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Heidelberg DWL 66FS Mask Writer

Standard Operating Procedure

4D Labs Confidential

Revision: 1.0 — Last Updated: Sept. 16/2009, Revised by Nathanael Sieb

Overview

This document will provide a detailed operation procedure of the Heidelberg DWL 66FS mask writer. Formal Training is required for all users prior to using the system.

Revision History

#	Revised by:	Date	Modification
1	Nathanael Sieb	September 16, 2009	Initial Release
2			
3			
4			
5			

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General Information

The Heidelberg DWL 66FS Mask Writer is a laser pattern generator with a 405 nm, 110 mW diode source laser.

1. Safety Considerations

1.1 Electrical

- The DWL 66FS Mask Writer contains high voltage electronics running at 240V, 16A.
- Except when loading media, never push objects of any kind through openings in the equipment. Dangerous voltage levels may be present. Conductive foreign objects could produce a short circuit resulting in a fire, electric shock, or permanent damage to the equipment.

1.2 Laser Radiation

- The DWL 66FS Mask Writer employs a Diode laser (~405nm) with a laser output power of 110 mW. Laser light exhibits many characteristics that are different from those found in conventional light sources. Safe use depends on awareness of these characteristics and proper treatment of the laser instrument. If a beam passes directly into the eye, serious damage may occur, including vision loss. In addition, a beam remains coherent even when reflected, and it may cause eye damage even when contacted indirectly from reflective surfaces.

1.3 Safety Interlocks

- The DWL 66FS protects operators from exposure to moving parts and laser energy while operating the equipment. All moving parts, lasers and their associated optics are enclosed within the laminar flowbox. During operation, opening the flowbox window will automatically stop an exposure. Users should never attempt to access the internal optics, electronics, or try to bypass the safety interlocks.

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1.4 Servicing

The following does not apply to users.

- When conditions require the removal of the sidewalls from the flowbox (*such as for servicing or troubleshooting by trained service personnel*), the accessible energy of the laser is of the class III b category. In such a case, personnel should observe all normal electrical and mechanical safety precautions as well as those applicable to lasers of this class.
- Both the laser head and power supplies contain electrical circuits operating at high voltages. If access to the laser interior or any power supply is necessary, exercise extreme caution to avoid contact with *lethal* high voltages.

2. Write Lenses and Parameters

Four lenses are available for the system, each with a different resolution and write speed as outlined in table 1. The measured data is included in the acceptance report for our system and meets or exceeds the nominal values listed below.

Table 1: Nominal parameters for the 4 lenses our system is equipped with.

Write lens	**2 mm**	**4 mm**	**10 mm**	**20 mm**
Focus Depth [μm]	1.0	1.7	8	~150
Macro Pixel Size [nm]	200	400	500	1000
CD Uniformity [3σ,nm]	80	100	220	440
Line width linearity [3σ,nm]	100	200	350	750
Minimum structure size [μm]	0.6	1.0	2.5	5.0
Write speed [mm^2/min]	3	10	36	119
Edge roughness [nm]	60	80	120	180
Alignment accuracy [3σ,nm]	200	250	500	1000
Orthogonality	2μrad			

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The parameters are defined as follows:

CD uniformity

The CD uniformity describes the linewidth stability of the printed structures at various positions over the mask. A number of linewidths are measured over the area of a mask and the CD uniformity is the 3σ standard deviation over all measurements.

Linewidth linearity

The linewidth linearity is the difference between the nominal width of various-sized lines and the printed linewidth. The result is a bias between the measured and nominal linewidth. The 3σ variation of this bias is calculated over all measurements and compared with the nominal value.

Minimum structure size

The minimum structure size is the width of the smallest possible exposed line.

Edge roughness

The edge roughness is the 3σ standard deviation between the actual edge position and a straight line fitted through a large number of positions over a specified length.

Write speed

The write speed is tested with a 100 mm long-test pattern. The write head is moved up during the test and no mask is necessary. The total time for the exposure is measured and the resulting write speed is measured.

Alignment accuracy

The alignment accuracy is tested by measuring the position of a central cross 50 times. This measurement uses the defined field alignment procedure, so the resulting position data can be used to calculate the alignment accuracy.

Orthogonality

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The raw coordinate system is not perfectly orthogonal due to the limited mechanical alignment of stage and mirrors. This is corrected via software rotation. From a detailed measurement of the alignment cross position on the acceptance mask, the deviation from 90° is calculated and included in the machine's system parameters. The measurement is then repeated and the remaining orthogonality deviation compared to typical values.

