

Pattern Generation for Masks *and* Reticles

Never do the following:

- Run the mask maker when the air pressure gauges are out of range:
 - AGF Air: $+20 \pm 5$ psi
 - Platen Clamp: $+55 \pm 5$ psi
 - Vacuum: -25 ± 5 mmHg
- Rotate the reticle carousel when the machine status is not “IDLE”.
- Turn off the lamp power supplies.
- Leave the spider resting on its pins
- Squirt methanol directly on the granite table
- Leave anything resting on the granite table
- Put a mask plate on the stage without using the spider – including the dummy plate.

Extremely Important! – If *anything* goes wrong with the maskmaker, you must tell the person in charge about it! *Please* don’t leave a problem for the next person to discover. This includes:

- Time-Out Errors
- Aperture Gage Errors
- IR can’t find fiducials
- Mask gets scratched
- etc.

As with many things in life, the best results occur when you offer to help.

The Basic Idea

- **Pattern Generation (PG):** This is the process of flashing the rectangles on a blank mask plate. Photoresist on the mask is exposed at each of the flashes. The photoresist is then developed and the chrome underneath is etched away.
- **Image Repeat (IR):** If a design is repeated several times on a mask (a die, for example), it would be time-consuming to use pattern generation to make the whole mask at once. Instead, a mask containing a single die, called a *PG reticle*, is created using pattern generation. This is made almost the same way as a regular PG mask, except the design on the reticle is the mirror image of the original design, and it is 5x larger. In addition to your design, two small alignment marks, called *fiducials*, are included in the corners of the reticle. Light is shone through the reticle and focused down by a factor of 5 with a lens, reversing the image as it goes through. The image is exposed onto a second mask in an array pattern, one die at a time. Image repeat has the added benefit of allowing smaller features to be created, due to the size reduction of 5 by the lens.

Layout Dimensions:

- Maximum pattern size:
 - PG masks: 100cm
 - IR masks: 19.96mm
- Minimum feature size*:
 - PG masks: $1.25 \pm 0.3 \mu\text{m}$
 - IR masks: $0.25 \pm 0.06 \mu\text{m}$

**Realistically however, min. size is limited by the development procedure (~1mm).*

1. Getting Started.

A. When you come in:

- Both lamp power supplies should be on (located under granite table). Power should be 500W on both.
- Air pressure gauges should be in proper ranges (see above)
- A dummy plate should be on the chuck with the vacuum on.
- A dummy plate should be in the reticle carousel covering the IR module

B. Wipe off the granite table with methanol. Do not squirt directly on the table. Use a wiper.

C. Log in your name, acct number, etc.

2. Open “Electromask II” on the desktop.

For PG masks (No IR): (default mode)

For PG reticles (for IR later): Open the file: C:\jobs\PG RETICLE.job

3. Mode Window

Click “Mode” button. Select the following:

Operation Mode:	Pattern Generator
Units	Metric (even though .int file is in English – it’s OK)
Options:	Zero Speed (Yes); Unload at EOJ (Yes)
Light Source:	G-Line
Plate Size:	5 x 5 (if you want a 4” mask...well, figure it out)

4A. Pattern Generation Window: Focus/Exp Job

If you’re concerned about getting the exact dimensions on your mask, you should perform a Focus/Exposure test job to determine the optimum exposure time. In this mode, the maskmaker will produce an array of flashes, starting at the top left, with each flash having a slightly longer exposure time than the previous one (Figure 1). This is nice because you can do all the exposure time characterization on one mask, all at once.

The exposure time for a specific flash in row R and column C is given by:

$$\text{Exposure Time} = T + [R_{tot}(C-1) + (R-1)] \times \text{Delta}$$

Where:

T = Base exposure time

R = row of interest

C = column of interest

R_{tot} = total # die in each column

Delta = exposure time increment

A. Click on the “PG” button. Select the following options:

Job Type: Focus/Exp

Exp/Lg Exp: N/A

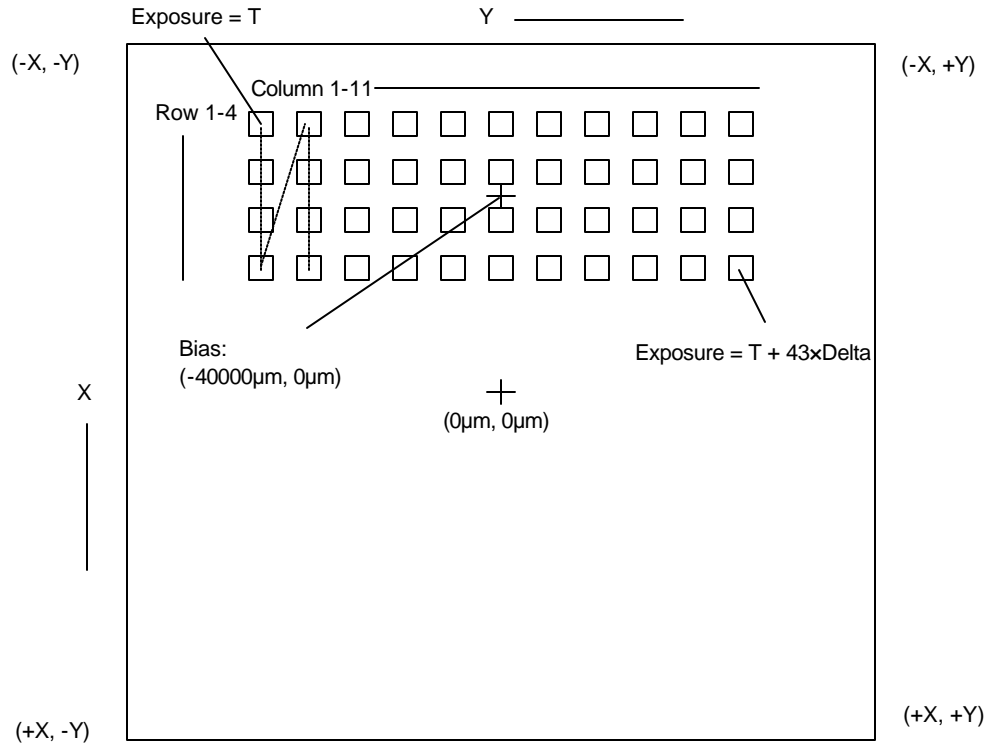


Figure 1: Example of a Focus/Exp job as it would appear on the Graph window. This job will create a 4x11 array of flashes with increasing exposure times. Biases (X,Y) are taken from the center position of each pass array.

