Standard Operating Procedure: Maskless Aligner

Heidelberg Instruments µMLA

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Contact Information:

Shawn Wagoner (swagone@gmu.edu)

Sezin Sayin (ssayin@gmu.edu)

Pranav Choori (pchoori@gmu.edu)

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1. Lab Safety Information

- ✓ All GMU NFF users are required to complete the Lab Safety Orientation (LSO) before performing any lab work.
- ✓ Proper Personal Protective Equipment (PPE) should always be worn before entering the clean room: safety glasses, hair net, shoe covers, gloves, and lab coat. Additional PPE is available for specialized chemical work as needed.
- ✓ No shorts, sandals, tank tops, or spaghetti-strap shirts are allowed in the clean room!
- ✓ Material Safety Data Sheets (MSDS) are available in a binder in the gowning room.
- ✓ Read the SDS for any chemicals you plan to use before proceeding with your work. Any materials used in the clean room for the first time should be brought in after the approval of NFF staff.
- ✓ A safety buddy is required in the clean room with you when doing chemical work. They must remain in the clean room the entire time you are handling the chemical. Feel free to ask NFF staff if no one qualified is available!
- ✓ Prohibited clean room items: cardboard, pencils, cloth, hats/coats, and contact lenses.
- ✓ Accepted clean room items: plastic, pens, synthetic fabrics, clean room paper.

2. Maskless Aligner Safety Information

- ✓ Any irregular system behavior should be reported to NFF staff promptly. Never attempt to fix the system yourself!
- ✓ During movement and while the system is in processing mode, the window cannot be opened.
- ✓ Do not upload .gds files by yourself, ask NFF staff to do it for you!
- ✓ Do not put wafers with unapproved materials that could contaminate their surroundings into the chamber.
- ✓ Don’t touch the optics, or open the chamber to expose yourself to the UV light when it is running! In particular don’t put your hands the chamber when the scan head is moving.
- ✓ Do not remove system files or attempt to clear up the hard drive yourself. If it is getting full and slowing down, inform NFF staff.
- ✓ Gloves can become contaminated when loading wafers or removing wafers. Always check your gloves and replace them when necessary.
- ✓ Failure to use the system safely and properly may result in your access to the system being reviewed and/or revoked.
- ✓ Fill out the logbook before you begin.
- ✓ If a new recipe is required ask for assistance from the NFF staff.

3. Principles of Maskless Aligner

Maskless lithography means that your design file is exposed directly onto the resist-coated wafer. The Heidelberg uses a 365nm ultraviolet LED to expose photoresist layers on wafers, without requiring the use of a mask. It accepts gds design files with a minimum feature size of 1um. File conversion process allows you to select one or multiple layers of a complicated design file to write. Edge detection process allows for seamless transition between wafers of different sizes and/or small test chips. Simple, effective dose test process makes it easy to ensure you're using the best possible dose/defocus values every time.

Specifications: Maximum substrate size: 6" X 6", minimum substrate size: 5 X 5 mm², maximum write area: 100 X 100 mm², 10mm maximum substrate thickness, substrate thickness: 0.1 to 12 mm.

4. Photolithography Process Flow

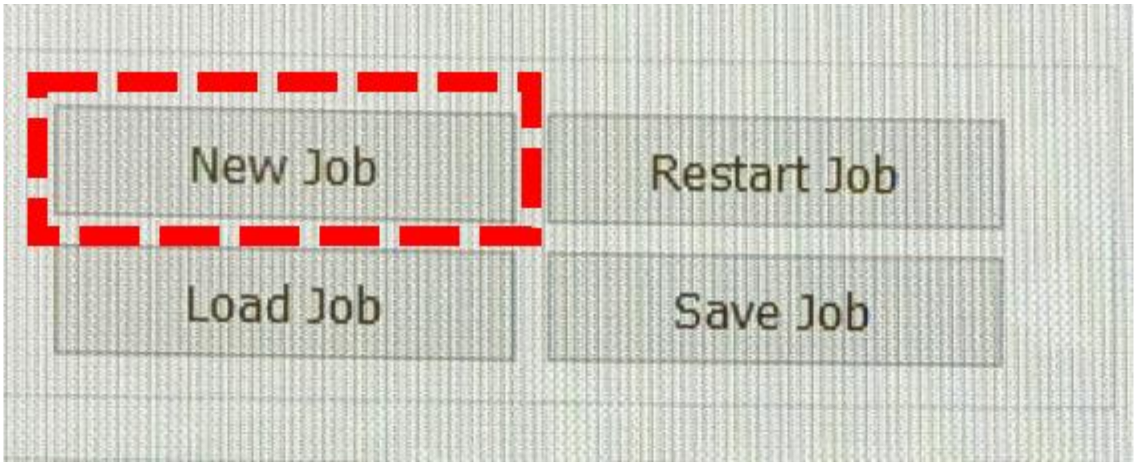
This is not intended to be an in-depth guide to the photolithography but a simple outline of the steps involved. There are several steps to the photolithography process. Each step is simple but proper execution is required for a successful result. The steps of the photolithography process are (in order):

1. Coating of the substrate with photoresist.
2. Baking the resist prior to exposure.
3. Exposing the resist in an exposure tool.
4. Baking the resist after exposure.
5. Development of the exposed resist.

5. Operation

5.1. Non-alignment Run

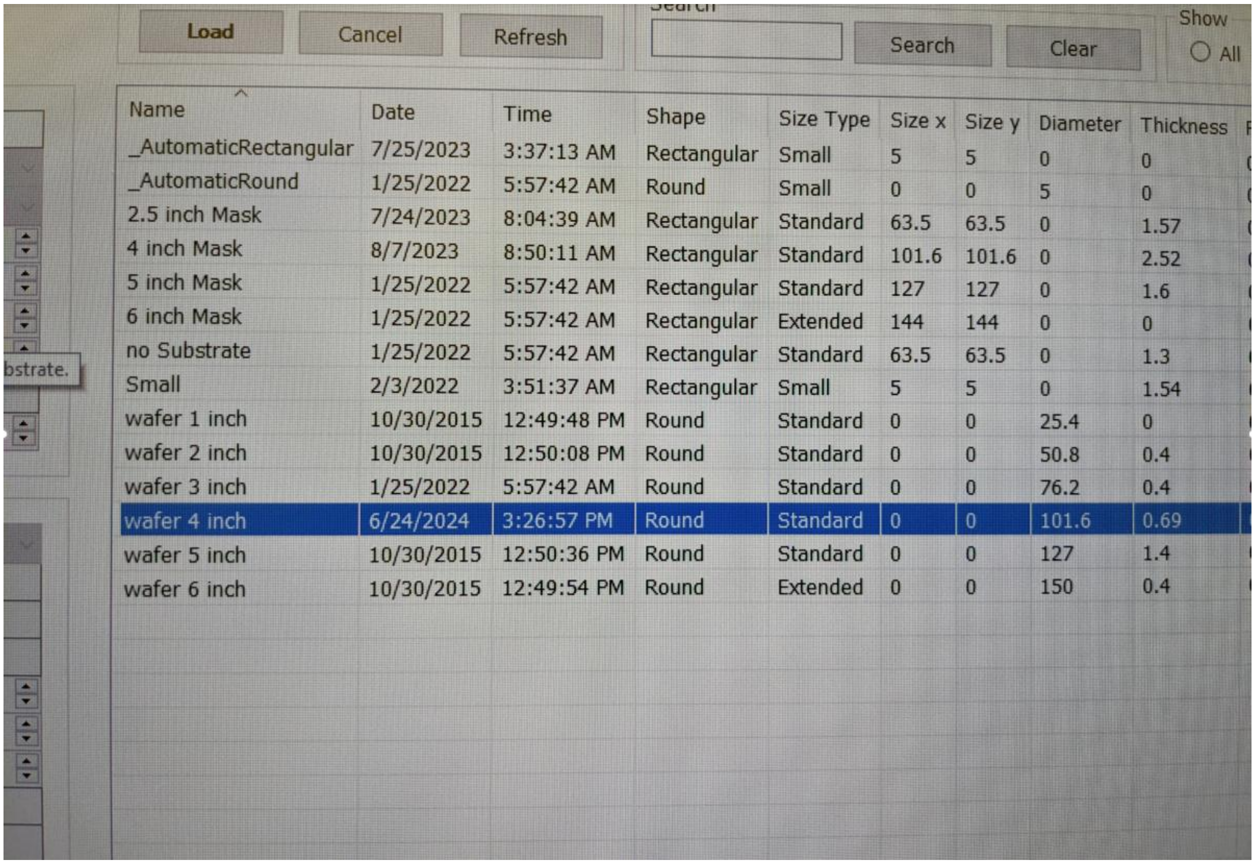
1. Before using the Heidelberg, reach out to NFF staff and send them a .gds file with the design you seek to pattern. NFF staff will load your design file into the Heidelberg for you. Speak to NFF staff if you seek to use a photoresist not readily available in the cleanroom, or if you are patterning a sample with unusual layers.
2. Click “New Job” on the main screen to reset the system settings.



