

Heidelberg MLA 150 Maskless Aligner  
Standard Operating Procedure Rev B  
AggieFab  
Texas A&M University

1. Brief introduction
2. Exposure procedures
  - Standard – 1<sup>st</sup> and 2<sup>nd</sup> layer (overlay exposure)
  - Series exposure
3. Tips for AutoCAD users

# Scope and Safety

- SCOPE

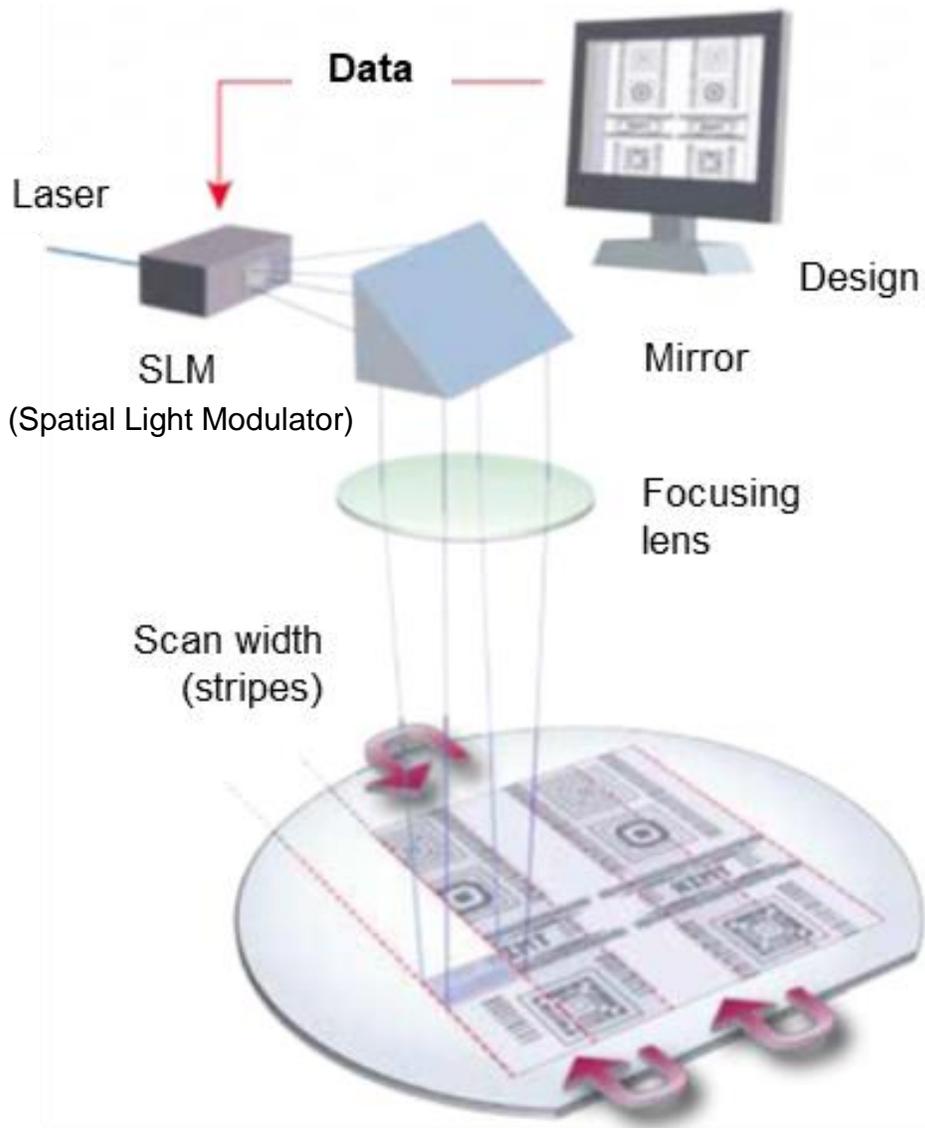
- The purpose of this document is to describe requirements and basic operating instructions for the Heidelberg MLA150 Maskless Lithography System. The use of this tool is limited to approved processes only.

- SAFETY

- Be sure that you are trained and signed off to use this equipment.
- Be sure to keep all doors and protective shields in place before operating this equipment.
- Use care when operating around high voltage or high current.
- If you are unsure about any procedure or indication while operating this equipment be sure to contact a staff member or trainer for assistance.

