NEGATIVE LITOGRAPHY WITH METAL SPUTTERING

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1. Wafer Preparation

Wafer Cleaning

The ideal process of silicon wafer cleaning is widely known as RCA cleaning process as it was first developed by RCA Labs. The RCA cleaning process consists of selectively removing organic and inorganic contamination that reside on the wafer surface without attacking the silicon wafer itself. In our Lab, we use a variation that is simpler as given below.

- The silicon wafer is kept in a water bath at around 70 ^{0}C for initial cleaning.
- Make sure that all of the equipment (wafer holder, tweezer, etc) are clean. If necessary, use acetone to clean them.
- Acetone is used to remove all organic, inorganic and metallic contaminant from the wafer surface.
- To remove acetone from the surface, rinse the wafer with water.

All the processes above are done in the fume-hood.

Figure.1 Wafer Cleaning Chemicals.

Dehydration Bake

- N_2 gun is used to spray-dry the wafer before baking. It is important to preheat the hot plate to reach 115 ^{0}C before using it.
- Use tweezer to put the wafer on the hot plate and then bake it to dehydrate the water for one minute.

Cool down the wafer before coating with photoresist as the wafer is expected to be at room temperature during coating.

2. Photoresist Coating & Pre Bake

Use SU8-10 or SU8-100 negative photoresists and spin-coating.

- Apply a couple of drops of SU-8 (approx. 1 ml) coating on the wafer. Control of the amount of the solution is important as adequate solution to cover the whole surface of wafer is needed. Avoid excessive drops that could possibly cause air bubbles in the coating that will reduce the quality.

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- Make sure that the wafer is placed it at the center of the spinner to maintain balance then spin at **3000 rpm for 45 seconds**. This speed and time were selected as best practice parameters considering the viscosity of the photoresist.
- After spinning, soft-bake the coated wafer on a hot plate by ramping temperature from 65 to 95 ^{0}C over 15 minutes and continuing with 95 ^{0}C for 5 minutes to finalize the baking process.

Since the lithography will be done at room temperature, it will be necessary to cool it down for 15-20 minutes before lithography. The main purpose of pre-baking is to drive-off excess photoresist from the surface.

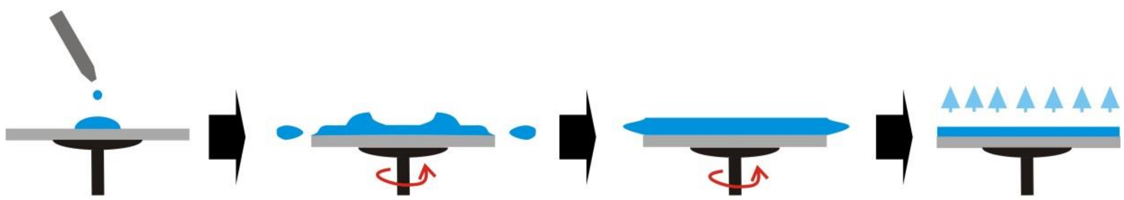

Figure 2. Spin Coating and Pre-Baking Process Map

3. Photolithography

Photolithography is the process to transfer the designs from a photo mask to the wafer using light exposure. The exposure to light causes a chemical change that allows some of the photoresist to be removed by a special solution, called "developer" by analogy with photographic developer. In this experiment, we will use UV light to expose the photoresist. The UV light has a wavelength range from 300-500 nm.

- Before starting, we have to make sure that the UV source is ready after warming up for 5-10 minutes and the mask is clean. Proper cleaning of the must should be done if necessary.
- Mask aligner is used center the wafer and put the mask on top of the wafer. It is a must to maintain a vacuum condition in between the wafer surface and the mask to get the best result. For this purpose air suction is used to obtain a vacuum surface.
- To expose the wafer with UV, we slide the mask aligner to the UV source area.
- Exposure timer needed to be set and we expose it with UV for 40 seconds.

The dose of the UV exposure has been determined from the swing curve for the photoresist. With light intensity of UV source set at 6.06 mW/second, the exposure time is determined to be 40 seconds.

