

# Photodefineable Polyimide Processing

## 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.

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### Goal:

Deposit, expose, and develop photodefineable polyimide layers.

### Warnings:

The chemicals you are working with here are not acutely hazardous, however, the developer (Cyclopentanone) is a severe skin, eye, and respiratory irritant. Thus, all processing (including hotplate bakes) must be done in the fume hood, as the solvent fumes released during processing have long-term health effects. The main thing is to not breathe any fumes, and not to get any polyimide, developer or rinsers on your skin. Also, do not spray any developer or rinsers on the hotplates while they are hot, as these two chemicals are flammable.

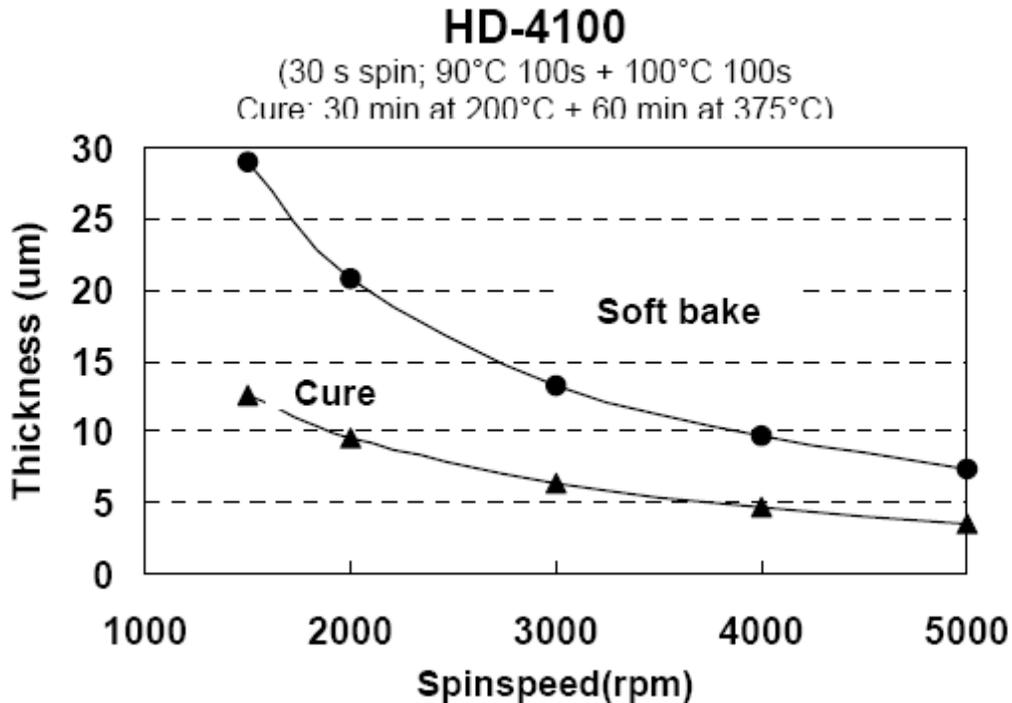
### **1. Material Requirements:**

- 1.1 Equipment and tools: Spin processor, photoresist oven, photoresist hotplates, wafer tweezers, mask aligner.
- 1.2 Chemicals: HD-4100 series photodefineable polyimide, PA401-D Developer (Cyclopentanone), PA400-R Rinser (PM Acetate)
  - 1.2.1 Hazards associated with chemicals:
    - 1.2.1.1 HD-4100 series polyimide: minor skin, eye and respiratory irritant. Not unusually flammable.
    - 1.2.1.2 PA401-D Developer (Cyclopentanone): Severe skin, eye, and respiratory irritant. Flammable (flashpoint 94°F).
    - 1.2.1.3 PA400-R Rinser (PM Acetate): Flammable. Vapors can be harmful (headache, anesthesia)
- 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 working in the fume hood, also wear trionic gloves, apron, and chemical goggles.

### **2.0 Procedure:**

- 2.1 A small working quantity of polyimide should be transferred to an amber bottle for processing. The polyimide is kept in the freezer; you need to let it warm to room temperature, then pour a working quantity into a clean amber bottle for your use. The polyimide stock bottle should be returned to the freezer. The polyimide can be kept in the amber bottle at room temperature for about a month before properties will start to degrade. *Make sure you do this the day before so that air bubbles have time to come out of the polyimide!!*
- 2.2 A squirt bottle should be loaded with some of the rinse (PA-400-R) and another with some of the developer (PA-401-D) prior to starting. These squirt bottles should be labeled and dedicated for this purpose. The squirt bottles should be stored in the solvent cabinet when not in use.
- 2.3 Wafer should be clean and dry prior to starting processing. A Piranha clean (see Piranha clean SOP) is suggested. A dehydration bake at 200 °C in the hotplate or oven may also help.
- 2.4 Spin on the polyimide. *Use the "dirty" spinner... the one designated for all materials.* (See Laurell Spinner SOP for instructions on using the spinner.)

- 2.4.1 Unlike the SPR resists, no adhesion promoter is required for the polyimide.
- 2.4.2 Pour a puddle of polyimide onto the wafer. Do not put too much on so it overflows and gets on the back of the wafer. Wipe the bottle edge with a fab wipe to remove excess polyimide.
- 2.4.3 Spread at 500 rpm for 5 sec
- 2.4.4 Spin for 30 sec. Spin rate (RPM) needs to be determined based on which polyimide viscosity you have purchased, and what final thickness you require. Spin speed curves are available from the manufacturer. An example appears below (thickness is reported after soft bake and after cure).