3. Specify the size of the sample you are seeking to pattern. Use “Automatic Rectangular” if you are using a diced piece of a wafer; edge detection will determine the size of the piece for you.

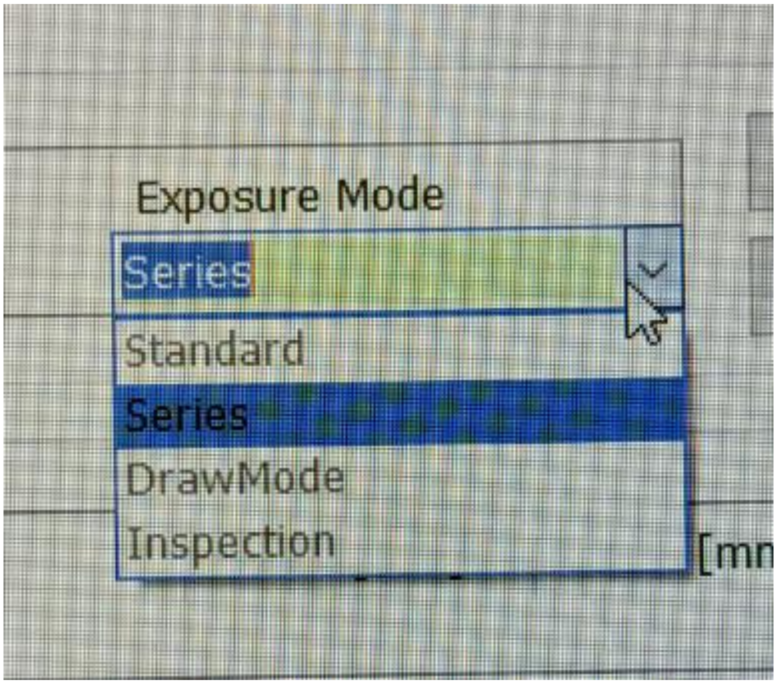
Substrate

Substrate Template
wafer 4 inch



Name	Date	Time	Shape	Size Type	Size x	Size y	Diameter	Thickness
_AutomaticRectangular	7/25/2023	3:37:13 AM	Rectangular	Small	5	5	0	0
_AutomaticRound	1/25/2022	5:57:42 AM	Round	Small	0	0	5	0
2.5 inch Mask	7/24/2023	8:04:39 AM	Rectangular	Standard	63.5	63.5	0	1.57
4 inch Mask	8/7/2023	8:50:11 AM	Rectangular	Standard	101.6	101.6	0	2.52
5 inch Mask	1/25/2022	5:57:42 AM	Rectangular	Standard	127	127	0	1.6
6 inch Mask	1/25/2022	5:57:42 AM	Rectangular	Extended	144	144	0	0
no Substrate	1/25/2022	5:57:42 AM	Rectangular	Standard	63.5	63.5	0	1.3
Small	2/3/2022	3:51:37 AM	Rectangular	Small	5	5	0	1.54
wafer 1 inch	10/30/2015	12:49:48 PM	Round	Standard	0	0	25.4	0
wafer 2 inch	10/30/2015	12:50:08 PM	Round	Standard	0	0	50.8	0.4
wafer 3 inch	1/25/2022	5:57:42 AM	Round	Standard	0	0	76.2	0.4
wafer 4 inch	6/24/2024	3:26:57 PM	Round	Standard	0	0	101.6	0.69
wafer 5 inch	10/30/2015	12:50:36 PM	Round	Standard	0	0	127	1.4
wafer 6 inch	10/30/2015	12:49:54 PM	Round	Extended	0	0	150	0.4

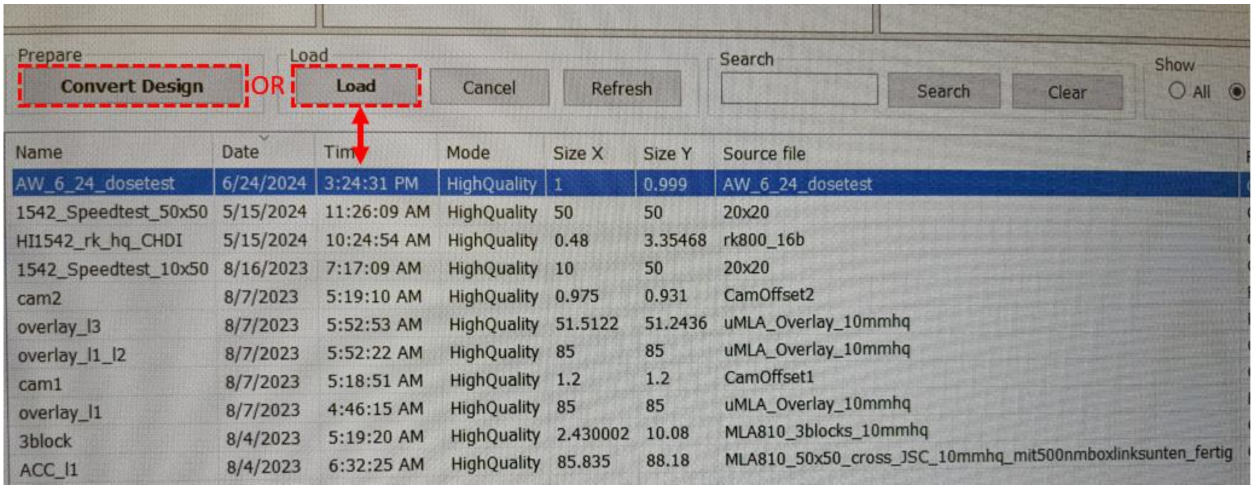
4. Set the exposure mode to "Standard" if you only seek to pattern the design on your .gds file once. Set it to "Series" if you wish to create your .gds pattern multiple times, or if you want to do a dose test.


