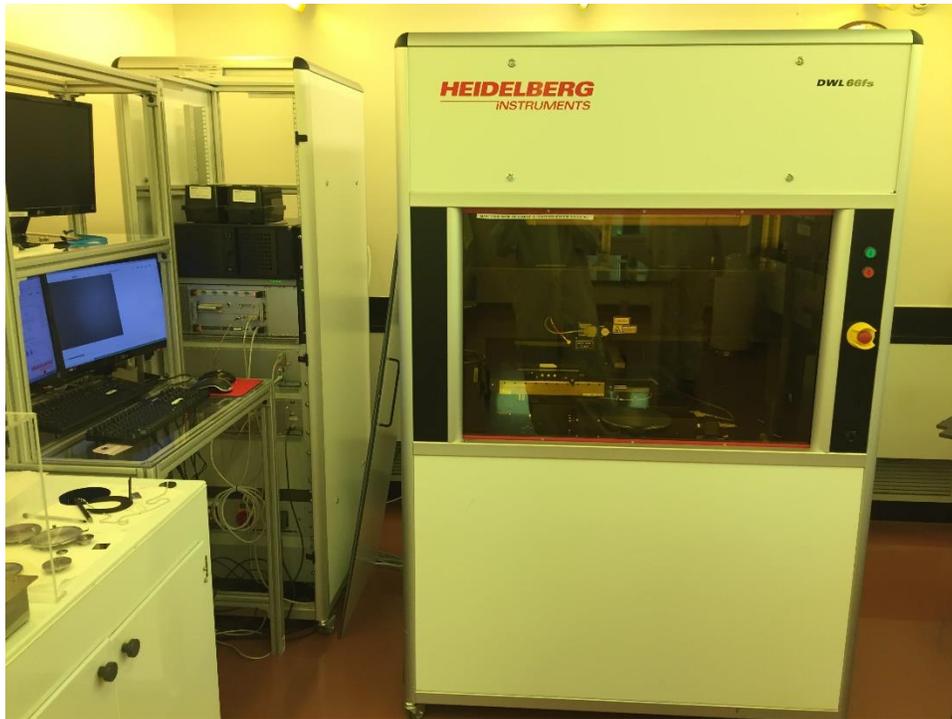


Heidelberg Writing User Manual (DWL66fs)



The DWL66fs laser lithography system is an economical, high resolution pattern generator for mask making and direct writing. It is useful in Advanced Packaging, MEMS, Micro-Optics, Semiconductor and other applications that require microstructures. It's equipped with alignment cameras for front only or front-to-backside alignment and can write a 2 μm line width with a 4 mm write head. The DWL66fs system consists of a Windows 7-based PC for running job files, a Linux-based PC for CAD file conversion, and the main system unit itself. **The tool accepts files of various formats, but for best results, the standard GDSII format is recommended.** The free CAD editor known as **K-Layout** can be downloaded and used to convert other file types to GDSII format. After passing the NCF safety exam, users can request training on this machine by requesting on iLab portal. Those not trained can request an NCF work service order by contacting the lab manager.

Location: cleanroom, lithography bay

Training: 3 sessions (2 trainings and a checkout session)

Technical Specifications:

- Available Write head: 4mm
- Minimum Line Width: 2 μm
- Mask type: Chrome, Iron Oxide
- Max Laser Power: 50 mW
- CAD File types: GDSII (recommended), CIF

Acceptable mask sizes	Thickness
4 x 4 inches (100 mm X 100 mm)	0.6 mm (600 μ m)
6 x 6 inches (150 mm X 150 mm)	0.6 mm (600 μ m)

Acceptable wafer sizes	Minimum Thickness
3 inches (75 mm)	0.5 mm (500 μ m)
4 inches (100 mm)	0.5 mm (500 μ m)
Smaller chips must 10 mm or larger	0.5 mm (500 μ m)

- This manual is intended to teach users on how to write designs on a Photo-Mask blank or wafers.
- You can submit work orders for printing masks on this machine. Details are mentioned in Appendix 2.

[Preparing a file for Heidelberg on Heidelberg Linux Computer](#)

1. The first step is to transfer the file to Heidelberg to convert it to a job file. For this, the Linux system is used (Top Monitor on the rack). Use a flash drive to transfer design file to the Linux computer. The Linux computer is the one kept on the lower level of the rack as shown in the figure 1. Flash drive ports can be found at the back of the CPU.

