Heidelberg DWL 66 Laser MaskWriter SOP*

1 SCOPE

This document establishes the procedures for data preparation, conversion of data files to machine (lic) format, setup and operation of the DWL 66 to produce a photomask and the subsequent processing (develop, etch, inspect and measure).

2 APPLICABLE DOCUMENTS

DWL 66 logbook and maintenance log
DWL 66 SOP
Layout and file guidelines—Appendix (this document)
Procedures for operation of both yellow room fume hoods and the mask inspection microscope.

3 MATERIALS AND EQUIPMENT

Data file in the appropriate format
Blank photomask plate (usually a 5 x 5 LRC chrome on soda lime and pre-coated with about 0.5 microns photoresist) supplied by NRF (Nanofilms 509SL10MLRC or equivalent)
AZ Developer (mixed 1:1 with water)
Chrome Etchant- (Cyantek's CR-7S or equivalent)
Appropriate acid and developer-resistant mask holder

4 DATA PREPARATION AND CONVERSION

4.1 Data Preparation. The data file(s) must meet the requirements and guidelines as set forth in the appendix of this spec. Data must be in one of the following formats: DXF, GDSII, Gerber, ODB or CIF (strongly0 preferred).

4.2 Data Conversion and Review convert machine uses SuSE Linux.

4.2.1. Fill out the data submission form and give it to one of the responsible engineers.

4.2.2 Schedule a time with a responsible engineer and email or bring the data file in the appropriate format (USB drive, CD disc).

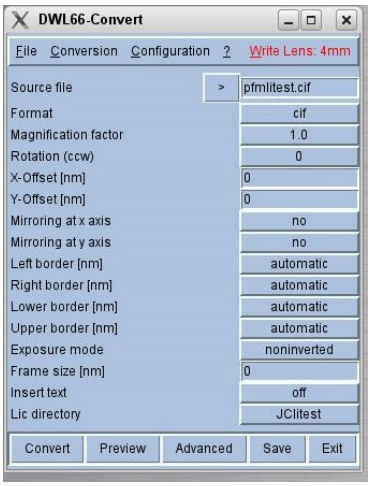
4.2.3 Insert USB drive, or CD into the DWL 66 Converter computer. Machine should already be on and no log on is required.

4.2.4 Open the home directory (by clicking ONCE) on the icon that looks like a house at the bottom menu.

4.2.5 Open the folder that coincides with your file format (eg cif for CIF files, gerber for Gerber files etc). You MUST copy your data file to the appropriate folder by drag and drop. Pay attention also to file name rules eg. no spaces, dashes or illegal characters.

4.2.6 Close the home folder and click ONCE on the Gear wheel icon labeled “Menu” on the desktop to open the DWL converter software.

4.2.7 A screen as shown below should appear:



4.2.8 Click on Write Lens (upper top of menu in Red) and select desired write head 4 mm as discussed in the Appendix.

4.2.9 On Format, select the appropriate file format.

4.2.10 Click the > sign next to Source file and navigate to the directory where you just loaded your file (eg for a cif file it will be in the cif folder.) Select file name and press OK to load it into DWL Converter

4.2.11 Complete each of the data entry blocks as:

- 4.2.11.1 Format—same as file type
- 4.2.11.2 Magnification—usually 1
- 4.2.11.3 Rotation—usually 0
- 4.2.11.4 X and Y offsets—usually 0
- 4.2.11.5 Mirroring at x—usually off
- 4.2.11.6 Mirroring at y-usually On
- 4.2.11.7 Left, right, lower and upper borders—This should be the minimum border in nm which encloses all your data to be printed. If only a portion of the data is to be printed, set the borders accordingly. Coordinates are referenced to data center which should be defined as the origin.

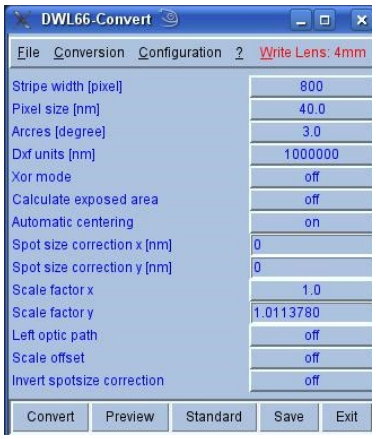
4.2.11.8 Exposure mode—noninverted is used to indicate that digitized regions will be exposed (ie dark field) and inverted indicates nondigitized regions will be exposed (usually clear field masks). See Appendix A2 for further information about clear and dark field.

4.2.11.9 Frame Size—usually 0.

4.2.11.10 Insert text—Usually off

4.2.11.11 Lic Directory—Click on the file name next to Lic Directory and scroll down to “other value. Type in a new file name obeying all naming conventions ie no spaces, dashes etc. and click OK.