3. Materials and Processing

Soda-lime and quartz photomasks were purchased from Nanofilm. These masks are coated with ~100 nm chrome and ~500 nm AZ1518 photoresist. The quartz masks are more expensive but are required for deep-UV applications. The masks are processed as follows:

1. Expose mask.
2. Develop exposed photoresist for 60 sec in PPD-455 followed by a water rinse.
3. Inspect.
4. Etch exposed chrome for 45 sec in CEP-200 followed by a water rinse.
5. Strip the remaining photoresist for 90 sec in PRS-100 or acetone, followed by a water rinse.
6. Ash the resist in the plasma etcher for 7 minutes in a 300W oxygen plasma (270-280 mTorr).

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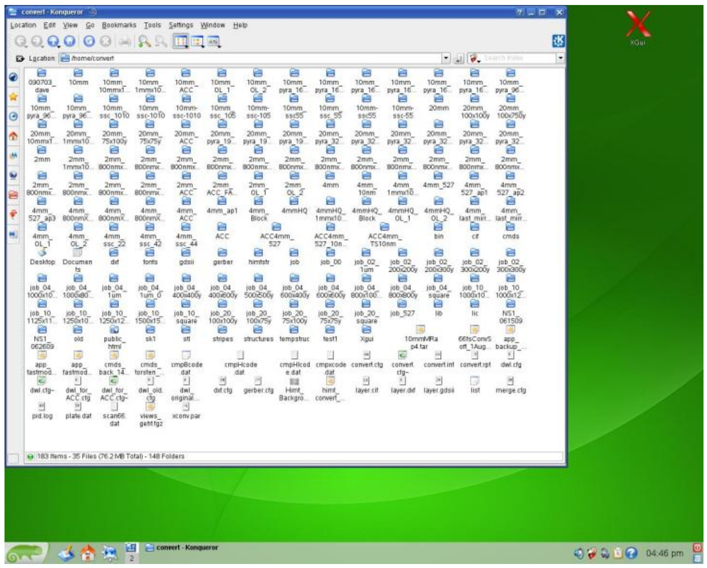
Operation Procedure

1. File Conversion

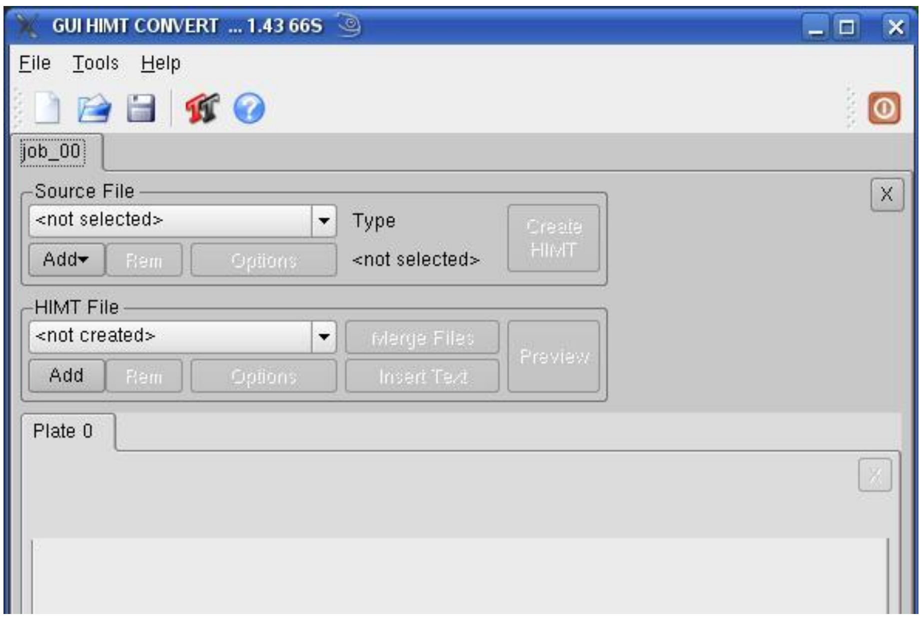
- Insert USB stick containing pattern into conversion PC.
- Transfer files to the appropriate folder in the Home directory (cif, gdsii, etc.).



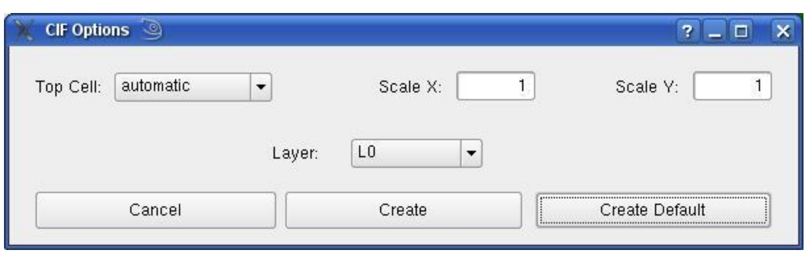
- Ensure the filenames have no hyphens or spaces in them.
- Start the conversion software, called XGui. 

