

Heidelberg DWL 66fs Laser Writer

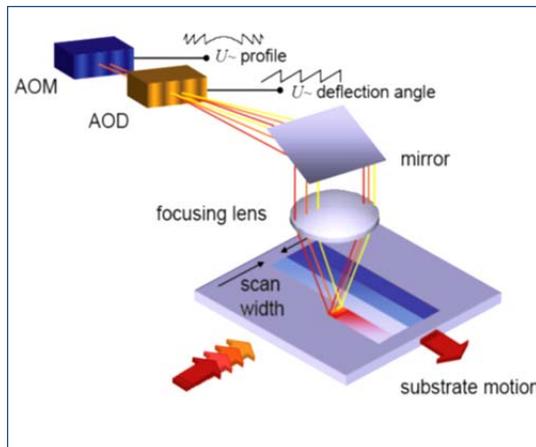
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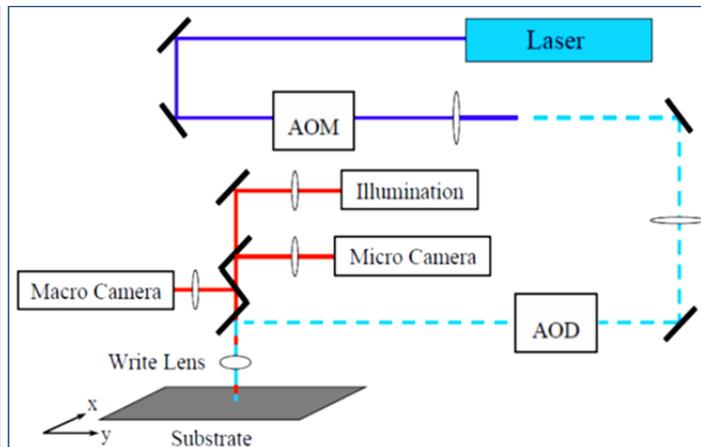
Introduction

The Heidelberg DWL 66fs is a high resolution pattern generator for mask making and direct writing. Its capabilities and flexibility make it an ideal lithographic tool for research. The system has three computers, one for converting user patterns to LIC files (**Linux PC**); one for setting up the writing job (**Windows PC**); and one for executing the job (**OS9**, on board of the tool). It uses acousto-optic modulators to adjust the laser intensity, and acousto-optic deflectors to scan the beam. During an exposure, only the stage moves. The substrate is held down on the stage by vacuum and moves in the x-y plane. Its position is constantly monitored by an interferometer system with a resolution of 10 nm.

The optical setup utilizes a single-mode diode laser ($\lambda = 405 \text{ nm}$) as its light source. It can expose both 2D and 3D structures (e.g. gray scale lithography with thick photoresists). There are two write heads available: 4 mm & 20 mm. Both heads use an air-gauge to monitor N_2 pressure change, which is then feedback to the lens piezo actuators for auto focus. During a scan, user patterns are divided into stripes along Y-axis, each stripe contains 100 pixels. The stage moves along Y-axis to finish exposing one stripe, then steps in X-axis to start exposing the next stripe. The user patterns are then stitched together. In term of resolution, the 4 mm write head can achieve a minimum feature size of $\sim 800 \text{ nm}$, the 20 mm head can achieve a minimum feature size of $\sim 4 \mu\text{m}$. The 20 mm head writes about 12 times faster than the 4 mm head.



DWL 66fs Writing Strategy



DWL 66fs Optical Setup

The DWL 66fs uses two CCD cameras for top side metrology and alignment, with two additional cameras for back side alignment. Standard crosses, squares or even arbitrary structures can all be used as alignment marks. The alignment accuracy is $\sim 250 \text{ nm}$ with 4 mm write head, and $\sim 1 \mu\text{m}$ when using the 20 mm head.

Preparation: (1). Pattern Files: GDSII, CIF, DXF, GERBER, HPGL or HIMT
 (2). Samples: Fresh photomasks (MNFL supplies standard Cr masks with soda lime glass plates, both 4 inch and 5 inch in size, manufactured by *Nanofilm*) or substrate coated with photoresists (substrate OD must be ≥ 10 mm).