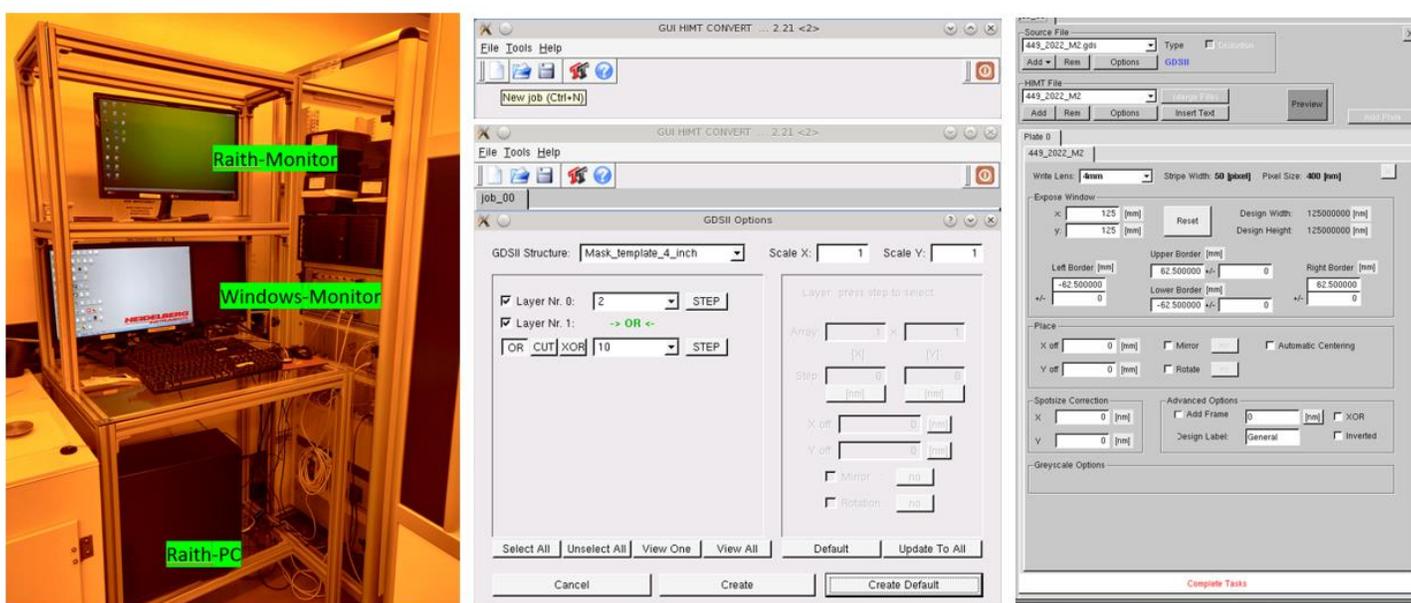
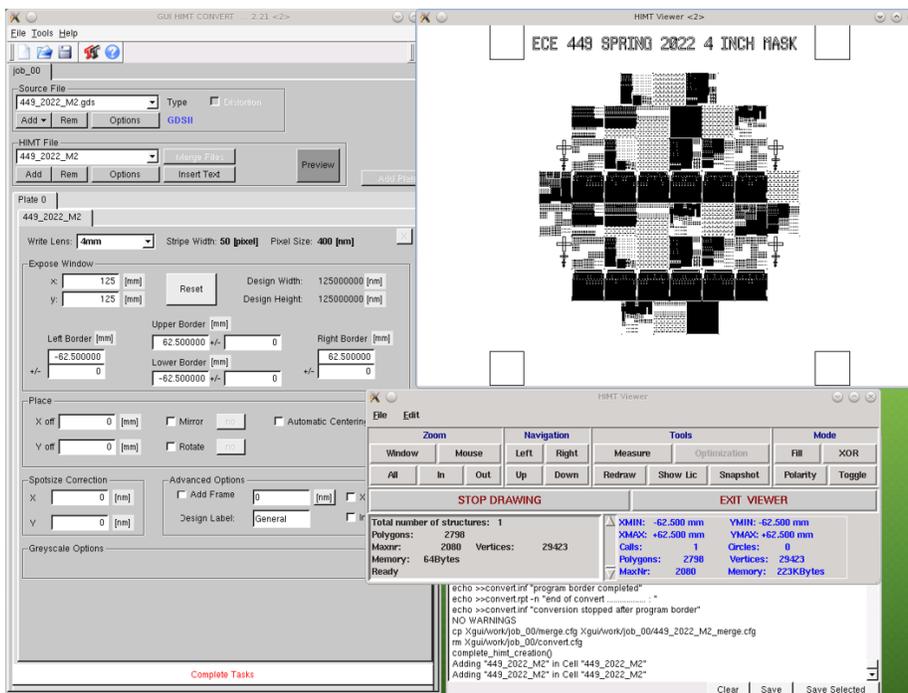


Figure 1

2. Once the flash drive is detected, open any folder on the desktop and navigate to the flash drive explorer. Right click on the file and click copy.
3. Select the folder on desktop as you file extension. If this is a GDSII format, copy the file in the GDSII folder only. Similarly, for DXF and other formats choose the respective folder.
4. Once copied, on the desktop open “Conversion” software by clicking the  icon.
5. Leave the job name as job_00 as this will be renamed later before conversion.