- Focus, Base: Refer to the front of the Maskmaker Logbook for the current PG focus value
- Symbol Gen: Produces text on the mask (See Step 5).
- Focus, Delta: 0
- Exposure, Base Starting value for exposure time (ms). I use 50.
- Exposure, Delta Amount exposure time will increase after each flash. I use 10
- Length/Width: Size of the flash.
- Step (X/Y): Pitch of the flashes (must be > Length, Width)
- Bias: The center position of the flash array (See Figure 1).
 - (0, 0): Mask center.
 - (-63500, 0): Upper edge
 - (63500, 0): Lower edge
- Rows/Columns: Up to you. As many as you can fit on the mask.

B. Skip ahead to Step 6 and continue.

C. Use a microscope to measure the width of the flashes after you've processed the test mask.

D. Once you've determined the optimum exposure time, you're ready to make the real mask.

4B. Pattern Generation Window: Normal Job

A. Click on the “PG” button. Select the following options according to the kind of mask you wish to make:

	PG Masks (No IR)	PG Reticles (for IR later)
Job Type:	Normal	Normal
Exposure:	Check log book for current values	Check log book for current values
Large Exposure:	Check log book for current values	Check log book for current values
Symbol Gen:	YES	YES
#Steps:	1 (typical)	3 (typical)

The #Steps option allows you to have more than one design on your mask or reticle. For PG reticles, the first 2 steps are always allotted for the fiducial marks and the third step is your design.

B. Select the Step Number of your design on the right side of the dialog box (For PG reticles, this is #3):

	PG Masks (No IR)	PG Reticles (for IR later)
Input:	.int file you wish to use (only one layer)	.int file you wish to use (only one layer)
Invert Data*:	NO (inversion should be done in the CONVERT program)	NO (inversion is unnecessary)
Magnification:	1 (Pos), 1 (Apt)	1 (Pos), 1 (Apt)
Bias**:	(-63500, -63500)	(-62230, -63500)†
Aperture:	0.000, 0.000	0.000, 0.000

* PG masks: data should appear backwards on Graph screen

PG reticles: data should appear normal on Graph screen

** This assumes you already centered your layout on the origin in your layout software.

† This provides a *necessary* +1270µm offset to compensate for the fiducials. Otherwise, part of the pattern may be cut off when you make your IR mask.

5. Symbol Generation Window

Click on the “SYM GEN” button. Select the following:

- Text: Name of your PG mask or reticle
- Exposure: Check log book for current values
- Character Size: Up to you. I like 1000µm
- X,Y offset & Orientation: Position of text on mask.
 - For text at bottom of screen: (0, 0) offset, 90° rotation, no invert
 - For text at top of screen: (-115000, 0) offset, 90° rotation, no invert
- Invert: YES: text will be right-reading chrome side down.
NO: text will be right-reading chrome side up.
- Zero Speed: YES
- Center Text: YES

6. Operation and Graph Windows

A. Click on the “OP” button and select “Verify”

B. Click on the “GRAPH” button and inspect your layout as it will appear on the mask or reticle. If making a PG reticle, the fiducials should appear in upper right and left corners.

C. *Important*: check that your pattern has the correct dimensions. Sometimes the patterns are off by a factor of 10. If this is the case, go back to the “Fracturing and Converting Files” instructions and check out the section “Whoops. My design is off by a factor of 10!”

5. Load Mask, Expose, and Clean up.

- A. Check PG lamp and make sure it's at 500. If not, contact person in charge.
- B. Turn off plate vacuum and remove dummy plate. Do not leave the dummy plate on the granite table.
- C. Place your plate on, chrome side (dark side) up and turn vacuum on again.
- D. Turn off the platen clamp. Level the stage by placing the "spider" (the large triangular piece of metal on top of the computer console) on top of the mask and pressing down in the center gently. Reapply the platen clamp and remove the spider. Do not lay the spider on its pins. Lay it upside down.
- E. Double check everything.
- F. Hit "Start Job" in OP window. Mask will slide in and lamp will start flashing.
 - The Graph window shows you each flash as it happens. The OP window gives you a running calculation of flashes per hour, and an estimated completion time (very useful for large jobs)
 - Sometimes you will get an error after you hit start and be given the option to abort. This happens if the machine gets stuck in a weird state. Hit abort, let the maskmaker reset itself, then hit start again. If it continues to be a problem, call a staff member.
 - When done, plate will come back out and System Status will go to "IDLE".
- G. Leave machine as you found it:
 - Remove your plate and replace the dummy plate. Turn vacuum back on.
 - You must spider the dummy plate.
 - Leave the both lamps on.
 - Clean up the area and put away your masks, notebooks, etc.
 - Close "Electromask II".

6. Develop PG masks (see "Developing Masks")

- Be absolutely sure to etch your chrome completely. This causes endless problems if you don't.
- If you're making a PG reticle, go on to "Image Repeat".
- If you're making a PG mask this is your last step.

Congratulations – time to party!

