

LOR20B Liftoff Resist

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.

For more information: the SOP of AZ Series Photoresist Processing and Metal Liftoff, the attached LOR data sheet, CS1701F Reactive Ion Etcher, NSC 3000 Sputter Deposition

Revised: March 10, 2017

Warnings:

The solvents used in this process are highly flammable. Be careful not to expose these solvents to high temperatures (such as a hotplate). Solvent fumes are also a health hazard, be sure to process in the fume hood.

Notes:

Remover 1165 and Remover PG are very similar so you may use either one as the liftoff off solvent. The process is exactly the same, wherever this SOP refers to “Remover 1165” simply substitute “Remover PG.”

The “B” style lift-off-resists from Microchem work with AZ photoresists, AZ400K developer, and Remover 1165 or Remover PG.

The “A” style lift-off resists work with SPR and S1800 series photoresists, MF CD 26 developer, and Remover 1165 or Remover PG.

Check with Microchem before running this process with an “A” series liftoff resists; the chemistry is different. This SOP specifically describes a process that works with “B” series LOR.

1.0 Material Requirements:

1.1 Equipment: Spin coater, two hotplates, wafer tweezer, pipettes, glass beakers, glass Petri dishes.

1.2 Chemicals:

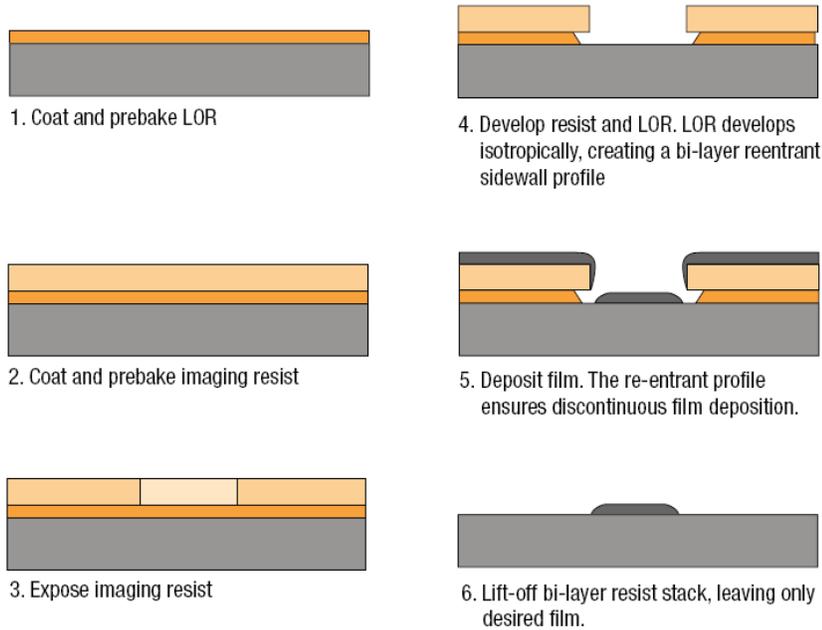
1.2.1 Lift Off Resist B (LOR-B) is 1-20% polyaliphatic imide copolymer (CAS 102322-80-5) dissolved dissolved in 65-90% cyclopentanone (CAS 120-92-3) and 1-20% propylene glycol monomethyl ether acetate (PGMEA, CAS 107-98-2).