Warning: (1). Never touch the interferometer's mirrors with your bare hands
 (2). Never open the coverlid during the exposure (you cannot resume it!)
 (3). Write head center to the edge of your substrate must be ≥ 5 mm

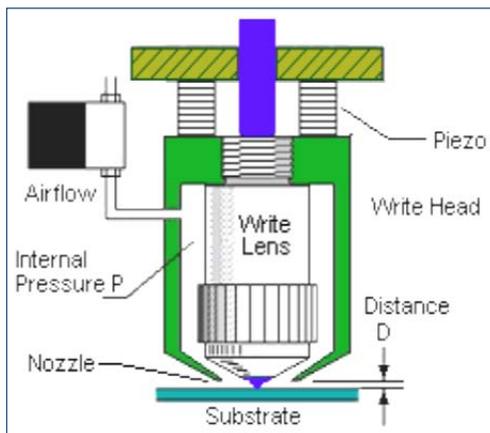
Before you start, remember to **LOG IN** online @ <https://prz-mnfl-1.princeton.edu/>

To purchase any masks/holders from MNFL, remember to fill in on the LOG Book.

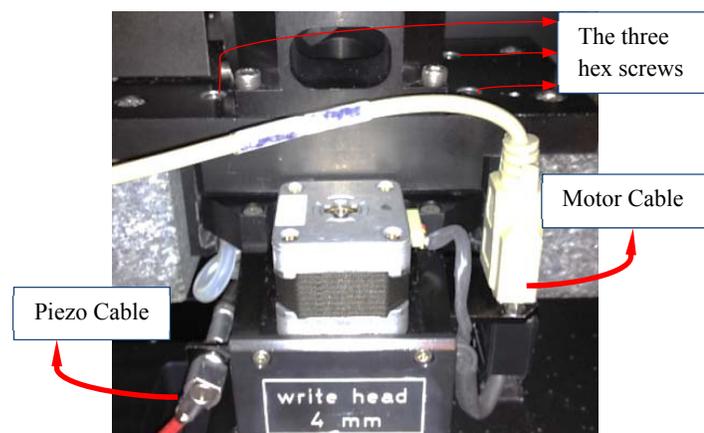
Step 1. Install the appropriate write head

Write Head	Critical Dimension	Focus Depth	Write Speed	Pixel Size	With Filter?
4 mm	$\sim 0.8 \mu\text{m}$	$\sim 1.8 \mu\text{m}$	$10 \text{ mm}^2/\text{min}$	200 nm	10%
20 mm	$\sim 4 \mu\text{m}$	$\sim 50 \mu\text{m}$	$119 \text{ mm}^2/\text{min}$	1000 nm	None

- To remove the write head, first unplug the Piezo cable (left) and Motor cable (right), firmly hold the write head with one hand, then use #3 metric Allen wrench to loosen the three hex screws. Slide the current write head out, be careful not to hit the nozzle, and place it upside down on the granite table.
- To mount a new write head, slide it into place, push it up with one hand, then tighten the screws X-wise (do NOT over tighten the screws). Finally, plug back the Piezo and Motor cables. Remember to install the 10% filter on the rail for the 4mm write head, and remove any filter when using the 20 mm head.



Schematic Image of Write Head



Write Head Installation Guide

Step 2. Load the substrate onto the stage

- If the laser writer is powered OFF for some reason, press the big green button on the front panel to turn the system back ON, wait about 30 minutes before it stabilizes.
- Switch to **Windows PC** by pressing the “**Scroll Lock**” button twice. Double-click  on the desktop to open a mini-terminal. This is to restore the connection between the **Windows PC** and **OS9**.
- Click “**OK**” on the “**Tera Term: New connection**” popup window. In the mini-terminal, type “**dwl**” in both the user name and password, then close it.



User name?: dwl

Password: dwl

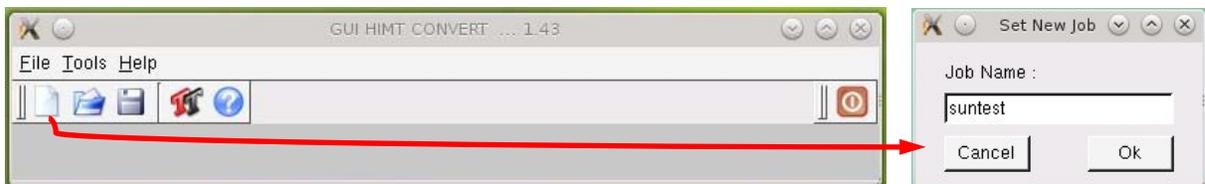
- If the **DWL66** software is closed by the previous user, double-click the icon  on the desktop to open it. In the **DWL66** menu, select “**Laser/On**” to switch on the diode laser. It takes about 3 minutes before the laser beam stabilizes.