Exposure Mode
Series

5. Double click the entry box under “Design” to enter the Design Menu.

Design
AW_6_24_dosetest

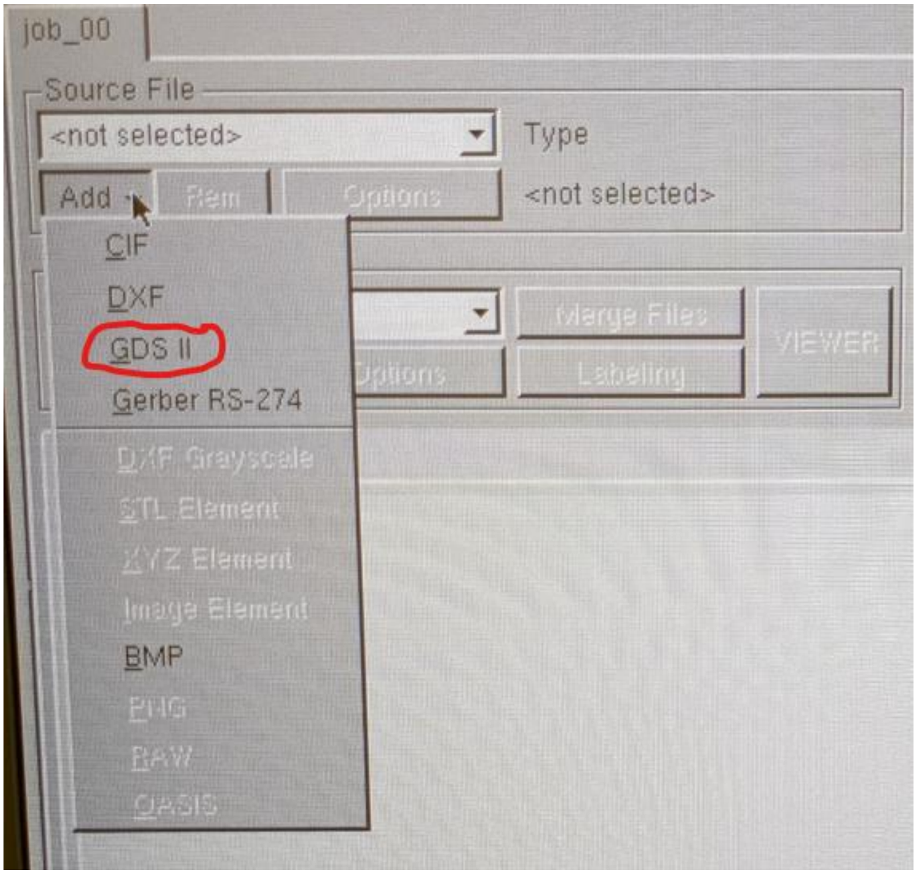
6. If you have previously converted your .gds file into a .job file, select the desired .job file, click load, and skip to Step ___. Otherwise, click the “Convert Design” button.



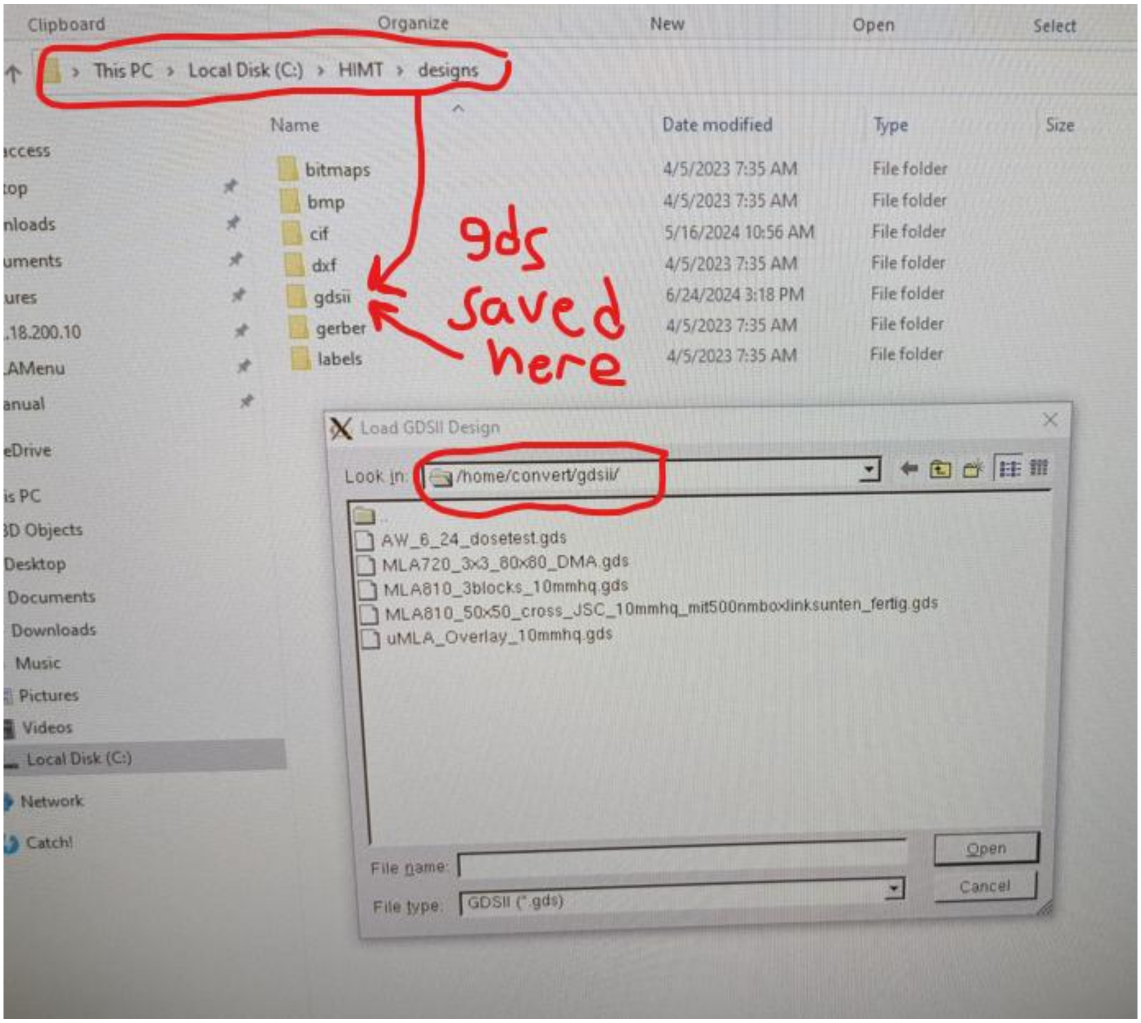
Name	Date	Tim	Mode	Size X	Size Y	Source file
AW_6_24_dosetest	6/24/2024	3:24:31 PM	HighQuality	1	0.999	AW_6_24_dosetest
1542_Speedtest_50x50	5/15/2024	11:26:09 AM	HighQuality	50	50	20x20
HI1542_rk_hq_CHDI	5/15/2024	10:24:54 AM	HighQuality	0.48	3.35468	rk800_16b
1542_Speedtest_10x50	8/16/2023	7:17:09 AM	HighQuality	10	50	20x20
cam2	8/7/2023	5:19:10 AM	HighQuality	0.975	0.931	CamOffset2
overlay_l3	8/7/2023	5:52:53 AM	HighQuality	51.5122	51.2436	uMLA_Overlay_10mmhq
overlay_l1_l2	8/7/2023	5:52:22 AM	HighQuality	85	85	uMLA_Overlay_10mmhq
cam1	8/7/2023	5:18:51 AM	HighQuality	1.2	1.2	CamOffset1
overlay_l1	8/7/2023	4:46:15 AM	HighQuality	85	85	uMLA_Overlay_10mmhq
3block	8/4/2023	5:19:20 AM	HighQuality	2.430002	10.08	MLA810_3blocks_10mmhq
ACC_l1	8/4/2023	6:32:25 AM	HighQuality	85.835	88.18	MLA810_50x50_cross_JSC_10mmhq_mit500nmboxlinksunten_fertig

7. When the “GUI HIMT CONVERT” window opens, click “New Job”. This will make the GUI HIMT window bigger.

8. Click the “Add” drop-down menu under “Source File”, then click “GDS II”.



9. Your .gds file, which was loaded into C>HIMT>Designs, should pop up in the next window. Select your desired .gds, and the click “Open”. Contact NFF staff if your design isn’t there!