System features	
Laser wavelength (nm)	375
Substrate size (mm <sup>2</sup> )	5X5 – 200X200
Substrate thickness (mm)	0-12
Minimum feature size (μm)	0.6
Global 2 <sup>nd</sup> layer alignment (3σ, nm)	500
Local 2 <sup>nd</sup> layer alignment (3σ, nm)	100
Grayscale	128 gray levels

# Work flow



## Design file generation

- GDSII, DXF, CIS, and Gerber formats



## Job file generation in the Heidelberg MLA150 PC

- Input laser exposure parameters
- Convert design to machine-readable data

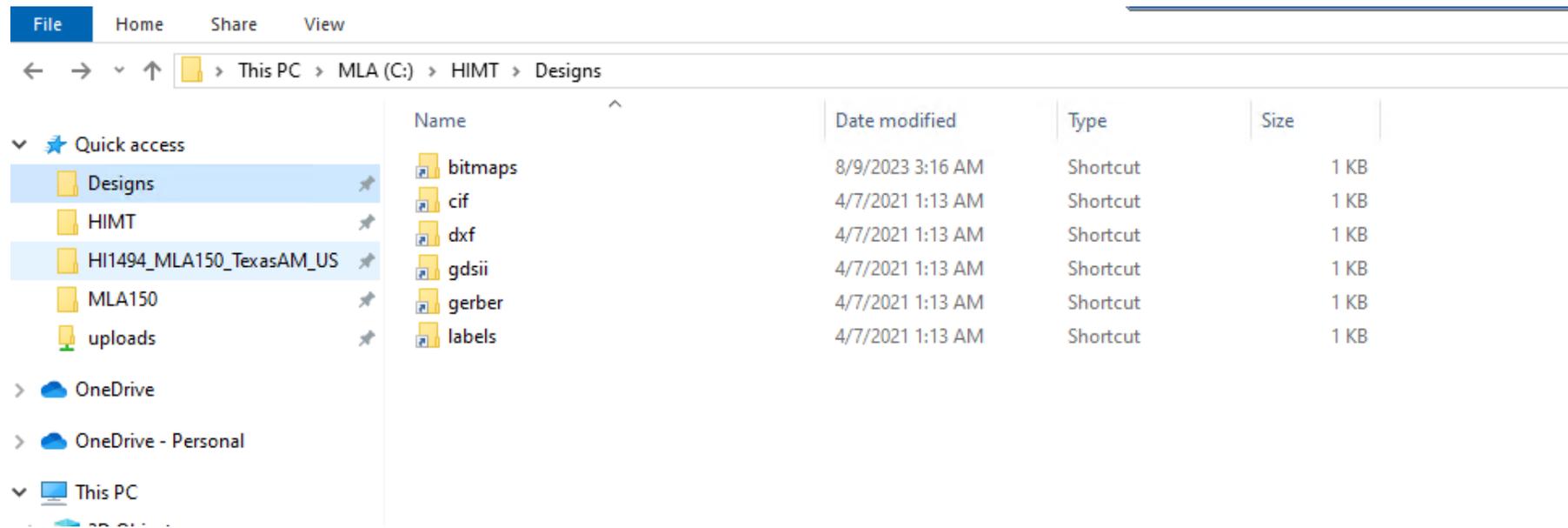


## Exposure

- **Standard:** binary lithography
- **Series:** dose and focus tests for optimization
- **Draw:** adding features to a previously patterned substrate such as lines, shapes, or bitmap.

# Save your design file in a proper location

1. Open Windows explorer
2. Copy your file in a proper according to your file format.
  - For example, test.gds file should be placed in the gdsii directory (Designs/gdsii/your place)
  - No special characters or spaces are not allowed.
  - Extension should be lower case (**test.GDS** will not appear during conversion)



# Main software

The screenshot shows the main software interface with several information panels:

- Exposure Info:**

Job Name	Job_0428	No.	428
Substrate Size [mm]		Height	
Design Name	NanoCavity_layer1_t	Layer	First Exp
Design Type	Binary	Convert	Prepare
Design Size [mm]	125.0 x 125.0	Mode	Quality
Dose [mJ/cm <sup>2</sup> ]		Defoc	
- Alignment Info:**

Exposure Bitmap Positions		
Pos	X [μm]	Y [μm]
1		
2		
3		
4		
Positions		

Alignment Cross Positions		
Pos	X [μm]	Y [μm]
1		
2		
3		
4		
Positions		
- Progress Info:**

Exposure Status		
Design Number		of
Stripe Number		of
Time [hh:mm]		of
Remaining Time [hh:mm]		
- Hardware Info:**