6. Add you file by clicking the add button and choosing the file format.
7. Once uploaded, all the layers should be visible as shown in the figure 1. If the layers are not visible, the file is not in the right format. Please check Appendix for file conversion and then start with step 1.
8. If all the layers are visible, select the layers you want to print and further select the Boolean operation required on the layers. Note,
 - If you want to print 2 layers – Use “OR” between them.
 - If you want to subtract 2 layers – Use “CUT” between them.
 - “XOR” operation is used if the design has overlapping boxes. The designer should be aware of this operation. Please confirm before proceeding.
9. On top of the window is an option to scale the design. Sometimes, the designs are shrunk with confusion in scales between mm, um and nm. If scaling issue arises in the design after confirming in step 12, change the scale here.
10. Once the layers and operations are selected, press “Create Default” and let the software convert the file. **DO NOT PRESS IT TWICE AS THIS WILL STOP THE CONVERSION IN BETWEEN.**
11. Once converted, the screen will show up as shown in the rightmost image in figure 1.
12. The first thing to check is the scaling. If the design is for a 5-inch mask, the size should be around 125 mm. If it is more or less, scaling is an issue. Please refer to step 9 and repeat the process.
13. Once scaling is accurate, press “Preview” button to preview the design. **This is an important step.**
14. The previewer will look like as shown:



- **Window** – Creates a window where to zoom
- **Mouse** – Use scroll on mouse to zoom
- **All** – Zoom out completely
- **In** – Zoom in one level
- **Out** – Zoom out one level
- **Navigation** – Movements in the viewer
- **Measure** – Allows you to measure
- **Snapshot** – Take a snapshot for the current view
- **Fill** – Fill all close loops in the view
- **XOR** – Enable XOR in the viewer
- **Polarity** – Invert the mask view

Figure 2

NOTE: Heidelberg automatically considers a closed loop (box, circle, polyline etc.) as a fill. This means that it will write inside the whole loop. In the preview, always make sure “FILL” is selected and then analyze the design.

FOR OUR SYSTEM – BLACK IS TRANSPARENT OR THE AREA WHICH WILL BE WRITTEN BY THE HEIDELBERG SYSTEM. This can be changed at Step 19 using the “Invert” button if the printing needs to be inverted.

15. Once the “Fill” option is selected, use the appropriate zoom functions to carefully examine the design. If any of the design is missing, here are the possible issues:
 - There is an open loop in the design. **Remedy** – Close all the loops in the design and try again.
 - The file format is not supported. **Remedy** – Use GDSII. Use K-Layout for conversion.
 - Sometimes, for GDSII as well will not show up for the files with multiple layers. This is generally due to low processing power of the system. **Remedy** – Use K-Layout to convert each layer or mask separately. Refer to Appendix for K-Layout conversion.
16. Screenshots can be taken as a proof using the screenshot button. When screenshot is hit, the design is stored as a .jpg file in path: convert/structures/ as file name design0, design1 etc. **To obtain them, before closing the “PREVIEW” window, go to the structures folder and copy the designs to flash drive. The files are deleted as soon as the preview window is closed.**
17. Once the screenshots are taken, close the preview window.
18. Select “Mirroring” if needed along x or y axis. **Note: Usually, the designs need to be mirrored along y axis. Please confirm with the designer before proceeding.**
19. If the fill needs to be inverted – Meaning that “White in the preview will now be written or transparent” - Select the “Inverted” check box before proceeding.
20. If the “XOR” function needs to be used, select the “XOR” button.
21. If the pattern is not designed to print at a specific place or coordinate (Could happen if the design is not a complete plate or wafer), do not use “Automatic Centering”. If a design is to be printed in the center or if the design is a whole plate or wafer, it is recommended to check “Automatic Centering” to make sure that it is printed in center of the substrate.
22. Hit “Complete Tasks” and wait for the conversion to end. Once ended, the following screen will pop up:
23. Click “Transfer”. This will initiate a FTP transfer of file from Linux system to the windows computer using the OS9 controller. The transfer button will be shown as pressed or engaged through the entire transfer process. Once it is depressed or disengaged, this means the transfer is completed. **Note: The transfer might take time if the pattern is a full plate or wafer. For a 5-inch plate pattern, it might take ~30 minutes to transfer the file.**
24. Once the transfer button is disengaged, it is not time to close the conversion software and move on to the windows computer.

