Anisotropic Silicon Etch Using KOH

INRF application note
Process name: KOH01

Overview

KOH is an etchant which attacks silicon preferentially in the <100> plane producing a characteristic anisotropic V-etch with sidewalls that form a 54.7 deg angle with the surface (35.3 deg from the normal). This etch process is independent of the doping concentration for As, P and Sb. For B, the >110> 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 um etch: 20 minutes prep time, followed by 40 minutes etching time. Lithography and reactive ion etch take additional time.

Materials needed

100 silicon wafers with thermally grown oxide or nitride layer (2000-3000 A)
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 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 etching (RIE) system to etch the exposed oxide or nitride surface. For oxides the recommended chemistry is CHF3 and O2 or CF4 and O2. Etch until the silicon is exposed (shiny); typically 5 minutes per 1000 A film.

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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 deg 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 deg C should be about 1 micron/minute.

Clean up

Dispose etchant in INRF labeled waste container. Rinse all lab ware 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 HCI. 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 of 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 a 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 and 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.

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Substrate must be clean with hard nitride or oxide mask. No photoresist.

Prepare KOH solution: 30% KOH by weight

Heat to 80 deg C on hot plate. Stirrer may also be used.

Soak wafer in etchant. Do not cover.

Etch rate is about 1 micron/minute.

Remove early DI rinse / blow dry. Check on profilometer.

Clean up and dispose of wastes.