Photolithography SOPs

The standard operation procedures (SOPs) provided here are to apply the Keck Facility to do microfabrication. Detailed SOPs for each individual photoresist such as the spin coat speed and UV exposure dose, can be found in the link provided below.

Negative photoresist:

(1) SU-8 2000.5, SU-8 2002, SU-8 2005, SU-8 2007, SU-8 2010 and SU-8 2015;
(2) SU-8 2025, SU-8 2035, SU-8 2050 and SU-8 2075;
(3) SU-8 2100 and SU-8 2150;
(4) MICROPOSIT S1800 SERIES;

Positive photoresist:

(1) AZ4000 SERIES;

A hard copy of fabrication SOPs using these photoresists is provided in the Keck Lab.

IMPORTANT!

- **Always keep the working area clean!**
- **Always turn off the liquid nitrogen when not in use!**

Substrate preparation

When feature size is less than 20 μm, fabricated patterns using SU-8 can be peeled off with PDMS. To increase the adhesion and obtain maximum process reliability, three methods are recommended to use:

(1) Heat Si Wafer at 180 ^{o}C for about 5 hours for dehydration;
(2) Wash Si Wafer with piranha solution (H_2SO_4 & H_2O_2=3:1, v/v), followed by a DI water rinse to remove any residuals;
(3) Pretreatment of substrate with MCC Primer 80/20 (HMDS).

1. Spin Coat

(1) Preparation:
    a. Take out the photoresist that will be used from the fridge and warm up at RT for about ~10min.

NOTE: *For photoresist with high viscosity such as SU8 2100 series, warm up in a water bath at 65^{o}C for at least 30 min to slightly decrease the viscosity, followed by pouring on the Si Wafer and cooling down for about 5 min to get uniform coating.*

b. During this time, turn on the hotplates or ovens and adjust to the desired temperature, then turn on the mask aligner pump and UV lamp, and wrap up the spin coater using Al foil.

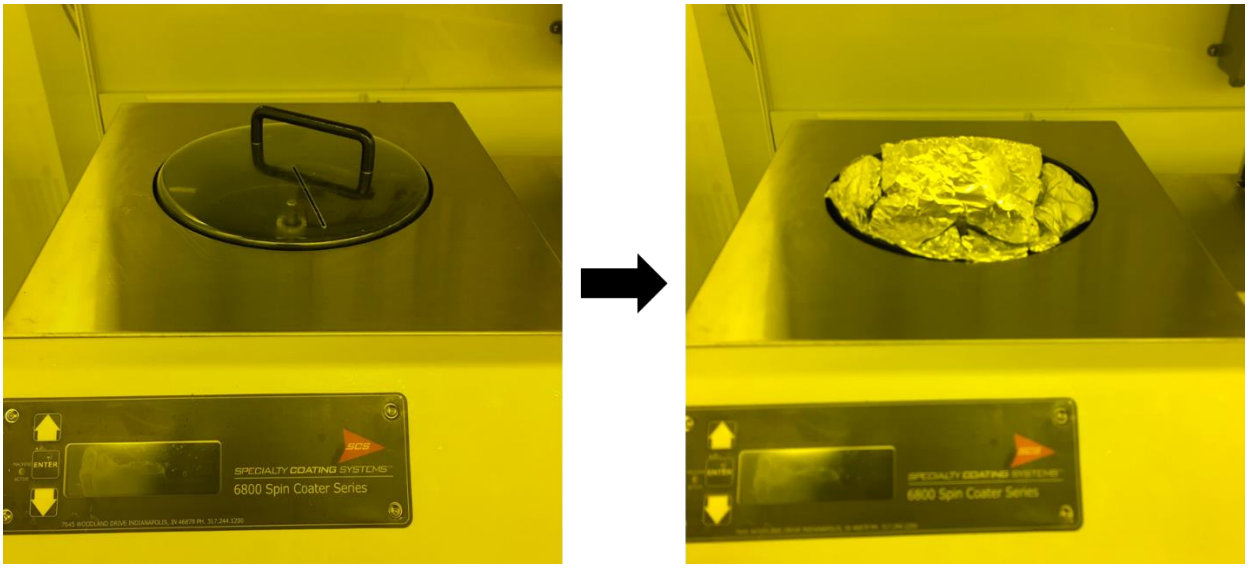

Figure 1*. Wrap up the spin coater with Al foil.*

(2) Put an appropriate chuck onto the spin coater, followed by a piece of Si wafer or glass slide on. Center the wafer using the 3'' or 4'' centering tool.