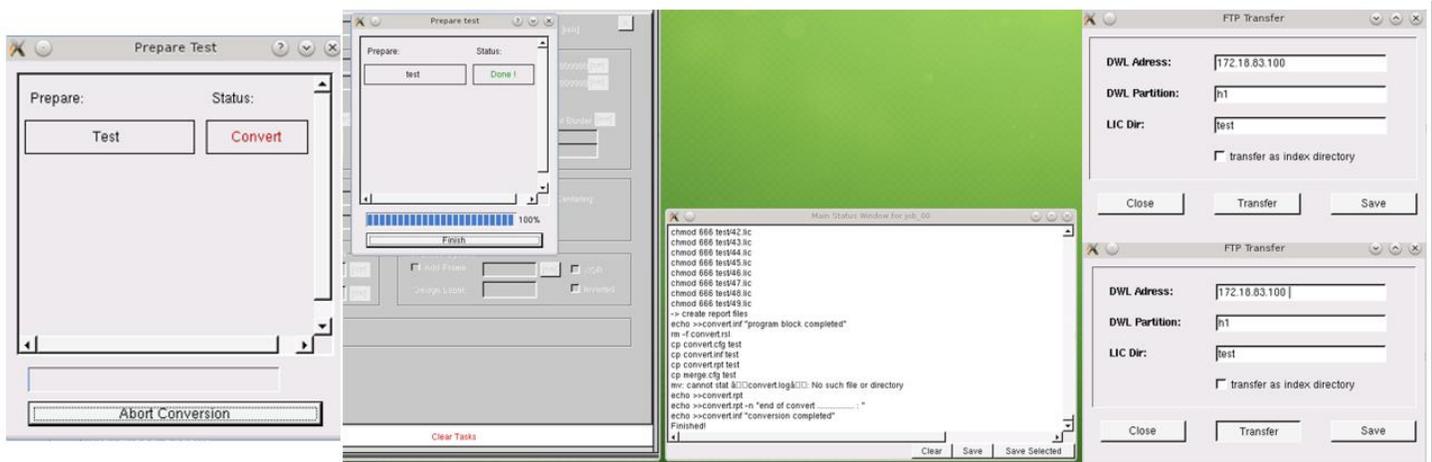


Figure 3

Starting the Heidelberg System and Loading the Substrate

Note: Confirm that compressed air is open which can be turned on by opening the valve behind the rack as shown below



Figure 4

25. On the windows computer, open the “Hi” software by clicking the  icon in the task bar.
26. Enter the password which can be obtained from the **passwords** file on the desktop.
27. The system will now run an initial warm up of all the components. Make sure all the components have a green tick before going further.

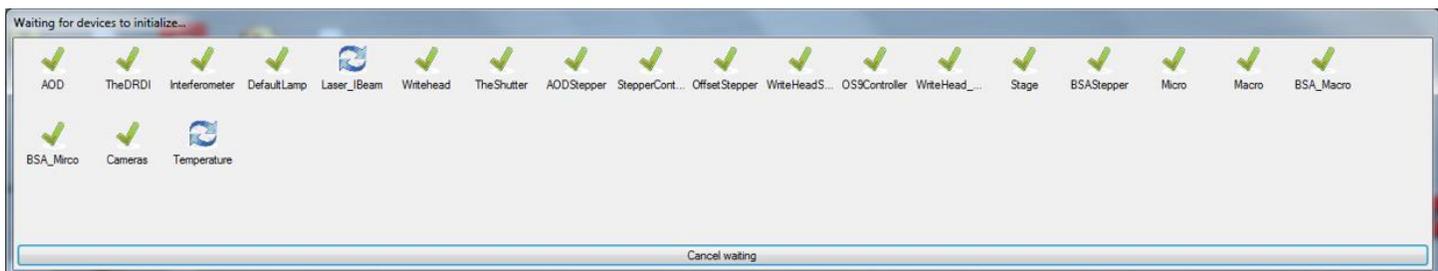


Figure 5

28. Once all the components are green, an error may pop up in the start up suggesting “Coordinates not initialized.” You can safely close the error and proceed further.
29. Once the Hi software is on, the screen will look like as shown in Figure 6.
30. The first thing to do is to initialize the coordinates. Hit  button on the General menu reset coordinates and then hit  to initialize coordinates.

It is important to note the stage movements at this point. The stage should slowly move all the way forward (towards you) and then all the way left. At this point, the status should say “ready” confirming successful initialization.

31. Click the “**Load**” button. This will move the stage to the sample loading position.
32. From the Heidelberg machine’s front, take the tag and place is on the Vacuum pump switch on the right wall on the room next to the optical microscope. This vacuum pump is shared with Mask Aligner and spinner.

NOTE: The vacuum pump is time limited. If the system needs to be used overnight, contact NCF staff first to switch the vacuum pump to continuous/unswitched mode.