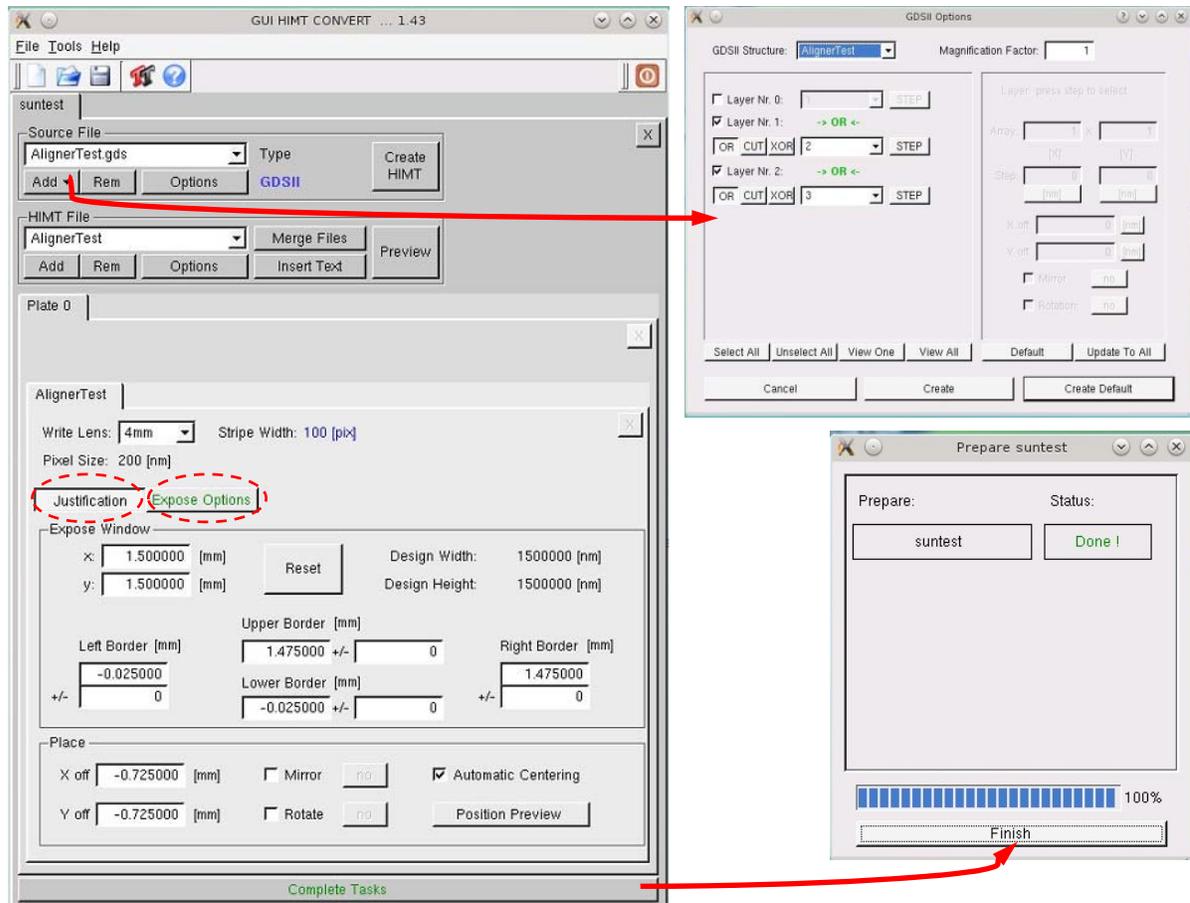
- Verify that the correct write head configuration is loaded. If not, double-click on the configuration field, select the correct write head, select “**uni-directional**” writing, and press “**Load it!**”. A terminal window with a list of tool parameters will pop up, click “**OK**”.
- Manually move the stage into loading position. Clean the substrate with N2 gun, carefully place it at the center of the stage chuck, with resist side facing up (**substrate OD \geq 10 mm**).
- Turn on the vacuum switch, and adjust the white screws on the chuck side to open/close rows of Vacuum holes (open ; close .
- Close the coverlid. To keep the internal environment stable, the coverlid should be kept closed for at least 15 minutes before starting your exposure job.
- The status of the interferometer can be seen here , check the status by clicking “**IF ?**”, when “**IF: OK**” appears, then the interferometer is working correctly. When “**IF: FAIL**” appears, click “**IF R**” to reset it (you may have to click “**IF R**” twice).

