ECEn 452 – Semiconductor Devices Lab

Week 3: "Lithography"

Objectives

Introduction

This lab will allow you to practice the basic steps of lithography. Through experimentation you will determine a recipe for optimal lithography, including the amount of photoresist required to coat a wafer, exposure time, and developing time.

Prelab Questions

1. In order to understand the process of exposure and development, it is important to know the effects of UV light on photoresist. Briefly describe how exposure to UV light affects positive photoresist and prepares it for development (page 412 of your text discusses this topic).

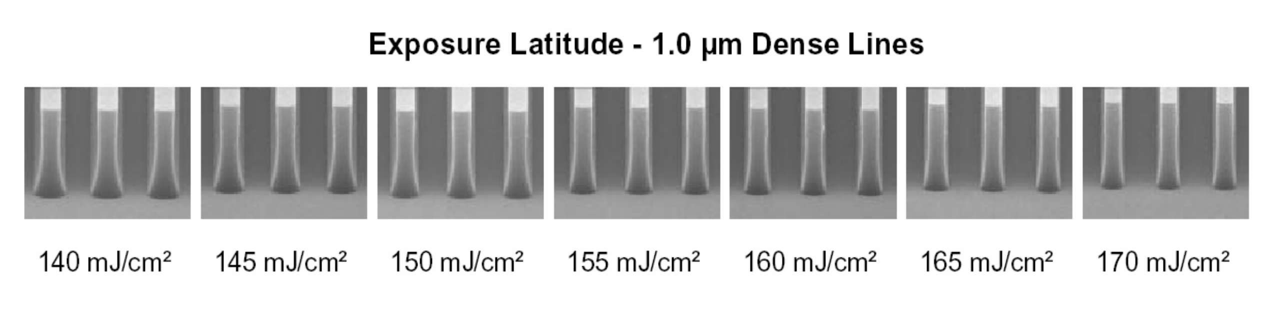
2. Why is UV light chosen over other types of light within the spectrum?

3. How is the wafer pattern affected by over- and under-exposure with positive photoresist? (See http://www.memsnet.org/mems/beginner/lithography.html, under Exposure**,** for more help on this topic)

Objectives

1. Exposure Dose:

The photoresist used to coat your semiconductor wafers requires a certain amount of UV light exposure before it can be developed properly. Have a supervisor show you how to measure the flux of light produced by one of the Karl Suss Aligners using an optical power meter. The pictures below are side view photos of photoresist lines after they have been exposed and developed. The lines are supposed to be 1.0 micron wide and should be of uniform width. Determine which exposure dose produces the best line and then compute the total exposure time needed in each of the aligners to get this total dose.



2. Feature Sizes of Photomask:

Examine the sample photomask provided that has the very small feature sizes. This photomask was made using a commercial electron beam writer capable of producing very high-resolution features. Using the optical microscope, choose features you think will help you evaluate your lithography process. Draw the feature shapes and estimate their sizes. Also examine the MOSFET masks for 452 created using a lower resolution mask generator here at BYU. Compare how the lines look under high magnification to the cleaner lines from the earlier mask.

3. Coating Wafers with Resist:

Getting a high quality coating of resist on a wafer is very important in lithography. It is important to prep the wafer properly so the resist adheres correctly. Follow the following steps when coating your wafers:

- Drive water off the surface of the wafer by using a dehydration bake (120 °C for 10 minutes in the clean-room ovens)
- Properly place wafers on spinner
- Coat wafers with the adhesion promoter (HMDS from dropper bottles 2 or 3 drops will suffice)
- Spin wafers @ 5000 RPM for 60 seconds to drive off everything but a mono-layer of HMDS on the wafer.
- Apply AZ3330 resist from the dropper bottle (you will determine the optimal number of drops)
- Spin wafers @ 5000 RPM for 60 seconds to get the correct photoresist thickness
- Remove wafers from spinner and place on hot plate (90 °C for 60 seconds). This is called the soft bake or pre-exposure bake and serves to drive the most of the solvents out of the resist

Your objective in this step is to find the minimum number of drops of photoresist to create an even coating over your wafer. Have a supervisor show you how to load your wafers into the ovens, onto the spinner, and onto the hot plate before attempting this objective. Have the lab supervisor give you 3 “dummy wafers” that you will use to practice coating and develop your lithography recipes with.

4. Cleaning Wafers – stripping photoresist:

After coating wafers with photoresist and using this coating for a subsequent process step, you will typically strip the resist from your wafer. The fastest way to do this is with chemical solvents (you will learn other methods for stripping including plasma in a later week). Photoresist dissolves in acetone very readily. Have a supervisor show you how to remove the resist using Acetone followed by an Isopropanol rinse. All of this should be done using the Solitec Spinner or at the solvent bench. At some point, practice stripping photoresist from your wafers. This will probably need to occur as you experiment with coatings (objective 4) and exposure parameters (objective 5).

5. Exposure and Pattern Developing:

Use the mask aligner to transfer the pattern from the sample mask you examined in Objective 2. This will involve exposing a photoresist-coated wafer with UV radiation and then "developing" the pattern using a chemical bath. You will follow the steps below to produce your pattern.

- Load a resist coated wafer into the mask aligner
- Load the required photomask into the mask aligner
- Choose the correct exposure time for the resist, and expose
- Unload the wafer from the aligner
- Develop the pattern using the chemical developers
- Examine the pattern under the microscope

Have the supervisor show you how to load wafers into the aligners as well as how to do the development process. Your objective in this step is to find optimal exposure and development times that you will use for the rest of your labs. You should vary the exposure times below (underexpose) and above (overexpose) the time you calculated in Objective 1. You should also vary the times used for developing the pattern in the chemical developer. When using the AZ400 K developer, 60 seconds is probably a good place to start for developing. When inspecting under the microscope, you should note the effects of under and over-exposure as well as under and over-development. It is anticipated that you will go through several coating, exposure-development, and stripping steps in order to verify your optimum process.

The objectives above were not meant to be accomplished in a particular order, although Objective 3 (coating wafers) needs to be accomplished before either 4 or 5. One group in a section could probably start with Objective 3 while the other group starts with Objectives 1 and 2. By the end of the lab, it is anticipated that both groups from a section will be working on Objective 5. It is important for you to develop a good lithography recipe because you will be using your recipe in practically every lab session until the end of the semester.