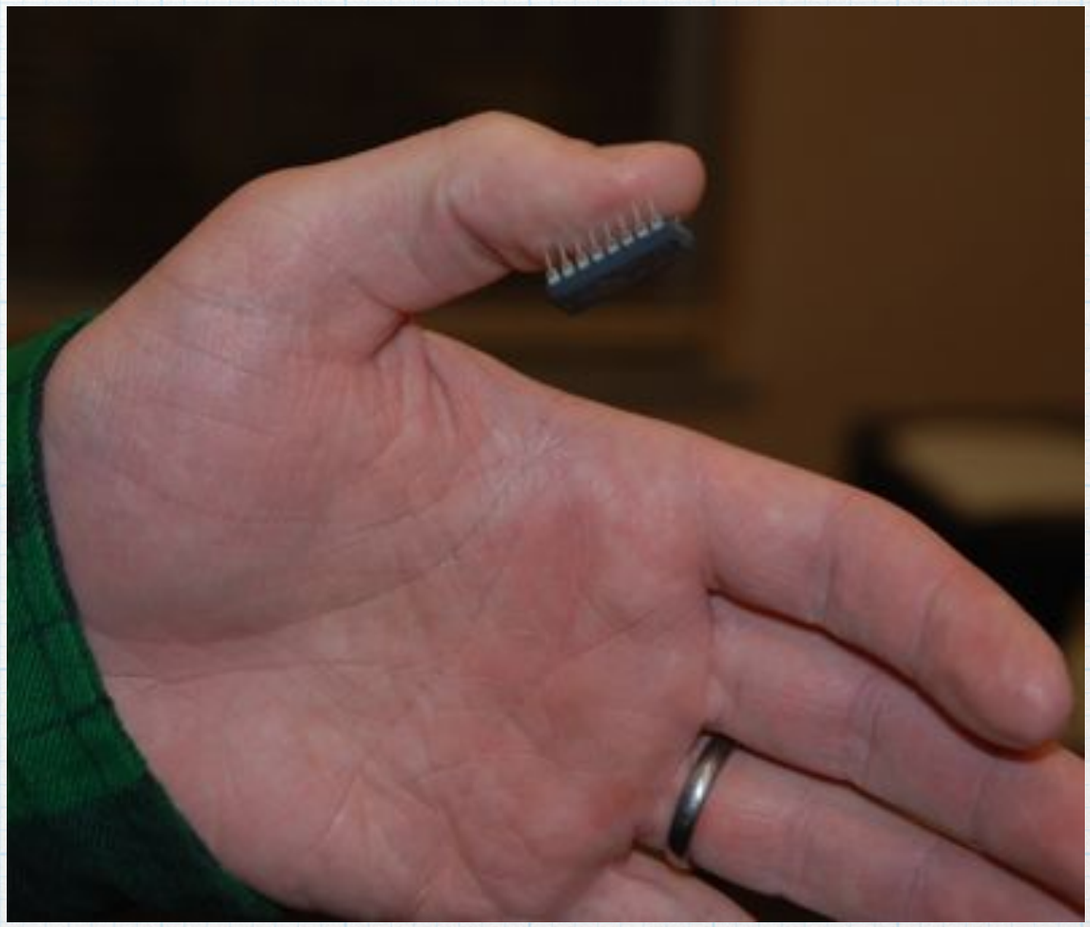
EE 432/532 safety

In most EE labs, safety is not a big concern. The worst things that might happen are:

dropping a multimeter on your foot

or poking an IC into your thumb



However, in EE 432, there are a number of potentially dangerous – even lethal – things that we use on a daily basis.

Safety – basic considerations

1. **Follow the standard operating procedures (SOPs)**.
2. Understand that you have a "right to know" about proper procedures and dangerous materials.
3. Know how to use the material safety data sheets (MSDSs).
4. Never work in the lab without having a lab supervisor (TA) available. (Never work alone.)
5. Work in the proper areas (chemicals in the fume hoods, test equipment on the test bench, etc.)
6. For each task, use the proper personal protective equipment (PPE).
7. Know the location and use of safety equipment (shower, eye-wash, fire extinguisher, etc.)
8. Know how to handle a chemical spill (onto a person or onto the floor.)
9. Know where go in case of a fire or tornado.
10. **Follow the SOPs**.