Step 3. Convert user patterns to *.LIC files using **Linux PC**

- Switch to **Linux PC** by pressing twice the “**Scroll Lock**” button on the keyboard. Transfer your GDSII file using a USB memory stick. All GDSII files should be stored at “**/home/convert/gdsii/**”. Other files, such as CIF, please store at “**/home/convert/cif/**”; DXF files, store at “**home/convert/dxf/**”, etc.
- Click  to open **GUI HIMIT Convert**, select “**File/New**” to create a new job. The job name should have no hyphens or spaces. For an existing job, select “**File/Load**” to reload it.



- Click “Add”, select “GDSII” (or other file format) to pick your file, the “GDSII Options” window will pop up. Select the correct cell and layer number, then click “Create Default”.
- To modify your selection, click “Options” in “Source File”.
- Click “Preview” to inspect your pattern with HIMIT Viewer. Make sure the pattern is correct.



- Select the correct “Write Lens” - must be the same as what you plan to use in DWL66 menu
- In the “Justification” tab, select “Automatic Centering” to center your pattern design.
- In the “Exposure Options” tab, type in the “Spotsize Correction” parameters (for the 4mm write head, $x = -100 \text{ nm}$, $y = -100 \text{ nm}$; for the 20mm write head, $x = 0 \text{ nm}$, $y = 0 \text{ nm}$)
- Click “Complete Tasks”, the conversion will start. After the conversion, click “Finish”. When “FTP Transfer” pops up, click “Save”, then “Transfer”. The “Transfer” button will remain depressed until all data transfer is complete (Do NOT disrupt the program while the data is being transferred). All *.lic files will be transferred to the OS-9 computer.



Still transferring...

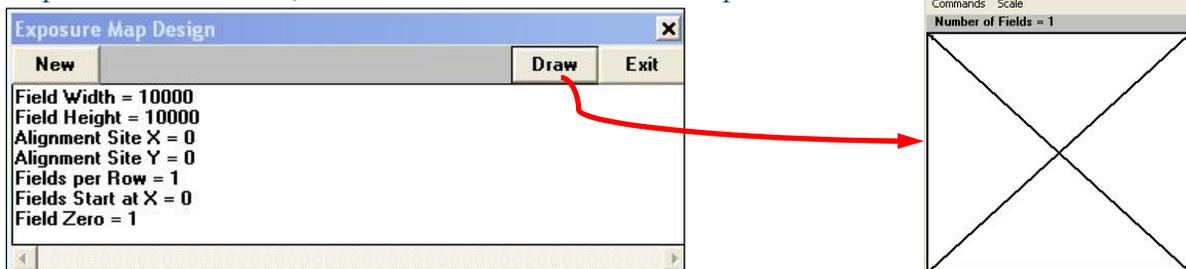
Transfer completed!

Step 4. Set up an exposure job using Windows PC

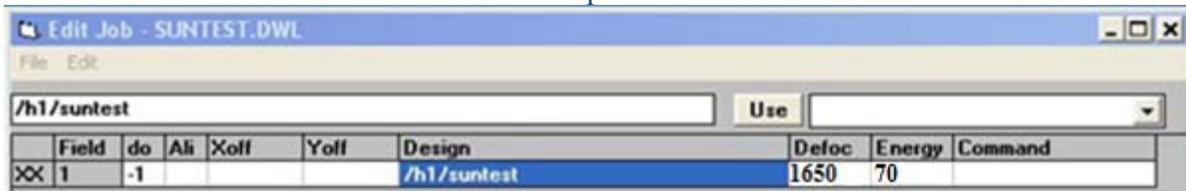
- On the keyboard, press “**Scroll Lock**” button twice to switch back to **Windows PC**. In **DWL66** menu, select “**Setup/New**”. In the popup window, click “**Create Map**”. A new folder will be created under “**C:\vbmenu\wafer**”. Double-click on the folder, your *.MAP file will appear on the right. Double-click the *.MAP file, then “**Set Environment to xxx**” (your map name), and click “**Exit**”. If you switch to a different write head, you should create a new map, please do NOT simply edit the old map file, or the **DWL66** menu may crash.



- In **DWL66** menu, select “**Setup/Exposure Map**”. In the popup window, set **Field Width** and **Field Height** to be \geq size limits of your pattern (unit: μm). For an exposure job without alignment, set **Alignment Site X** = 0, **Alignment Site Y** = 0. For a single field, set **Fields per Row** = 1, **Fields Start at X** = 0, **Field Zero** = 1. Click “**Draw**” to display the exposure map. And click “**Exit**”, select “**Yes**” to overwrite the map file.