4.2.12 Click on “Advanced” at the bottom of the menu to bring up the following screen:

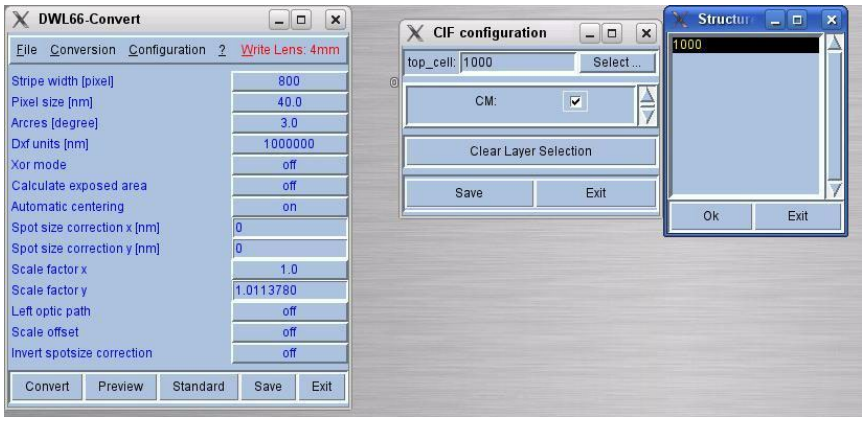


4.2.12.1 Stripe width—800 (pixels)

4.2.12.2 Pixel Size—40

4.2.12.3 All other entries are as shown above—usually. A spot size correction may be needed in rare cases.

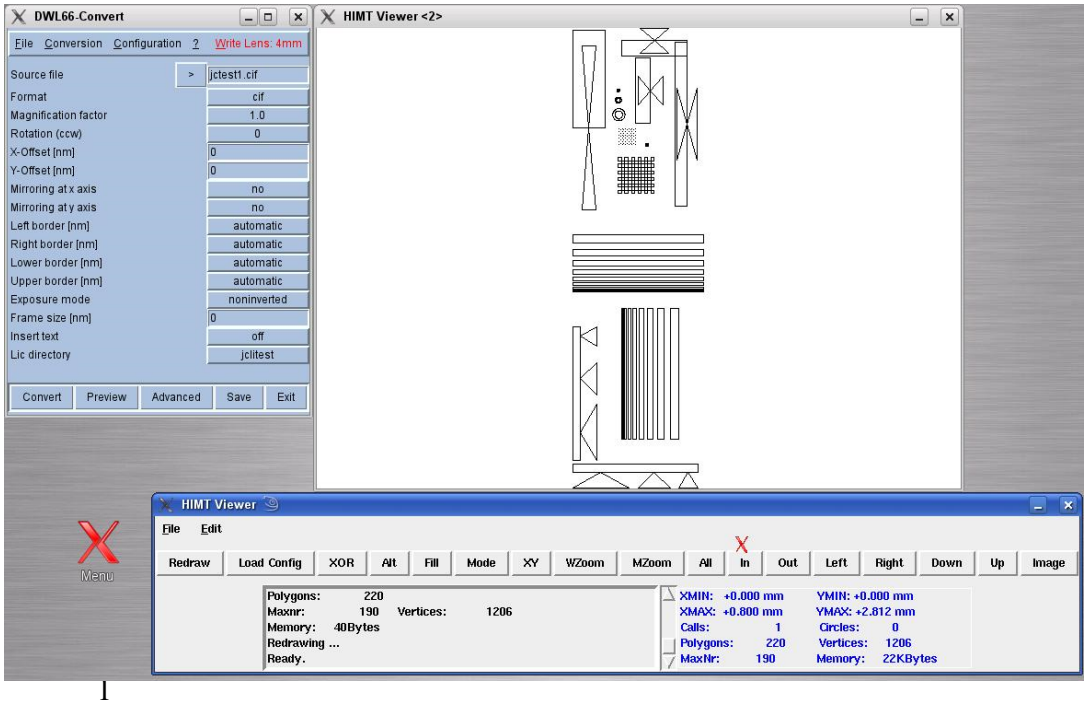
4.2.13 Click on Configuration and scroll down to the file type (in this case CIF) to bring up the next screen as shown:



4.2.14 Click on the check box next to the CIF layer or layers to be fabricated. In this case, the CIF file contains only the layer. Click on "Select" and, under "Structure", choose the first # on the top (most case).

4.2.15 Click on "OK" and 'Exit" in the Structure menu and then click on "Save" and "Exit" in the Configuration menu.

4.2.16 Click on Preview to see your data plot. (It takes a few seconds before the plot appears). Two windows will appear, one of the drawing and another of the control window (lower window in screen shot below).