This PC › Local Disk (C:) › HIMT › designs

Name	Date modified	Type	Size
bitmaps	4/5/2023 7:35 AM	File folder	
bmp	4/5/2023 7:35 AM	File folder	
cif	5/16/2024 10:56 AM	File folder	
dxf	4/5/2023 7:35 AM	File folder	
gdsii	6/24/2024 3:18 PM	File folder	
gerber	4/5/2023 7:35 AM	File folder	
labels	4/5/2023 7:35 AM	File folder	

gds saved here

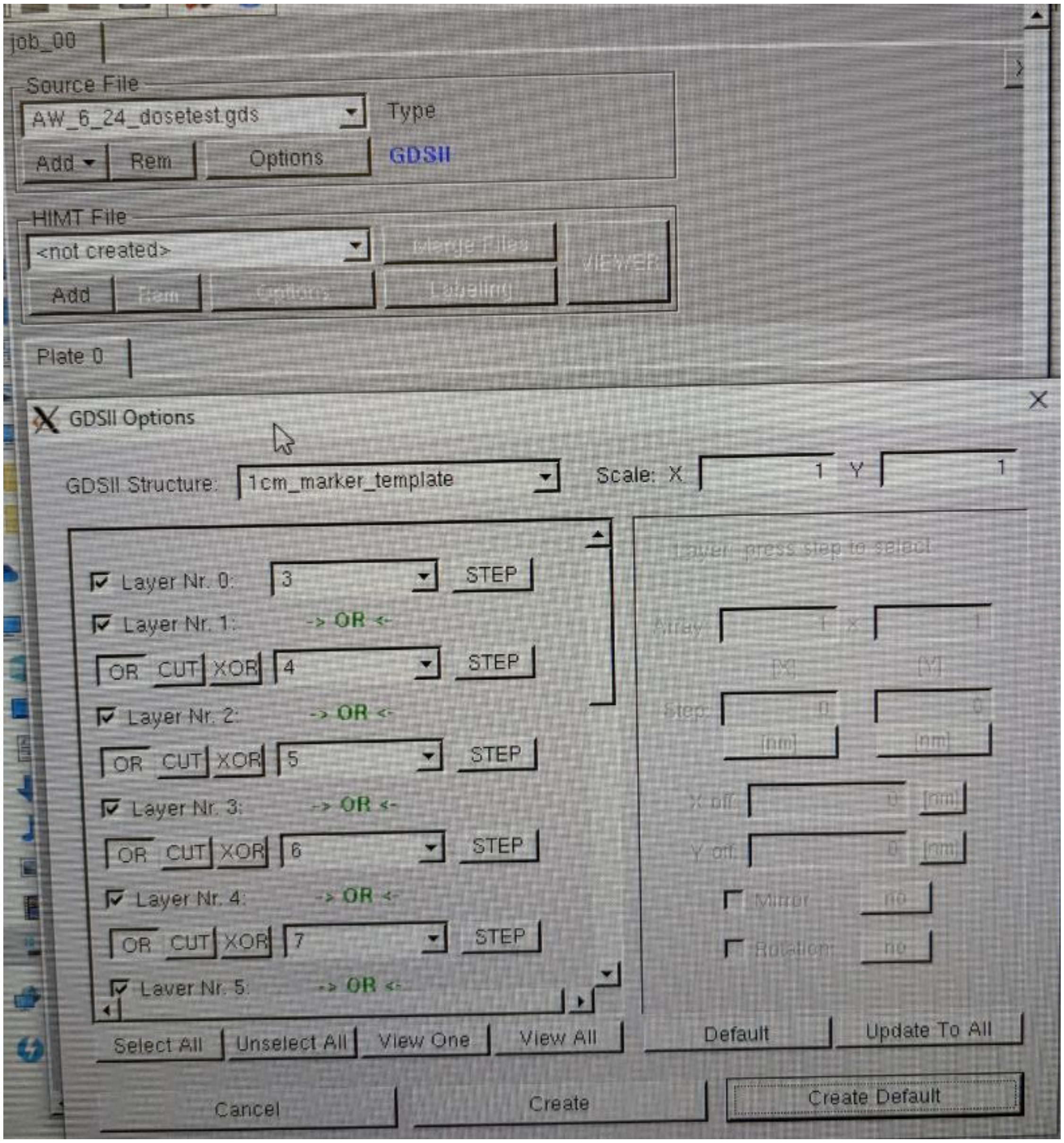
Load GDSII Design

Look in: /home/convert/gdsii/

..
AW_6_24_dosetest.gds
MLA720_3x3_80x80_DMA.gds
MLA810_3blocks_10mmhq.gds
MLA810_50x50_cross_JSC_10mmhq_mit500nmboxlinksunten_fertig.gds
uMLA_Overlay_10mmhq.gds

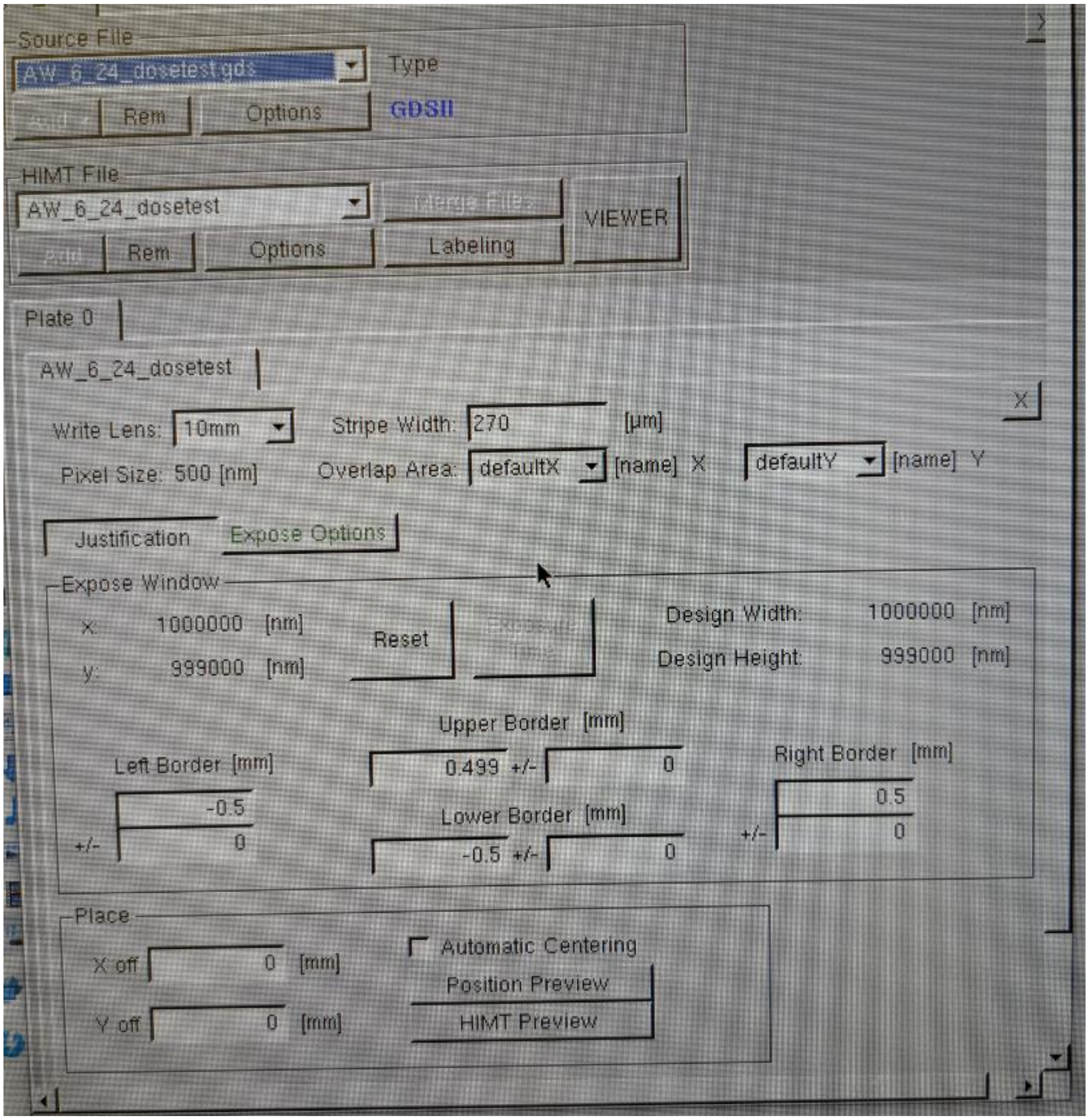
File name:
File type: GDSII (*.gds)

