STANDARD OPERATING PROCEDURE

CORAL Name: *MA-4*

Model Number: MA-4

Location: EML

What it does: mask alignment, UV exposure of photo resist

Introduction: The Karl Suss aligner is a precision mask alignment and UV exposure system, with a split field revolving microscope with 3.5x, 10x, and 25x objectives, and 10x binocular eyepieces. Three viewing modes (split field, full left-hand image, and full right-hand image) are possible. There are four directional buttons for movement of the microscope, and a FAST button for rapid movement. The exposure system uses a 350 W high pressure mercury lamp and has an exposure controller set at CI-1, for 9.5 – 10.5mW of output power of 365 & 405nm wavelength. Wafer stage movement is controlled by x, y and theta aligning verniers. A variety of chucks and mask holders are available to accommodate various wafer and mask sizes. There are four wafer to mask contact modes of std. soft, std. hard, soft vac. and full vacuum, essentially going sequentially from lower to higher contact force and therefore resolution, at the tradeoff of more compression damage or potential alignment shift in the case of non ideal resist conditions. Vacuum Mode only works with standard 5” Cr on glass mask with 4” wafers.

There are two cntrol panels. The "Front Panel Control" houses:
Regulator & gauges, typically set by staff to a marked value.
ON/OFF switch, always left ON
Wafer/Contact/Separation/Parallelism Indicators

The "Operational Control" Panel has soft-touch buttons, and houses:
Microscope "Directional" buttons
Wafer Stage (Shuttle) "Command" buttons
Contact mode buttons
Vacuum to chuck to secure wafer to chuck alignment, which turns on automatically when the chuck is pulled out all the way for loading substrate.

N2 Purge (not supported) to use with older style noxious negative photoresist.

Safety: A mercury bulb generates the UV light, which has shielding to prevent erythema of the skin (similar to sunburn), or possible retinal burns. Don’t look at the stage during exposure, especially when exposing without a mask holder, as with flood exposures. Remember, even indirect UV light can damage retinas.

Procedure: **Processing Considerations**

Resist Types:

1. Currently stocking several types of standard resin positive resists, including 1 um OCG 825 and 10 um AZ 9260
2. Negative resin resists include several variants of the NR series, with different thicknesses and optimizations
3. Image Reversal (positive/negative selectable) 1.5um AZ 5214
4. SU8, mostly varying viscosities of the 2000 series epoxy resists

Mask Making Tips are at the END OF THIS SOP:

Exposure Tips:

1. Set exposure time by pressing the "Set Exposure Time" button, and by Using the microscope up/down keypad arrows, in conjunction w/ holding down the "fast" button to set the desired exposure time. Standard positive resists shouldn't be exposed more than about 20 seconds per flash, to limit joule heating, with multiple flashes and wait times often equal or longer than the flash time, selectable with the Right Arrow in the menu for #intervals and for wait time. OCG 825-20 should take about 10 sec, and thicker AZ 4620 or 9260 may take 1-2 minutes. SU8-xx may take20+ seconds, depending on thickness. AZ5214, usually used as a negative resist, will require about 10 seconds for the first exposure and about 50 sec for the mask less flood exposure. Close the "set exposure time" subroutine by pressing the "set exposure time" button again, and verify "Multiple Exposure" is selected if needed. If Using a transparency for features larger than 25um, increase your time of exposure by 20 seconds plus 25%, because the defects inherent in the film need to be obscured, and the reflections and absorption from layers need compensating.
2. In cases of high humidity, greater than 50%, consider reducing your exposure times for many resists, perhaps by 25% if 70% humidity, and overexpose if lower than 35%, but don't compensate with SU8. Keep your substrate dry on a hotplate, or consider an O2 Asher plasma immediately before HMDS then coating resist.
3. When Using thicker, thermally poor conducting substrates, such as glass slides, skip the hot plate and use the convection oven, set in the 85-90C but never higher than 90C, for ~ 30 minutes. It will save you time, really.
4. If Using transparent substrates, make the chuck black to prevent reflected, randomly scattered light from ruining your lithography. Use Black marker or film.
5. Clean your mask with acetone, keeping wet, & swab if necessary, then rinse with isopropyl alcohol before acetone dries. Put on nitrile gloves over your normal PVC gloves if risk of chemical contact exists.

Recipes:

1. Staff can often give approximate recipes for standard processes
2. See a chronological history of user recipes and results, with more current information here /view responses/:
3. Be sure to enter your results to keep the peer feedback going, when done. Staff will modify posted results if requested.