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Magnification of the drawing can be changed by clicking "In" or "Out" or using "MZoom". Image may be shifted by pressing "Left", "Right", "Down" and "Up". Image can be refreshed by clicking "Redraw" and hollow shapes can be filled in by pressing "Fill". Distances may be checked by clicking on "XY" and then clicking twice on one feature and moving the mouse to the next feature. *Note for those controls that turn red such as XY and MZoom, you must click the middle mouse button with the cursor in the drawing window to exit the mode before switching to another function.*

4.2.16.2 The overall drawing size, xmin, xmax, ymin, ymax as well as pertinent file data is displayed in the right side of the lower window in blue.

4.2.16.3 Make sure your drawing, and its coordinates are correct before proceeding to the next step. Click and hold on "File" and scroll to "Exit" (bottom window) to leave the "Preview" mode.

4.2.17 Click “Convert” in the lower part of the main window to begin data conversion. An info window will pop up with some pertinent information. Click “Yes” to continue.

4.2.18 Conversion begins and depending on the data file size, can take between a few seconds or many minutes. The system will display a conversion completed window when it is done. Click OK.

4.2.19 During the conversion, the number of stripes will be shown in the file header.

4.2.20 Click on “File” and scroll to “Transfer” to upload files to the DWL 66’s hard drive. This may take a few minutes. Make sure you know the name of the file that has been uploaded.

4.2.21 After completion “Goodbye” will be shown in the transfer window. Close the window and save and exit the DWL 66 program. Proceed to the next section.

5 DWL 66 OPERATING PROCEDURE

Never touch the interferometer mirrors.

Before operating: Please make sure the compressed air is turned ON. Focusing the laser without the compressed air will cause the write head to crash into your substrate, and none of us wants that. You should hear a hissing sound coming from the write head when the air is on.

5.1 Preparing the Mask Writer The laser needs to be warmed up for at least 20 minutes before starting your exposure.

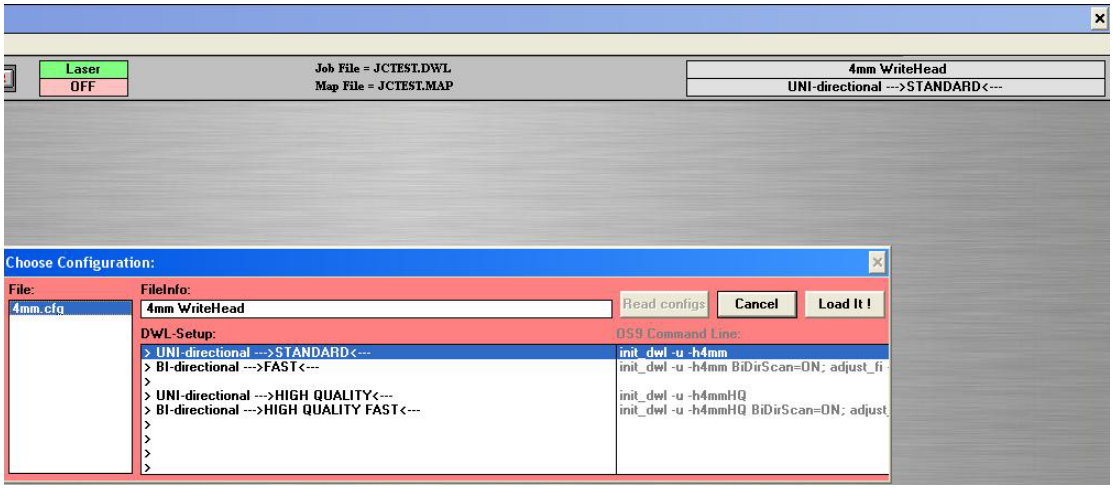
5.2 System Verification Verify from the log book that the last user had no problems and verify that power is on to the PC computer.

5.3 Write Head Selection 4mm writer head is installed. *CAUTION: These write heads are verydelicate and extremely expensive. Only authorized, trained superusers may handle them.*

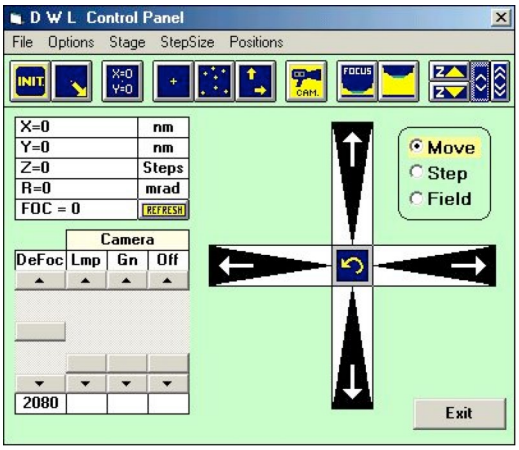
5.4 Unloading the stage. The PC is usually on, with Windows XP running. If not, reboot the computer following standard Windows procedures. When the password screen comes up, Password is same as username. Open up the **DWLII** user menu, by clicking on the  icon. The following window will appear:

5.4.1 Check the interferometer status by clicking on “IF?” and if it fails, click on “IF R” twice to reset it as shown below. *Note: If “IF” is green with OK on it instead of red or a question mark, then the interferometer is OK.*

5.4.2 Click on the write head selection in the upper right corner of the Window. Select the write head to be used (this MUST match the selection in your data conversion and the head actually installed on the system) from the pull-down menu. Also highlight the setup file in the middle column next to the write head and press “Load it”. The display in the top right corner should now indicate the desired write head.



5.4.3 Open the control panel by pressing  on the tool bar menu. The control panel opens as shown below.



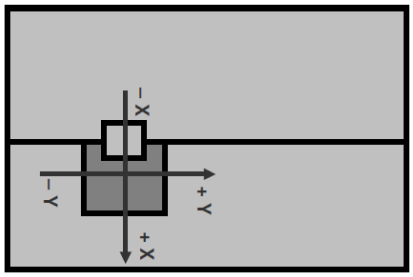
5.4.4 Click on the blue INIT button (top left of menu) to initialize the stage.

5.4.5 Click on the  icon to put the stage in the load/unload position.

5.4.6 Flip the toggle button on the left side of the DWL environmental chamber to raise the access window. *Note this disables the stage motor. Only do this after the stage has finished going to the unload position.*

5.5 Loading a blank mask plate. 5 inch resist-coated chrome plates should never be handled in white light or too close to the Computer Monitor. Carefully scribe run # (from log book) in the front, right corner of the mask.

Note that the coordinate system for the stage is;



Front of DWL 66

5.5.1 Verify that the lens head is in the up position and then carefully reach in and gently pull the stage towards you and to the right.

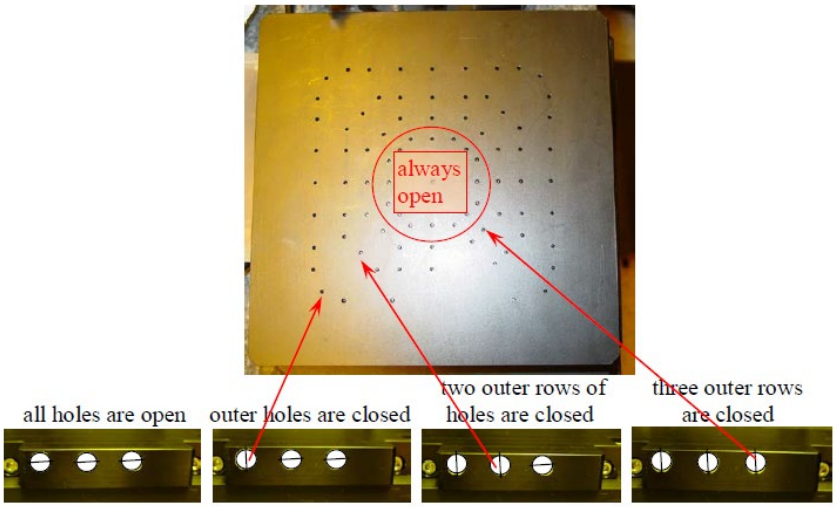
Be extremely careful not to touch the mirror or interrupt the red laser beam to the right of the stage.

5.5.2 Turn off the vacuum, if it is on, by rotating the black valve to off.

5.5.3 Place clean blank plate, resist side up over the stage chuck holes. There are 3 guide pins to help align the plate. The plate edges should sit firmly against these pins.

5.5.4 Turn the vacuum back on with the black valve. If a hissing is heard, turn off the vacuum and reposition plate to block vacuum holes and then turn vacuum back on. There should be almost no sound if the plate is properly positioned.

The following settings apply to the solid chuck:



5.5.5 Gently push on the plate to verify it is tightly clamped to the stage.

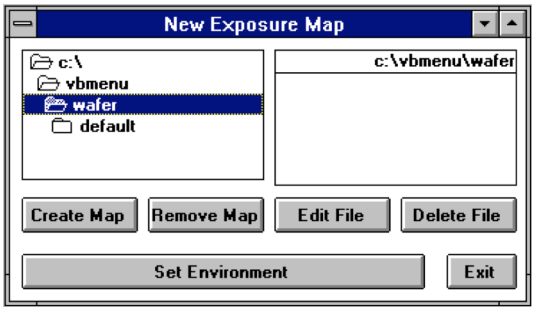
5.5.6 Gently push the stage in, so that the plate is approximately centered under the lens head.