10. The HIMT program will read your .gds file and extract the different cells (Under “GDSII Structure”) and layers (Under “Layer Nr. __”) in the “GDSII Options” menu. In this menu, select which cell of your .gds file you want to draw patterns from, and which layer (Can use one or more!) you want to use for your patterning. Be sure to double check the cell and layer(s) that you choose!



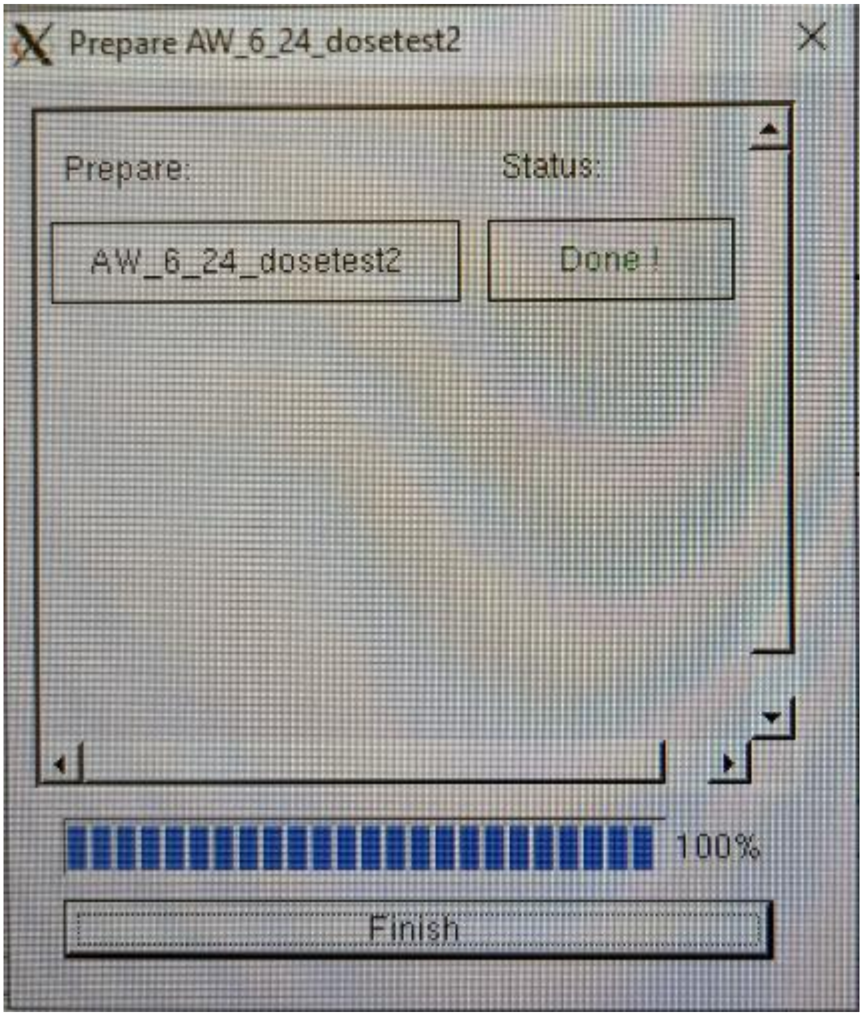
Source File: AW_6_24_dosetest.gds
Type: GDSII
HIMT File: <not created>
GDSII Structure: 1cm_marker_template
Scale: X 1 Y 1
☑ Layer Nr. 0: 3
☑ Layer Nr. 1: -> OR <- 4
☑ Layer Nr. 2: -> OR <- 5
☑ Layer Nr. 3: -> OR <- 6
☑ Layer Nr. 4: -> OR <- 7
☑ Layer Nr. 5: -> OR <-

11. Once you have selected your cell/layer(s), a secondary overview window will pop up that gives you an overview of the pattern(s) you've selected. Observe the design height, design width, and border boundaries that that this window displays. They should match what you're expecting to see from the pattern you create!



Source File: AW_6_24_dosetest.gds
Type: GDSII
HIMT File: AW_6_24_dosetest
Plate 0
AW_6_24_dosetest
Write Lens: 10mm
Stripe Width: 270 [µm]
Pixel Size: 500 [nm]
Overlap Area: defaultX [name] X defaultY [name] Y
Expose Window
x: 1000000 [nm]
y: 999000 [nm]
Design Width: 1000000 [nm]
Design Height: 999000 [nm]
Upper Border [mm]: 0.499 +/- 0
Left Border [mm]: -0.5 +/- 0
Lower Border [mm]: -0.5 +/- 0
Right Border [mm]: 0.5 +/- 0
Place
X off: 0 [mm]
Y off: 0 [mm]
☐ Automatic Centering

12. If everything looks OK, click the green “Complete Tasks” button at the bottom of this window. It will give you the opportunity to choose a name for the .job file the conversion software will be making from your .gds file.
13. Once you’ve picked a name for the .job file and clicked “Save”, the GUI HIMT CONVERT window will be mostly greyed-out and unable to be changed. Click “Complete Expose Jobs” to finish the conversion process, and then “Finish” once the status bar reaches 100%.