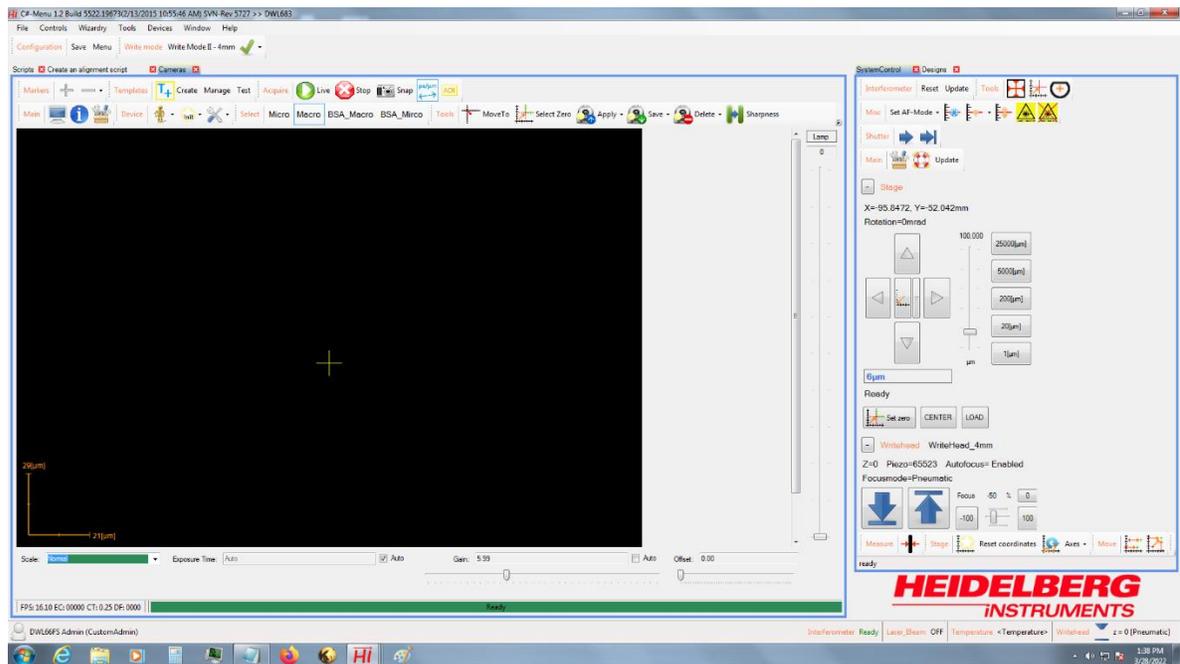


Figure 6

33. On the front of the machine, use the toggle button to open the window (Figure 8). Once open, turn the light on by toggling the switch. The light and switch are mounted to the roof inside the machine.
34. Next, it is important to select the stage according to the substrate. We have different stage for 4-inch mask, 5-inch mask and wafers. To remove the stage, simply slide it out and pick it up. Stages can be found in a drawer below the oven on the left shelf. To put the desirable stage, just slide it in place. (Figure 8)

CAUTION: While removing **DO NOT** hit the **WRITE HEAD**. While changing, do not turn the stage as the alignment pins might fall off.

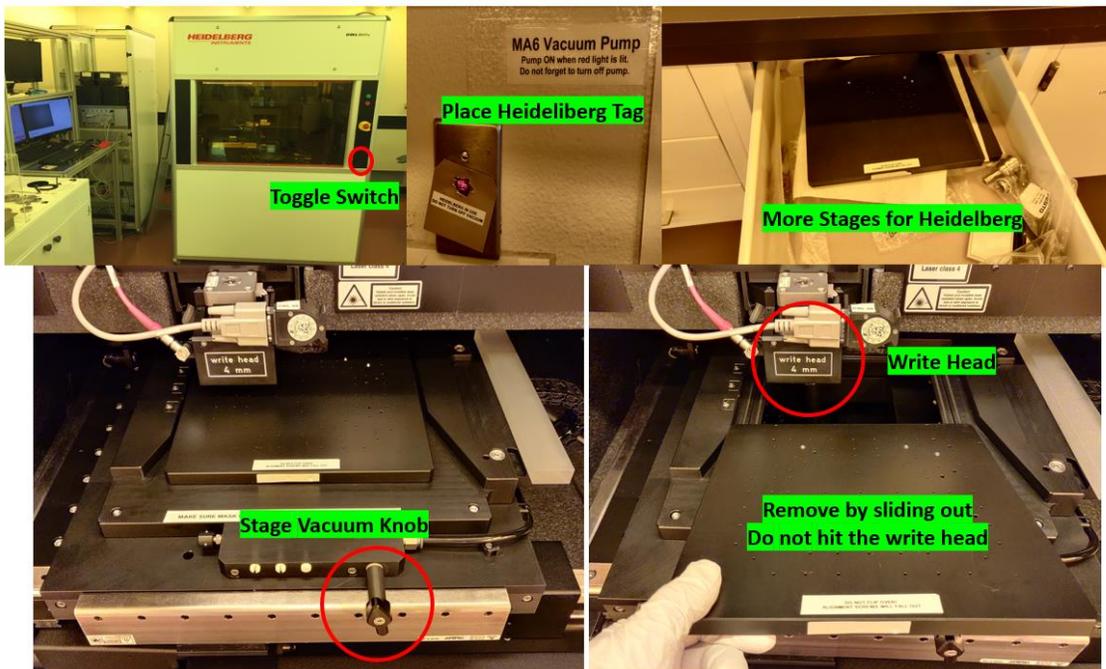


Figure 7

35. Once the stage is in, load the samples such that it perfectly sits with the alignment pins (Figure 9).
36. Turn the vacuum on by rotating the knob (figure 8) and make sure the sample is hard to move. Close the window by toggling the button in front of the machine.