- Select New Job.
- Create a name for the job without hyphens or spaces.

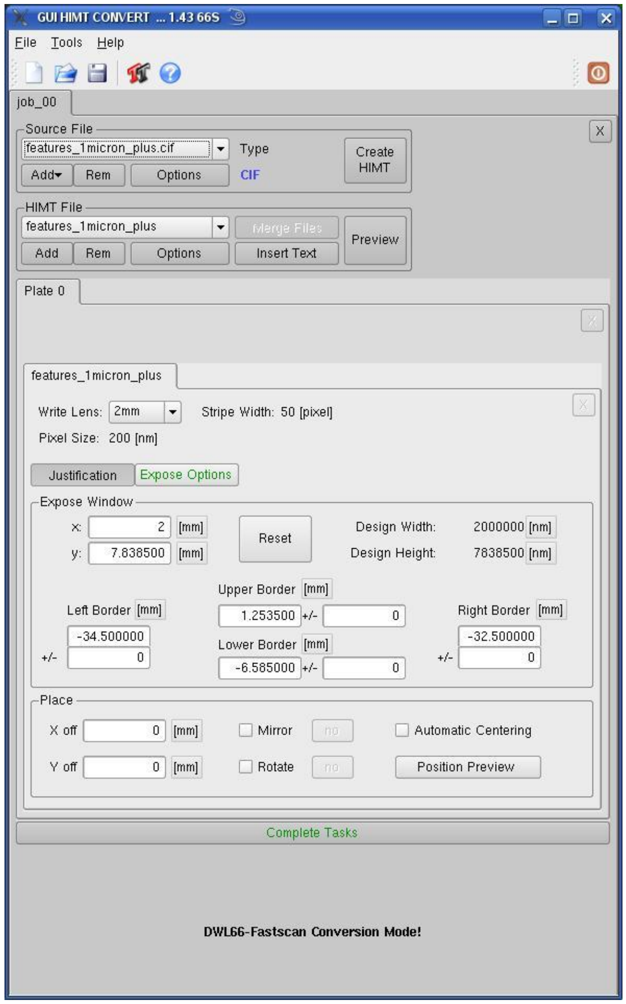
- Select the appropriate file type to add. The folder containing those file types will automatically open. Select the file that was previously copied to the computer.



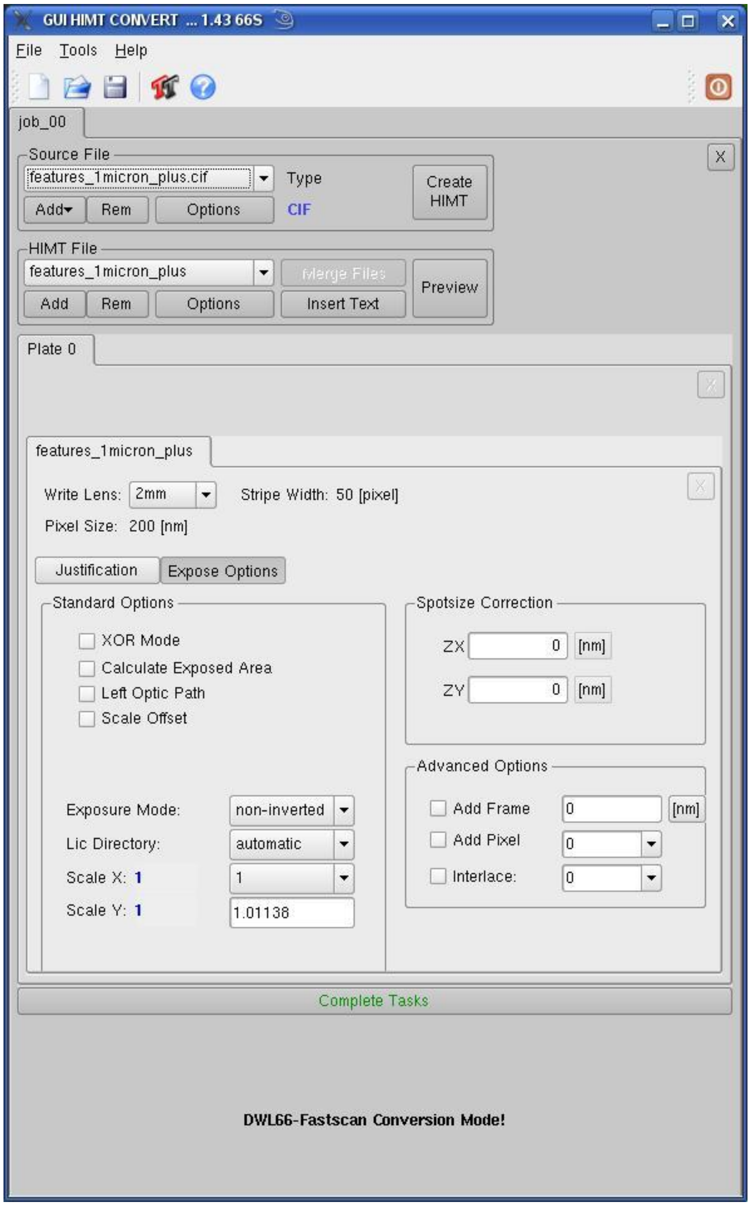
- For *.cif files, select the layer that contains the design of interest. Other files types have similar options.