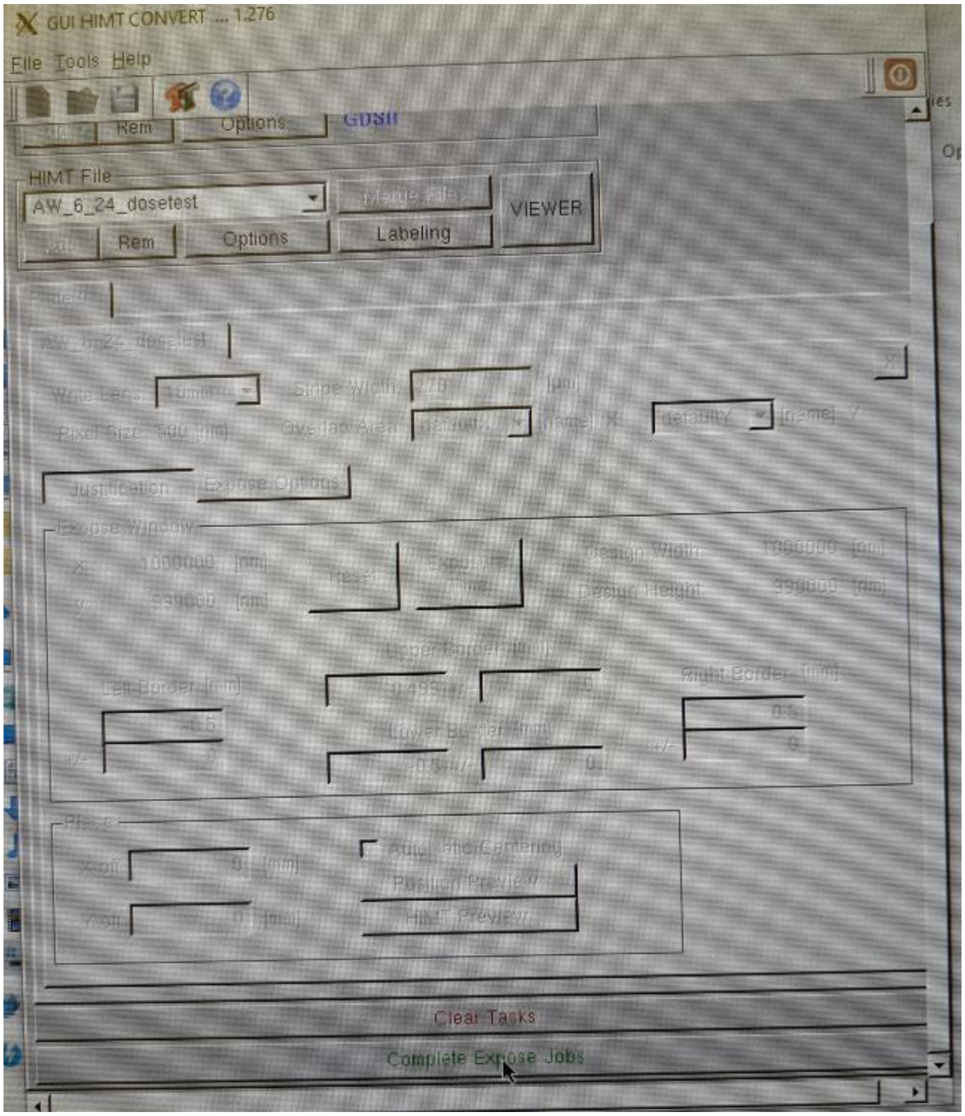


Prepare AW_6_24_dosetest2

Prepare: AW_6_24_dosetest2

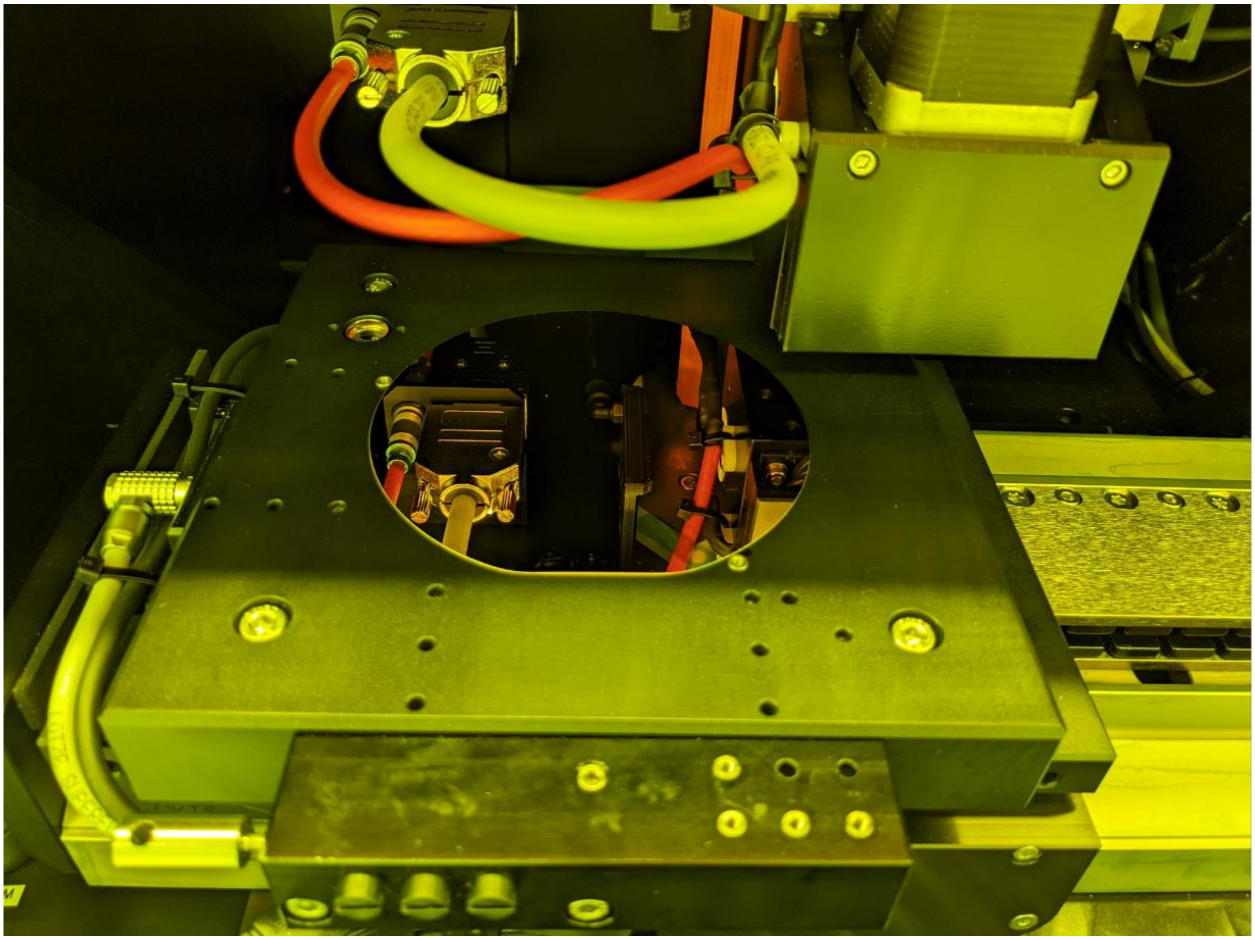
Status: Done !

