

Photolithography using the Karl Suss MJ-3 contact aligner

INRF application note
Process name: POSLITH01

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Overview

Photoresist is patterned using a mask and UV light in a contact aligner. The resist is exposed to the light then developed in a special developing solution. This is a level-2 process; it requires superuser instruction.

Time needed

The lithography and developing process takes typically 20 minutes. Hard bake is an additional 20 minutes. If critical alignment is required between masks, the lithography process may take an hour or more.

Materials needed

- ☐ Substrate with photoresist prepared
- ☐ Mask plate
- ☐ Developer solution
- ☐ Glass container

Preparation

Protective eyewear and gloves must be used when working with developer solution. Pour about 50 ml to 100 ml of Microposit 319 developer (methyl ammonium hydroxide solution) or MF-351 (sodium hydroxide) into a glass container large enough to hold your wafer. Cover with a glass top.

Exposing the pattern

Make sure the Karl Suss MJ3 aligner¹ is turned on. Place the glass mask, emulsion side down, in the mask aligner plate and turn on the vacuum². Place the wafer on the wafer chuck and move into position under the mask. Using the z-height adjustment knob on the aligner, move the wafer chuck up until just comes into contact with the glass plate. Adjust the height appropriately so that when the contact lever is pushed, the wafer and mask emulsion are in intimate contact, but without excess stress. Use the green light to view the Newton's rings which can help you estimate the proximity of the mask to the wafer.

Pull the contact lever back to produce a small gap between the mask and the wafer. Using the microscope align the mask with respect to the wafer as desired³.

¹ Users must be trained to use the mask aligner. See the user manual or policies note book for more details.

² Some users may be using "soft masks" which are made of cellulose film. In this case, the aluminum mask plate holder should be replaced with a glass mask plate. The soft mask should be placed directly on the wafer.

³ This may require some skill and special training. In general, only iron oxide masks should be used for multiple mask operations, since iron oxide is transparent to the green light used for viewing.

When the wafer is suitably aligned, bring the wafer into contact with the mask by pushing the contact lever forward.

Set the exposure timer to 30 seconds (for Shipley 1813 or 1827 positive resist), then press the “expose” button to begin UV exposure. Look away from the light source during exposure to minimize UV exposure to your eyes. Keep other photosensitive resists and items away from the aligner during exposure.

Developing the resist

Remove the wafer from the contact aligner and place in the developer solution. Mildly agitate for 60 seconds until the pattern has appeared. Thoroughly rinse the wafer in DI water, then blow dry. If you intend to use the developer again, it may still be used as long as it is clean. Don't use dirty developer—it will leave residue on your wafer.

Inspect the wafer pattern under the microscope. If it is imperfect, you will need to start over again by cleaning the wafer. Do not accept an imperfect pattern—it will result in an imperfect device later.

Descumming

If the photoresist pattern leaves some residue, the most likely reasons are dirty developer, under-developing, or under-exposing (in that order). The appropriate action is to tune the process to eliminate this problem. If however, the residue still persists, one can use an oxygen plasma to remove a small amount of residue from the wafer. Place the wafer in an O₂ plasma (the Bransen plasma oven is dedicated for this purpose⁴) for 5–10 minutes. This is known as “descumming”.

Hard bake

The developer must be evaporated, the photoresist must be cured and annealed, and the substrate dehydrated before the patterned wafer can be used. To do this, the patterned wafer should be placed in a 120 °C oven for 20 minutes. After this, the patterned wafer may be taken into white light.

Safety and emergency

All INRF safety and procedural regulations must be followed. Review the INRF standard operating procedures for fire, chemical spill, and chemical exposure. Developer is a caustic chemical. Any small spills should be wiped up immediately with wipes. Dispose the wipes in the corrosive waste container.

In case of exposure to skin or eyes, flush immediately with water for 15 minutes. Remove all clothing that are exposed and flush with water. Report to INRF staff or report to EH&S. Seek medical attention to ensure that the burns are minimal. In case of large spill, follow the INRF Standard Operating Procedure for chemical spills.

Clean up

Dispose the developer waste in the labeled waste containers provided. Rinse all glassware with DI water.

⁴ Users must be trained to use the oxygen plasma oven. See the user manual or policies note book for more details.

References

Prudent Practices in the Laboratory, National Research Council, 1995.

W. Kern and J. Vossen, Eds., *Thin Film Processes*, Academic Press: New York, 1978, Ch V-1.

Shipley-Ronal product literature.

Photolithography with contact aligner Checklist

The following checklist is designed to aid the researcher when performing this process.

- ☐ Prepare developer solution bath. Reduce the chemical usage.
- ☐ Mount mask in aligner.
- ☐ Mount wafer in aligner.
- ☐ Adjust z-height of aligner for good mask contact when contact lever is engaged.
- ☐ Pull contact lever back. Perform alignment between wafer and mask.
- ☐ Push contact lever forward to engage contact.
- ☐ Expose 30 seconds.
- ☐ Develop 60 seconds (in Microposit Developer 319).
- ☐ DI rinse / blow dry.
- ☐ Inspect. Do not accept imperfect patterning.
- ☐ Descum (optional).
- ☐ Hard bake
- ☐ Clean up, dispose wastes