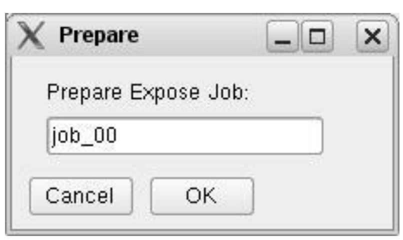
- Select create default.
- Set the appropriate justification parameters. First, choose the correct lens that the pattern will be written with. Next, the boundaries of the pattern may be changed if the whole pattern does not need to be written. Finally, automatic centering will place the center of the pattern at 0,0.



- Set the appropriate exposure parameters. The main parameter to set is the spotsize correction required for the write lens that will be used.



- Select complete tasks. Select ok to use the same expose job name (recommended).



- The pattern will now be converted into *.lic files. When the conversion is complete, click Finish.

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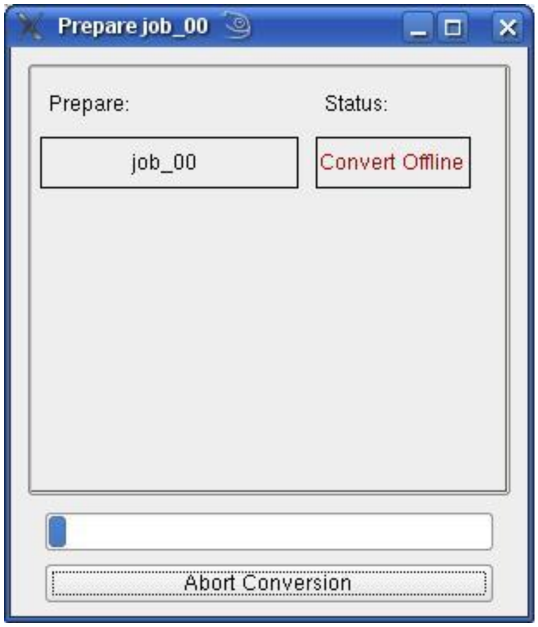

- Click save and then click transfer to send the pattern *.lic files to the mask writer operation pc.

- After the transfer button has popped back up, close the window, clear tasks, and exit the program.

