH\(_4\)F to avoid depletion of the fluoride ions. It has also been reported that this also lessens the attack of the photoresist by the hydrofluoric acid.

Both thermally grown and deposited \( \text{SiO}_2 \) can be etched in buffered hydrofluoric acid. However, etching of deposited films proceeds a lot faster than that of the thermal oxide. Densification of the deposited films, by heat treatment at 1000-1200°C for about 15 minutes, results in a fall in the etch rate to approximately the same as that for the thermally grown oxide. Refer to section 7 for the etch rate of different oxides.
3. LOCATION OF EQUIPMENT, ACCESSORIES, TOOLS AND SUPPLIES

Buffered Oxide Etch should only be carried out in the “Non-MOS” Hamilton laminar flow wet bench located in Room B025 of the Electrical Engineering Microfabrication Laboratory. The wet benches are located at the north side of the lab in a semi-enclosed area and are equipped with deionized water taps, normal water taps and nitrogen blowguns.

For general applications, users should use the “Non-MOS” laminar flow wet bench. The MOS bench should only be used for CMOS microelectronics fabrication processes.

10:1 Hydrofluoric Acid is stored in a covered pale blue polypropylene bucket (figure 1) within the fume hood of the wet bench. Extra supply of the acid can be found in the cupboard labeled “ACID” under the wet bench.

Polypropylene 4” wafer holders (in pale blue color) must be used for dipping wafers into the hydrofluoric acid and these are stored in the cupboard directly above the ACID storage compartment (figure 2).

Glassware must not be used because hydrofluoric acid corrodes glass.

Trionic gloves must be worn over the latex laboratory gloves when handling the hydrofluoric acid, which is highly corrosive. These gloves can be found in the middle shelf of the middle closet in the gowning area.

Tweezers for wafer handling are stored in a glass jar in the cupboard directly above the ACID storage compartment.

The hydrofluoric acid antidote for accidental skin contact is located next to the wet bench.

A hydrofluoric acid spill kit (“HF Acid Spill” in figure 3) for up to one liter of spill is available on the desktop next to the wet bench directly above the ACID storage compartment.

A logbook for the wet bench is located on the desktop directly above the ACID storage compartment. All materials used and processes performed in the wet bench must be recorded.
4. PERSONAL SAFETY EQUIPMENT

In addition to the standard cleanroom clothing (lab coat, shoe covers, hair cap, latex powder-free gloves), Trionic acid resistant gloves and eye protection goggles must be worn for handling hydrofluoric acid and all equipment that would be potentially in contact with the acid. A face shield, if available, is strongly advised.

5. MATERIAL COMPATIBILITY

Hydrofluoric acid is not compatible with glassware. Do NOT use glass beakers/containers. Also, always use the Trionic gloves on top of the latex lab gloves when handling hydrofluoric acid.

For long duration etching, such as under-etching of suspending MEMS structures, photoresist will be etched and is not a suitable masking material. A suitable masking material for that purpose can be silicon nitride.

6. PRIMARY HAZARDS AND WARNINGS

Hydrofluoric acid is extremely hazardous (NFPA704M code = 4-0-0). It can cause severe burns of the respiratory, digestive tracts and permanent damage to the cornea. It is extremely dangerous to skin contact and can cause deep tissue and bone damage. The slight anesthetizing effect of the hydrofluoric acid makes the burn not immediately felt, but when it hurts, the pain will be intense. There is no real remedy for HF burns at present so use extreme caution in handling this acid. The antidote is for temporary relief of pain ONLY.
7. OPERATIONAL PROCEDURE CHECKLISTS

1. Material Preparation:
   - Before the BOE etch, the wafer should have been post-bake if photoresist is the
     masking material.

2. Loading Wafer:
   - Place wafer(s) into the slot(s) in the pale blue polypropylene wafer holder. Maximize
     the spacing between wafers for better circulation of fresh fluoride ions to achieve
     uniform etch rate across the wafer surface.

3. Etching with BOE:
   - Put on the Trionic acid resistant gloves.
   - Attach the handle snugly to the wafer holder.
   - Carefully lower the wafer holder into the BOE solution. Make sure that all the wafers
     are immersed.
   - Hold on to the wafer holder throughout the etching process. The polypropylene
     wafer-holder floats so it has to be secured manually.
   - The average etch rate of thermally grown oxide in the 10:1 BOE solution is 600
     A/min and for sputtered oxide 900 A/min. The solution deteriorates with use and the
     etch rate may be lower; check the logbook for remarks from the previous user.

4. Rinsing and Drying Wafers:
   - When the etch is finished, carefully remove the wafer holder from the solution and immerse it into
     the bucket of DI water.
   - Leave the wafer holder in DI water for a few minutes. Shake gently.
   - Remove the wafers from the wafer holder using a pair of tweezers. Place the wafer, one at a time, on
     the spinner (figure 4) and spin dry (refer to the SOP of the spinner).

Figure 4 The spinner for wafer drying
5. Cleaning of Work Surface and Equipment:

- Clean any spill with large quantity of DI water and wipe dry with lab paper towels. Discard the towels immediately.

- Rinse the wafer holder and handle in a lot of running DI water.

- Rinse Trionic gloves in large quantity of running DI water. Take them off without directly contacting them and hang them on the sink to dry.

- Replace your latex lab gloves.

8. HELPFUL HINTS, COMMON QUIRKS, AND TROUBLESHOOTING

Check the logbook for the age of the BOE solution. The rate can be slower than the stated 600/900 A/min, for thermal oxide and sputtered oxide respectively after several uses. Also check the remarks in the logbook for any other remarks. Log all the materials used and process performed.

9. ENVIRONMENTAL HEALTH AND SAFETY ISSUES

Trionic acid resistant gloves must be worn over latex gloves during the whole process. Used BOE solution must not be dumped into the sink. Discard used BOE solution in the container labeled “Used BOE” located in the cabinet under the wet bench. Clean any acid spill immediately to avoid endangering other users.