



Lab Manual

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Sink 3 Operation

(sink3)

1.0 Title

Sink 3 Operation

2.0 Purpose

This document specifies information about Sink 3, the isotropic silicon etch sink.

3.0 Scope

Sink3 is assigned for isotropic silicon etching, which houses TetraMethyl-Ammonium Hydroxide (TMAH) and Potassium Hydroxide (KOH) solutions.

Sink3 consists of two baths, one QDR, a general drain area, a deck hose, and a N2 gun (see an overview picture and a detailed one in Section 11).

4.0 Applicable Documents

Revision History

- H. Seidel, L. Csepregi, A. Heuberger, and H. Baumgartel, **Anisotropic Etching of Crystalline Silicon in Alkaline Solutions, I. Orientation Dependence and Behavior of Passivation Layers**, J. Electrochem. Soc., Vol. 137, No. 11, pp. 3612-3626, Nov. 1990.
- H. Seidel, L. Csepregi, A. Heuberger, and H. Baumgartel, **Anisotropic Etching of Crystalline Silicon in Alkaline Solutions, II. Influence of Dopants**, J. Electrochem. Soc., Vol. 137, No. 11, pp. 3626-3632, Nov. 1990.
- G. T. A. Kovacs, **Micromachined Transducers Sourcebook**, McGraw-Hill, New York 1998
- G. Lin, B. Eyre, K.J.S. Pister, **Bulk Micromachining of Standard Cmos Using Silicic Acid Added to TMAH for Aluminum Passivation**, UCLA MEMS Technical Report. Electrical Engineering, UCLA TRN 95-13, 1995.
- Merlos et al., **TMAH/IPA Anisotropic Etching Characteristics**, Sensors and Actuators A 37-38, pp. 737-743, 1993.

5.0 Definitions & Process Terminology

Quick Dump Rinse (QDR) – DI water fills the sink followed by a quick dump to get rid of excess acid and/or contaminants.

Plenum L/L High – Early warning alarm indicates sink drain failure.

6.0 Safety

For details, see MSDS sheets.

EPO red button ([Figure 3](#)): Cuts power to the sink in case of emergencies. Report promptly on FAULTS.

Never touch any surface while wearing chemical-resistant gloves that other lab members may come into contact with, such as the table tops, door handles, computer keyboards, face shields, aprons, etc. If you need to step away from the sink at any time, rinse off the gloves, dry with techni-cloths, and put away in your drawer until you are ready to resume your work at the sink.

6.1 Tetramethyl-Amonium Hydroxide (TMAH)

Flammable (in 100% solution).

Toxic, causes burns. Poisonous. May be fatal or cause blindness if swallowed. Vapor Harmful. Target organs: eyes, kidneys.

Store only in Old Lab chemical cabinet. Bottles of 25% TMAH are stocked in the "bases" cabinet in the Microlab lobby, on the bottom shelf. Open under fume hood in Sink 3 only. Wear chemical gloves, rubber apron, and face shield provided in Sink 3.

6.2 Potassium Hydroxide (KOH)

POISON! DANGER! CORROSIVE. CAUSES SEVERE BURNS TO SKIN, EYES, RESPIRATORY TRACT, AND GASTROINTESTINAL TRACT. MATERIAL IS EXTREMELY DESTRUCTIVE TO ALL BODY TISSUES. MAY BE FATAL IF SWALLOWED. HARMFUL IF INHALED.

POTENTIAL HEALTH EFFECTS

INHALATION

RESPIRATORY TRACT IRRITANT, MAY CAUSE SERIOUS BURNS ON ACUTE CONTACT. SEVERE INJURY IS USUALLY AVOIDED BY THE SELF-LIMITING COUGHING ANDSNEEZING SYMPTOMS.

INGESTION

TOXIC! CORROSIVE TO MUCOUS MEMBRANES AND MAY CAUSE PERFORATION OF THE ESOPHAGUS AND STOMACH. ABDOMINAL PAIN, NAUSEA, VOMITING, GENERAL GASTRO-INTESTINAL UPSET CAN BE EXPECTED.