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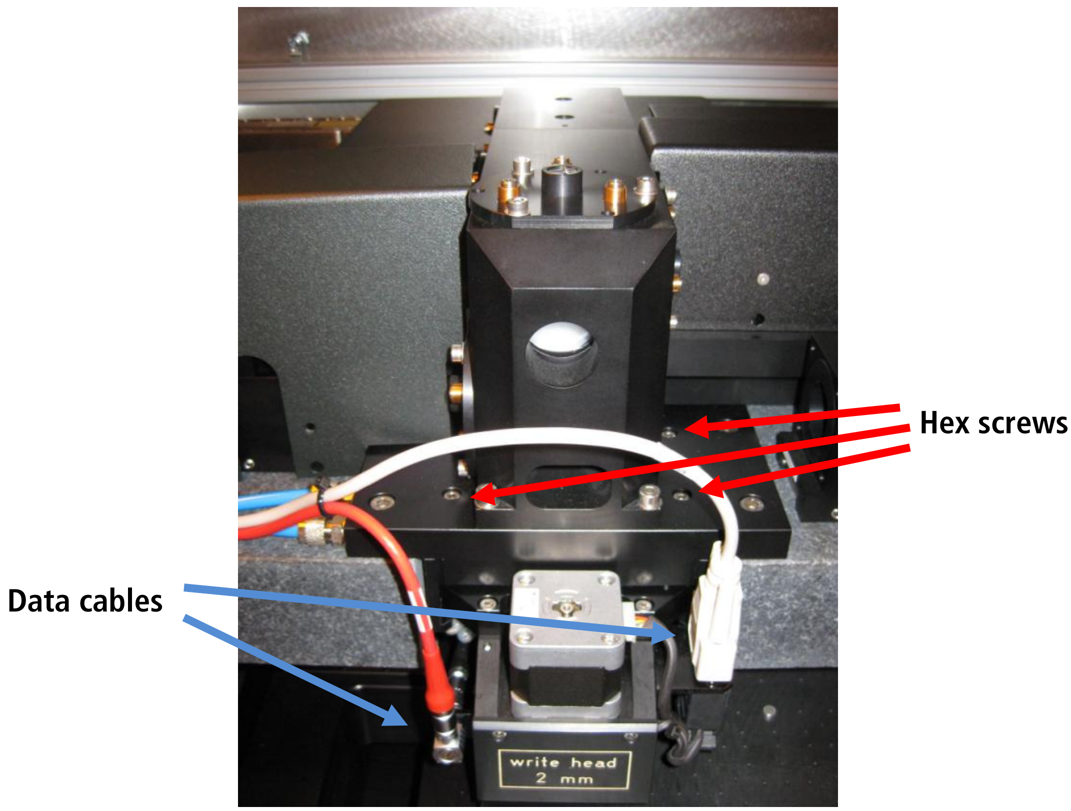
2. Writehead Installation

- Select appropriate writehead for the pattern being written.

	2mm	4mm	10mm	20mm
Minimum Feature Size	800 nm	1.0 µm	1.2 µm	2.0 µm
CD Uniformity	80 nm	100 nm	220 nm	440 nm
Feature Size Limit	1 µm	2 µm	5 µm	10 µm

- Unplug the two data cables from the current writehead.
- While supporting the writehead, remove the three hex screws.



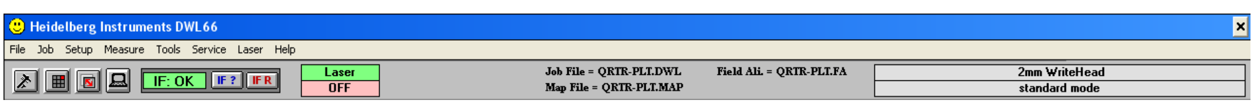
- Slide the current writehead out and place upside down on the granite table.
- Slide the new writehead into place. DO NOT TOUCH THE GOLD DISC ON THE BOTTOM OF THE WRITEHEAD.
- While supporting the new writehead, install the three hex screws.

- Attach the two data cables to the new writehead.
- Install the correct filters. Try to line them up with the end of the rail.

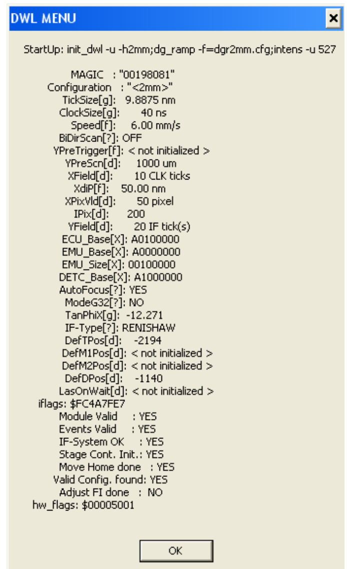
	2mm	**4mm**	**10mm**	**20mm**
Filters	30% + 1%	30% + 10%	30% + 50%	30%

3. Software Initialization

- Start DWLmenu from the desktop.

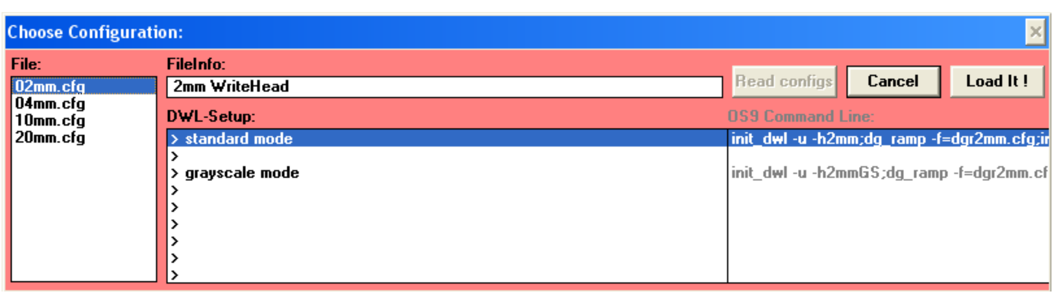


- When the system is started for the first time, communication must be established between the user PC and the instrument PC. To initialize communication, open up the terminal and press enter. The text prompt will ask for a username ("dwl") and password ("dwl"). After closing the terminal window a list of the machine parameters will display, confirming that the software is communicating correctly with the instrument.