Standard operating procedures

- Step-by-step rules for all lab work.
- If you follow them, you will automatically be doing the work in a safe manner.
- In lab, have one person (group leader) read out the SOPs while the others perform the work.

Standard Clean for Silicon

ESSENTIAL SAFETY PRECAUTIONS

- Verify wet process station exhaust fan operation by checking air flow at the perforated front of the bench using a piece of paper. The paper should be sucked firmly against the perforated plastic strip at the front of the wet process stations. *DO NOT PROCEED IF THERE IS NOT ADEQUATE VENTILATION*.
- Assemble and don the personal protective equipment required for this procedure: lab coat, eye goggles, vinyl cleanroom gloves, heavy rubberized lab apron, and the yellow chemically resistant gloves.
- Note the location of the safety shower and eyewash station and check to make sure the path is clear of obstructions.
- Note the location of the telephone to summon help in the event of an emergency by dialing 911.

IMPORTANT BACKGROUND INFORMATION

- Cleaning should be performed immediately prior to any high-temperature processing. If the furnace processing cannot be performed within a couple of hours, the wafers will need to be cleaned again.
- Always use fresh cleaning solutions.
- Use only plastic tweezers after cleaning—metal tweezers should not be used to handle clean wafers.
- Read and understand the document "Using the Wet Process Benches."
- Use only the high-purity 18 MΩ•cm deionized water during this process.

PREPARE SOLUTIONS

1. Remove the white polypropylene lids from the clean tubs and the adjacent cascade rinse tub. Remove the inner lids from the two clean tubs. Place the inner lids in a clean place, such as on the shelf above the tubs. Be careful not to interchange the lids.

2. Turn on the heater N_2 purge valve by lifting the handle to the upright position. This purge must remain on whenever there is liquid in the tub.
3. Rinse the 1000 ml graduated cylinder and the two tubs thoroughly with deionized water. Make sure that the tub drains are open and the tubs are fully drained.
4. Close the tub drains. Measure 2500 ml of DI water into the left tub (SC-1). Measure 3000 ml of DI water into the right tub (SC-2).
5. Measure 500 ml of ammonium hydroxide (NH_4OH, green label) into the left tub.
6. Rinse the graduated cylinder with DI water.
7. Measure 500 ml hydrochloric acid (HCl, blue label) into the right tub.
8. Rinse the graduated cylinder with DI water.
9. Turn on the two temperature controllers located in the center top of the bench. The green lights should come on and indicate the present temperature of the solutions. Verify that the setpoints are at 80°C, by pressing the button marked *.
10. When the SC-1 solution (left tub) reaches 75°C, measure 500 ml of hydrogen peroxide (H_2O_2, purple label) into the tub.
11. Rinse the graduated cylinder with DI water.

CLEAN

12. When solution SC-1 reaches 75°C a second time, lower the wafer carrier into the tub. Start timing 15 minutes. With about 5 minutes left in the first step, turn on the blue cascade rinse valve.

    While the wafers are in SC-1, you can heat the furnace(s) for the upcoming hot processing. See the SOPs for the appropriate furnace for temperatures and procedures.
13. When the 15 minutes is up, move the wafer carrier into the cascade rinse tub. Open the yellow nitrogen valve just enough to get gentle agitation of the water. Start timing 5 minutes.
14. Turn off the temperature controller for SC-1 (the left tub).
15. Measure 500 ml of hydrogen peroxide (H_2O_2, purple label) and pout it into the SC-2 (right tub).

Material Safety Data Sheets (MSDSs)

A standard form provided by vendors of chemicals describing the properties of various and their potential health risks. These are the first step in educating yourself about potential hazards of the materials we use in the lab.

Health	2
Fire	3
Reactivity	0
Personal Protection	H

Material Safety Data Sheet
Acetone MSDS

Section 1: Chemical Product and Company Identification

Product Name: Acetone

Catalog Codes: SLA3502, SLA1645, SLA3151, SLA3808

CAS#: 67-64-1

RTECS: AL3150000

TSCA: TSCA 8(b) inventory: Acetone

CI#: Not applicable.