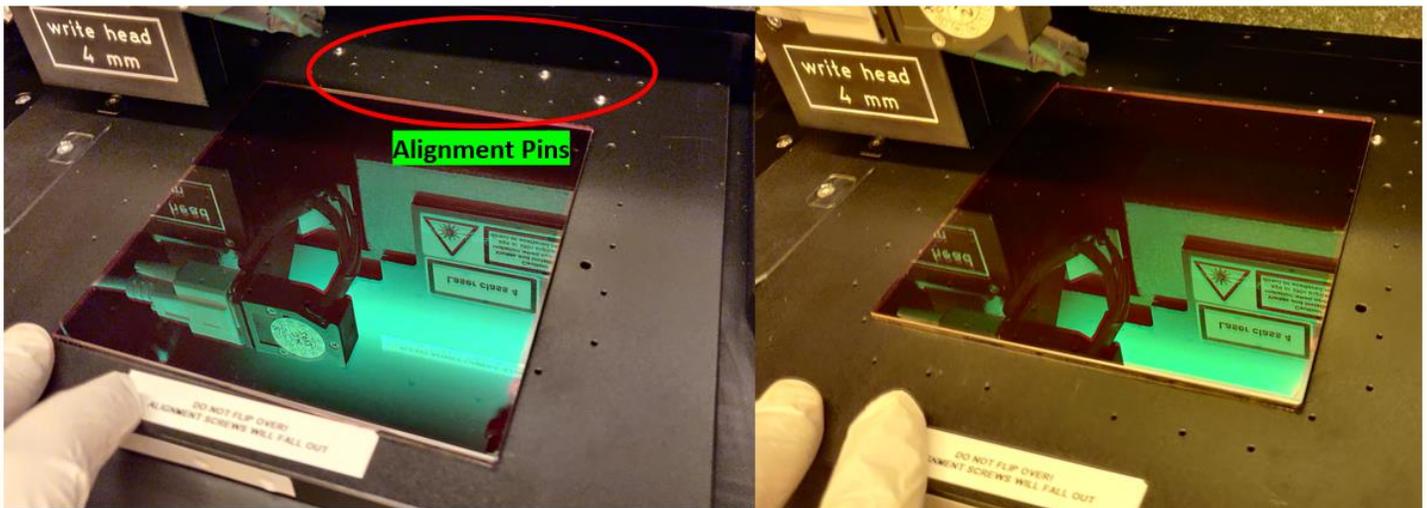
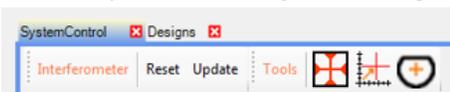


Figure 8

37. On the windows computer, in system control panel, click **center**. 
38. Click the down **arrow**  to focus on the substrate.
39. Once “ready” is displayed on the status line, press **plate center**  or **wafer center** . The machine will do subsequent stage movements to find the dimensions of the substrate. You can check the progress as the button will now be filling green to mark the progress.

- Plate center is used if the substrate is rectangular shaped or for Photomasks.
- Wafer center is used if the substrate is circular shaped or for wafers.

40. At the end of plate center, the machine will output the size of the substrate. Make sure this matches your sample.
41. Once step 39 is done, go to “**designs**” panel by choosing designs next to system control (Above the plate center)



and click “**Update**”. A message saying “**Updating**” will appear on the bottom right. Wait until its done.

42. If the file was transferred successfully, the file will now appear in the designs with the name saved.

Setting up the Job and Writing

43. On the job window (figure 9), it is best to use the existing format. On the existing file, right click, select clear and choose designs. This will clear the design column.
44. From the designs window on previous window (as used to update designs), drag and drop the design to the empty column. The design should be filled.
45. If you **do not** need multiple copies of this design on the same substrate, skip to step 46.

