

GCA Autostep200 Training Guide & References

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General Information about system

The stepper system is used to shoot a repeating pattern over wafer. It is primarily needed for jobs where feature resolution and/or alignment is critical. The contact aligners can be used for many jobs. There is a sign-up sheet on the web for the stepper and you must look at the tool status before signing up for time on this equipment. Please plan your time out as this system can get heavily used.

Also, this system is very expensive and replacement parts, especially the optical column, are also expensive. Please be careful, slow, and meticulous when operating this piece of equipment. Many students rely on this piece of equipment for their research. Here are a few important things to remember:

- 1) Do not hit the two alignment objectives when loading a wafer.
- 2) At the end of each job, use RMSR command to get reticle BEFORE removing reticle box, then use RMSL to get your box.

System specifications:

- 1) System: 5x reduction i-line step and repeat, $\lambda = 365$ nm.
- 2) Lens system mirrors both X and Y from mask to stepper.
- 3) I-line intensity is ~ 420 mW/cm² at the wafer.
- 4) Lens: Tropel 2145: 21mm circular field on wafer, NA = 0.45
- 5) Maximum die size ~ 15 mm x 15 mm
- 6) Resolution: 0.6 μ m reproducible, 0.4 μ m achievable R&D.
- 7) Registration tolerance: Max 0.25 μ m global alignment, Max 0.15 μ m local alignment (With care, you can achieve < 0.10 μ m registration)
- 8) Minimum substrate size: ~ 15 x 15 mm
- 9) Maximum substrate size: > 4 inch wafer (round). Larger wafers may require custom paddles to be made by RTS
- 10) Automatic Wafer Leveling and Mask Alignment.

- 11) The system focus is calibrated daily and registration is checked weekly.
- 12) System stages are oiled weekly.

The system will be down from the following lab conditions:

- 1) Power Outage. For outages of 1 hour or less, system will be back on line in 2 hours. Four outages more than 1 hour, system will be back on after 8 hours so that mechanical system restabilizes to the environmental chamber.
- 2) Cooling Water Outage. Environmental unit goes down. For outages of 1 hour or less, system will be back on line in 2 hours. Four outages more than 1 hour, system will be back on after 8 hours so that mechanical system restabilizes to the environmental chamber.
- 3) House Vacuum. System will be back up as soon as house vacuum returns.

This document should answer most questions and prepare you for most operations necessary to achieve good results on the stepper. Manuals are available for more detailed descriptions of the stepper operation.

Logging into computer/checking the system

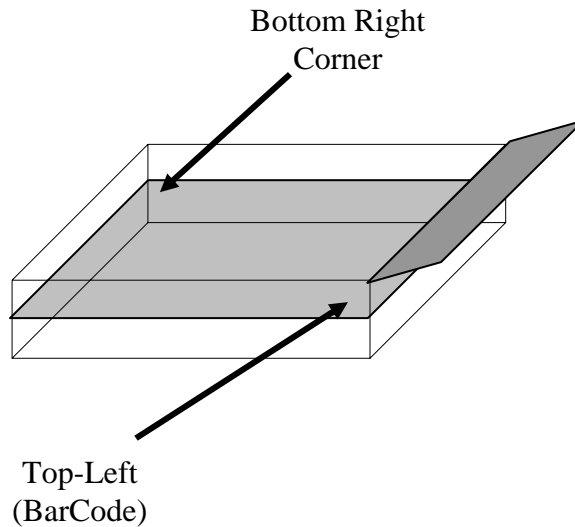
The system administrator will set up a directory for you to log in and use the stepper at the time of training. Before using the system, you will need to log in and perform an interferometer zeroing routine.

- 1) Check to make sure vacuum is > 60 on gauge
- 2) At the colon log into the system using LOG IN [10,xxx] where xxx is your account number.
- 3) Type CHUCK and select chuck size. Use 2 for 2" diameter wafers, 3 for 3" diameter wafers, 100 for 4" diameter wafers, and 142 for pieces or smaller substrates. This number is used for for telling the system where the chuck center is and for wafer autoleveling. Quit when done.
- 4) Type ORIG and hit enter. This resets the laser interferometer position measurement system and moves the stages through its entire motion.

Loading a reticle (mask)

Mask Alignment on this system is automatic. You need to have the square marks on the top and bottom of the mask. These are put on automatically by Photronix and the gds file can be obtained from Brian Thibeault if you use a different vendor. There are 10 reticle box positions on the elevator. Slot 1 is dedicated for a calibration mask. Slots 2-10 are for your use. Slots will NOT be dedicated for any users.