5.5.7 At this time, verify that the appropriate filter or filters (6, 20 or 50) are inserted on the optical track in the path of the laser. Each Write Head requires a unique set of filters, focus setting and energy. This

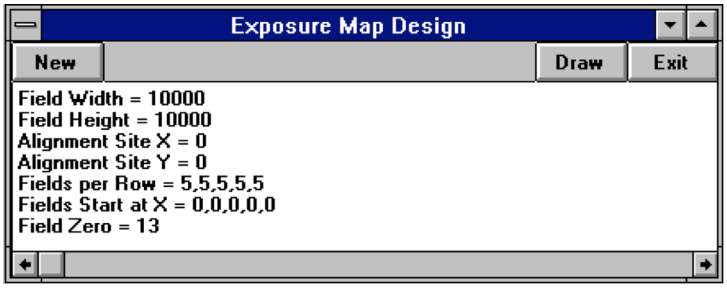
chart is posted on computer table of the DWL 66.

5.5.8 Lower the chamber window with the toggle valve.
5.5.9 At the PC, click on the focus icon in the menu. *CAUTION: Make sure the plate is completely under the lens. Failure to do so will damage the lens!*
5.5.10 A pop up screen asks "Set Defoc to Center during focus?" Click no.
5.5.11 The head will move down and find the focus.You are now ready to set up the exposure map and make a job.

5.6 Setting up the Environment Before you can start exposing, you must set up a map with exposure, location information.
5.6.1 Click New under Setup in the main menu. The following window



5.6.2 Highlight \vbmenu\wafer as shown above.
5.6.3 If the map you wish to use already exists, navigate to it and select it; otherwise click on "Create Map".
5.6.4 To create the new directory, type in an eight character name (legal characters only) in the popup window and press return.
5.6.5 A second popup window asks "Set environment?" Click Yes.
5.6.6 In the left window, scroll down to the name of the directory you just created and double click it.
5.6.7 Three or four files should appear in the right column with the directory name followed by a suffix. Double click on the file which has .map as an extension and click "Set Environment" followed by "Exit".
5.6.8 Click on "Exposure Map" under Setup to get the following window:



5.6.9 Click o ı the "New' button at the top to clear the data and start fresh.

5.6.7.1 Field Width is the value in microns of x. At a minimum, it must be wide enough to include all data to be printed. If multiple fields are to be printed, it should be slightly wider to include a gap between fields, if desired.

5.6.7.2 Field height is the value in microns of Y. Its minimum must also be large enough to include all data and a gap if multiple fields are printed.

5.6.7.3 Alignment sites X and Y. Should be 0 for most users

5.6.7.4 Fields per row. Number of fields in the 1st row, followed by number in 2nd row etc. For a single field this would be 1.

5.6.7.5 Fields start at X is the value in microns in X where each field starts. Most often this would be 0 unless an X offset is required.

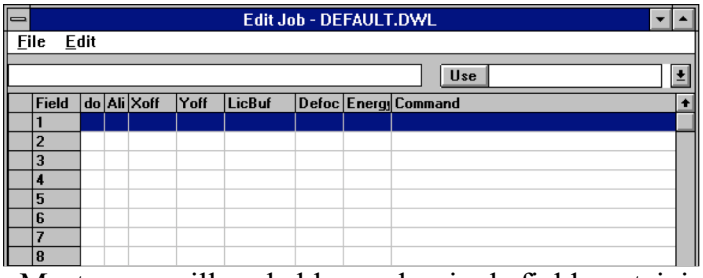
5.6.7.6 Field 0 is the field containing the origin. For most users this will be 1 unless multiple fields are used.

5.6.7.7 Click on the 'Draw" button and a corresponding map will be shown.

5.6.7.8 Close the window and a popup asks "Set environment?" Click Yes.

5.6.8 Making the Job. The next step is to tie together the data file, exposure and focus information and layout on the plate.

5.6.8.1 Click "Make Job" under the Job menu and the following spreadsheet appears (along with the field map):



5.6.8.2 Most users will probably need a single field containing their entire job so that only field 1 above needs to be filled in. However, it is useful to use multiple fields for testing purposes ie to find the correct energy, focus etc. In this case, each field may be exposed at different energy or focus to determine the optimum conditions and therefore multiple fields would be filled in for the spreadsheet.

5.6.8.3 Begin filling in the spreadsheet:

5.6.8.4 In the do column, -1 is used to indicate a field is to be exposed. If it is blank or 0, the field is NOT exposed.

5.6.8.5 For most users Ali, Xoff and Yoff can be left blank

5.6.8.6 Click once in the Design column of the field to be exposed and then select "Designs" under "File" menu. This will open the h1 data file directory.