- From left to right, the main menu displays the status of the interferometer, the laser, the current software configuration, and the current writehead configuration.
- In order to load a new writehead configuration, double-click the writehead status 

. Select the correct writehead and click **Load It!**.



- Open the DWL Control Panel .

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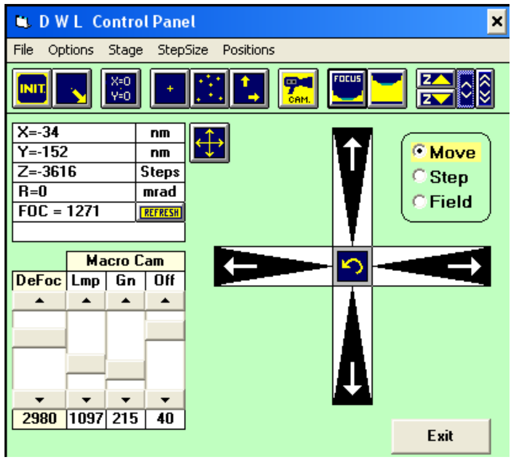
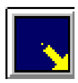
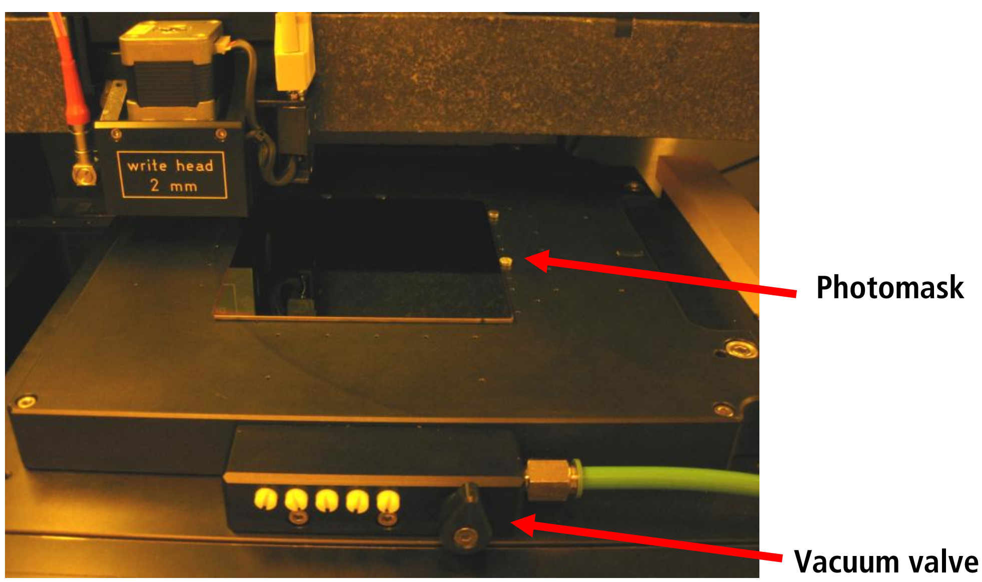
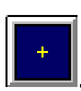
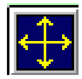


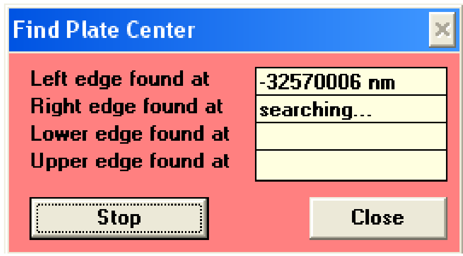
4. Loading a Photomask

- Ensure that the vacuum pump is turned on.
- Click the load button  to move the stage to the load position.
- Open the environmental chamber. Place the photomask in the center of the stage (align against pins if possible) and open the vacuum valve. Ensure that the photomask will not move. Close the chamber.



- Move the stage back to 0,0 .

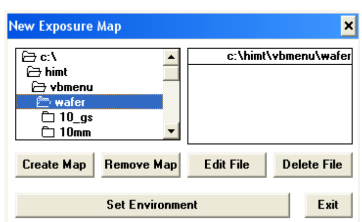
- Lower the lens into the focus position . Do NOT let the lens go lower than -4000 for our masks.
- To find the center of the photomask, press Find Center  and then select **Start**. The stage will scan over the area of the photomask and find the edges.