SKIN CONTACT

IRRITANT, POSSIBLY CORROSIVE IF CONTACT IS PROLONGED. SORENESS, REDNESS, DESTRUCTION OF SKIN MAY RESULT.

EYE CONTACT

IRRITANT, POSSIBLY CORROSIVE TO EYE TISSUES. TEARING, REDNESS, PAIN, IMPAIRED VISION ARE SYMPTOMS.

CHRONIC EXPOSURE

DEVELOPMENT OF A DEFATTING DERMATITIS ON PROLONGED CONTACT WITH POTASSIUM HYDROXIDE HAS BEEN REPORTED. CONTINUED IRRITATION MAY LEAD TO INCREASED SUSCEPTIBILITY TO RESPIRATORY ILLNESS.

AGGRAVATION OF PRE-EXISTING CONDITIONS

PERSONS WITH PRE-EXISTING SKIN DISORDERS OR EYE PROBLEMS, OR IMPAIRED KIDNEY OR RESPIRATORY FUNCTION MAY BE MORE SUSCEPTIBLE TO THE EFFECTS OF THE SUBSTANCE.

Wear chemical gloves, rubber apron, and face shield provided in Sink 3.

7.0 **Statistical/process Data**

Problems and comments Section under Equipment section of the Wand.

8.0 Available Processes, Gases, Process Notes

| Bath | Chemical | Temperature |
|--------------|----------|-------------|
| Left-Heated | KOH | 80°C |
| Right-Heated | TMAH | 80°C |

Both available silicon etchants etch silicon 100 planes at a relatively high rate to other crystal planes. For the plane (111) etch rate as a reference rate '1', the (100) is 300-400, and (110) is 600 typically. Silicon Nitride is a good mask material for both etchants, and Silicon Dioxide may be used as a mask for TMAH. KOH solutions can produce smoother etch surfaces, yet the free radicals in KOH may affect device performance on wafers with fabricated devices. Solutions can have dramatically reduced etch rates based on doping, and n and p doped regions may be selectively etched with an applied bias during etching. Additives to TMAH can improve the selectivity to metals. See noted references for details.

9.0 Equipment Operation

The sink operation is relatively easy. The main difference between the old and the new style sinks is: at the new sinks, members invoke the dump rinse cycle, QDR and heated baths from a keypad mounted on the face of the station

9.1 **Control Key Description**

There are three control/displays at this station (see Appendix 1). The single UFT-820 ([Figure 1](#)) temperature control panel is for both heated baths. The UFT-48-8 Dump Rinser ([Figure 2](#)) control panel is for the quick dump rinse (QDR) station. The QDR is currently set up for two dump rinse cycles. Wafers are initially showered with DI water followed by two DI fill-dump cycles. These cycles end with wafers submerged in the water for operator to extract and dry with the N2 gun. See Appendix 1 for more details. The station performs an automatic self-cleaning, every 60 minutes by one QDR cycle. The Resistivity Monitor panel is not used at this sink.

9.1.1 **Power Control Key Description for Temperature Controller**

| | |
|-------------------------|--|
| PWR ON/OFF | Turns on/off the power control panel (Figure 1). |
| HEAT ON/OFF | Puts system in HOLD mode. This deactivates the heater output. |
| RESET | Exit the program mode. |
| PROG | Access to change or step through various setup parameters. |
| SAVE | Permanently save the system setup parameters. |
| TIME RUN | Use of this button is optional; times the step. Maximum time is 99 min. 59 sec. |
| TIMER STOP/RESET | Stops or interrupts a timed etch or the temperature control panel. |
| ALARM/SIL | <ul style="list-style-type: none"> - Silences the timer, any alarm conditions. - Cancels flashing alpha code in the displays. - Examines the process set point and the Time Preset. |

9.1.2 **Control Key Description (QDR)**

| | |
|--------------|--|
| START | Activates dump rinse cycle / Reactivates dump rinse cycle. |
| RESET | <ul style="list-style-type: none"> - Silences alarm. - Deactivates the quick dump rinser. - Automatically reset itself in preparation for another run. - Exits program mode. |
| HOLD | - Halts rinse cycle. |

– Manually dumps the tank.

PROG Parameters to be written in the EEPROM memory.