5.6.8.7 Click "refresh" at the bottom of the menu and then scroll down to the name of the data file you wish to choose and click twice on it followed by "Exit". You should now see that the Design column is filled in with the name of your data file.

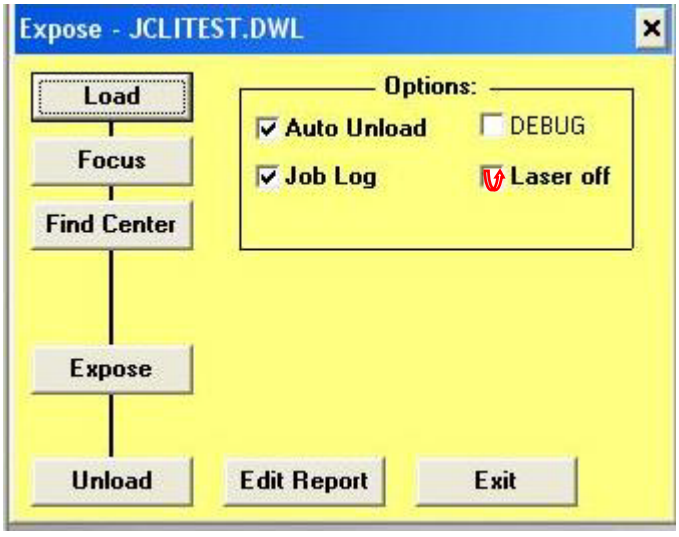
5.6.8.8 Fill in the Defoc and Energy columns using the chart posted at the machine. Note that the values MUST match the Write Head being used.

5.6.8.9 Leave the Command column blank.

5.6.8.10 Upon completing the spreadsheet, press "Save" under "File" and then press "Exit". When the popup asks "Overwrite file?", click Yes. *Note: If an error is encountered in making the job, for example if the map file doesn't agree with the environment, click cancel when the error is reported to force the loading of the appropriate files.*

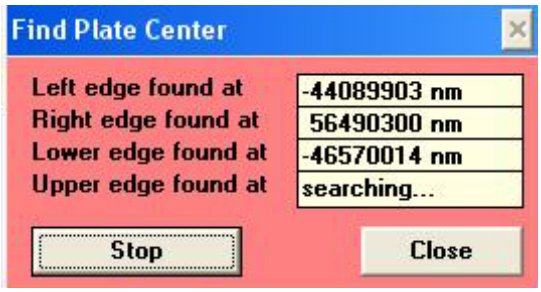
5.6.9 Running the Job. You may now begin running the job. First verify in the header, next to IF R, that the proper job file and map files are loaded.

5.6.9.1 Under Jobs, select run job. The following graphic appears:
Check "Laser off" if you only have one pattern to run.
Check "Auto unload" if you only have one pattern to run.



5.6.9.2 If you have already focused, click on the box named "Find Center" and then click "Start". The stage will look for the edges of the plate, giving each edge coordinate as it finds

them. After it finishes, it will move to the center of the plate. This
will take a few minutes. Warning: if this operation is taking



longer than 10mins, the program is hanging. If this is the case, stop the procedure and contact the responsible engineers.

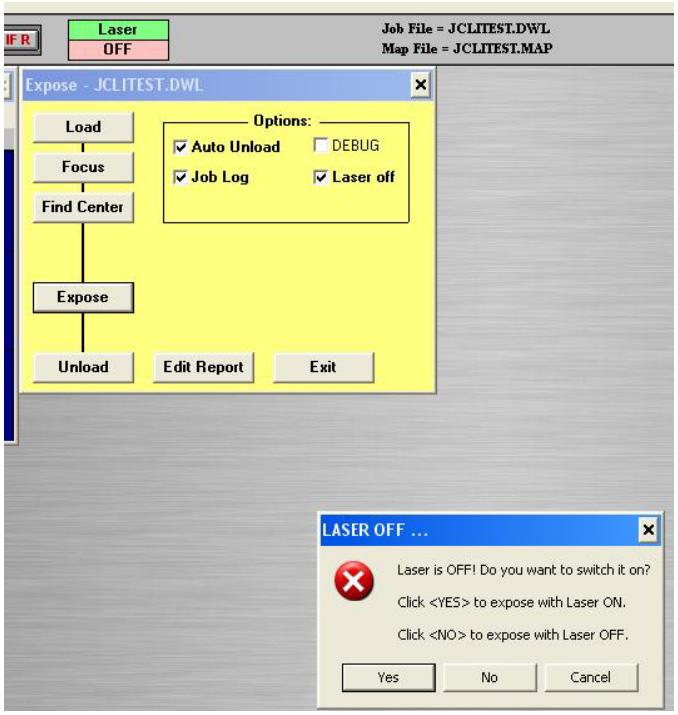
5.6.9.3 Another pop-up window asks “Do you want to set origin to plate center?” Click Yes.

