

Anisotropic Silicon Etch Using KOH

INRF application note
Process name: KOH01

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Overview

KOH is a wet etch which attacks silicon preferentially in the $\langle 100 \rangle$ plane, producing a characteristic anisotropic V-etch, with sidewalls that form a 54.7° angle with the surface (35.3° from the normal). This etch process is independent of the doping concentration for As, P and Sb. For B, the $\langle 110 \rangle$ etch rate drops quickly at high doping concentrations. This is a level-1 process and requires basic INRF safety certification. The use of dangerous chemicals requires that the user may not perform the process alone.

Time needed

The KOH process takes typically 1 hour for a $40\ \mu\text{m}$ etch: 20 minute prep time followed by 40 minutes etch. Lithography and reactive ion etch take additional time.

Materials needed

- 100 silicon wafers with thermally grown oxide or nitride layer ($\sim 2000\text{--}3000\ \text{\AA}$)
- KOH pellets (available from chem stores)
- Glass container
- Thermometer
- Hot plate

Preparation

Wear protective nitrile gloves and eye protection. Prepare a fresh KOH solution in the following manner. Weigh 1 part KOH pellets (by weight) into a plastic beaker. Add 2 parts DI water. For example, use 100 g KOH with 200 ml water. Mix on warm surface until KOH has dissolved. Add 40 ml of isopropyl alcohol to the solution. The isopropyl alcohol increases the anisotropy in the etch. Store in plastic bottle labeled "30% KOH solution", then add your name, the date, and a target organs sticker.

KOH recipe (30%)

- 70 g KOH pellets
- 190 ml DI water
- Mix on warm surface until KOH has completely dissolved.
- Add 40 ml isopropyl alcohol

The KOH etch requires a "hard mask" of silicon dioxide or silicon nitride (nitride is preferred since oxide is slowly etched by KOH). The details on making a hard mask can be found in other documents. The basic approach is as follows. Start with silicon 1-0-0 polished wafers. Clean wafers and pattern with photoresist. Use the reactive ion etch (RIE) system to etch the exposed oxide or nitride surface. For oxides, the recommended chemistry is CHF_3 and O_2 or CF_4 and O_2 . Etch until the silicon is exposed (shiny); typically 5 minutes per $1000\ \text{\AA}$ film.

Rinse the wafer with acetone to remove the remaining photoresist. Rinse with DI water, then blow dry.

Procedure

Put KOH solution in glass container and warm to 80° C on a hot plate. If desired, use a mixer to agitate the solution. Place patterned wafer (with patterned hard mask) in the KOH solution. The KOH will bubble at the exposed silicon sites while etching occurs. The etch rate for 30% KOH at 80°C should be about 1 micron/minute.

Clean up

Dispose etchant in INRF labeled waste container. Rinse all labware three times in clean water.

In very small amounts (less than 30 ml): Dilute the KOH with cold water, then neutralize with a small amount of HCl. If the pH is below 12.5, you may pour the solution down the drain, flushing with plenty of cold water.

Safety and emergency

All INRF safety and procedural regulations must be followed. Use of KOH requires at least one other person in the clean room (buddy system). KOH should be handled in a laminar flow bench, using nitrile gloves and eye protection. Any small spills should be wiped up immediately with wipes. Dispose the wipes in the corrosive waste container. DO NOT LEAVE the etchant on the hot plate unattended.

In case of exposure to skin or eyes, flush immediately with water for 15 minutes. Remove all clothing that are exposed and flush with water. Report to INRF staff or report to EH&S. Seek medical attention immediately.

In case of large spill, follow the INRF Standard Operating Procedure for chemical spills.

References

W. Kern and J. Vossen, *Thin Film Processes*, Academic Press: New York, 1978, Ch V-1.

L. Ristic, *Sensor Technology and Devices*, Artech House: Boston, 1994, Ch 3.

KOH anisotropic silicon etch Checklist

The following checklist is designed to aid the researcher when performing this process.

- Substrate must be clean with hard nitride or oxide mask. No photoresist.
- Prepare KOH solution: 30% KOH by weight.
- Heat to 80 °C on hot plate. Stirrer may also be used.
- Soak wafer in etchant. Don't cover.
- Etch rate is about 1 micron/minute.
- Remove early, DI rinse / blow dry. Check on profilometer.
- Clean up, dispose wastes.