100%

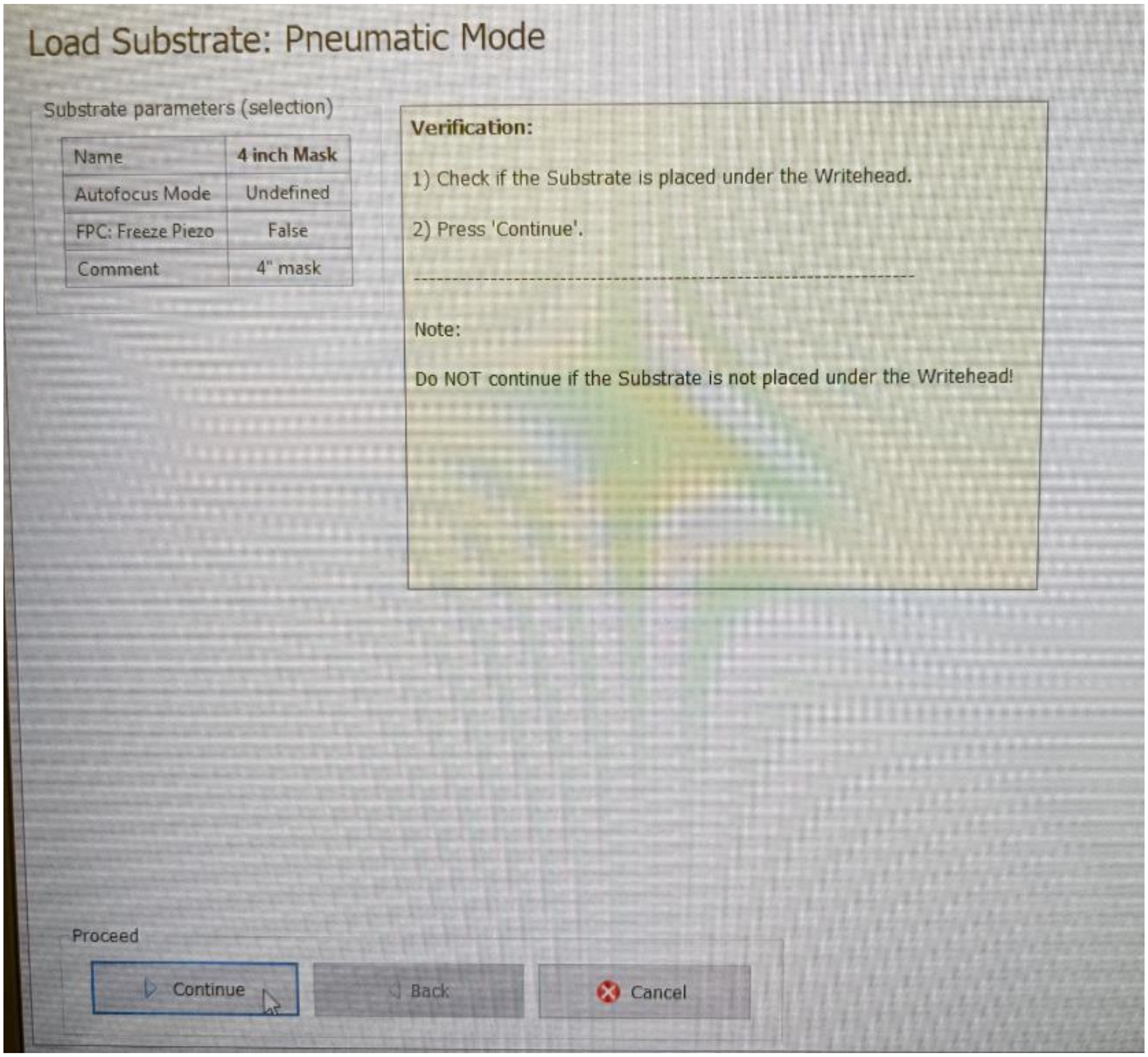


HIMT File: AW_6_24_dosetest

14. After clicking "Finish", you can close the GUI HIMT CONVERT window, which returns you to the "Load Design" subsection of the main software. If you did your conversion correctly, your design should be visible in the list of available jobs. Click the "Refresh" button if you aren't seeing it there… the system may just be taking a moment to update! Select the job you wish to use and click the "Load" button to return to the main screen.
15. If all the settings look OK, you should now load your sample into the chamber. Place it in the middle of the sample stage, engage the vacuum, and then close the lid of the chamber.



16. Click “Load Sample” to begin the sample alignment process. If you are happy with the position you put your sample in and confident the vacuum is engaged, you can then hit “Continue”.
17. If you are confident that you place your sample directly in the middle of the sample stage, you can click “Continue” again to begin the edge detection process.



Load Substrate: Pneumatic Mode

Substrate parameters (selection)

Name	**4 inch Mask**
Autofocus Mode	Undefined
FPC: Freeze Piezo	False
Comment	4" mask

Verification:

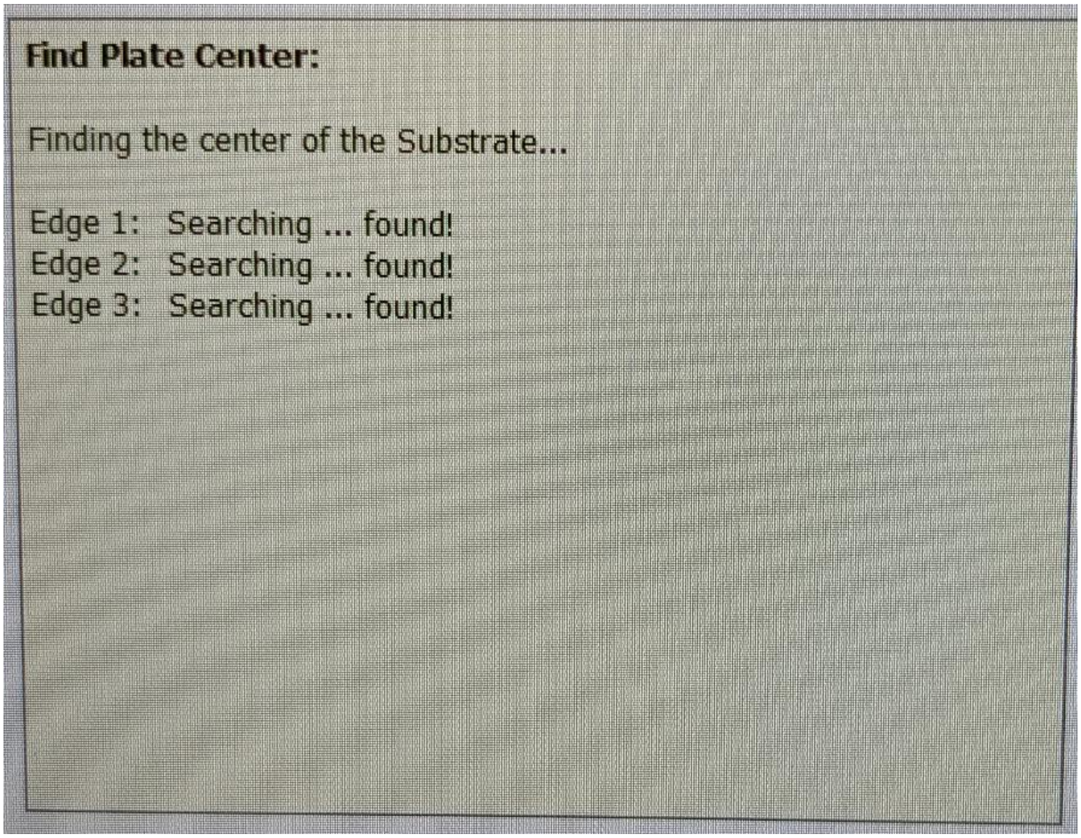
1) Check if the Substrate is placed under the Writehead.

2) Press 'Continue'.

Note:

Do NOT continue if the Substrate is not placed under the Writehead!