(3) Set up a program/recipe:

a. Spin at 500 rpm for 5-10 seconds with acceleration of 100 rpm/s;
b. Spin at a desired speed (*see figure of spin speed versus thickness*) for 30 seconds with acceleration of 300 rpm/s;
c. Spin to 500 rpm with deceleration of 300 rpms/s.
d. Spin to 0 rpm with deceleration of 100 rpm/s.

(4) Dispense a small amount of resist on the wafer or glass slide (usually 1mL of resist for 1'' of substrate diameter).

(5) Spin coating.

2. Edge Bead Removal (optional)

During the spin coat process step, a build up of photoresist may occur on the edge of the substrate. In order to

minimize contamination of the hotplate, this thick bead should be removed. This can be accomplished by using a small stream of solvent (MicroChem's EBR PG) at the edge of the wafer either at the top or from the bottom. Most automated spin coaters now have this feature and can be programmed to do this automatically.

By removing any edge bead, the photomask can be placed into close contact with the wafer, resulting in improved resolution and aspect ratio.

3. Soft Bake

The recommended soft bake temperatures and times for resists products at selected thickness are provided in the aforementioned link. A hard copy of SOPs for each individual resists is also provided in the photolithography room.

Both the two SCS hotplates and two cleanroom ovens can be utilized for baking. If more than one wafer or glass slides to be baked at one time, cleanroom ovens may be more efficient.

NOTE: *To optimize the baking times/conditions, remove the wafer from the hotplate after the prescribed time and allow it to cool to room temperature. Then, return the wafer to the hotplate. If the film 'wrinkles', leave the wafer on the hotplate for a few more minutes. Repeat the cool-down and heat-up cycle until 'wrinkles' are no longer seen in the film.*

4. UV Expose

The corresponding exposure energy for the resist and thickness can be found in the SOPs provided before. Normally, the dose for *negative photoresist* can be 5-10 mJ/cm^2 higher than the recommended (a little bit *overexposure*); while the dose for *positive photoresist* need to be 5-10 mJ/cm^2 lower (a little bit *underexposure*).

NOTE: *To obtain vertical sidewalls and good small feature size (such as 10 μm), the long pass filter to eliminate UV radiation below 350 nm is highly recommended. An increase in exposure energy of* ***at least 40%*** *is required to reach the optimum dose.*

The way of using the mask aligner to get good contact and exposure will be covered in details during on-site training. To get good exposure results:

(a) The big round chuck needs to be applied when using Si Wafer (3'' or 4''), and the small rectangle chuck can be replaced when working with glass slides.
(b) For the big chuck, photomask needs to be inside of the rubber seal to reach optimum contact vacuum (*see below*)