X [mm]	0.000	Y [mm]	0.000
--------	-------	--------	-------

Status	
DMD	OK
Interferometer	OK
Window	OK
Write Head	Initialized
Stage	OK
Cameras	OK
Laser	OK
Conversion	OK

Numeric Values	
Z Motor [Steps]	0
Piezo [Steps]	65535
Stage Air Pressure	OK
AF Air Pressure [bar]	Off
Chuck Vacuum [bar]	-0.04
DMD Voltage [V]	5.13
Laser Power [%]	100.0
Laser Wavelength [nm]	375

## Information

The Setup Job dialog box includes the following sections:

- Job:** Name (Job\_0428), Number (428), Exposure Mode (Standard). Buttons: New Job, Restart Job, Load Job, Save Job.
- Substrate:** Substrate Template (Wafer 4 inch), Shape (Round), Size X [mm], Size Y [mm], Diameter [mm] (100), Thickness [mm] (0.5).
- Layer:** Table with columns: Layer, Laser [nm], Laser Power [%], Focus Mode, Design, Mode, Exposure Bitmaps, Alignment Settings, Resist, Status, Dose [mJ/cm<sup>2</sup>], Defoc, Duration, Angle [mRad], Date.

Instructions for the numbered callouts:

- 1) Job: Load a Job or enter the name for a new Job. Select the Exposure Mode.
- 2) Substrate: Choose a Substrate template or shape.
- 3) Layer: Select the Layer to expose. In the chosen Layer, select the Lightsource wavelength and load or create a Design. For overlay exposure, load Alignment template.
- Optional: In the chosen Layer select a Resist template.

## Instructions

1. **Job name:** machine generates it.

2. **Exposure Mode:** exposure option

3. **Selection proper substrate template**

4. **Focus mode:** 'Optical' or 'Pneumatic'

5. **Design CAD file -> machine-readable file**

6. **Resist:** a file for exposure information, required exposure parameters can be typed in manually later

'Standard': standard binary exposures, single, overlay exposures

'Series': dose and focus test on a single substrate

'Draw': draw shapes onto substrate via view camera

'Optical' for high resolution (0.6 - 1μm features are in the design)

'Pneumatic': focusing using pressure sensing (> 1μm features)

# Standard exposure (1<sup>st</sup> layer)

## Start a new job from your new design

1. Click 'New Job' button
2. Select Exposure mode
3. Double click the 'Substrate Template' and choose the substrate.
4. Double click the 'Design' and convert your design from CAD file.

## Restart a job

1. Click 'Restart Job' button

## Load a job

1. Click 'Load Job' button
2. Then, click 'Restart Job' go further

The screenshot displays the software interface with a sidebar on the left containing a tree view with 'Setup Job' selected. The main area is divided into three panels: 'Exposure Info', 'Alignment Info', and 'Setup Job'. The 'Setup Job' panel is the primary focus, showing fields for Job Name (Job\_0399), Number (399), and Exposure Mode (Standard). It includes buttons for 'New Job', 'Restart Job', 'Load Job', and 'Save Job'. Below these are sections for 'Substrate' (with fields for Substrate Template, Shape, Size X, Size Y, Diameter, and Thickness) and 'Layer' (with a table for Layer, Laser, Laser Power, Focus Mode, Design, Mode, and Exposure Bitmaps). A yellow box on the right lists '1) Job: t', '2) Subst', '3) Layer', and 'Optional'. Blue arrows point from the text instructions to the 'New Job' button, the 'Restart Job' button, and the 'Load Job' button.

Job Name	Job_0399	No.	399
Substrate Size [mm]		Height	
Design Name		Layer	First Exp
Design Type		Convert	
Design Size [mm]		Mode	
Dose [mJ/cm <sup>2</sup> ]		Defoc	

Pos	X [μm]	Y [μm]
1		
2		
3		
4		
Positions		

Job	Name	Number	Exposure Mode	New Job	Restart Job
	Job_0399	399	Standard		

Substrate Template	Shape	Size X [mm]	Size Y [mm]	Diameter [mm]	Thickness [mm]

Layer	Laser [nm]	Laser Power [%]	Focus Mode	Design	Mode	Exposure Bitmaps
FirstExposure	375	100%	Pneumatic			

# Standard exposure

# Selection of a substrate template

Exposure Info

Job Name	Job_0399	No.	399
Substrate Size [mm]		Height	
Design Name		Layer	First Ex
Design Type		Convert	
Design Size [mm]		Mode	
Dose [mJ/cm <sup>2</sup> ]		Defoc	

Alignment Info

Pos	X [μm]	Y [μm]
1		
2		
3		
4		

1. Double click '**Substrate Template**': the software will bring you to the Load substrate (below)
2. Select a template that fits your substrate. If not found, choose one with similar dimensions with your substrate.