- 1) Load the reticle into a box as shown in the figure with chrome side down:



- 2)
- 3) Type RMSL on the main computer at the colon prompt.
- 4) Swing the reticle forks 90 degrees away from the reticle elevator.
- 5) Pull out knob, insert box, release knob to hold box. Make sure it is properly in place.
- 6) Hit Enter on the computer and the system will map the reticles.

Loading a wafer into the system

- 1) Attach the appropriate chuck to the system.
- 2) Place your wafer centered on the chuck, noting the orientation. If you are doing an alignment step, make sure to place the wafer in the same orientation and as best as possible in the same location as the first exposure. The set screws in the chuck can help to get reproducible placement of the wafer. When the wafer is in place, flip the chuck vacuum switch upwards to hold the sample.
- 3) Place the sample chuck onto the stage, again trying to be repeatable, and flip the stage vacuum switch upwards to hold the chuck. If your sample is more than 150um thinner than the number on the chuck for thickness, then you can try to cut some shim stock with holes in it to adjust the wafer thickness to the appropriate range.
- 4) Be careful when placing the chuck on to the system. Do not set the chuck onto the built-in reticle on the left side of the stage.
- 5) Also, make sure the chuck vacuum is properly holding the chuck in place. It can tip forwards before the vacuum holds it in place.
- 6) At this stage type *AWLT Jobname\Passname*. This will test the autoleveling of your wafer.
- 7) At "START AWH" prompt, press MANUAL button.
- 8) Press MANUAL again.
- 9) Choose "N" in an answer to all questions.
- 10) If you have an autofocus error or leveling error, the system will tell you.

Setting up / editing an exposure job (Section 5 of Instruction Manual)

Setting up the job:

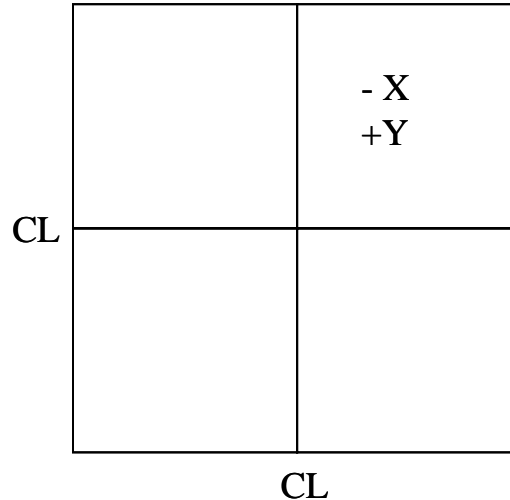
This section describes how to set up a job to do a step and repeat exposure of your patterns. A more detailed description is given in section 8 of the Autostep 200 Operations manual. Jobs are created using the SPEC command. First information about the array steps, alignment offsets, and general job is asked for. Passes are attached to each job to apply parameters unique to each pass specified. In this way all exposure information for a complete mask set can be specified all in one job. Following is the procedure for setting up a job and passes.

Notes: If at any point you wish to stop and start over with the job description hit CTRL C followed by A and ENTER on the keyboard to abort the SPEC command. An abort of this type will result in no saved information. Also when a * is displayed, this indicates the default value if you hit enter for a reply to a question asked by the computer in setting up or editing any job. If a numeric value is asked for hitting enter will leave the value previously specified, if that exists. Also, if you put in an incorrect value and wish to go back a step type "?" and ENTER.

- 1) At the colon sign type SPEC "filename" and hit enter. The filename can be 1 to 9 characters long.
- 2) Select metric units
- 3) Input a job comment such as "HBT-1 process"
- 4) Set tolerance to 1
- 5) Hit Enter for scale.
- 6) Hit enter for orthogonality.
- 7) at the Leveler Batch Size prompt input 1 to use wafer leveling, and -1 to turn leveling off.
- 8) Enter the wafer diameter in mm. This defines the maximum area in which exposure can occur. If you have a square or non circular piece, you will need to specify a diameter that includes the entire square, not the length of a square.
- 9) Enter the step size in X in mm at the wafer plane
- 10) Use "C" for specifying the number of columns to expose and A to fill in all area in X direction to the edge of a circular wafer. For square pieces you will always use "C". For quarter wafers, you will most likely use "C" and make the job array look square. You will then use dropouts in each pass to specify more complicated array shapes.
- 11) When "C" is entered, you will then be able to enter the number of columns desired.
- 12) Repeat 9 through 11 for the Y step. The final array is centered on the wafer.
- 13) Translate Origin is generally used only if the wafer is off-center.
- 14) If you wish to see an "*" cartoon of the exposure array hit Y for display, otherwise hit Enter.