18. The system will now lower the scan head to focus on your sample, and then use an algorithm to detect the edges of your sample along with the angle that it is sitting at relative to the scanhead. If the system detects a large variation in heights when sweeping the surface of your sample, this part of the process can fail. This typically happens when photoresist gets contaminated and creates a flaky layer on the outer edge of your sample after it is baked. Extraneous flaky bits of photoresist should be removed with a sharp object and then blown off of the sample surface with a Nitrogen gun prior to loading the sample into the chamber for patterning.

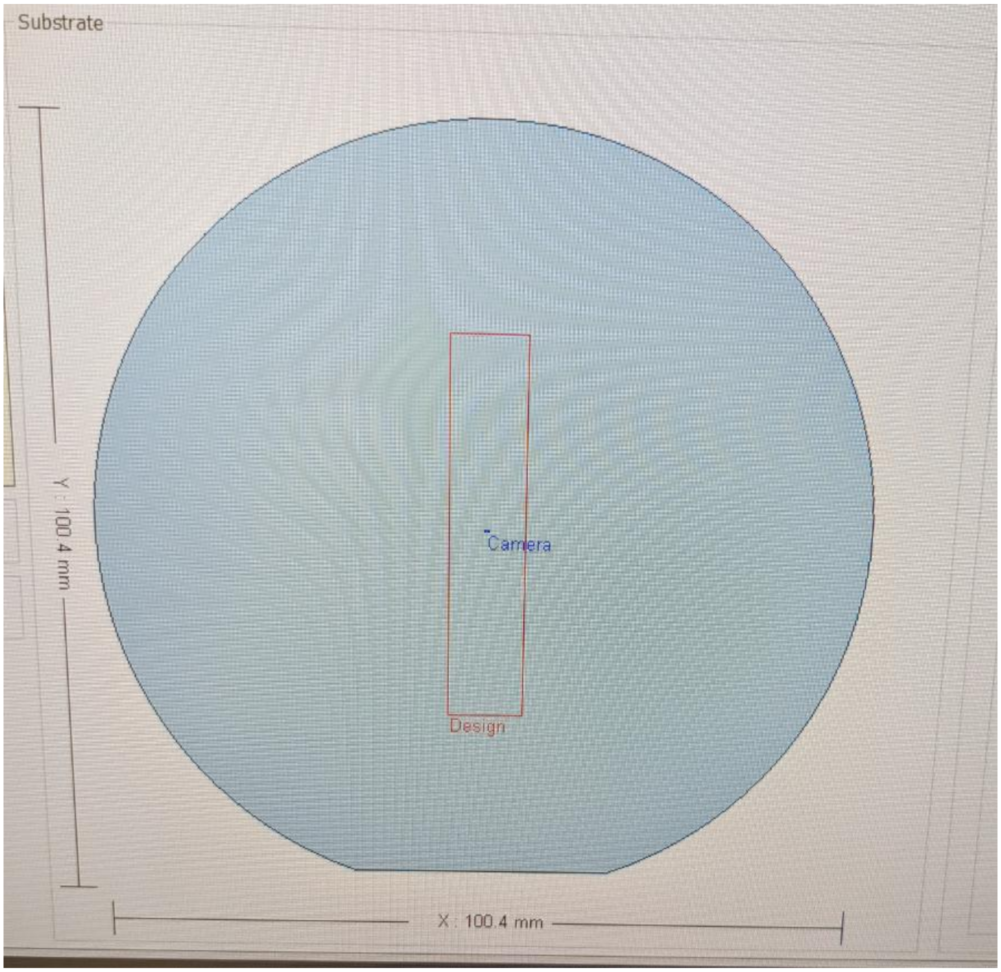


Find Plate Center:

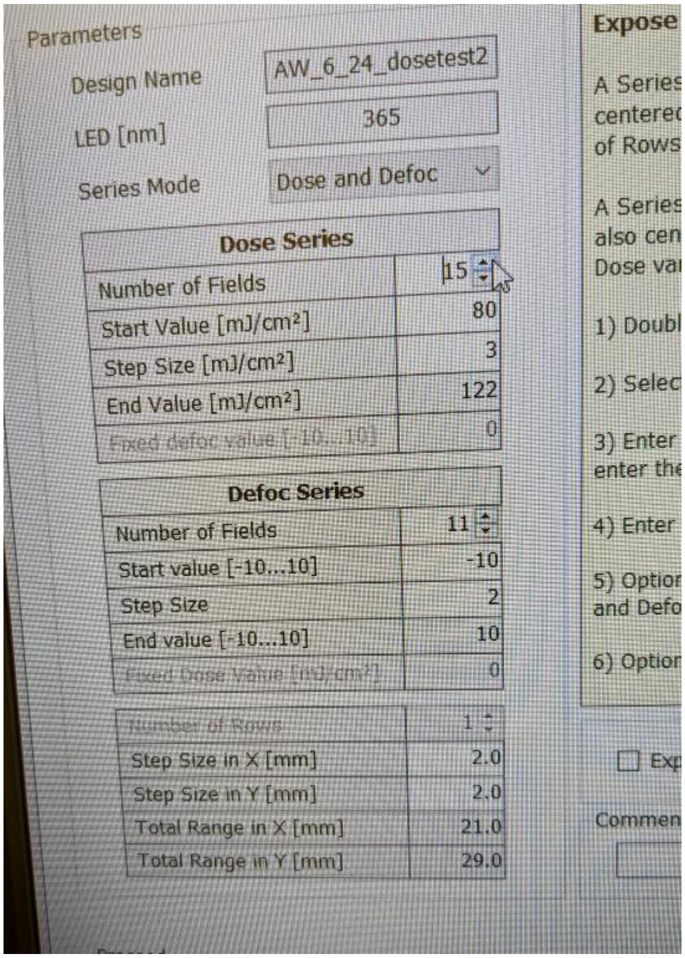
Finding the center of the Substrate...

Edge 1: Searching ... found!
Edge 2: Searching ... found!
Edge 3: Searching ... found!

19. Once edge detection finishes, the software will display a graphical approximation of what it has detected to be your sample surface, while overlaying the expected area your pattern will take up on top of it.



20. If you are running:
    - A standard exposure: Verify that the pattern being displayed on the graphical depiction of your pattern looks correct. If it looks good, click “Start Exposure” and wait for the machine to finish.
    - A dose test: Confirm the starting value, the step size, and the number of tests you want to run for the dose and defocus values. The graphical representation of your sample on the GUI should make it obvious whether or not the number of tests you’ve chosen will fit fully. If it looks good, click “Start Exposure” and wait for the machine to finish. If the number of tests you’ve chosen extends off of your sample, either:
    a. Decrease the spacing between each dose test
    b. Decrease the number of tests you are running
    c. Create a new, smaller .gds pattern



Parameters

Design Name: AW_6_24_dosetest2

LED [nm]: 365

Series Mode: Dose and Defoc

Dose Series	
Number of Fields	15
Start Value [mJ/cm²]	80
Step Size [mJ/cm²]	3
End Value [mJ/cm²]	122
Fixed defoc value [-10...10]	0

Defoc Series	
Number of Fields	11
Start value [-10...10]	-10
Step Size	2
End value [-10...10]	10
Fixed Dose Value [mJ/cm²]	0

Number of Rows	1
Step Size in X [mm]	2.0
Step Size in Y [mm]	2.0
Total Range in X [mm]	21.0
Total Range in Y [mm]	29.0

21. Once the exposure finishes, the system will ask you if you want to unload your wafer. If you are done, click “Yes”, wait for the scanhead to retract and the stage to stop moving, then remove the wafer and prepare it for development. Otherwise, click “No”, then start again with a New Job and a new .job file.