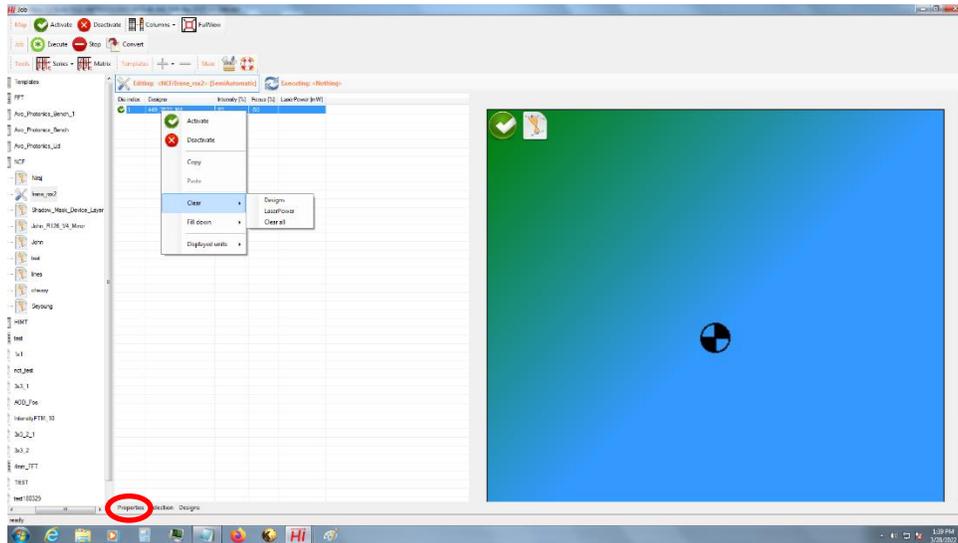


Figure 9

46. To create multiple copies, click properties (figure 9) and adjust rows and columns depending on copies needed. This will shrink the design to the area left for one box. Once done, you can adjust parameters for each row separately. (Figure 10)

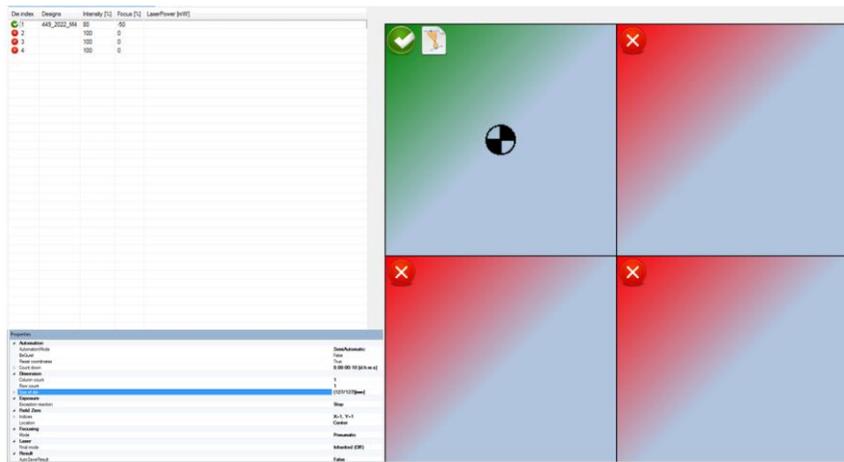


Figure 10

47. For each row (if multiple), select the row and click properties.

- **Count Down** – The time the machine counts down before starting writing.
- **Row and Column** – Adjust if multiple designs are needed on same plate.
- **Size of Die** – This parameter must match with the size of substrate you want to print on.
- **Focusing Mode** – Only **Pneumatic** works for our system

48. Once all the properties are verified, click “execute” on top of the screen. Heidelberg will ask you to load the sample in. Click **OK** as the sample is already loaded. This is a failsafe mechanism.

49. The Heidelberg should now write the pattern strip by strip.

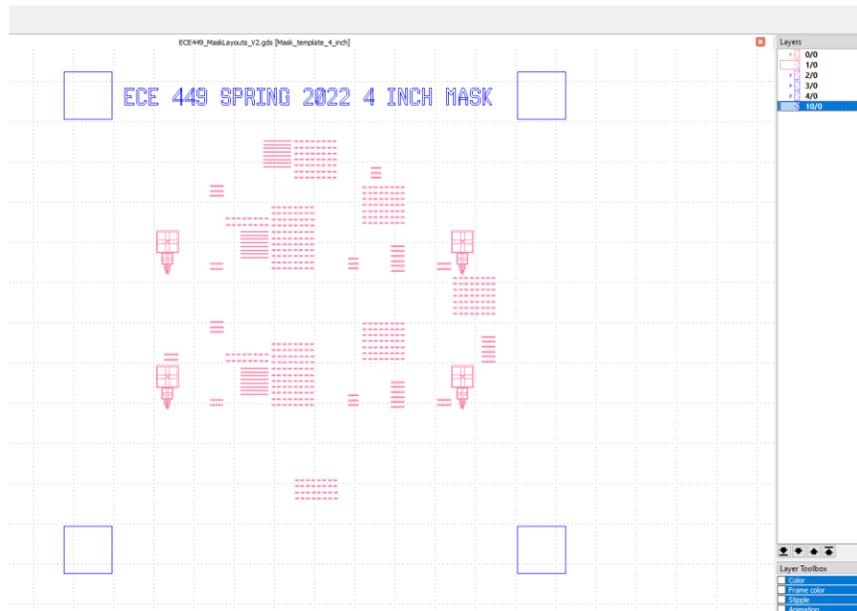
Development of Masks

Masks procured from Nanofilm. The underlying material is low reflectivity chrome that is 100 nm thick. The resist is AZ 1518, baked at 103 degrees C and is 500 nm thick.