- 15) Layout will give you a display of the number of rows and columns and the distance from die 1,1 to the array center, taking origin translation into account.. Usually this is not looked at. Hit enter to pass this up.
- 16) If you wish to adjust the numbers of rows and columns you can do this at the Adjust prompt. Usually, you can hit enter to skip this.
- 17) Standard Keys. If this is used, then the die used for right and left alignment is chosen automatically by the system. This is good if you have a wafer larger than 63.5 mm in the X direction and both alignment marks are exactly 63.5 mm apart. If you do not meet these conditions (most jobs), you will need to choose N.
- 18) If "N" is chosen you will need to enter the row and column of the right alignment die.
- 19) Right Key Offset. The distance from the die (mask) center to the alignment mark center on the first layer (or the layer you will be aligning to). Enter the number in mm at the wafer plane. See picture below for sign convention of an alignment

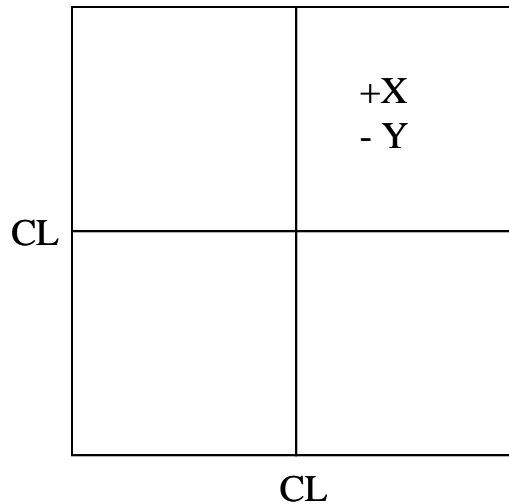
Sign for Alignment Key On Mask



- mark placed in quadrant 1 on the mask. The picture assumes normal Cartesian coordinates with the center lines crossing at 0,0 and the mask is chrome-side down and oriented as it would be on the stepper. (This is the same orientation that you will have when viewing your LEdit file)
- 20) If non-standard alignment keys are selected, you will need to select the left alignment die row and column and the Left Key Offset (same as right) as well.
 - 21) Skip through epi shift.
 - 22) Now you are ready to enter information specific to passes.
 - 23) Enter the name of the first pass. When you expose a job, you will specify it as filename\pass. The name of a pass can be 1 to 9 alphanumeric characters long. (i.e. emitter)
 - 24) Next enter a pass comment
 - 25) Enter Y or N for local alignment: You need special alignment marks for this.
 - 26) Expose Mapping Pass: Yes for die x die alignment and exposure.
 - 27) Use two point alignment: Yes will check your local alignment marks on your global alignment die and correct for rotation error prior to shooting.

- a. Set Rotation Tolerance to 2microRadians
 - b. Continue with Mapping: Yes if mapping should continue after 2-point alignment.
- 28) Number of alignments per die: Enter 1
- 29) Local Alignment Mark Offset: Enter the alignment mark position in X and Y just as used for global alignment above (step 19 ff)
- 30) Monitor Mapping Corrections: Choose Y if you want to see data before exposure to make a judgement on whether to continue.
- 31) Map Every Nth Wafer: Enter 1 to map every wafer you shoot.
- 32) Next, input an exposure time between 0 and 128 sec. The calibrations are done at 0.38 sec. for 0.9um SPR 955-CM resist on silicon. This time should be optimized for your substrate and process before doing the real devices to ensure optimum resolution. Dose is calibrated for the system each lamp change.
- 33) Expose Calib Factor: 1
- 34) Focus Offset: Based on a focus calibration that you do, you will have a focus offset from the baseline calibration job. This calibration is done daily with a mark built-in to the system. Focus offset is an integer. +1 = 0.1 microns of lens movement up from the wafer. -1 = 0.1 microns towards the wafer.
- 35) Microscope focus offset: Same units as above. Used so that your wafer will be in focus right away. You will find out this number the first time you expose.
- 36) Enable Match: Can use marks on your mask to make sure reticle is exactly aligned. If you have the marks (standard on Photronix masks), and say yes:
- a. Match Template Name: MATCH
 - b. Match every Nth Wafer: Enter 1.
 - c. Reticle Rotation Offset: Enter 0.
 - d. Reticle T: 0
- 37) AWA Parameter File Name: just press Enter
- 38) Use pass shift to shift all exposures in this pass by a set amount. Usually this option is passed over, but may be used if you have multiple levels on a single mask and are aperturing all layers but the one of interest and this pattern is off-center. You would enter the correct offset to ensure pattern alignment. See picture below for sign convention for X and Y for pass shifts to place pattern into center of wafer. Enter the number in mm at the wafer plane. See picture below for sign convention of pass shift for a pattern placed in quadrant 1. The picture assumes normal Cartesian coordinates with the center lines crossing at 0,0 and the mask is chrome-side down and oriented as it would be on the stepper.

