

# Standard Lithography

## Standard Operating Procedure

**Faculty Supervisor: Prof. Robert White, Mechanical Engineering (x72210)**

**Safety Office: Peter Nowak x73246 (Just dial this directly on any campus phone.)**

**(617)627-3246 (From off-campus or from a cell phone)**

**Tufts Emergency Medical Services are at x66911.**

**Revised: May 29, 2020**

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### Goal:

Deposit, expose, and develop standard positive photoresist films as an etch mask, liftoff mask, or sacrificial layer.

### Warnings:

The chemicals you are working with here are not acutely hazardous. However, all processing (including hotplate bakes) must be done in the fume hood. The main things are to avoid skin contact with the MF CD26 developer, not breath any solvent fumes, avoid skin contact with HMDS or photoresist and not to spray any acetone or isopropanol on the hotplates while they are hot.

### **1. Material Requirements:**

**1.1 Equipment and tools:** Spin processor, photoresist oven, photoresist hotplates, wafer tweezers, glass Petri dish, two glass beakers (1000 mL).

**1.2 Chemicals:** photoresist (recommend Rohm & Haas SPR220 series), MF CD26 developer, MCC Primer 80/20 or Hexamethyldisilazane (HMDS), acetone, isopropanol

#### **1.2.1 Hazards associated with chemicals:**

**1.2.1.1** SPR 220 photoresist contains Cresol Novolak Resin (<35%) and the following volatile solvents: ethyl lactate (30-50%), anisole (15-25%), 2-methyl butyl acetate (<5%), n-amyl acetate (<10%). It also contains Diazo Photoactive Compound (<10%), Cresol (<0.5%) and Organic Siloxane Surfactant (<1%). It is a combustible liquid and vapor. It causes irritation to eyes, nose, and respiratory tract. Prolonged, repeated contact, inhalation, ingestion, or absorption through the skin, may cause toxic effects to internal organ systems.

**1.2.1.2** MF CD26 developer is an alkaline (base) corrosive liquid containing tetramethyl ammonium hydroxide (TMAH). It will cause irritation and burns if it contacts the skin. It may react violently with acids. Do not mix with acids!!

**1.2.1.3** MCC Primer 80/20 is a mixture of 80% PM Acetate (1-Methoxy-2-propanol acetate) and 20 % HMDS (hexamethyldisilazane). HMDS will cause irritation and burns if it contacts the skin, and is flammable.

**1.2.1.4** Acetone is a volatile, flammable solvent. Avoid heat sources. Do not breath fumes. Conduct processing in the fume hood.

**1.2.1.5** Isopropanol is a volatile, flammable solvent. Avoid heat sources. Do not breath fumes. Conduct processing in the fume hood.

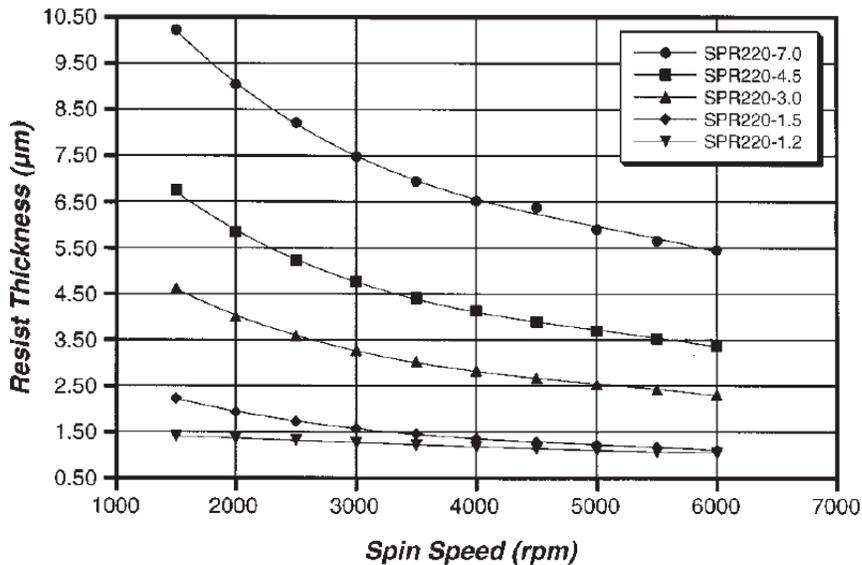
**1.3 Engineering Controls:** Conduct procedures in the fume hood. Dispose of chemicals as described at the end of this document.

