

Mask Alignment and the Microtech Mask Aligners

In order to fabricate IC devices it is necessary to accurately align patterns already present on a chip to the next pattern in the lithography sequence. The instrument used for this purpose is called a Mask Aligner, for the obvious reason that it aligns a mask to a pattern already on the chip; it also exposes this pattern in the photoresist after the alignment is complete. We use a manual alignment procedure, which is probably the most challenging and time-consuming step in our lab processing. The purpose of this OP is to familiarize you with the operation of our Microtech Mask Aligners, and to provide some tips on how to perform your alignments. Fortunately, we have upgraded these aligners significantly, and you should now find them somewhat easier to use.

A mask aligner must serve two purposes: first, it must provide a means to align a pattern on a chip to the pattern on a mask; and second, it must then expose this pattern. Our aligners use a rigid frame which holds the mask that moves (ideally) only in the vertical direction (z-axis), and a separate wafer chuck which holds the chip that can rotate about the z-axis (θ axis) and move in the horizontal plane (x-y plane). A very small gap is set between the chip and mask, and a microscope is used to examine the mask pattern and alignment marks on the chip simultaneously. The x-y and θ adjustments are then used to bring the two patterns into alignment. After alignment, the mask and chip are pressed together by using a vacuum to apply about 14 pounds per square inch of pressure to them. A timer is used to open a shutter, allowing a UV lamp to expose the photoresist.

The most difficult step in this process is the alignment of chip to mask. In industry special alignment marks and automated pattern recognition are used to perform this step. We must perform the process manually, however. The technique that will allow you to achieve precise alignment in a relatively short time is called split-field alignment. The mask aligner microscope actually has two objective lenses, side-by-side. When in the split-field mode, the image you see is split in half, with the left image corresponding to one location on the chip, and the right half corresponding to another location about one inch away. By adjusting the separation of the objective lenses you will be able to see the same type of alignment marks at two widely separated points on the chip. When the θ and x-y translators are used to move the chip it will be very easy to tell when the whole chip is aligned, since you can see both of these areas. With this technique we can achieve

alignment tolerances of better than $\pm 5 \mu\text{m}$, which is adequate for our minimum critical dimension of about $20 \mu\text{m}$.

Tips on Using the Microtech Mask Aligners

One of the most important factors in aligning is maintaining the smallest possible separation between mask and substrate during alignment. With these aligners the best technique is to initially place the mask and chip in hard vacuum contact. You should then focus the microscope on the chip and mask patterns. While watching through the microscope, slowly pull out the z-axis separation lever; as the mask rises away from the chip it will go slightly out of focus. You should then use the x-y translation micrometers to check for adequate separation: if there is not enough gap to completely separate mask and chip, when you try to move the chip the mask will be dragged along with it, which is clearly visible through the microscope. There is no substitute for practice in this process, so be patient until you develop a feeling for how the machines operate.

Please be careful while using the mask aligners: it is relatively easy to scratch both masks and your chips if you use the aligners improperly.

Mask Aligner Operating Procedure

1. Start the U.V. lamp:

Turn the U.V. Lamp Power Supply on, and then depress the START BUTTON for approximately 1 sec. The lamp should start immediately. Allow a MINIMUM 15 MINUTE WARM-UP PERIOD.

Step 1 should normally be performed by the Lab TA before you arrive.

2. Turn the Aligner ON. Pull the Contact/Separate Control Knob all the way **OUT** (full separation position between substrate and mask).

3. Load the Mask:

- a) Slide the Substrate Chuck all the way forward by pulling on the Substrate Chuck Slide Knob.
- b) Slide out the Mask-Holder Tray.
- c) Load mask, pattern side **down**.
- d) Slide Mask-Holder Tray back into the Mask Frame.