### Setup Job

Job

Name	Number	Exposure Mode	New Job	Restart Job
Job_0399	399	Standard	Load Job	Save Job

Substrate

Substrate Template	Shape	Size X [mm]	Size Y [mm]	Diameter [mm]	Thickness [mm]

Layer

Layer	Laser [nm]	Laser Power [%]	Focus Mode	Design	Mode	Exposure Bitmaps
FirstExposure	375	100%	Pneumatic			

### List of substrate template

substrate information

Name	Date	Time	Shape	Size Type	Size x	Size y	Diameter	Thickness
_Automatic rectangular	6/23/2016	8:41:38 AM	Rectangular	Undefined	0	0	0	0
_Automatic round	7/7/2016	2:45:50 AM	Round	Undefined	0	0	0	0
Chip	11/27/2023	2:48:30 PM	Rectangular	Standard	25	25	0	0.5
chip_half_inch	12/7/2023	2:52:15 PM	Rectangular	Standard	15	15	0	0.5
cover_glass_1	10/24/2023	3:34:23 PM	Rectangular	Standard	20	20	0	1.25
ITO_glass	12/1/2023	3:17:07 PM	Rectangular	Standard	50	50	0	1.1
Mask 2_5 inch	8/17/2023	3:21:43 AM	Rectangular	Standard	63.5	63.5	0	1.6
Mask 4 inch	8/17/2023	3:21:53 AM	Rectangular	Standard	101.6	101.6	0	2.3
Mask 5 inch	8/17/2023	3:22:00 AM	Rectangular	Standard	127	127	0	2.3
Mask 6 inch	8/17/2023	3:22:10 AM	Rectangular	Standard	152.4	152.4	0	0
Small	4/5/2016	3:33:52 AM	Rectangular	Small	5	5	0	0
Wafer 2 inch	4/5/2016	3:28:38 AM	Round	Standard	0	0	50.8	0.28
Wafer 3 inch	4/5/2016	3:29:14 AM	Round	Standard	0	0	76.2	0.38
Wafer 4 inch	4/18/2024	2:15:39 PM	Round	Standard	0	0	100	0.5
Wafer 5 inch	4/1/2022	8:10:34 AM	Round	Standard	0	0	127	0.625
Wafer 6 inch	4/1/2022	8:11:14 AM	Round	Standard	0	0	150	0
Wafer 8 inch	6/17/2016	6:49:52 AM	Round	Standard	0	0	200	0
Wafer 9 inch	6/9/2023	7:25:55 AM	Round	Extended	0	0	228.6	0

Characteristics

Name	Mask 4 inch
Shape	Rectangular
Size Type	Standard
Size X [mm]	101.6
Size Y [mm]	101.6
Diameter [mm]	0.0
Thickness [mm]	2.30
Focus at Thickness [mm]	
Detection Offset [mm]	0.00

Advanced Parameters

Autofocus Mode	Undefined
Check with Overview Camera	<input type="checkbox"/>
Skip Find Plate Center (FPC)	<input type="checkbox"/>
FPC: Use Piezo Freezing	<input checked="" type="checkbox"/>
Focus Offset X / Y [mm]	0.0 / 0.0
Focus Offset Z [mm]	0.000
Max Velocity [mm/s]	0.0
Stop Autofocus Air	<input type="checkbox"/>
Expose with Camera Focus	<input type="checkbox"/>

Edit

New Copy Edit Save Delete

# Converting your CAD file to the machine processable file

1. Double-click the 'Design' in the Layer section → Design Conversion screen below
2. Click 'Conversion Design'. Then, small window will be popped left top. Be patience!

**Setup Job**

Job Name: Job\_0399, No.: 399

Substrate Size [mm]: , Height: , Layer: First Exp, Design Name: , Design Type: Convert, Design Size [mm]: , Mode: , Dose [mJ/cm²]: , Defoc: ,

**Layer**

Layer	Laser [nm]	Laser Power [%]	Focus Mode	Design	Mode	Exposure Bitmaps
FirstExposure	375	100%	Pneumatic			