9.1.3 Control Key Functions for Overall Sink Operations

EPO Big red button for emergency stop of entire sink operation.

All three:

POWER ON Main power on for top control panels ([Figure 3](#)).

POWER OFF Main power off for top control panels ([Figure 3](#)).

ALARM SILENCE Silences any alarm at this sink.

ALARM RESET Resets alarm system to this sink.

DRAIN ON/OFF Not in use.

ASP ON/OFF Not in use.

RESISTIVITY DISP/CHAN Not in use.

RINSER Start/Reset QDR.

Aspirator Dial on Top Panel Aspirates KOH and TMAH baths.

9.2 Quick Dump Rinse Operation ([Figure 2](#))

9.2.1 Place wafers in the tank; tank initially should be full of DI water.

9.2.2 Press **START** button to activate the dump rinse cycle ([Figure 2](#)). It will cycle down from 2 to 1 then show 0 in the display window. At the end of the two cycles a beeping alarm will sound.

9.2.3 Press **RESET** to silence the alarm.

9.2.4 Press **RESET** to reset itself in preparation for another run.

9.2.5 Press **HOLD** to manually dump the tank.

9.2.6 Upon completion of two rinse cycles remove wafers dry with N2 gun.

9.3 Etching

Etching instructions are applicable to both TMAH side (right) and KOH side (left) unless noted.

Etch recipes and pertinent information are given in Chapter 1.9 KOH etches silicon dioxide, so it is not a suitable masking material for long etches. Silicon nitride is the preferred masking material.

9.3.1 Rinse the beaker thoroughly and aspirate to make sure it is clean before processing. Turn the N2 flowmeter ½ way up next to the bath after mixing the new solution.

9.3.2 **(KOH)** With the cassette out of the beaker, add 2 liters of DI water by looking at the 2-liter mark on the beaker. For Critical runs, the DI water may be measured using the graduated cylinder located near the sink.

TMAH solution is commonly stocked in a 25 % concentration. Calculate the amount of 25% solution and DI water to make the desired etchant concentration (often 3%-15%). Under the hood, open TMAH container, and add desired amounts of solution and DI water to bath. Make enough solution to reach ½ inch below the cooling coil. This amount should be sufficient to cover a 6" wafer cassette.

Note: Needs 6 liters of solution to cover 4" cassette with wafers.
Needs 8.5 liters of solution to cover 6" cassette with wafers.

9.3.3 **(KOH)** Add 1 kg of KOH by simply adding the contents of two 500 mg bottles of KOH. For critical runs, weigh is on the portable balance inside the sink. Also, other ratios of KOH to water produce different results, so see references in this document.

- 9.3.4 Make sure the Main Power button is on the left front center of the sink.
- 9.3.5 Press the power ON/OFF on the Temperature Controller panel at the top of the sink.
- 9.3.6 Locate the KOH/TMAH switch on the top panel and set the toggle switch to the desired etchant.
- 9.3.7 Press the HEAT ON/OFF on the Temperature Controller panel at the top of the sink. The HEAT LED light will light up when the heater is on.
- 9.3.8 Typically the hot plate should be set to 80°. The temperature will reach the set point in 30-60 minutes for the bath. During the temperature stabilization, a visible interface may form between the hot and cold (KOH and water) liquids. Using the 4" cassette handle as a stirrer, this interface may be broken to allow the mixture to stabilize faster.
- 9.3.9 Load wafers to be etched in the cassette and place in the bath. Careful when removing the lid because solution condenses on it. Tap the lid a few times to shake off most of the drops of liquid and place the lid on a techni-cloth.
- 9.3.10 Replace the lid and start timing the etch. For critical runs, the wafer can be rotated during the run. The etch rate is temperature dependant (a factor of 2 to 3 for every 10°C for KOH), and temperature significant temperature gradients may develop in the solution. The etch rate is approximately 1 um per minute for both KOH (2:1) and TMAH (5%) at 80°C.
- 9.3.11 When the etch is completed, remove the lid and cassette. Let the wafers cool briefly before rinsing by partially dipping the wafers in the QDR (Quick Dump Rinse) to avoid breaking membranes. Initiate the rinse cycle. For gentle rinse, use deck hose instead of QDR rinse.
- 9.3.12 If you are finished etching, shut off the heater by pressing the heat ON/OFF button on the temperature controller panel (top panel). Turn the N2 off on the flowmeter. Aspirate the solution, rinse the bath and aspirate the bath 3 times with DI water. The bottom of each bath has a perforated screen with a small hole, the size of the aspirator tube diameter: the aspirator should be pushed through this hole to completely aspirate the solution from the bath. Disable the sink afterwards.