1.2.1.1 LOR-B is a flammable liquid, a severe eye irritant, and a skin irritant.

1.2.1.2 Solvent fumes from LOR-B can cause dizziness and nausea. Prolonged exposure could cause nervous system damage.

- 1.2.2** AZ series photoresist is a DQN resist dissolved in the flammable organic solvent PGMEA, 1-Methoxy-2-propyl acetate (CAS: 108-65-6); 58 %.
- 1.2.2.1** AZ series resist causes irritation to skin, eyes, nose, and respiratory tract. It is readily absorbed through the skin. Prolonged, or repeated contact, inhalation, ingestion, or absorption through the skin, may cause toxic effects to internal organ systems.
- 1.2.2.2** AZ series resists are flammable and should be kept away from ignition sources. Baking spun resist on a hotplate is, however, acceptable.
- 1.2.3** AZ 400K inorganic developer is a potassium developer buffered to maintain an alkaline pH. It contains Potassium borates (CAS: 20786-60-1) <15 %, 85% water.
- 1.2.3.1** Causes severe eye irritation.
- 1.2.3.2** Not irritating to the skin.
- 1.2.3.3** Prolonged and repeated exposure can cause kidney damage.
- 1.2.3.4** Not flammable.
- 1.2.4** Remover 1165 (Rohm & Haas) or Remover PG: A solvent mixture mainly composed (>95%) of N-methyl-2-pyrrolidine. It is flammable with a flashpoint of 88°C (that is, at and above 88°C the fumes ignite explosively by a spark or open flame.)
- 1.2.5** Isopropanol is a volatile, flammable solvent. Avoid heat sources. Do not breath fumes. Conduct processing in the fume hood.

- 1.3** Engineering Controls: Conduct procedure in the fume hood. Dispose of chemicals as described in the end of this document.
- 1.4** Personal Protective Equipment: Nitrile gloves and eye protection for all procedures.



2.0 Procedure:

2.1 Wafer preparation

If possible (depending on what material are already on the wafer) Piranha clean (see Piranha clean SOP) and O₂ plasma clean to improve resist and metal adhesion. If a Piranha clean is not possible, a solvent clean with acetone/IPA may be of somewhat lesser utility. **Note:** if doing a solvent clean, be sure to finish with a careful DI water rinse and follow up with air drying and a dehydration bake, or you may get very poor resist adhesion.

2.2 Dehydration bake your wafers at 150 C.

2.2.1 Perform dehydration back on an aluminum foil topped SU-8 hotplate (5 min) or in the SU-8 convection oven (30 min).

2.3 Lithography

2.3.1 First layer - LOR 20B

2.3.1.1 Dispense LOR20B onto the wafer with a pipette.

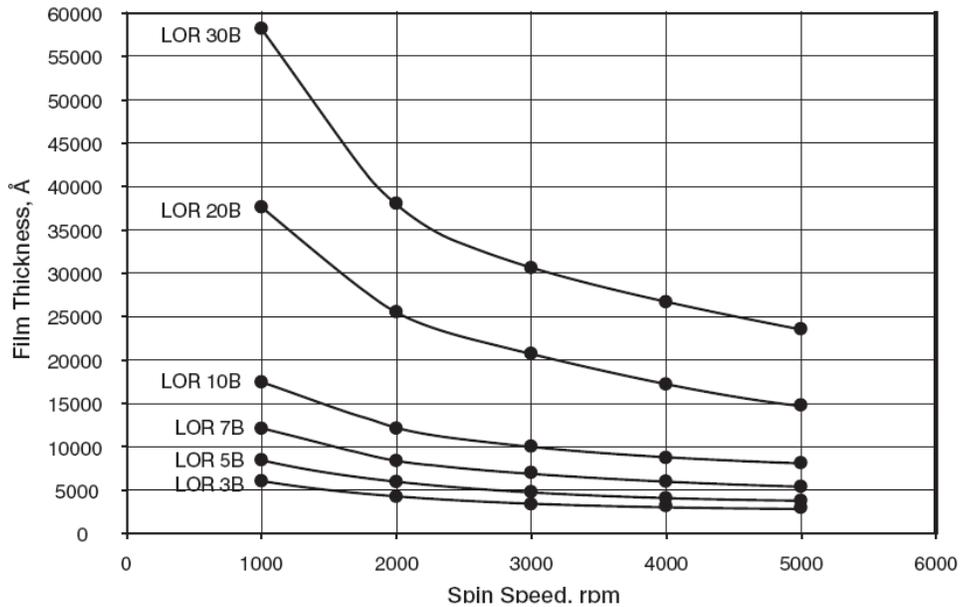
2.3.1.2 Spread @ 500 rpm for 5 sec.