**1.4 Personal Protective Equipment:** Nitrile gloves and eye protection required for all procedures. When pouring MF CD26 from the gallon jug to petri dish wear trionic gloves, apron and faceshield. For all other steps you should wear two pairs of nitrile gloves. Confirm both pairs are free from holes, tears, etc. Re-glove if necessary.

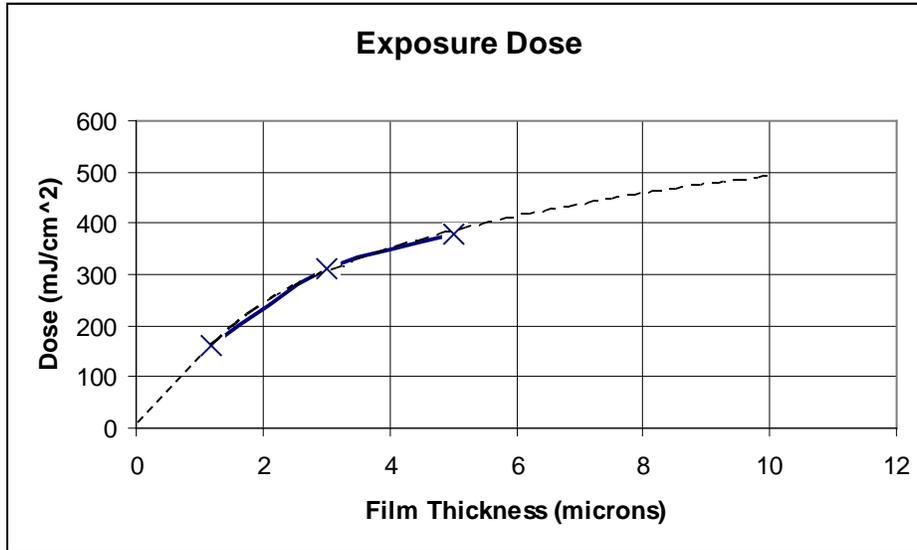
## 2.0 Procedure:

- 2.1 Wafer should be clean prior to starting processing. A Piranha clean (see Piranha clean SOP) is suggested.
- 2.2 Dehydration bake your wafers at 200 °C.
  - 2.2.1 Perform dehydration back on a clean hotplate (5 min) or in the clean convection oven (30 min).
- 2.3 Center your wafer on the spinner using the alignment tool and turn on the vacuum. (See Laurell Spinner SOP for more information).
- 2.4 Spin on adhesion promoter. (See Laurell Spinner SOP for instructions on using the spinner.)
  - 2.4.1 Put a puddle of MCC Primer 80/20 or HMDS on the wafer with a pipette. Do not put too much on so it overflows and gets on the back of the wafer.
  - 2.4.2 Spread at 500 rpm for 5 sec
  - 2.4.3 Spin for 30 sec at 4000 rpm. The adhesion promoter should complete dry off the wafer (you should see rainbow fringes appear and disappear).
- 2.5 Spin on your photoresist. (See Laurell Spinner SOP for instructions on using the spinner.)
  - 2.5.1 Put a puddle of photoresist on the wafer with a pipette. Do not put too much on so it overflows and gets on the back of the wafer.
  - 2.5.2 Spread at 500 rpm for 4 sec
  - 2.5.3 Spin for 30 sec. Spin rate (RPM) needs to be determined based on which photoresist viscosity you have purchased, and what final thickness you require. Spin speed curves are available from the manufacturer. Examples appear below.