- 2.5 Remove the wafer from the spinner using the wafer alignment tool.
- 2.6 Soft bake (should be conducted with the hotplates in the chemical hood or under the snorkel). Bake at 100 °C for 200 seconds.
- 2.7 Expose (OAI 204 Aligner). See SOP for the OAI Model 204 aligner.
  - 2.7.1 Use a transparency or soda-lime glass mask.
  - 2.7.2 Expose for the total desired dose. The exact exposure dose will depend on film thickness. Thicker films will require a larger dose. The manufacturer only gives broad guidelines: 150-400 mJ/cm<sup>2</sup> at I-line. Recall that the aligner is set up with 20 mW/cm<sup>2</sup> at I-line. You will have to optimize exposure dose to get good feature reproduction.
- 2.8 Post-exposure-bake (should be conducted with the hotplates in the chemical hood or under the snorkel). 80 °C for 60 seconds.
- 2.9 Develop (spinner in chemistry hood or under snorkel). See Laurell Spinner SOP.
  - 2.9.1 Put the wafer onto the “dirty” Laurell spinner.
  - 2.9.2 Program the spinner for a 1000 rpm for 30 seconds followed by 3000 rpm for 30 seconds.
  - 2.9.3 Load a puddle of the PA401-D developer (Cyclopentanone) onto the wafer from the squirt bottle. Wait 30-60 seconds (time it, develop time will depend on polyimide thickness, this will need to be optimized).
  - 2.9.4 Start the spinner while continuing to spray on more developer.
  - 2.9.5 After about 10 seconds, switch from developer to rinsing spraying (wafer is still spinning).

- 2.9.6 Continue to spray rinser until the wafer speeds up to 3000 rpm.
- 2.9.7 Stop spraying rinser once wafer speeds up, and allow wafer to spin dry.
- 2.9.8 If the film is not fully developed, repeat develop procedure as needed.
- 2.9.9 Remove the wafer from the spinner. Clean the backside of the wafer with both developer and rinser directly into the solvent waste bottle (use a funnel).
- 2.9.10 Blow dry the wafer with the air gun in the hood.

#### 2.10 Curing

- 2.10.1 Once the pattern is developed according to your needs, the material needs to be cured.
- 2.10.2 Curing must be performed in a nitrogen ambient in a furnace.
- 2.10.3 Ramp up 10°C/min to 200°C.
- 2.10.4 Hold at 200°C for 30 minutes.
- 2.10.5 Ramp up at 10°C/min to 375°C
- 2.10.6 Hold at 375°C for 60 minutes.
- 2.10.7 Ramp down to room temperature at < 10°C/min.
- 2.10.8 The furnace can be cleaned at 700 °C in air for 1 hour.

#### 2.11 Stripping:

- 2.11.1 Cured polyimide is difficult to strip.
- 2.11.2 A straight (49%) HF solution may be able to strip the polyimide from a silicon wafer.
- 2.11.3 An O<sub>2</sub>/CF<sub>4</sub> plasma (80/20%) can remove the polyimide with etch rates on the order of 100 nm/min.
- 2.11.4 A Piranha clean will attack the Polyimide but not strip it.

#### 3.0 Cleanup:

- 3.1.1 Turn off the hotplates.
- 3.1.2 Clean any polyimide residue out of the spinner with fab wipes and dispose of in the photoresist/solvent waste bin.
- 3.1.3 Go through the Laurell Spinner clean procedure using a dummy wafer, PA-401D and PA-400R (in place of acetone and IPA). See the Laurell SOP.
- 3.1.4 MAKE SURE NOT TO GET SOLVENT INTO THE VACUUM PATH OF THE SPINNER! ONLY SPRAY SOLVENT INTO THE SPINNER WHEN A WAFER IS ON THE CHUCK!
- 3.1.5 After the spinner bowl is all cleaned out (use fab wipes and solvent as needed), dump out the waste reservoir from the back of the spinner into the solvent waste bottle.
- 3.1.6 Clean off any residue from any tools or surfaces using PA-401D and PA-400R and cleanroom wipes. Dispose of in the solvent/photoresist trash.
- 3.1.7 Remove the hotplates from the hood.
- 3.1.8 Shut down the OAI aligner as described in the OAI aligner SOP.

#### 4.0 Storage:

- 4.1 PA-401D and PA-400R should be stored in the “solvent” cabinet.
- 4.2 The small amber “working” bottle of polyimide should be stored in the photoresist cabinet.
- 4.3 The larger stock bottle of polyimide should be stored in the freezer.

#### 5.0 Waste Disposal:

- 5.1 Polyimide, PA-401D, and PA-400R waste:
  - 5.1.1 Solid waste should go in the solvent/photoresist trash.
  - 5.1.2 Liquid waste should go in the solvent/photoresist liquid waste bottle.

#### 6.0 Accident Procedures:

- 6.1 Contact: Read MSDS prior to working with any chemical to familiarize yourself with the symptoms of exposure and recommendations for treatment.
  - 6.1.1 There are solvent fumes from the PA-401D, PA-400R and the polyimide. 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.

- 6.1.2** Skin contact from the chemicals, particularly the strong irritant PA-401D (Cyclopentanone) will cause burning. For minor contact, exit the lab and rinse the affected area with water. For major contact (such as breaking a large bottle of PA-401D so it splashes all over you) get in the safety shower and remove the affected clothing. Have someone call emergency health services.
- 6.1.3** Eye contact from either solvent or polyimide: Rinse well with water in eye wash for 15 minutes. **Contact Tufts Emergency Services x6-6911.**
- 6.1.4** Ingestion: Do not induce vomiting. Immediately contact **Tufts Emergency Services x6-6911.**
- 6.2** Spill:
  - 6.2.1** 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.
  - 6.2.2** 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).
- 6.3** Fire: There is a medium fire hazard associated with the PA-401D and PA-400R solvents. 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.**