50. Use N₂ to remove any lingering particles from the mask surface.
51. Place mask into Heidelberg and write pattern. Writing parameters are:
 - a. 80% intensity
 - b. -50 focus --- this is the best focus on the NCF Heidelberg
 - c. 50 mW power – max power is limited to 70 mW to prolong life of laser
52. Once done, develop the mask within 48 hours for ~45 seconds (0.7 on timer at fume hood) in AZ 340 developer mixed with DI water in 1:3 ratio. **MAKE SURE NO BUBBLES FORM ON THE MASK WHILE DEVELOPING. BUBBLES WILL STOP THE RESIST FROM DEVELOPING WHERE THERE ARE PATTERNS. If you are dealing with masks that has patterns ~2um, please do development in steps to make sure you do not overdevelop.**
53. Rinse in DI water.
54. Etch the chrome or Iron Oxide using the dedicated chrome mask etchant or Iron Oxide Etchant. **Etch for 40 seconds for a Chrome Mask and 2 minutes 20 seconds for an Iron Oxide mask (2.3 on timer at Fume Hood). Inspect the pattern to make sure the pattern is completely transparent.** You may want to use more time if it seems there is still chrome at the bottom of the pattern.
55. Strip the photoresist with AZ Kwik Strip. Sonicate the stripper for ~4 minutes to make sure residual resist is gone.
56. Rinse in DI water for ~2 minutes.
57. Spray the mask with IPA to remove the stripper if left.
58. Dry with N₂ and inspect the mask under a microscope.

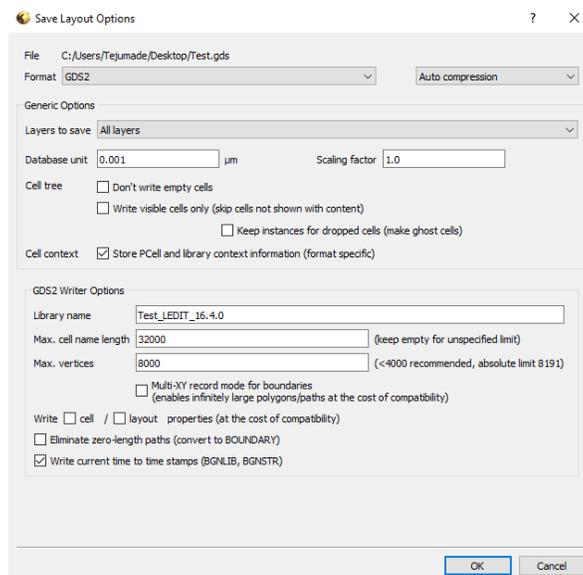
APPENDIX I

- I. Heidelberg can accept file formats like GDSII, DXF etc. It is recommended that GDSII is used for trouble-free file preparation. Users can download **K-Layout Viewer**, a free software for viewing files on GDSII. To convert file to GDSII, open the file in K-layout and follow the steps. If you are creating individual file for every layer, just right click on the layers and select “**Hide all**” and then right click on the layers needed and select “**show**”. Once the layers to be converted are selected, the other should be hidden and look as following



Appendix Figure 1

- II. Click “**file**” and select “**Save As**”, name the file, select GDSII as format and set the location and the following window will show up:



Appendix Figure 2

- III. Do the following steps:
 - a. Instead of auto compression, change it to no compression to avoid scaling issues.
 - b. In “Layers to save” select “Visible layers only”.
 - c. Tick “Don’t write empty cells”
- IV. This should save the file as GDSII format.

APPENDIX II

NCF has now started Photomask printing facility using the Heidelberg DWL66fs laser writing system. The requester needs to provide us with the design file ready for printing. The file is converted, and proof is sent to the requester. The details are as mentioned:

4-inch Mask Printing

Including 4-inch Chromium/Iron Oxide mask

Resolution (CD): up to 2um

Price - \$150 (Includes conversion. Does not include shipping and designing)

5-inch Mask Printing

Including 5-inch Chromium/Iron Oxide mask

Resolution (CD): up to 2um

Price - \$200 (Includes conversion. Does not include shipping and designing)

Note: To use this service, the requester may or may not be a NCF User. For more details on the policy, please refer to the policies section.