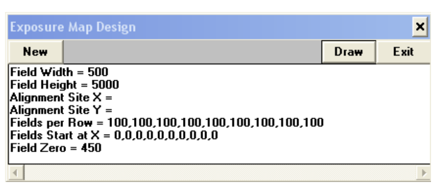
- When prompted, select **Yes** to set 0,0 to the plate center.
- Turn the laser on by clicking the laser status . Allow 5 minutes for the laser to warm up from standby or 20 minutes for the laser to warm up from power off.

5. Setting Up an Exposure

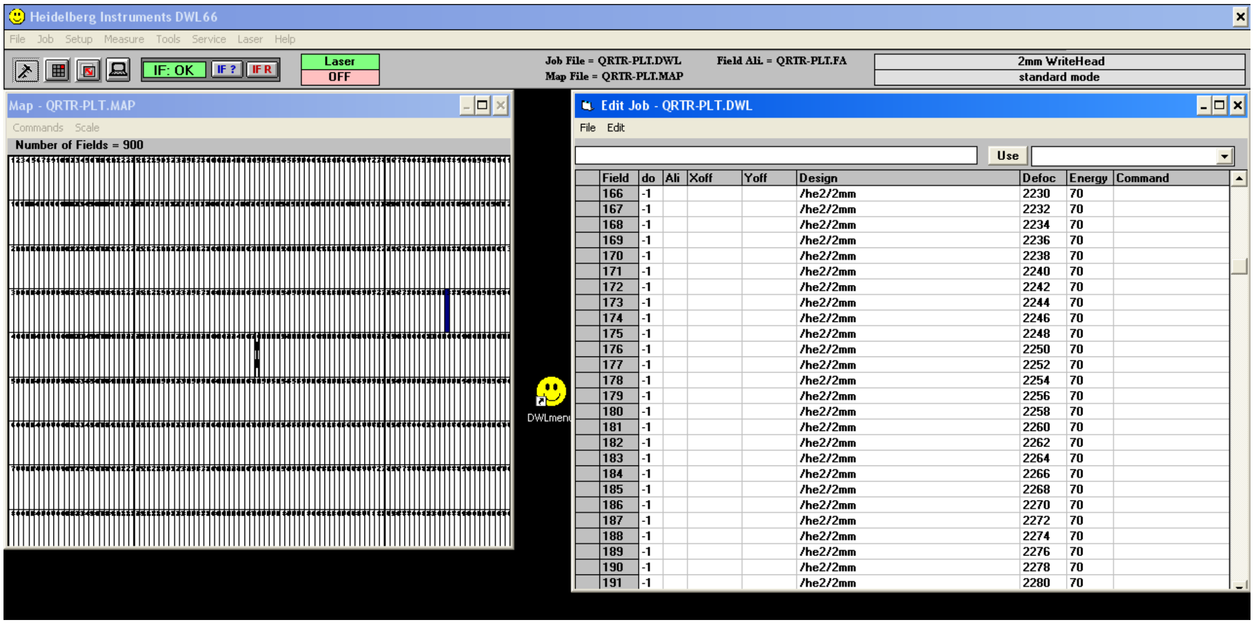
- Go to Setup → New to select a new exposure environment. You may create a new map or load an old map (Set Environment).



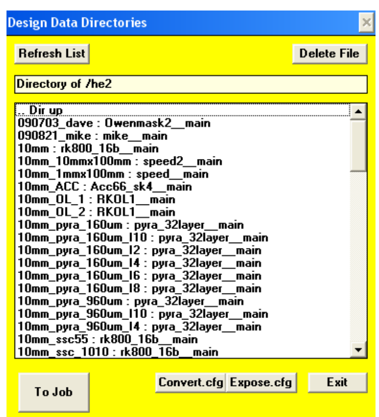
- Go to Setup → Exposure Map to edit an exposure map. All units are in microns. The alignment sites are only used if there are alignment marks on the mask. Field Zero is the center field of the mask.



- Select Job→Make job.



- Select the writefield to be setup.
- Go to File→Designs.
- Select design (refresh if necessary) and send to job.



- Set the appropriate defoc and energy values for the writehead being used.