2.3.1.3 Ramp to final spin speed at a high acceleration rate (4s) and hold for a total of 45 seconds. See spin speed curve below. For clean lift-off processing, the LOR film should be thicker than the metal deposition thickness, typically 1.2 to 1.3 times the thickness of the metal film.

2.3.1.4 Soft Bake: Hot plate at 200 C for 5 min. **Important:** *If you want more undercut, decrease the temperature. Do not go higher than 200 C. Do not go lower than 160 C. Temperature is the most influential variable in changing the amount of undercut.*

Spin speed vs thickness for LOR B series resists.

Other film thicknesses available upon request.



2.3.2 Second layer - AZ series

Follow the SOP of AZ Series Photoresist Processing to spin, pattern, develop, softbake, and develop a layer of AZ series photoresist (such as AZ9245). Good results have been achieved with 1) 3.5 μm thick AZ9245 using spinning speed of 4500rpm for 60sec, 20 sec exposure with hard contact, and 2 min developing; 2) 4.7 μm thick AZ9245 using spinning speed of 2500rpm for 60sec, 22 sec exposure with hard contact, and 3 min developing;

- Make sure to examine the resist after processing by eye and under the microscope to be sure it is fully developed. You should see the undercut from the top in the microscope, which looks like a shadow or double line along the edge of the pattern. If there is no undercut at all, it means it is not fully developed, additional develop time may be needed.

- If the minimum feature size is very small, you should watch out how much is undercut to avoid the small feature is undercut thoroughly and peeled off. Longer developing time, more undercut, and the undercut is roughly tested as shown in the table below.

Develop time	1.5 ~ 2 mins	2~3 mins	3~4 mins
Undercut (@ 2000 rpm and 200C softbake)	0~2 μm	2~5 μm	5~7 μm

2.4 O₂ Descum. For best results, a brief oxygen plasma “de-scum” is suggested between lithography and metal deposition. This brief plasma etch will remove any thin photoresist residue which could cause poor metal adhesion or contact. The de-scum can be performed in the March CS1701F RIE tool. A 150W, 30 second oxygen plasma at 100% O₂ flow rate (all other gases off) should be sufficient. See the SOP for the CS1701F for details.

2.5 Sputtering. Follow the Nanomaster NSC 3000 DC Magnetron Sputter Tool SOP or use another metal deposition tool to deposit the metal layer on top of the photoresist.

2.6 Liftoff. The metal liftoff can be performed either with or without a sonicator. The sonicator will decrease the time required for the Remover 1165 soak and increase pattern quality, but may generate more tiny metal particles so as to increase the possibility of metal particles dried on the wafer.

2.6.1 Liftoff without the sonicator.

2.6.1.1 Use the glass Petri dish marked “Remover 1165 Liftoff” and two 100 mL beakers marked “Remover 1165 rinse”.

2.6.1.2 Fill the petri dish half way with either Remover 1165 or Remover PG.

2.6.1.3 Use wafer tweezers to put the wafer in the remover, and heat it to solution temperature of 60 C on a hot plate. For the glass petri dish we have in the lab, using the hotplates we currently have in the lab (March 2017), a front panel setting of 80 C on the hotplate should be used. **DO NOT HEAT ABOVE 80 C!!! THIS IS A FLAMMABLE LIQUID WITH 88C FLASHPOINT!!!**

2.6.1.4 Leave the wafer in the remover 1165 until the liftoff is complete. A long soak is recommended – at least 1 hour. But the user can vary this. If doing a long soak make sure the glass cover is on the dish or the remover may evaporate away!!

