

MEMS LAB SESSION 1

Patterning Silicon Nitride using Photolithography and Dry Etching

OVERVIEW OF LAB SESSION:

This lab session will utilize photolithography and dry etching to transfer a pattern from a mask to a substrate. In Step 1.1, the thickness and the refractive index of the silicon nitride film are measured. In Step 1.2, the wafers will be first undergoing a treatment using Hexamethyldisilazane (HMDS) vapor, then be coated by photoresist-containing solvents using a spin-on process. The wafers will then be pre-baked in order to evaporate the solvents and leave the photoresist behind. In Step 1.3, the wafers will be aligned to the first mask and the photoresist exposed using ultra-violet light. In Step 1.4, the exposed photoresist will then be removed by development and the unexposed photoresist will be post-baked in order to improve adhesion. In Step 1.5, the wafers will be inspected under the microscope. Then in Step 1.6, using the photoresist as an etch mask, the silicon nitride will be dry-plasma etched. This will selectively remove the silicon nitride that is not masked / protected by photoresist and reveal the underlying silicon. In Step 1.7, the masking photoresist will be removed by an oxygen plasma by a tool called “asher”. After the pattern transfer is completed, the thickness of the remaining silicon nitride film will be measured in Step 1.8.

LAB OBJECTIVES:

This lab session has the following primary objectives:

- Introduction to basic photolithographic processes and procedures.
- Complete photoresist patterning and etching of the silicon nitride.
- Instruction on the following major pieces of lab equipment:

KLA Tencor UV1280 Film Thickness Measurement System
SSI Coater Track
EV1 Mask Aligner
Lam 490B Plasma Etcher
Matrix 106 System One Stripper (Asher)

Before the beginning of this lab, make sure to read the corresponding Standard-Operating-Procedures (SOP) for these major pieces of equipment. The SOP for each piece of the equipment can be accessed at the following site:

<http://www-mtl.mit.edu/mtlhome/3Mfab/sop.html>

LAB PROCEDURES:

MEMS Lab Session 1 has 8 steps:

1.1 CHARACTERIZE SILICON NITRIDE

- 1.1.1. Tool: UV 1280
- 1.1.2. To determine the thickness of the low-stress, silicon-rich, LPCVD silicon nitride.
- 1.1.3 To measure the refractive index of the low-stress, silicon-rich, LPCVD silicon nitride.

1.2 HMDS VAPOR, PHOTORESIST DEPOSITION, PRE-BAKE

- 1.2.1 Tool: SSI Coater Track
- 1.2.2 Follow the SOP for the SSI Coater Track, using the following modules:
 - In-line HMDS treatment
 - Spin-on module: dispense "SPR700 1.2" and spin for ~2 micron thickness ("SPR700 1.2" is a positive photoresist. A positive resist will be removed where exposed to UV light in the development p step. A negative resist has the opposite properties where exposed to UV light.)
 - Pre-bake module: 95 C on hot plate.

NOTE: Do NOT take any wafer coated with unexposed and/or undeveloped photoresist out of a "yellow-light" or dark-room area before developing (Step 1.4) is completed.

1.3 EXPOSURE (IN TRL)

- 1.3.1 Tool: EV1
- 1.3.2 Use the EV1 Mask Aligner for mask alignment and wafer exposure. This photo step will use the NITRIDE mask. Since the NITRIDE mask is the first-level mask, no precision mask alignment will be necessary. Expose for 8 seconds.

NOTE: Contamination control is of extreme importance in TRL. You must know what contamination level your wafers classify into, and use labware and equipment of the same classification. Broadly, the lab and equipment are classified into "GOLD" (red-tagged) and "Si-CMOS" (green or blue-tagged) contamination categories.

1.4 DEVELOPMENT & POST-BAKE

- 1.4.1 Tool: SSI Coater Track
- 1.4.2 Develop device wafers using the following modules of the SSI Coater Track:
 - Development: by developer "LDD 26 W"
 - Post-bake: 130 C on hot plate (In order to enhance the adhesion of the remaining photoresist, the wafers must be post-baked before etching.)

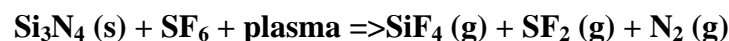
1.5 INSPECTION

- 1.5.1 Tool: Optical Microscope
- 1.5.2 Inspect wafers visually under an optical microscope. There are 2 sets of resolution features which can be checked to assess the overall results of photolithography.

NOTE: Step 1.6 should immediately follow step 1.5. Photoresist can degrade over time during storage due to exposure to humidity.

1.6 DRY-ETCH SILICON NITRIDE AND INSPECTION

- 1.6.1 Tool: LAM490B
- 1.6.2 Use the nitride recipe with end-point to etch the silicon nitride. Silicon nitride etches readily in plasmas that contain lots of free fluorine (such as Sulfur Hexafluoride). The equation for this reaction is:



Other typical etchants include CF_4/O_2 , CF_4/H_2 , and CHF_3/O_2 , and CH_2F_2 .

- 1.6.3 After the etch is complete, inspect the wafers under the microscope. The exposed patterned regions should appear to be silicon colored (metallic whitish or grayish). If not, report to the specialist in charge of the LAM490B. The wafers should be evaluated and may need further etching.

1.7 REMOVE PHOTORESIST

- 1.7.1 Tool: Matrix 106 System One Stripper (Asher)
1.7.2 For 2 μm thick photoresist on a 6" wafer, the ashing time is 4'30" per wafer to remove the photoresist.

1.8 MEASURE NITRIDE THICKNESS

- 1.8.1. Tool: UV1280
1.8.2. The thickness of the remaining silicon nitride film will be measured so we know the thickness of the cantilever that will be released in lab session 2.

PRE-LAB QUESTIONS:

1. Why is the photoresist soft-baked before exposure?
2. What is the difference between a positive resist and a negative resist?
3. Why is it important to keep gold processing separate from CMOS processing?
4. Is the NITRIDE Mask clear-field or dark-field?
5. Using the mask shown below (Figure 1.1), sketch how the cross-section A-A would appear after Step 1.6.

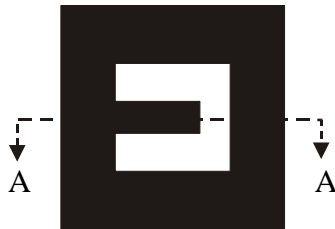


Figure 1.1