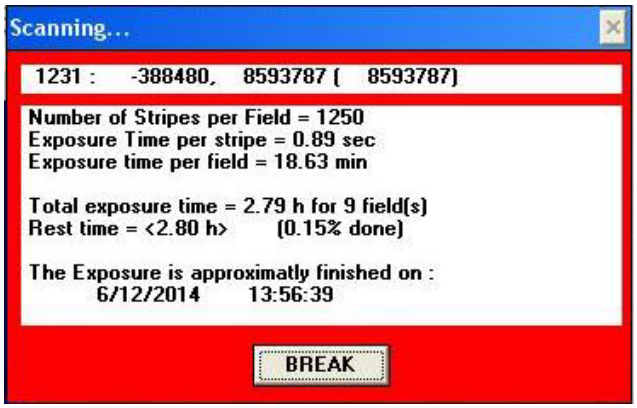
5.6.9.4 Go back to the Expose flow chart and make sure BS is unchecked.

5.6.9.5 Press Laser “OFF” to “ON”.

Press “Expose” to begin exposing the plate. If a window asks“Are you sure the stage is initialized?”, press Yes.

If Laser is off, Click “ Yes” to turn on the laser for exposure





5.6.9.7 For multiple fields, exposed fields are green, the field being exposed is yellow and fields to be exposed are blue. Fields aborted with a problem will be red. White fields are ignored.

5.6.9.8 Stay several minutes into the job to make sure your job is going as planned. If at any time the job needs to be stopped, press the "Break" button on the PC monitor. You do not need to be present for the whole job, especially if it is a long job.

5.6.9.10 Click on "Unload" in the Expose window. Stage will move to the unload position.

5.6.9.11 Open chamber window with toggle switch.

5.6.9.12 Verify that the lens head is up and gently pull the stage forward and to the right.

5.6.9.13 Turn off vacuum and remove plate.

5.6.9.14 Close chamber window and make sure log book is filled in completely. Note any problems.

6 DEVELOPING THE MASK PLATE

6.1 This procedure applies to mask plates coated with approximately 0.5 microns of AZ1518 on chrome (standard plates offered by NRF) and is a starting point for successful development. Some experimentation may be required to optimize results.

6.2 Development must be done at a yellow room fume hood and all safety procedures including using gloves, safety glasses and apron while pouring must be followed. The developer is an alkaline mixture which can cause severe burns and blindness.

6.3 Developer baths should be less than 2 days old. If not, mix a 1:1 mixture of DI water and AZ Developer in the specially designed rectangular beaker labeled Mask Developer. Fill it to the fill line on the beaker.

6.4 Use the single mask holder to submerge the mask completely in the solution and gently agitate the mask within the solution for about 60 seconds.

6.5 Carefully remove the mask from the developer and immediately plunge it in running DI water (the cascade rinse may be used for this purpose). Agitate the mask in DI water for at least 2 minutes.

6.6 Remove plate from the holder and blow dry both sides of the plate using

nitrogen gun and clean wiper.

7 INSPECTING THE MASK PLATE

7.1 Use the mask inspection microscope in the E152B which uses a 5 inch plate holder. Follow the procedure at the microscope to set it up.

7.2 Use the green filter to prevent further exposing the plate. Thoroughly inspect the plate using top light for complete development, pattern fidelity etc.

7.3 If necessary, redevelop the plate as in previous section; otherwise go to next section.

8 ETCHING THE MASK PLATE

8.1 This procedure applies to mask plates coated with approximately 0.5 microns of AZ1518 on chrome and is a starting point for successful etching. Some experimentation may be required to optimize results.

8.2 Etching must be done at a yellow room fume hood and all safety procedures including using gloves, face shield and apron while pouring must be followed. The etcher is an acid mixture which can cause severe burns and blindness.

8.3 Etch baths should be less than 5 days old. If not, pour chromium etchant (Cyantek's CR-7S or equivalent) into the specially designed rectangular beaker labeled Mask Etchant. Fill it to the fill line on the beaker. Note that the etchant is NOT diluted.

8.4 Use the single mask holder to submerge the mask completely in the etch and gently agitate the mask within the solution for about 60 seconds.

8.5 Carefully remove the mask from the etch and immediately plunge it into running DI water (the cascade rinse may be used for this purpose). Agitate the mask in DI water for at least 2 minutes.