10.0 Troubleshooting Guidelines

10.1 Status Sidebar at Temperature Control Panel ([Figure 1](#))

Red LED will light up to indicate a problem:

| | | | |
|-----------------|-------------------|--------------------------|----------------------|
| HGH TEMP | OVER TEMP | DEFFECTIVE SENSOR | SYSTEM FAULT? |
| LOW TEMP | LOW LIQUID | POWER FAILURE | HEAT |

10.2 Sink System Status Indicators (located on top sink panel to the immediate left of the KOH/TMAH toggle switch)

| | |
|-------------------|--|
| LOW PURGE | Red indicator light will come on when there is low air purge to cool off electronics for the sink. |
| PLENUM L/L | Red indicator light will come on when the plenum liquid level is too high. |
| ASPIRATOR | Red indicator light will come on when aspirator is in use. |
| DRAIN | Not in use. |

PLENUM L/L HIGH: If it sounds, push the **ALARM SILENCE** button on the sink, and notify the process staff and post the problem on Faults, as a full plenum lockout is an early warning alarm indicating sink drain failure. The area under the deck of a wet process station (sink) is known as the plenum. This area receives the water and chemicals when they drain from the tanks and the utility sink. When the level of water in the plenum reaches 3 inches, a float activated switch opens a valve and the waste is removed. Should the water rise too high in the plenum because of a failure of the system, all sources of water to the sink are shut off

and the alarm will sound. This is to prevent an overflow. If the user silences the alarm, it will again sound when the problem is solved and the water level has returned to normal.

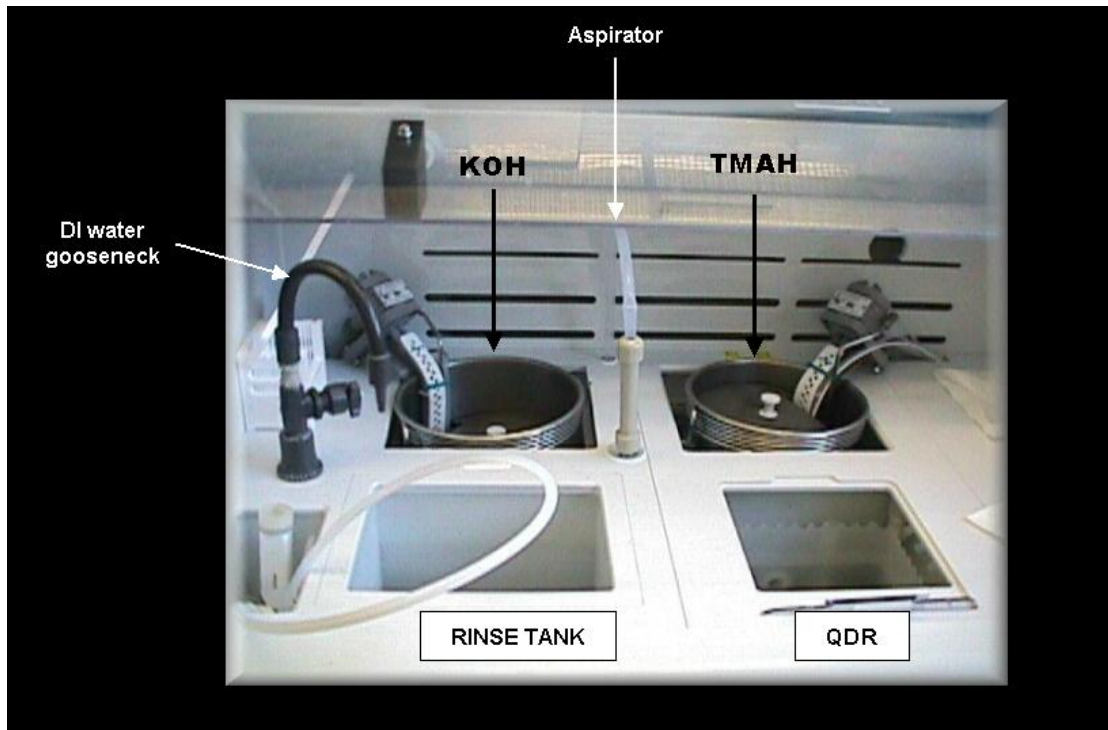
10.3 If EPO is pushed, follow instructions:

- 10.3.1 Pull out EPO button.
- 10.3.2 Open head case pull down breaker switch and then lift up.
- 10.3.3 Push button on front of sink that says on.
- 10.3.4 Push power button on heater controller.
- 10.3.5 Push heat button on controller.

11.0 Figures & Schematics



Sink3 Overview



Note: Both KOH and TMAH must have enough liquid in both baths to keep the LOW LIQUID alarm silent.

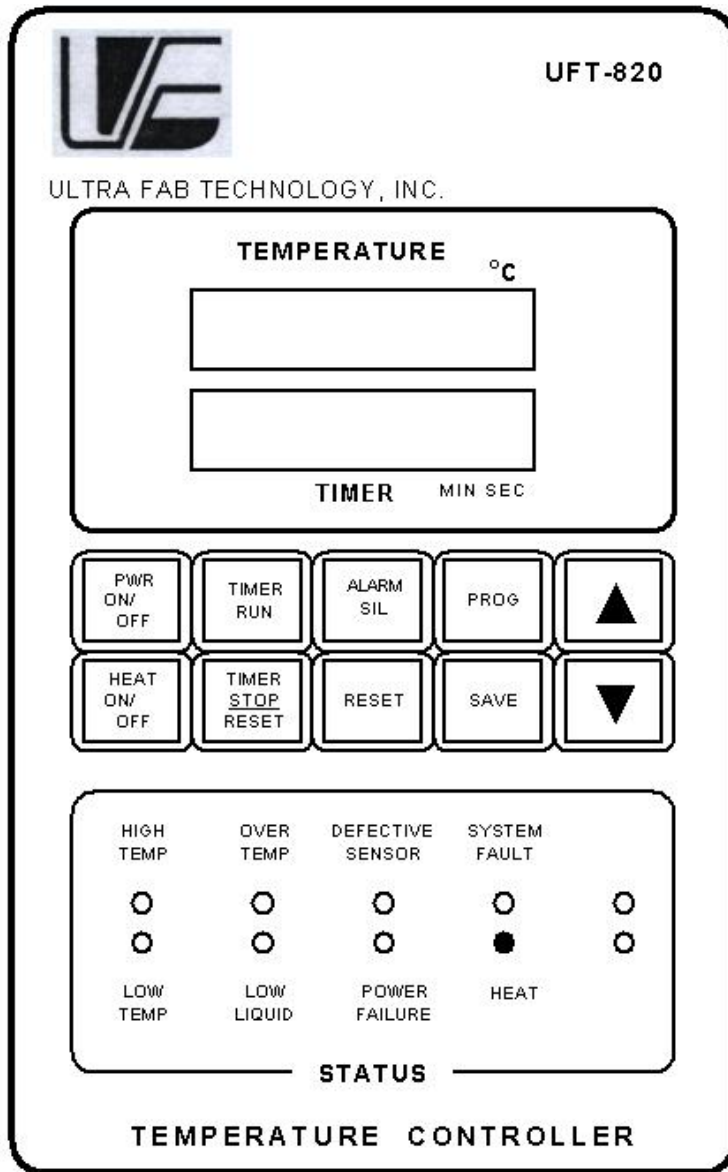


Figure 1

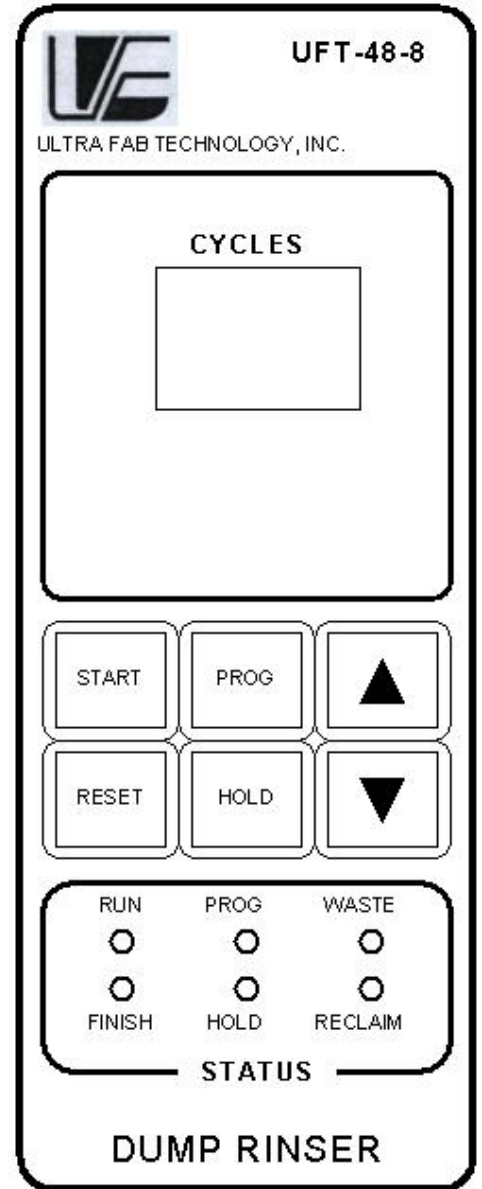


Figure 2

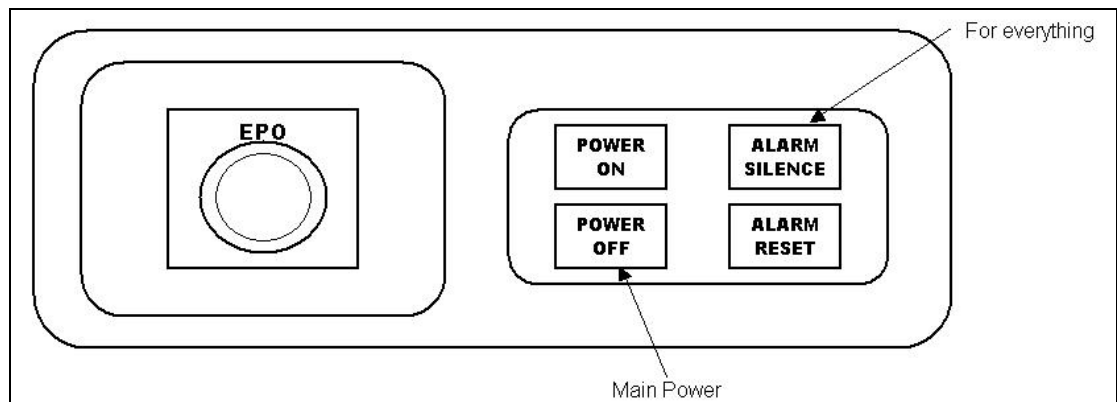


Figure 3

12.0 Appendices

Appendix 1

DECK HOSE Instructions

The de-ionized (DI) water deck hose for the sinks is **ALWAYS** available for emergencies; it provides a good safety backup in the event of exposure to chemicals.

Appendix 2

| Temperature Controller | | Dump Rinser | |
|------------------------|--------|-------------|----|
| C5 | 99:59 | AF | |
| PA | 30 | CY | 2 |
| P5 | 80.0°C | rC | 0 |
| Hi | 85.0 | Fp | 60 |
| Lo | 16.9 | dp | 3 |
| dr | 30.0 | SC | 0 |
| dl | 7:18 | Ad | 0 |
| Cr | 10 | n2 | n |
| Pb | 10.0 | Ac | 0 |
| rE | 0.5 | PC | 5 |
| rA | 1.0 | Pn | 1 |
| CA | 0.0 | rP | L |
| AC | 00 | | |
| Cd | dn | | |