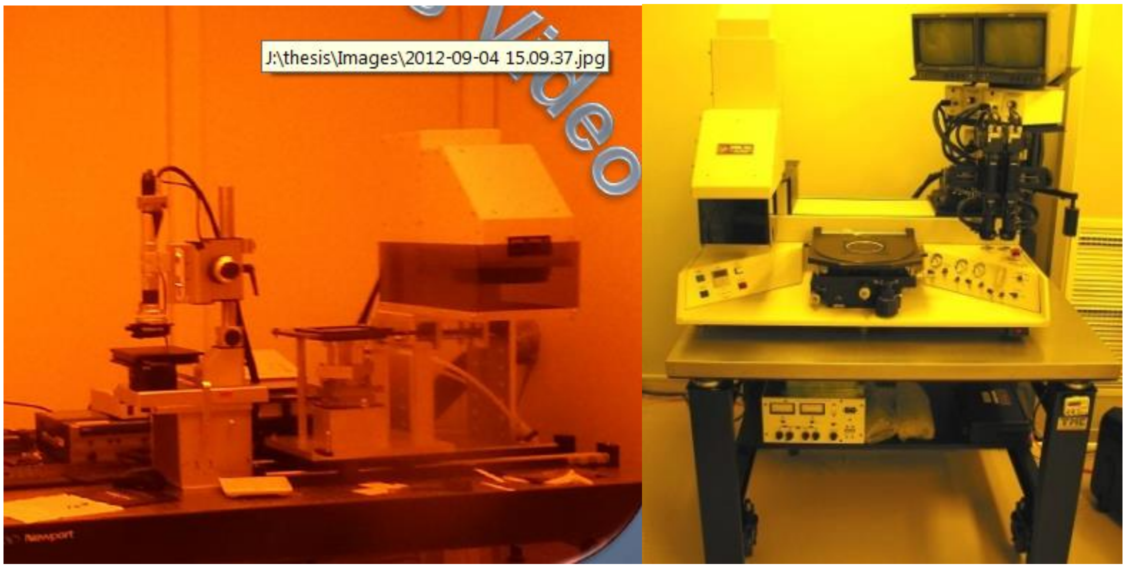

Figure 3. OAI UV Exposure Unit and ABM Mask-Aligner.

4. Post Bake

A post-exposure bake (PEB) is performed before developing to help reduce standing wave phenomena caused by the destructive and constructive interference patterns of the incident light. PEB is done on a hot plate by ramping-up the temperature from 60 to 100 ^{0}C within 30 minutes followed by hard-baking at 100 ^{0}C for 5 minutes.

5. Metal Sputtering (Sputter Deposition)

Sputter deposition is a physical vapor deposition (PVD) method of depositing thin films by sputtering. This involves ejecting material from a "target" that is a source onto a "substrate", which in this case is silicon wafer.

At this stage, as the photoresist has not been developed yet, we need to protect the wafer from light exposure prior to metal sputtering. Therefore, metal deposition will be done in the dark.

To do metal deposition, place the die (or wafer) inside the metal deposition chamber as shown in Figure 4. Then, vacuum the chamber and pump inert gas (Argon) to ionize the target. Subsequently, the ion charge will drive the ionized metal to the wafer surface. It takes about 10 minutes to have 10 nm of metal (for e.g., platinum) coating.

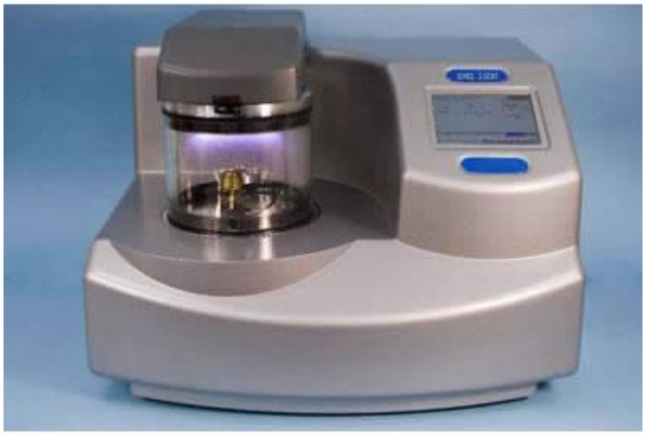

Figure 4. Metal Sputtering Unit.

6. Developing and Resist Strip

Prepare a developer solution by mixing SU8 Developer and DI water in a ratio of 1:5. Typical development time is about two minutes; but visual observation is needed to estimate the best development time. Inadequate development time will result in an underdeveloped feature, whereas over-developing the wafer might cause the loss of features.

With regard to the deposited metal, metal parts on the polymerized (developed) resist will stick to the unexposed SU8 while those on top of the non-polymerized photoresist will be washed away together with the photoresist. After further stripping, all the remaining photoresists will be washed away.

Using a wafer holder or tweezer will be helpful to manipulate the wafer and agitate it gently during development.

Figure 5. Development using ultrasonic agitator.

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7. Characterization/ Imaging

Use Hirox 3D microscope for optical characterization of the final chip. There are two knobs that can be used to move the object in vertical and horizontal direction to center the object. Typically, you will need to use 50x to get full image and 100x magnification to have a detailed visualization. Make sure to use the focus knob properly, to get the best resolution.

Figure 6. Hirox 3D Digital Microscope.

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