- Back to **DWL66** menu, select “**Job/Make Job**”. In the “**Edit Job**” window, highlight the **Field** (e.g. **Field 1**), type -1 in “**do**” (-1 means to expose the field, 0 means NO). Type 0 in “**Ali**” (NO alignment), 0 in “**Xoff**” and “**Yoff**” (NO X or Y offset). For “**Defoc**” (depth of focus) and “**Energy**” (percentage of the laser power), please refer to the parameters given by the .tif file stored on the **Windows PC** desktop. You can leave “**Command**” blank.

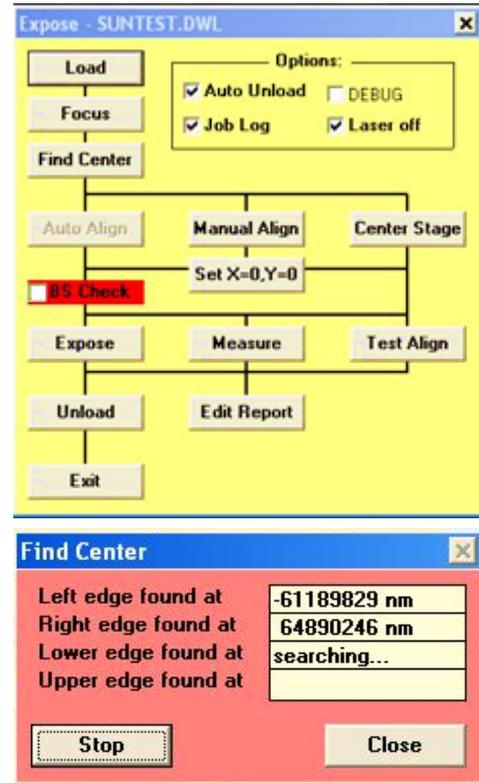


- Highlight “**Design**”, go back to the **DWL66** menu, select “**File/Designs**”. In the popup window, select the pattern converted in **Step 3** (if it is not shown in the list, try clicking “**Refresh**”), click “**TO Job**” to fill “**Design**” in “**Edit Job**”.
- Close “**Edit Job**” window, select “**YES**” to overwrite the job file. At this point, your job file *.DWL and the map file *.MAP should both appear on the **DWL66** menu bar.



Step 5. Expose your pattern

- In **DWL66** menu, go to “**Job/Run Job**” to open the “**Expose**” window (see below).
- In “**Options**”, check “**Auto Unload**”, “**Job Log**” and “**Laser off**” (Laser should be OFF after the exposure to extend its life span). Uncheck “**BS Check**” (this is for backside alignment).
- Select “**Load**” to load your substrate. Look through the coverlid, make sure the write head is right above the substrate before clicking “**Focus**”. The write head defines focus by monitoring N2 pressure, if it lands on an edge during “**Focus**”, the sensor won’t “feel” its presence, so the write head will keep on going until it crushes into your substrate. This will damage both the write head and your sample!
- Click “**Find Center**”, the write head will move across your sample to find the 4 edges. When completed, it will ask “**Do you want to set origin to plate center?**”, select “**Yes**”.
- Click “**Expose**” to start the exposure job. A popup window will give an estimate of the exposure time.



Step 6. Unload your sample

- After the exposure, your sample should automatically move to the unloading position. Verify the laser is OFF. Open the coverlid, turn off the vacuum, and carefully remove your sample.
- Close the coverlid, close the **DWL66** menu. Remember to **LOG OUT** online.

Processing Note

- To develop the photomasks, we recommend Laurell Spin Processor. A standard photomask is developed 60s in AZ400K:H₂O = 1:4 (Recipe: AZ400KMask).
- To etch the Cr masks, we recommend Polos Spin Processor. A standard photomask is etched 90s in Cr-7 etchant (Program #1).
- For standard Si wafers coated with the following resists, see the processing condition below:

Resists	AZ1505	AZ1505 / LOR3A	AZ1505/LOR5A
Write Head	Spin @ 4000rpm, 60s Bake AZ1505 @ 95C, 60s	Spin @ 4000rpm, 60s Bake LOR3A @ 175C, 5min Bake AZ1505 @ 95C, 1min	Spin @ 4000rpm, 60s Bake LOR5A @ 175C, 5min Bake AZ1505 @ 95C, 1min
4 mm (with 10% filter)	Defoc 1650; Energy: 70%	Defoc 1650; Energy 70%	Defoc 1650; Energy 70%
20 mm	Defoc 2000; Energy: 80%	Defoc 2000; Energy 80%	Defoc 2000; Energy 80%

Note: All test wafers are developed 60s in AZ300MIF