**Figure 3. Spin Speed Curves on 4”**



- 2.6 Remove the wafer from the spinner using the wafer alignment tool.
- 2.7 Soft bake (should be conducted with the hotplates in the chemical hood). For resist thickness less than 4 microns, bake for 115 °C for 90 seconds. For thicker films, a longer bake will be required. You will need to experiment, find some literature, or talk with the manufacturer.
- 2.8 Expose (OAI 204 Aligner). See SOP for the OAI Model 204 aligner.
  - 2.8.1 Use a transparency or soda-lime glass mask. With the transparency mask, cut it out to 5” square and lay it on a blank soda-lime glass mask. The mask frame clamps work very well to hold the transparency mask in place (see Aligner SOP).
  - 2.8.2 Expose for the total desired dose. See chart below. For example, if you spun on 3 micron thick SPR220, you want approximately 300 mJ/cm<sup>2</sup>. This will require 20 seconds exposure at 15mW/cm<sup>2</sup>, which is the intensity setting for the aligner. Note that the dashed line is a log fit and is approximate at best.



2.9 Post-exposure-bake (should be conducted with the hotplates in the chemical hood or under the snorkel). For resist thickness less than 4 microns, bake for 115 °C for 90 seconds. For thicker films, a longer bake will be required. **NOTE: A post exposure bake should NOT be used for S1800 series photoresists!**

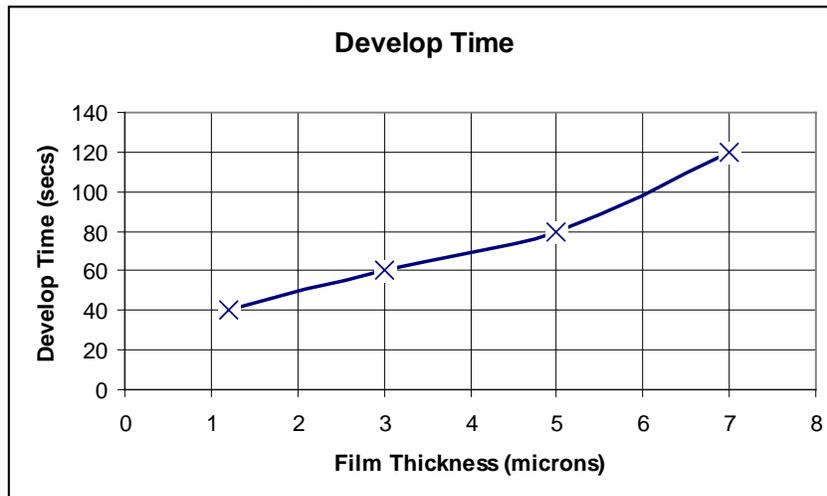
2.10 Develop (chemistry hood)

2.10.1 Before beginning, fill two 1000 mL beakers (labeled “MF CD-26 Rinse 1 & 2”) with DI water.

2.10.2 Don appropriate PPE – trionic gloves, apron faceshield - and pour MF CD-26 Developer (Metal Ion Free developer containing TMAH) into a glass Petri dish labeled “MF CD-26 Developer”. Once complete you may remove the PPE however, during the remainder of the process you should wear two pairs of nitrile gloves. Confirm both pairs are free from holes, tears, etc.

2.10.3 Let substrate soak for desired time (see below). Gentle agitation may help development, we have seen great results with and without.

**NOTE – this data appears to be for a more concentrated developer!** Typical times will be longer. For example, a ~3µm layer required ~3 minutes. Please check the litho logbook for more data points. It may take several runs to determine the optimal time.