2.6.1.5 **IMPORTANT:** at this point you will have lots of metal particles. You do not want them to dry on the surface of the wafer. So, take the glass dish off the hotplate (carefully), use your tweezers to lift the wafer out of the solution, and **WHILE DOING SO**, spray the surface with Remover 1165 from the Remover 1165 squirt bottle. Make sure you wash all the particles off as best you can and do not let the surface dry. This is very important for reducing particle defects!!!

2.6.1.6 **If using the sonicator:** (skip these steps if you don’t want to sonicate)

2.6.1.6.1 Pour some remover 1165 or Remover PG into the bottom of a glass beaker large enough to

- hold the entire wafer (beakers larger than 1500 mL will not fit in the sonicator). Use enough remover to completely cover the wafer.
- 2.6.1.6.2 Fill the sonicator with enough DI water to ensure the water level in the sonicator with the beaker in there is at the “fill line”.
 - 2.6.1.6.3 Turn on the main power to the sonicator.
 - 2.6.1.6.4 Use the “Select Option” button to switch between modes.
 - 2.6.1.6.5 Set the “Set Temp” to 20° C to ensure that the remover will not be heated.
 - 2.6.1.6.6 Set the “Set Sonics” to the desired time for the sonication (5 minutes recommended – user can vary at will).
 - 2.6.1.6.7 While on the “Set Sonics” screen, press “On/Off” to activate the sonication.
 - 2.6.1.6.8 The “On/Off” button can be used to end the process early, otherwise the process will end after the time prescribed in “Set Sonics” has passed.
 - 2.6.1.6.9 **IMPORTANT:** at this point you will have lots of metal particles. You do not want them to dry on the surface of the wafer. So, use your tweezers to lift the wafer out of the solution, and **WHILE DOING SO**, spray the surface with Remover 1165 from the Remover 1165 squirt bottle. Make sure you wash all the particles off as best you can and do not let the surface dry.
- 2.6.1.7** Transfer the wafer to the 1000 mL glass beaker of DI water and soak for 3 minutes. **IMPORTANT:** you must use a sufficient volume of water and a long enough rinse, otherwise solvent residue will remain and any future lithography or polymer patterning you attempt may experience poor adhesion. Do not attempt to do the rinse in a small container like a glass petri dish.
- 2.6.1.8** Transfer the wafer to the 2nd 1000 mL glass beaker of DI water and soak for 3 minutes.
- 2.6.1.9** Use wafer tweezers to remove the wafer from the water, and blow dry with the air gun
- 2.6.1.10** Inspect the wafer under a microscope to ensure that the liftoff is complete.
- 2.6.1.11** Additional time may be required if the liftoff is not complete.
- 2.6.2** Dispose of the remover 1165/remover PG, and water in the solvent waste container.

- 2.6.3 Rinse the glass beakers and Petri dishes with DI water twice and dump it into the solvent waste container.

3.0 Storage:

- 3.1 The Remover 1165 and Remover PG should be stored in a closed, capped bottle in secondary containment in the solvent cabinet.
- 3.2 Remover 1165 squirt bottle stays in the hood.

4.0 Waste Disposal:

- 4.1 Solvent waste (Remover 1165, Remover PG, rinse water)
- 4.1.1 Wipes are disposed of in the solvent trash can.
- 4.1.2 Liquid waste and rinse water are collected in the solvent waste bottle.

5.0 Storage:

- 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 Solvents
- 5.1.1.1 Skin contact: Flush with water.
- 5.1.1.2 Eye contact: Flush with copious amounts of water for 15 minutes.
- 5.1.1.3 Ingestion: Do not induce vomiting. Give large amounts of water.
- 5.1.1.4 Inhalation: Remove to fresh air. Resuscitate if necessary.
- 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 appropriate trash container.
- 5.2.2 If a large spill occurs that you are not comfortable cleaning up:
- 5.2.2.1 If it is a solvent spill, make sure that there are no ignition sources (open flames, hot filaments...most likely there will not be any), evacuate the room, close the door, and allow solvent to evaporate. Notify the Tufts emergency services (x66911) immediately. Also notify the faculty advisor.

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).

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.