Sign for Pass Shift On Mask



- 39) Reticle Bar Code: If you have a bar code on your reticle, enter the value here, otherwise hit enter.
- 40) Masking Aperture Setting: You can set the aperture blades independently, entering values between 0 and 97 for the blade movement, in millimeters. 0 is completely open for all blades. The smallest square you can aperture to is 5mm x 5mm (that means 1mm x 1mm at the wafer plane)
- 41) Reticle Alignment Offset: Enter 0 for all these values.
- 42) Reticle Alignment Phase: Enter N for negative (clear squares)
- 43) Reticle Transmission: Hit Enter.
- 44) Array or Plug. When P is entered, only those row and column sites that the user enters will be exposed. When A is entered all sites previously specified will be exposed except dropouts specified later.
- 45) When P is entered, enter the row and column numbers of die you wish to be exposed. Enter D at the R prompt to display the currently selected die. Press return with a blank entry at the R prompt when finished.
- 46) In the dropouts section, sites or entire rows or columns can be removed from the exposure. Enter the row. Then enter at the C prompt : nothing to remove the whole row, the first and last column number with a dash in between (i.e.3-6) to remove several sites, or a single number to remove a single site. Enter D at the R prompt to view the die that will be exposed. Enter V at the R prompt to see a list of dropouts. Enter ? at the R prompt to put back in the last die that was dropped out. Again hit return with no entry at the R prompt to exit.
- 47) Answer Y to save pass.
- 48) If no other passes are desired, hit enter with no entry at the name prompt.
- 49) Enter another pass name if desired and hit enter.
- 50) If the pass information is mostly the same as a previous pass, hit Y at the Copy prompt and enter the name of the pass to be copied, then change any needed parameters after the job is saved using the EDIT command.
- 51) Say Y to Write to Disk or all information will be lost.

52) You are ready.

Editing an existing job:

To edit an existing job, use the EDIT command followed by the file name. You can then scroll through job and all passes and change any desired parameters. Don't forget to save the changes. If you just wanted to look at the program you can use the EDIT command and then use CTRL C followed by A and a carriage return to abort the command and not save any changes.

You can also edit a job by using the JOB command. You can play with this. It is menu driven and lets you easily change parameters without having to scroll through an entire program.

Performing an exposure job

- 1) Make sure you have loaded the reticle as described above.
- 2) Type EXEC jobname\passname and hit enter. (See "*Wafer alignment to mask / Local Alignment (DFAS)*" below for local alignment job syntax)
- 3) Type in the desired exposure time if different
- 4) Type in desired focus offset.
- 5) Reticle T: 0
- 6) Reticle BarCode: Enter a bar code name if you have one on the mask, otherwise, hit Enter.
- 7) Floor#: Enter the elevator slot number where you put your reticle.
- 8) If MATCH was enabled, the system loads the reticle and you will see the left screen perform the InSitu-Match routine on your mask.
- 9) Press MANUAL key when "Start AWH" prompt is seen.
- 10) Press MANUAL Again as prompted
- 11) Sample will move to alignment position/do global alignment.

Wafer alignment to system / Global (Manual Operation Only)

The keyboard alone is used in this part of the exposure sequence to align the wafer to the system. The sequence of operations you do will depend on whether or not you used standard alignment keys or not. If you placed the sample close to the position you did during the first exposure, you should see an alignment mark in the right side of the screen. If not, you will need to find this mark using the position joystick by following a spiraling outward from the initial position. Pressing "F" repeatedly on the keyboard will do this spiral finding for you automatically. The red arrows on the number keys indicate the direction of movement for each key stroke. There are also + and -theta (angle) keys for rotation. Inc and Dec are used for microscope focus. The enter key on the numeric keypad changes from fast to slow movement. To change the joystick speed hit O on the main keyboard. Once the alignment mark is found follow one of the following procedures.