2.10.4 Move wafer from developer into water rinse. Allow to soak with agitation for 2 minutes.

- 2.10.5 Fill a second glass beaker with DI water. Transfer the wafer to this water and agitate for 2 minutes.
  - 2.10.6 Remove the wafer from the rinse and blow dry with the CDA gun in the hood. Examine under the microscope.
  - 2.10.7 If you feel further development is needed return the wafer to the developer dish for some additional time. Re-rinse, re-dry and re-examine under the microscope. Iterate as necessary.
  - 2.10.8 Once you are satisfied the resist is fully developed, move on to -
- 2.11 Cleanup:
- 2.11.1 Turn off the hotplates.
  - 2.11.2 Clean off any photoresist residue from any tools or surfaces using acetone, isopropanol, and cleanroom wipes. Dispose of in the solvent/photoresist trash.
  - 2.11.3 Remove the hotplates from the hood.
  - 2.11.4 Make sure the spinner has been cleaned according to the procedures in the Spinner SOP.
  - 2.11.5 Dump MF CD-26 developer, and DI water used to rinse the wafers into the MF CD-26 developer waste (glass or HDPE bottle). Rinse the developer container with water and dump this also into the MF CD-26 developer waste.
  - 2.11.6 Rinse all the beakers and containers a second time with water, and dump into the “dilute acid/base waste” 5 gallon jug.
  - 2.11.7 Return glassware to the shelves; stand it upside down on cleanroom wipes. Use enough wipes that it does not drip onto items on lower shelves!

### 3.0 Storage:

- 3.1 MF CD-26 developer should be stored in the “base” cabinet.
- 3.2 Photoresist should be stored in the photoresist cabinet.
- 3.3 MCC Primer 80/20, HMDS, Acetone, and Isopropanol should be stored in the “solvents” cabinet.

### 4.0 Waste Disposal:

- 4.1 Photoresist, Primer, HMDS, acetone, and isopropanol waste:
  - 4.1.1 Solid waste should go in the solvent/photoresist trash.
  - 4.1.2 Liquid waste should go in the solvent/photoresist liquid waste bottle.
- 4.2 MF CD-26 developer waste:
  - 4.2.1 Solid waste should go in the acid/base trash.
  - 4.2.2 Liquid waste should go in the alkaline liquid waste bottle.

### 5.0 Accident Procedures:

- 5.1 Contact: Read MSDS prior to working with any chemical to familiarize yourself with the symptoms of exposure and recommendations for treatment.
  - 5.1.1 There are solvent fumes from the HMDS, acetone, IPA and photoresist. If you breath these fumes, you may feel dizzy. If this occurs, turn off the hotplates and leave everything in the hood. Leave the room and get some fresh air. If symptoms persist, contact Tufts health services and inform the lab directory and Tufts health and safety office.
  - 5.1.2 Skin contact from HMDS will cause irritation and minor burning. For minor contact, exit the lab and rinse the affected area with water. For major contact (such as breaking a large bottle of HMDS so it splashes all over you) get in the safety shower and remove the affected clothing. Have someone call emergency health services.
- 5.2 Spill:
  - 5.2.1 If a small, contained spill occurs, such as inside the hood, wipe it up with chemical wipes and dispose of in the solvent trash container.
  - 5.2.2 If a large spill occurs that you are not comfortable cleaning up, such as breaking a bottle on the floor, evacuate the lab and contact Tufts emergency services (x66911).

**5.3** Fire: There is a fire hazard associated with acetone and isopropanol, and, to a lesser extent, with MCC Primer/HMDS. Do not put these on or near the hotplates when they are turned on. If a fire starts, remove any solvents from near the fire if it is safe to do so, and exit the lab. Do not try to fight the fire. Immediately contact Tufts emergency services once you are outside the lab at **Tufts Emergency Services at x66911.**

If at any time you feel a situation is dangerous, do not hesitate to call the safety office (x73246, Peter Nowak) or the faculty supervisor (x72210, Robert White). Please inform of the faculty supervisor and/or the health and safety office of any accident or health concern.

**Report all accidents (injuries, major spills, fires) to the safety office at x73246 (Peter Nowak) and the faculty supervisor at x72210 (Robert White). For emergencies, call Tufts Emergency Services at x66911.**