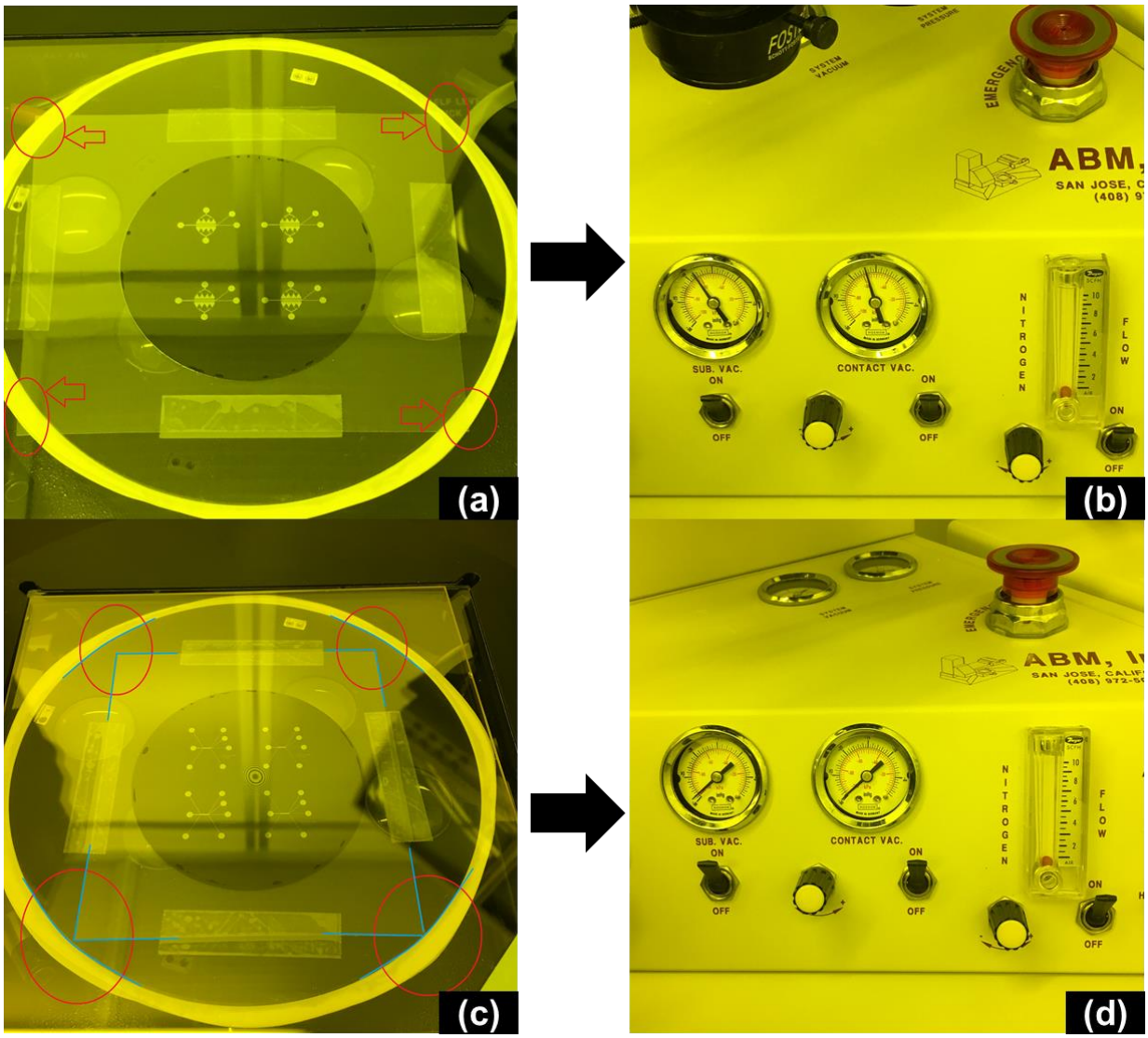

Figure 1*. The effect of photomask position on the contact vacuum. (a) Photomask is placed outside the seal; (b) The corresponding vacuum obtained from (a); (c) Photomask is placed inside the seal; (d) The corresponding vacuum obtained from (c).*

5. Post Bake

Post bake should take place directly after exposure. The recommended times and temperatures for each individual resist can be found in the provided links.

Note: *After 1 minute of PEB at 95°C, an image of the mask should be visible in the SU-8 2000 photoresist coating. If no visible latent image is seen during or after PEB this means that there was insufficient exposure, heating or both.*

6. Develop

A shaker is provided in the fume hood to achieve automatic agitation during development. However, shaking is not recommended for small feature size (*such as 10 µm)*.

NOTE: *The development times provided in each SOP are approximate since dissolution rates vary as a function of agitation rates.*

7. Rinse and Dry

After development is done, wash patterned wafer or glass slides with washing solution (isopropyl alcohol for SU-8 and purified DI water for AZ4000), followed by air dry with filtered, pressured nitrogen gun.

8. Hard Bake

For applications where the imaged resist is to be left as part of the final device, a hard bake for SU8 series can be incorporated into the process. A final bake temperature 10°C higher than the maximum expected device operating temperature is recommended. Depending on the degree of cure required, a bake temperature in the range of 150°C to 250°C and for a time between 5 and 30 minutes is typically used.