Synonym: 2-propanone; Dimethyl Ketone; Dimethylformaldehyde; Pyroacetic Acid

Chemical Name: Acetone

Chemical Formula: C3-H6-O

Contact Information:

Sciencelab.com, Inc.
14025 Smith Rd.
Houston, Texas 77396

US Sales: **1-800-901-7247**
International Sales: **1-281-441-4400**

Order Online: ScienceLab.com

CHEMTREC (24HR Emergency Telephone), call: 1-800-424-9300

International CHEMTREC, call: 1-703-527-3887

For non-emergency assistance, call: 1-281-441-4400

Section 2: Composition and Information on Ingredients

Composition:

Name	CAS #	% by Weight
Acetone	67-64-1	100

Toxicological Data on Ingredients: Acetone: ORAL (LD50): Acute: 5800 mg/kg [Rat]. 3000 mg/kg [Mouse]. 5340 mg/kg [Rabbit]. VAPOR (LC50): Acute: 50100 mg/m 8 hours [Rat]. 44000 mg/m 4 hours [Mouse].

Personal protective equipment

- Lab coats – always. (Everyone will be provided with a personal lab coat).
- Clean-room gloves – always. (Provided in lab.)
- Safety goggles – chemicals, furnaces, mask aligner. (Everyone will be provided with their own set of goggles.)
- Heavy apron – chemicals. (Provided in lab.)
- Chemically resistant gloves – chemicals. (Provided in lab.)
- Heat-resistant gloves – furnaces. (Provided in lab.)
- Sandals – NEVER. (You must wear shoes that cover your feet.)

Handling chemicals

We use a number of strong acids, bases, and solvents for processing. These are used for wafer cleaning, etching silicon dioxide and metals, and for the lithography process.As always, follow the SOPs when working with the chemicals.

- All work must be done in the chemical fume hoods. Make sure bottles are inside the fume hood before opening them. Always make sure that the fans are working before opening the bottles.
- Be sure to wear the proper protective equipment and use the proper handling tools.
- Know what to do in case there is a chemical spill.

PPE for chemicals

Work is done in the fume hood.
Protective equipment includes:

- Lab coat
- Goggles
- Heavy rubberized apron
- Chemically resistant gloves
- Note: no sandals

If you spill an acid or a base on yourself:

1. Immediately tell the lab supervisor or one of your lab partners what has happened. If something has gotten into your eyes, you will need assistance with the eye wash.

2. Begin rinsing the contaminated areas with large amounts of water. This can be done in the sink (for exposure on fingers or hand) or under the shower for exposure over larger areas of the body. Remove any clothing that was contaminated. If you need to use the eye wash, have someone help you get to the station and direct the water onto your face. You must keep your eyes open when rinsing in order to for the chemical to be flushed out. Continue rinsing for at least 15 minutes.

3. For a serious exposure (large areas of your body or anything in the eyes), have someone take you to the emergency room or call an ambulance.

4. Be sure to monitor your health carefully for the next few days. If you are not feeling well anytime after the exposure, go see a doctor immediately. The course instructor may ask you to see a doctor in any case.

5. Any spillage on the floor must be cleaned with a chemical spill kit, located in the lab. Follow the instructions on the kit. Be sure to put on the correct PPE before cleaning the spill.

Hydrofluoric acid

We use hydrofluoric acid to etch silicon dioxide, which is done several times in our process. Even though is considered to be a “weak” acid, it has particularly nasty effects on the human body.

- If you get it on your skin, it may not burn right away, so you are not necessarily aware of the exposure.
- It will soak into your flesh and will destroy tissues and de-calcify bones. However, there may be a delay of several hours, by which time it is very difficult to treat.
- A large exposure may cause electrolyte imbalances which can lead to heart failure.

Working with HF acid is serious business.

If you get HF on skin, follow the emergency procedures outlined in the previously, with the following exceptions:

- Rinse in the sink or under the shower for **5 minutes**.
- Apply a heavy dose of **calcium gluconate** gel to the exposed area. The calcium will bind with the fluorine ions to lessen potential damage. The calcium gluconate is kept in the lab.

Here are links to some sites describing the effects of hydrofluoric acid burns and safety precautions. (Warning: some of these have graphic pictures of injuries.)