Standard Alignment Keys:

- a) Adjust the focus (Inc and Dec keys) to get a crisp image (you might have to change speed with the Fast/Slow key).
- b) Align the right mark using the numeric keys labeled with arrows.
- c) Use the Theta keys to rotate the left image into position. Positive Theta = clockwise rotation of chuck. If you run out of theta alignment, you will need to adjust your sample on the chuck.
- d) The left image is used for theta only.
- e) Repeat process until satisfied with the alignment. You can obtain better than 0.2 um alignment consistently if you are careful.

Non-Standard Alignment Keys:

- a) Adjust the focus (Inc and Dec keys) to get a crisp image (you might have to change speed).
- b) Align the right mark using the numeric keys labeled with arrows.
- c) Press A on the main keyboard to toggle to the left alignment mark.
- d) Use the Theta keys to rotate the left image into position. Positive Theta = clockwise rotation of chuck. If you run out of theta alignment, you will need to adjust your sample on the chuck.
- e) The left image is used for theta only.
- f) Press A again to move to the right alignment mark
- g) Again adjust the right alignment mark
- h) Repeat process until position and theta are acceptable.

9) After global alignment, press EXPOSE key.

Wafer alignment to mask / Local Alignment (DFAS) :

The best way to use this is to use a mapping routine followed by a shoot using the corrections given by the map. A mapping routine should be set-up in your job with a pass name named mapxx. Make sure you specify die x die is to be used and that you have the correct key offsets for the global and local alignment marks. The command you will then use is: MAP jobname\mapxx.jobname\passname. The first exposure is the mapping pass. When asked to make corrections, say yes. The exposure job will then be performed. Follow instructions on screen when using this function.

- 10) Remove the sample from the stage when done. (If Match was enabled, you will have to wait until the match is done again. It will do this before asking you for the next wafer)
- 11) Develop resist and inspect in microscope for alignment (if needed)
- 12) Computer will ask for next wafer. To escape out of this press CTRL C followed by A and the enter key to abort out of the loop. If you have another wafer with the same job\pass, you can do it now without aborting by placing it on the chuck and hitting MANUAL..

Focus / Exposure optimization (End of Section 5 of Instruction Manual)

The system is calibrated weekly on 2 inch Si wafers with the 2" wafer chuck. Your substrate type/thickness/resist may require different focus and exposure settings than the standard calibration. A focus / exposure optimization should be done to tweak your process relative to the calibration baseline. To do this you can use one of your already defined jobs and passes and your highest resolution mask. The command EXPO will shoot a specified serpentine array based on the parameters in your job\pass. The focus and/or exposure can be varied across this array to determine the optimum focus relative to the baseline. One focus step is equal to 0.1 um of focus depth.

- 1) Use the command EXPO jobname\passname and hit enter
- 2) Enter starting row within array specified in the pass
- 3) Enter ending row within the array specified in the pass
- 4) Enter starting column within array specified in the pass
- 5) Enter ending column within the array specified in the pass
- 6) Enter F to vary the focus in a serpentine pattern, E to vary the exposure in a serpentine pattern, or R to increment focus for each row and exposure for each column within the array.
- 7) Enter the parameters as prompted by the computer. They will differ based on which option is chosen.
- 8) To "Start AWH" Press MANUAL when prompted
- 9) Press the MANUAL again.
- 10) If you are doing an aligned test (like for exposure on top of a mesa) align the wafer now.
- 11) press the EXP key on the small keyboard to shoot the array.
- 12) When done, do the PEB and development according to the process and inspect in the microscope.
- 13) The computer will ask you for the best row and column.
- 14) The computer will then tell you the focus and exposure based on the row and column you input.
- 15) **Do not update system focus !** Input a focus offset into your own exposure job. (If you update the focus, you must change it back using the MODE command when you are done)

Logging out of computer when done/End of job

- 1) Type RMSR to get your reticle (DO NOT REMOVE RETICLE BOX UNTIL YOU HAVE RUN RMSR)
- 2) Type RMSL, wait until robot is done moving, then rotate robot out of the way and remove your reticle box.
- 3) Press Enter when done removing box.
- 4) Remove your chuck and hang it on the side panel.
- 5) LOG OUT of system.
- 6) Make sure the doors to the environmental chamber are closed.