Procedure

Make appropriate machine reservations in CORAL, and be kind by only reserving the time needed, and remembering to cancel the reservation if not needed. You will need to "Engage" in CORAL to enable the machine's operation. Guess the quantity of wafers that you expect to process, and when you disengage, update this value. Always remove your glass mask BEFORE disengaging, or the mask will drop and break, as several functions such as vacuum don't work with the machine disengaged.

Zero wafer chuck by moving x, y and theta micrometers in the "wafer shuttle" first, superimposing the white and black crosses on the right side of the stage. This first step is critical if doing multiple levels of exposure.

Choose your contact mode: soft or hard for less or more contact pressure, or press vacuum if the

better resolution provided by this mode is required. Remove mask-holder from stage by loosening the knurled knobs. Slowly remove mask-holder to allow the microscope time to move up, being careful not to crash the microscope optics with the mask holder.

Either a pieces to 2” maximum wafer, or a standard 4” substrate chuck may be selected, and either a small, or standard 5” mask holder may be selected.

Place mask on the mask holder - shiny glass side down, so the brown CrOx is up. Then turn on the vacuum toggle (test it!) and return mask-holder assembly to the shuttle, which inverts the mask to CrOx down, contacting the resist on the substrate after loading, and clamp the mask holder into place. If Using a transparency, use a “clean” clear mask, making sure it is clean beforehand.

- Never touch a mask except by the edges.
- Never put a mask down flat on any surface, except briefly, then only on a clean fabwipe.
- Instead, keep in shipping box or loaded in the mask aligner
- Return mask before disengaging MA4, otherwise it will drop and break

Set exposure time, with the labeled button. Select the time by up/down arrows on the membrane pad, and choose interval and wait states by Using the right arrow. Close “Set Exposure Time” button, and if needed, select “Multiple Exposures” button.

Loading substrate onto wafer chuck

- Place the wafer on the chuck with the wafer resting against the pins. Use caution near the inflatable red rubber gasket around the chuck; puncturing it will damage the seal in the Vacuum Chamber contact mode.
- Slide TRANSPORT SLIDE in until it locks. Vacuum to substrate is automatic with movement of wafer chuck.
- Make sure SEPARATION LEVER is at zero, full contact.
- Use the CONTACT LEVER located on the left hand side of WAFER SHUTTLE and steadily turn lever clockwise approximately 90 degrees (1/4 turn), “up”, until you hear a "click". The light on the CHUCK DOWN button will appear on the front of the touch pad. CONTACT and WAFER MASK PARALLEL buttons will light up on FRONT PANEL CONTROLS. CAUTION: Never use CONTACT LEVER to bring the wafer chuck down; always use the CHUCK DOWN button.
- Separate wafer from the mask by pulling SEPARATION LEVER toward the front of WAFER SHUTTLE. Separation can be adjusted from 0 to 90 um. CONTACT button will go off and SEPARATION button will light up on FRONT PANEL CONTROLS.

Align the microscope to the mask Using split-field microscope and 3.5X optics initially.

Note: One Level or First level exposures do not require aligning microscope to the mask other than

chuck centering, and the following paragraph can be skipped.

- Turn microscope power supply ON, above microscope. Turn OFF when done! (Same holds true for all microscopes)
- Focus the microscope to the mask pattern by rotating coarse and semi-fine focus knobs, located on the back on both sides of the microscope. Note: The Fine focus/objective separator knobs, located on the front face of microscope, serve the dual purpose of separating the objectives from 30-90 mm as well as for fine focUsing to achieve the same focus depth for the two objectives.
- Separate the dual optics to approximately the width of your alignment features, if whole wafer, or center one optic, and move the other close to the middle, if doing pieces alignment, by unlocking the knob screw for separation of the optics and adjusting as necessary. Continue to align the microscope objectives to the aligning marks on the mask. Turn objective lock-knobs counter-clockwise to unlock the objectives to change separation, then retighten to enable local focus. Locate aligning marks on the mask by combining microscope DIRECTIONAL BUTTONS and OBJECTIVE SEPARATION movements.
- Slide SEPARATION LEVER to maximum separation, and move wafer, with verniers “X”, “Y” and “theta” to bring substrate under mask. **CAUTION**: Damage to mask and wafer may occur if x-y-theta on the WAFER SHUTTLE are moved while wafer is in contact with the mask.
- Reduce separation distance to ~30um, and check alignment. Both substrate and mask should be somewhat in focus now.
- If doing “HARD” or “VACUUM” contact, press “CHECK” to see if alignment shifts, caUsing compression between mask and substrate, caUsing good simultaneous focus of these. If ok, press expose, otherwise, correct now by pressing “CHECK” again, and re-doing alignment.

Press EXPOSE. If necessary, lift the u-scope slightly.

Warning: Do not look at UV light while wafer is being exposed.

Check the EXPOSURE CONTROLLER to make sure 9-10mW/cm2 is displayed during exposure.