- http://en.wikipedia.org/wiki/Hydrofluoric_acid
- https://www.emsworld.com/article/10319665/hydrofluoric-acid-what-you-need-know
- http://emedicine.medscape.com/article/773304-overview
- https://www.oatext.com/Chemical-burn-caused-by-high-concentration-hydrofluoric-acid-a-case-that-followed-a-lethal-course.php
- http://www.nejm.org/doi/full/10.1056/NEJMicm055763

Shower and eyewash station

- One in each lab
- Shower operated with pull chain
- Eye wash operated with foot pedal (remove plastic covers first)
- Rinse for at least 15 minutes
- Assistance is (probably) needed for using the eye wash
- No drain, so don't mess with it until it is needed

High temperature furnaces

The high-temperature furnaces are slightly less dangerous, but still required some precautions.

- Typically operating temperatures of 800°C – 1150°C (1550°F – 2100°F).
- Must be careful when handling the hot glassware.
- Remember that everything that goes into the furnace will come out hot. (People tend to forget this when working with the push rods.)

PPE for furnace work

- Lab coat
- Goggles
- Heat resistant gloves

Mask aligner

Also on the lower end of the “danger” scale, but still something to be mindful of is the ultraviolet light generated by the mask aligner.

- Erythema (sunburn)
- Photokeratitis (sunburn of the cornea, snow blindness)
- Increased risk of skin cancer
- Lab coats, clean-room gloves, plastic eye goggles provide effective protection.

PPE at the mask aligner

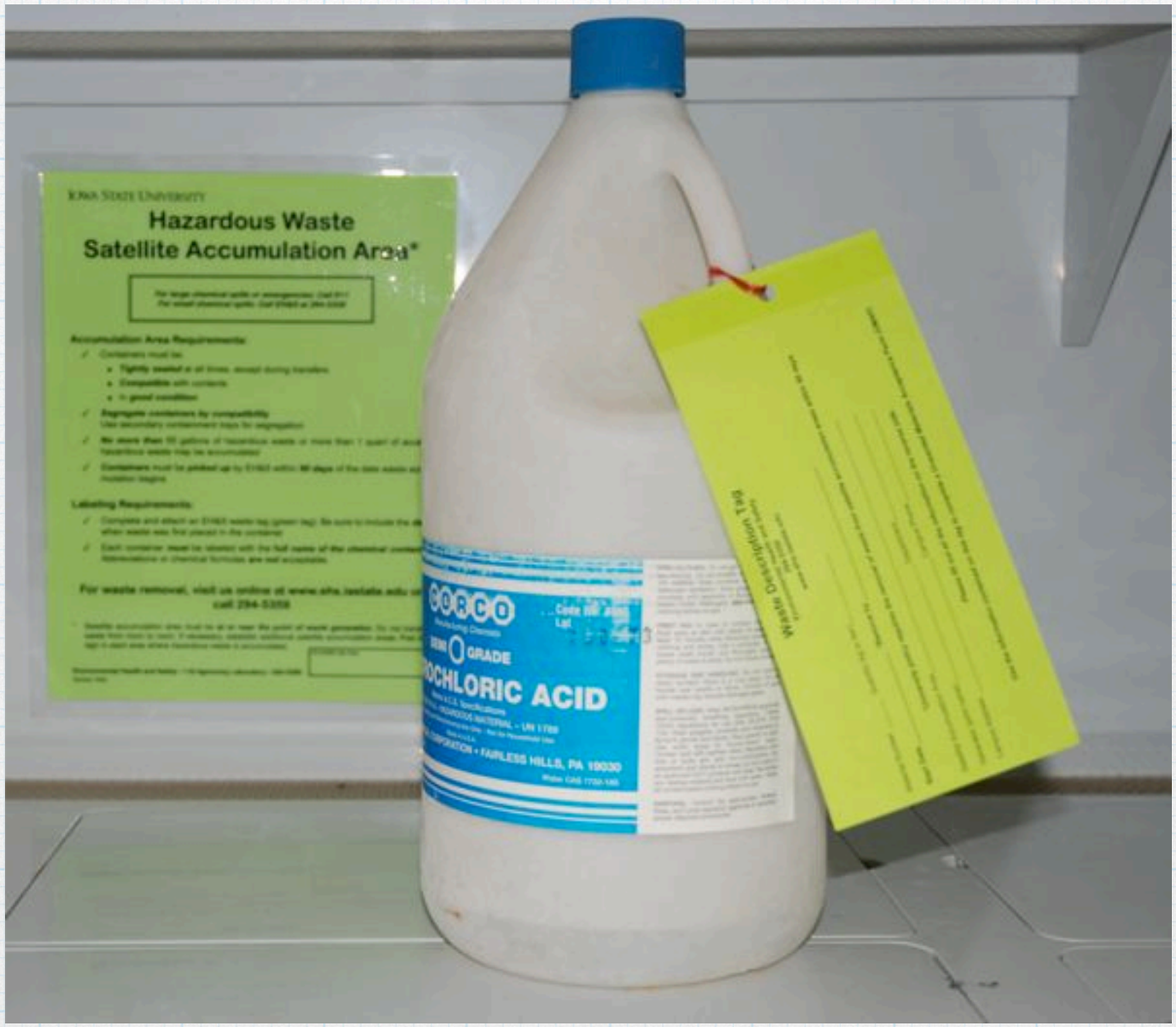
- Lab coat
- Goggles
- clean-room gloves