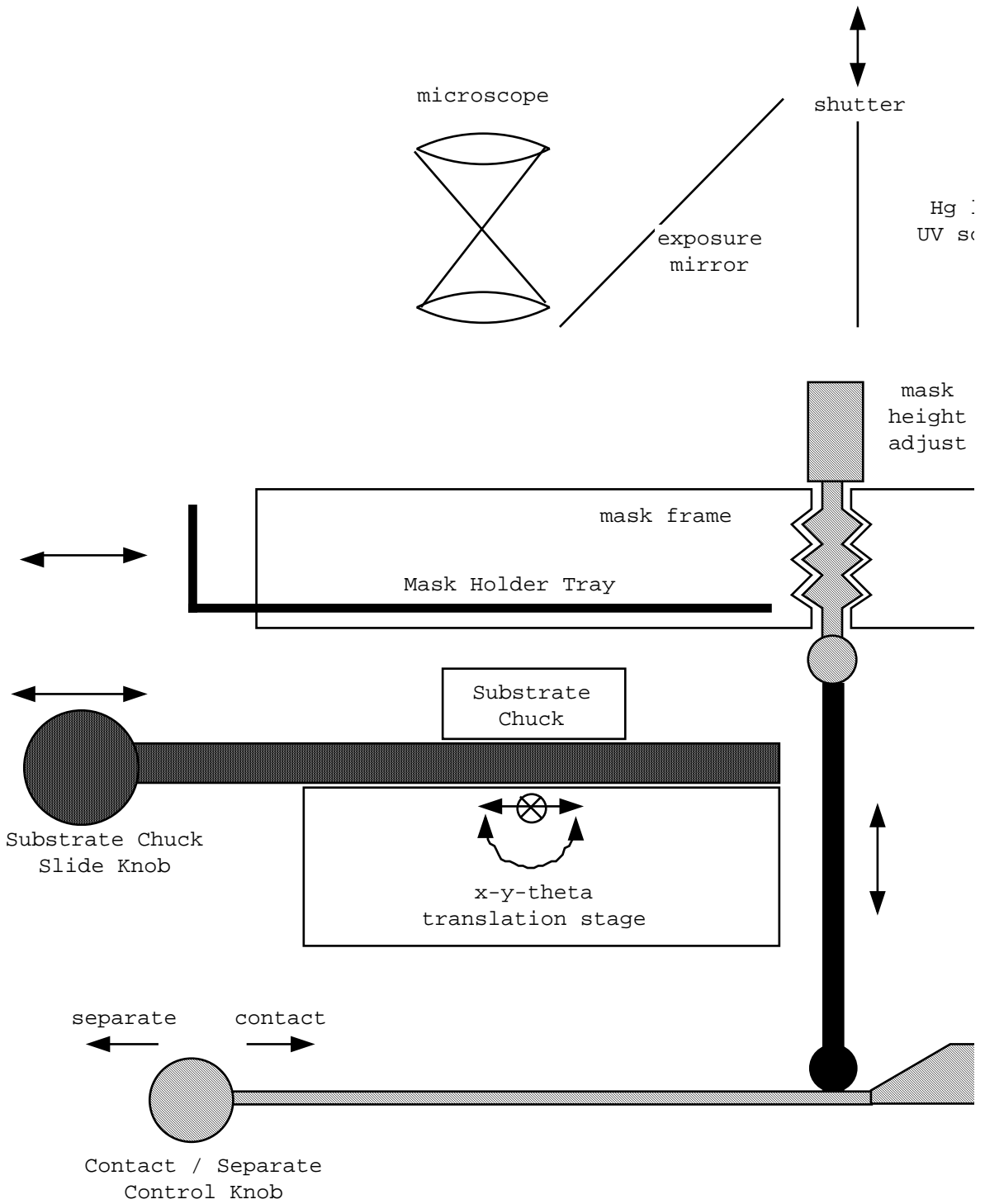


Figure 1: Schematic diagram of the Microtech Mask Aligners

4. Load the Substrate:
 - a) The Substrate Chuck should still be out from step 3a.
 - b) Place your sample on the center of the chuck; orient it so it will be roughly aligned with the mask pattern.
 - c) Turn the Substrate Vacuum ON.
 - d) Slide the Substrate Chuck all the way back under the Mask Frame.

5. Check for Coarse Alignment:

Check the rotational alignment visually; if necessary, slide chuck back out (step 3a) and rotate the chuck manually.

6. Planarize Substrate to Mask:
 - a) Turn the Substrate Vacuum OFF.
 - b) Slowly push the Contact/Separate Control Knob back in; the Mask Frame should drop down towards the substrate, rapidly at first, and then more gradually.
 - c) When the Contact/Separate Control Knob is all the way in (full vacuum contact position) the substrate and mask should be in hard vacuum contact. Sample is now planarized.
 - d) Turn the Substrate Vacuum back ON.

7. Align:
 - a) To move the chip relative to the mask the Contact/Separate Control Knob MUST be in the SEPARATE Position: from fully-in position (hard vacuum contact) slowly pull the knob toward you. The Mask Frame will rise slightly, allowing free motion of the substrate stage. Watch for it through microscope, mask image will blur.
 - b) Use the rotation micrometer to achieve θ -axis alignment; check opposite corners of your chip with the microscope to determine θ -axis.
 - c) Use the Fine Translation Micrometers to align in x-y plane. Check several locations on the wafer with microscope.

USE OF SPLIT-FIELD ALIGNMENT:

Put microscope in split-field mode; the image seen through the microscope should now appear cut in half, the left side corresponds to the right microscope objective lens, and the right side of the image to the left objective. Locate an alignment mark in one field; turn the Objective Lens Separation Adjustment (located to the right of the two objective lenses) until both fields show the same alignment mark. It should now be possible to simultaneously perform θ and x-y alignment.

- d) Push the Contact/Separate Control Knob all the way in (hard contact position).
 - e) Check alignment again with microscope; if necessary repeat steps a-d. When alignment is satisfactory, make sure the Contact/Separate Control is in the contact position.
8. Expose:
- a) Pull the microscope head all the way forward to bring the mirror over the sample.
 - b) Set timer for desired exposure time.
 - c) Press Expose button.
9. Remove your sample:
- a) After the expose cycle is complete, pull Contact/Separate Control all the way out to the fully separated position.
 - b) Slide the Substrate Chuck all the way out, turn the substrate vacuum off, and remove your sample.
10. Remove mask:
- a) The substrate chuck should still be out from step 9b.
 - b) Slide out the Mask-Holder Tray. Carefully remove the mask, and replace it in its storage box.
 - c) Slide the Mask-Holder Tray back in; slide the Substrate Chuck back in. Turn the Mask Aligner Power switch off.

DO NOT TURN THE UV LAMP POWER SUPPLY OFF.