After exposure wafer/chuck will drop and the WAFER SHUTTLE should come out. Do not rush to remove wafer from TRANSPORT SLIDE as lock pin remains on for 10 seconds after exposure.

Carefully pull TRANSPORT SLIDE out and remove wafer. Repeat above operations to expose other wafers.

Always develop/inspect the first exposed wafer to make sure exposure and pattern are correct BEFORE exposing other wafers

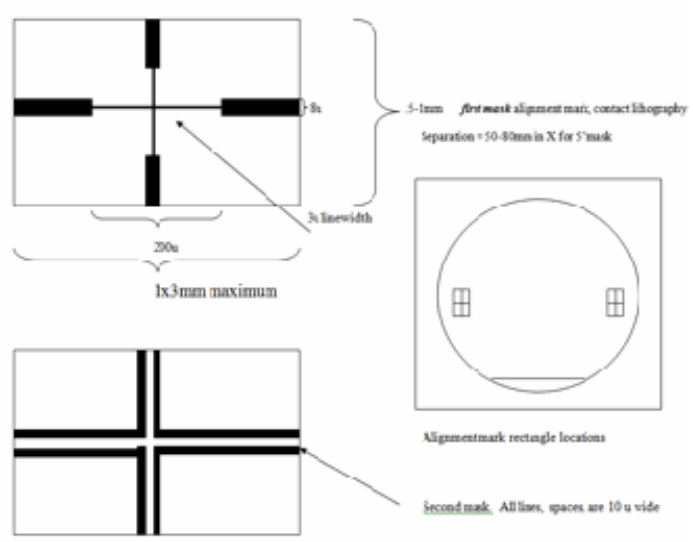
"Disengage" in CORAL.

Mask Making Tips:

a. Contact Cr Glass and Emulsion Mask Tips:

Alignment Marks: Here is a typical Alignment Mark setup for multiple level alignments on 4” wafers. Always choose 5” masks for 4” substrates. Use standard thickness Cr on soda lime glass for contact masks.

Notes: Y should be centered, +/- 5mm. Second Mask Alignment window MUST BE Clearfield.



Fine Resolution Contact Masks:

Fine features success, below 3um, for use with thin, 1-2um photo resist, requires understanding of, and compensation for, proximity effects. Proximity effects result from light scattering in a somewhat Gaussian distribution after transmission through the mask, so clear areas near other clear areas are over exposed from shared light. Design receded clear areas in these cases. Conversely, clear lines which terminate abruptly have less light at the ends than the line middle, so increase the clear dimensions slightly, perhaps by 1 um in length. For example, a 2 x 10um CLEAR line, could be designed at 12 um long, as the line ends will be underexposed, with no shared light. Or it could be designed at 1.5 x 11um, and deliberately overexposed, widening the activated region. If instead, it is a DARK 2x10um line, consider making the width 2.5 um wide, and maybe 11um long, as the ends will receive extra proximity light effects. Parallel lines of 2um width, 4um period, should be 1.5um clear, 2.5um dark.

Pieces Mask - 4 Masks in 1:

If doing pieces, one mask can be used to expose up to 4 patterns or layers. Choose a 4” Cr on glass mask, and have 4 discrete patterns, of up to one inch, tightly packed in the center of the mask. During exposure, we use the 2” mask holder and rotate the mask accordingly. Because of the frame dimensions, a 5” glass mask can’t be offset far enough for this application. Do note that the piece being exposed must always sit on the center of the aligner chuck, or it will not be in contact with the mask during exposure due to the likely failure of the planarization step prior to exposure.

Transparencies Masks:

Transparencies of the Emulsion, not ink jet, laser, or electrostatic copier type which aren’t dark enough for patterning, are commonly used when multi layer alignment and fine resolution below 20um aren’t needed, frequently associated with~100 um SU8 resist thickness. You will benefit from consideration of the proximity effects, from slightly different causes, but with similar results, just one order of magnitude larger. First, consider the defects inherent in the clear, not emulsion side of the film will always have air bubbles about 3um distributed throughout. Second, the edges of the line will be rough on the order of 3+ um.

Third, scattering besides being a function of the .4um light wavelength, is also proportionate to resist thickness. To compensate for the first two defects, we will always add ~200mJ additional exposure to wash out these imperfections. Consider a 25 x 100um CLEAR line should be made 20 x 95um, with knowledge that deliberate overexposure, including proximity effects, caUsing the width to grow to 20um, and some non- proximity effect lengthening of the line, as well. A similar DARK line could be designed at 25 x 105um. It is critical to have the emulsion “down” contacting the resist, and as it is impossible to clean these films, so consider designing duplicate patterns.

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