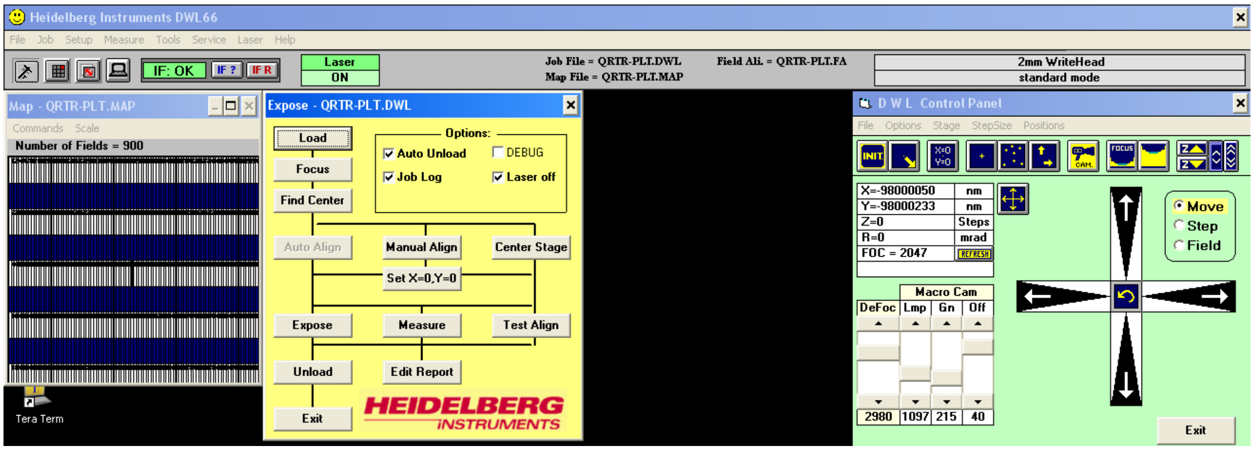
	2mm	**4mm**	**10mm**	**20mm**
Defoc	2180	2150	2200	2047
Energy	100	100	60	60

- Set do = -1.

- When setting up arrays, fill functions can be used that are located under the Edit menu.
- Close the job and save it.

6. Exposing

- Open Job→Run job.



- The **Load**, **Focus**, and **Find Center** steps have already been completed.
- Select the **Auto Unload** option to unload the sample after the exposure.
- Select the **Job Log** option to record a log of the write field exposures.
- Select the **Laser off** option to turn the laser off after the exposure.
- Press **Expose** to begin the exposure.
- A window will open that will provide an estimated write time. Also the exposure map will show which fields have been written (green), which one is in progress (yellow), which ones are remaining (blue), and which ones had errors (red).

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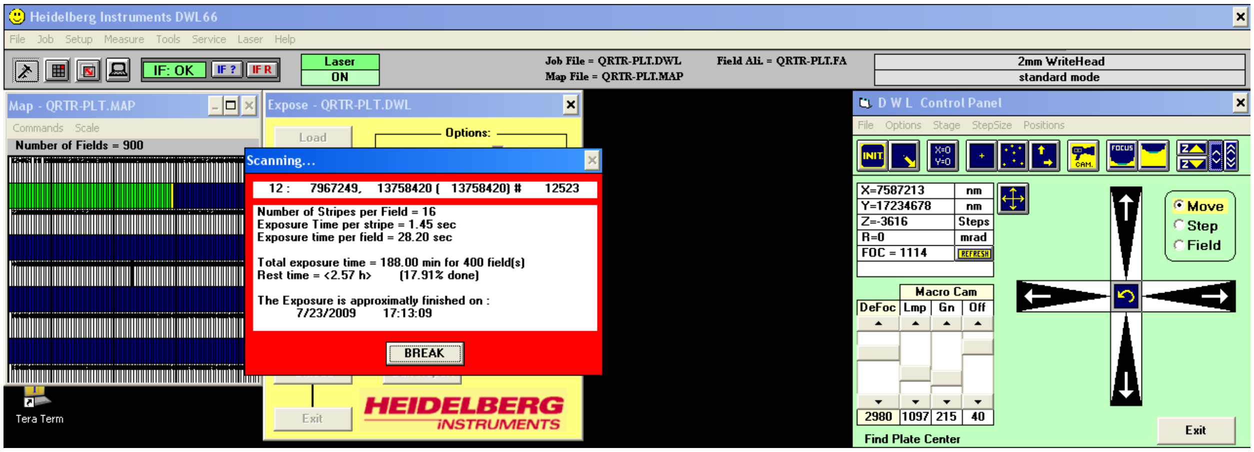

7. Unloading Photomask

- After exposure, press **Unload** to move the mask to the unload position.
- Close the vacuum valve and remove the photomask.
- The pump and monitors can be turned off if no more exposures are planned.

Reference and Files

Heidelberg DWL 66FS Manual and training notes.

Contact

Questions or comments in regard to this document should be directed towards Nathanael Sieb (sieb@4dlabs.ca) in 4D LABS at Simon Fraser University, Burnaby, BC, Canada.