High-pressure gases

- Escaping high-pressure gases can be very dangerous. (Potential rocket!)
- Regulators minimize risk.
- Follow SOPs, and there should be no problems.

Waste Disposal

- We use a number of toxic chemicals in the lab. The waste must be disposed of properly.
- Generally, waste needs to be stored until it can be picked up and disposed of in a proper chemical waste facility.
- Each chemical (or combination of chemicals) needs to be stored in a separate container. The containers must remain capped. (Except when adding new waste, of course.)
- The container is labeled with a distinctive tag. The tag will have information about what wastes are being stored.
- Don't mix different wastes. This can be dangerous and makes the disposal process much more difficult and expensive.
- Before adding new wastes to a container, check to make sure that there is adequate space in the container for the new material.
- Lab supervisors can provide a new waste container, if the current one is full.
- Filled waste containers are picked up periodically by representatives from Environmental Health and Safety. Details about the waste disposal process can be found at https://www.ehs.iastate.edu/services/waste/wasteremoval.
- An exception to the waste container rule is the waste generated in the standard clean process. We neutralize the used chemicals directly in the lab bench.


IOWA STATE UNIVERSITY
Hazardous Waste
Satellite Accumulation Area*
Accumulation Area Requirements:
Labeling Requirements:
For waste removal, visit us online at www.ehs.iastate.edu
call 294-5359
ORCO
GRADE
CHLORIC ACID
FAIRLESS HILLS, PA 19030
Waste Description

Protecting your work

Semiconductor wafers are highly susceptible to contamination by impurities. (We will have a separate lectures on this. In the lab, to help protect your wafers:

- Work only in the "clean" areas – under laminar flow filters and clean fume hoods.
- Use only high-purity de-ionized water.
- Always wear clean room gloves.
- Handle your wafers only with tweezers. Don't pick them up with your fingers, even if you are wearing gloves.
- Keep the wafers inside the blue boxes. When not in use, store everything in the dry nitrogen cabinets.
- Remember that your body is one of the biggest sources of contamination. Don't lean over your wafers, don't talk while you are working with the wafers, keep your hair pulled back, etc.

Before working in the lab, you will need to sign a safety checklist, verifying that you have been informed about safety procedures in the 432/532 lab.

NSF Lab safety checklist

1. I understand that I have a "right to know" about lab safety issues. _____.
2. I understand about the information available in material safety data sheets and where to find those for chemicals used in the NSF labs. _____.
3. I know whom to contact in case of a lab emergency. _____.
4. I understand that I am not to work in the laboratory without a lab partner and that I should never start a process without the guidance of a lab supervisor. _____.
5. I understand that I am always to wear proper protective apparel in the lab, including closed-toe shoes. (i.e. no sandals). _____.
6. I am aware of the locations of lab safety equipment (showers, eyewash, fire extinguisher), the phone for use in emergency situations, and escape routes from the laboratory. _____.
7. I have been instructed in the use of chemical safety apparel and safe chemical practices. _____.
8. I have been informed of the particular dangers of hydrofluoric acid and in the use of calcium gluconate to mitigate the effects of exposure. _____.
9. I am aware of the standard operating procedures (SOPs for lab equipment and processes and the need to follow SOPs while working in the lab. _____.
10. I have been informed about the proper methods for disposing of used chemicals in the lab. _____.

I agree to follow all lab safety procedures, I understand that failure to follow the safety rules will be grounds for dismissal from the laboratory.

Name (please print)_____.

(signed) _____ date_____.