8.6 Remove plate from the holder and blow dry both sides of the plate using nitrogen gun and clean wiper.

8.7 Re-inspect plate if desired per previous section.

9 STRIPPING RESIST FROM MASK PLATE

9.1 Re-insert plate into mask holder and proceed to the ALEG strip bath.

9.2 Bath should be heated to between 45-80 Deg C. Observe all safety cautions as before, lift lid and place mask and holder into ALEG stripper so that the plate is completely immersed. Gently agitate back and forth for 30-60 seconds.

9.3 Carefully remove plate and holder and immerse into running DI water (a cascade rinse may be used for this purpose).

9.4 Agitate in DI water for at least 2 minutes.

9.5 Blow dry using N2 gun and clean wipe as before.

9.6 Re-inspect plate again using top and bottom light to get the best image. A green filter is not necessary. Inspect the mask carefully for pattern and edge fidelity, printing and placement of critical features etc.

9.7 The tool doesn't have CD measurement capability.

9.8 If plate is acceptable, make comment in log book (in the same run entry) that plate is accepted; if not contact area engineer to resolve problem.

9.9 Place the accepted plate in an empty mask box and fill out the mask label.

*Reference: **Heidelberg DWL 66 user guide,** UCLA **APPENDIX**

A1 Data Preparation

Ledit and CIF file preparation-flattening the file
GDSII and DWX file preparation

It is highly recommended that the mask file is provided in either CIF or GDS II. CAD software such as L-Edit or CADENCE can readily convert to either format. If both formats are available in the CAD, CIF will be the best choice. AUTOCAD DXF's files are also acceptable, but some restrictions in terms of shapes and transformations have to be observed. The following are some tips in terms of pattern coding which have been detected so far in our DWL66.

L-Edit and CADENCE pattern coding tips:

- Pay attention to the centering of the layout and make sure that you specify any offsets on the plate at the time you submit your job. Under normal circumstances the "Autocentering" option is selected in the converter, which means that the center of the pattern itself will be set right at the center of the plate. Notice that the center of the pattern may not coincide with the pattern origin.
- Flatten the file before converting the cell into CIF. By flattening the file, all the cell hierarchy is removed and the cell ends up reduced to simple shapes. Both L-Edit and CADENCE have an option to flatten the cell and that should work for most of the cases. However, we have noticed that for very dense patterns or when special shapes are used, the CIF file increases dramatically in size upon flattening. In those cases, it is probably better to select the whole cell and ungroup it several times until there are no more grouped features and then group it back into one single cell. Even though the latter is a cell flattening operation, we have seen that it produces a smaller file, which is easier to handle by the converter.
- Be aware of special shapes (Circles and Wires). Even though the DWL66 can handle curved shapes and circles, the converter software may spend a lot of time producing the corresponding LIC files for the writer. Thus, in some cases, it is recommended to replace the circles with polygons with as many sides as necessary; given the resolution limit of the writer, these polygons will end up as circles. Other special shapes, for which some issues have been detected, are wires. The DWL66 rounds off the corners of the wires instead of writing them as a rectangle with sharp corners and ends. This does not break apart the continuity of the printed line, but if the sharp corners of the wires are desired, then it is better to replace the wires with rectangles.

Autocad pattern coding tips:

- Close all polygon shapes. Use rectangles to join different shapes, if necessary, instead of lines.

A2 Layout considerations

Mirroring: In most of the cases, what it is desired on the mask is a mirror inversion of the pattern. This is because the mask turns over on the wafer, which is equivalent to a mirror transformation.

Extra Pixel: For the 10mm write head, an extra pixel is added to the pattern by the converter. As the conditions on the optics and other hardware of the DWL66 change, more or less pixels may be needed. The staff in charge will be responsible for determining whether extra pixels are necessary or not. At the moment, no extra pixels are needed for the 4mm and 2mm write heads.

Inverting data ie clear field vs dark field: When the pattern is non-inverted, the digitized areas are exposed by the laser writer and subsequently removed during the developing process. At the end, these areas are cleared out by the chrome etcher. This is what is usually called “Dark Field”. On the other hand, if the pattern is inverted, all the area will be exposed with the exception of the digitized areas which will remain upon developing and etching. This is usually called “Clear Field”. Notice that for Clear Field it is recommended to set a frame around the pattern. This frame should be some distance away from any feature in the mask.

Spot Size Correction: This corresponds to a correction on the pattern scale which will compensate for the actual spot size of the laser. This is usually done during the tool setup and on a regular basis by the responsible engineers.

Scale factor: As the name suggests, this is a way to change the overall size of the features to be written.

Write time considerations: The total write time is a function of the maximum extent of the pattern, i.e. the distance measured from the lowest coordinate point to the highest coordinate point for each dimension for a single field. The graph below gives an approximate write time estimate for 3 different write heads and chips of varying size.