User Accessible Commands – Definitions

CHUCK – To change chuck size
COPY – Use this to copy a file from someone else's directory to your own. You will need to know the user log in drive and the filename
DELETE – Removes a file from system
DISP – Display the parameters for a job
EDIT – Use to edit exposure jobs and passes
EXEC – Use this to execute an exposure job
EXPO – Use this to perform a focus and/or exposure calibration
HELP – Use this to find out the syntax and use of any command.
JOB – To edit a job from a menu
LISTF – Lists a directory of files
LOAD – moves the stage to the load position, may be needed if the stage/computer hangs up.
LOG IN [10,xxx] – To log into computer
LOG OUT – To log out of system.
ORIG – Use this to retune the originate the laser counter / move the stages through their entire motion.
PURGE – Delete files from directory
RENAME – Rename a file
RMSL – To Load a reticle box into the elevator
RMSR – To return a reticle from the stepper to the box.
SPEC – Create a job file, must go all the way through to save the job.

Useful Control Characters

CTRL C followed by A and Enter – Abort back to colon prompt
A – Toggles between left and right alignment die when using non-standard keys
D – Sets joystick to move from die to die.
T – Sets joystick to move left alignment die under right objective.
E – Exit out of D or T mode so that joystick is back to normal.
O – Vary fast and slow alignment and focus speeds.
F – Each time you press this, it will move the stage about an increasing spiral path away from the initial location. Use this repeatedly to find the alignment marks for samples placed differently on chuck than in initial exposure.
CTRL S – stops monitor scrolling function
CTRL Q – resumes monitor scrolling function

Troubleshooting.

What to do in case of computer (monitor) freeze-up. Please try these things in this order.

- 1) Try CTRL C followed by A and Enter. This will abort any command that may have hung up.

- 2) For Reticle Robot Hang Up: See step 25 of start-up procedure. Call Bob, Brian, or RTS

What to do in case of unplanned power outage.

- 1) CR Staff will take care of the system in the morning.

What to do for alignment error.

- 1) Verify that correct alignment key offset is being used
- 2) If you have DFAS alignment marks, perform a MAP job to verify alignment.

What to do for focus resolution problems.

- 1) Perform a focus (EXPO) job using the same type of wafer that you will use for your real job and use the optimal focus offset determined from this job. You may need to look at both exposure time and focus.
- 2) If you have been running the same process and now have issues, run SETUP from the : prompt, following the instructions on the GCA Regular Maintenance Sheet.

What to do in case of the stage limit going too far (red stage limit light will be lit inside the stepper chamber next to the joystick).

- 1) Press the lit limit switch to release the stage.

Contacts to call if you cannot undo the problem. Do not call after 10 p.m. unless there is a real emergency (A deadline for a paper or conference is not a real emergency)

- 1) Brian Thibeault : x 2268 Work or 964-4009 Home
- 2) Bob Hill : x 7975
- 3) RTS Inc. (These guys know all about the stepper, they rebuilt it and service it under contract for us). Ask for Matt or Mike. 480-892-4433.
- 4) If neither can be reached, leave a note on the stepper and the white board that the stepper is down. E-mail Brian Thibeault at thibeault@ece.ucsb.edu to report the problem.

Mask Layout / Alignment Marks

- 1) Alignment marks in exposure field, Global, Local (DFAS). To learn more about how these alignment marks work with the system, see the reticle handbook. In our system we mainly use manual global alignment to get +/- 0.25 or better alignment tolerance. Local alignment can be used but needs some characterization for each process.

Global alignment marks: These marks and how to place them on the mask are described on page 5-44 to 5-47 of the reticle handbook and are included as an

attachment to this document. The difference of our system from the manual is that the objectives are 63.5 mm apart, not 76.2 mm as indicated in the manual. The distance of this mark (or marks) to the center of the cell in X and Y should be noted, this is the key offset and will be required when exposing a job. (Positive offset values are left for X and up for Y)

Local alignment marks: These marks and how to place them on the mask are described on page 5-33 to 5-34 of the reticle handbook and are included as an attachment to this document. If possible use one of each type if you desire to try to use local alignment. These can be light or dark field in nature. The distance of the center point of this mark (or marks) to the center of the cell in X and Y should be noted, this is the key offset and will be required when exposing a job.

- 2) *Vernier Scales:* These can be included to quantify the alignment offset after an exposure is done. The reticle handbook has an example of vernier scales on pages 5-49 to 5-53. You should include them for any layers that require critical alignment.
- 3) *Resolution:* If you have room in the mask layout, it is good to have features that can give the resolution of a given exposure. The resolution should show both “pillars” and “trenches” in the resist so that you can see whether the focus or exposure needs some tweaking for your particular process.