**Load Design**

Prepare: **Convert Design** Load Cancel Refresh

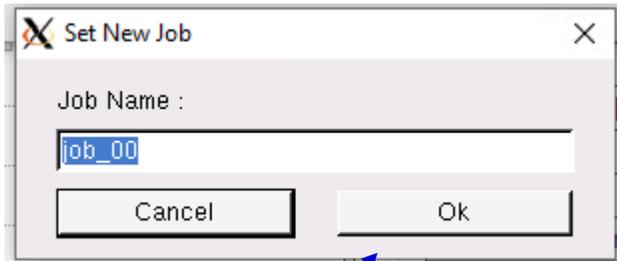
Name	Start Conversion software	Mode	Size X	Size Y	Source file	Prep Mode
dose_test	10/18/2023 2:54:43 PM	Quality	18.75	18.75	dose_test	Completed
NanoCavity1	10/17/2023 4:19:01 PM	Quality	86	86	Nanocavity1	Completed
m1a_50	10/16/2023 4:18:44 PM	Quality	50	49.152	MLA1000_50mm	Prepared
FAT_100mm_L1	10/13/2023 12:23:04 PM	Quality	100	98.304	MLA1000_100mm	Completed
FAT_100mm_L2	10/13/2023 12:38:33 PM	Quality	99.8	98.304	MLA1000_100mm	Prepared
MLA1000_L2	10/12/2023 12:53:58 PM	Quality	2.8	8.192	MLA1000	Prepared
MLA1000_L1	10/12/2023 12:51:00 PM	Quality	3	10.96	MLA1000	Completed
FAT_Q_1708	8/17/2023 3:54:31 AM	Quality	96.96	103.051113	MLA320_Version0	Completed
Test200mm	8/16/2023 5:33:53 AM	Quality	200	200	MLA320_Version0	Completed
DoseDefoc	8/16/2023 3:30:01 AM	Quality	0.64	1.62	MLA320_Version0	Completed
Extendedarea_200x200F	8/16/2023 2:31:52 AM	Fast	200	200	MLA320_Version0	Prepared
Extendedarea_200x200	8/16/2023 2:26:47 AM	Quality	300	200	MLA320_Version0	Prepared
newUEA	8/15/2023 9:54:45 AM	Quality	200	200	MLA320_Version0	Prepared
200mm_UEA	8/15/2023 8:00:44 AM	Fast	200	200	MLA320_Version0	Completed
Test_200mm	8/15/2023 7:47:07 AM	Fast	200	200	MLA320_Version0	Prepared
Longlines	8/15/2023 3:53:36 AM	Fast	15.750625	120.3	longlines	Completed
job_01	8/15/2023 3:18:16 AM	Quality	1.075	2.066	pfm800	Prepared
FAT_L1_Quality	8/11/2023 7:22:04 AM	Quality	118	117.999998	MLA320_Version0	Completed
HIMT_Pyramids	8/11/2023 4:17:39 AM	Quality	1.02	3.825	4pyras_dxf	Completed
HIMT_Lenses	8/11/2023 4:15:38 AM	Quality	0.12	0.48	MLA_convex.bmp	Completed
FAT_L2_Quality	8/10/2023 2:06:57 AM	Quality	96.84	98.951	MLA320_Version0	Prepared

# Continued

1. Click 'new' or File - new

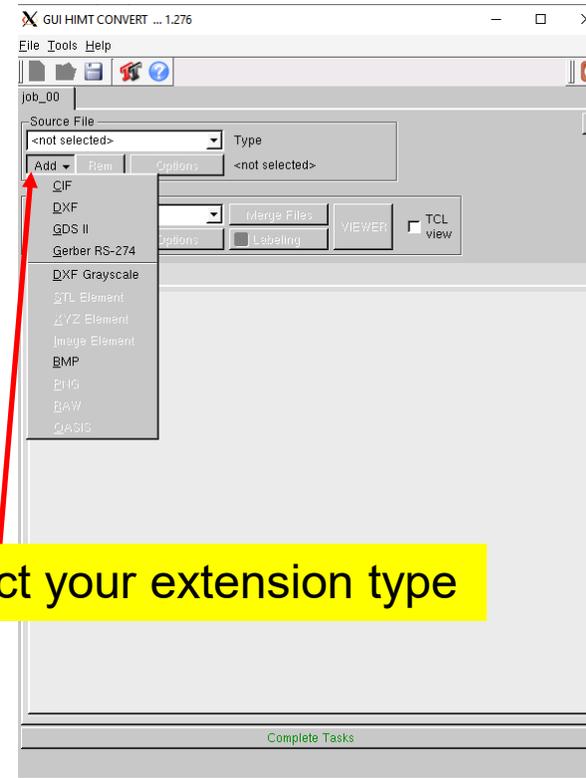


Extended Window for file name



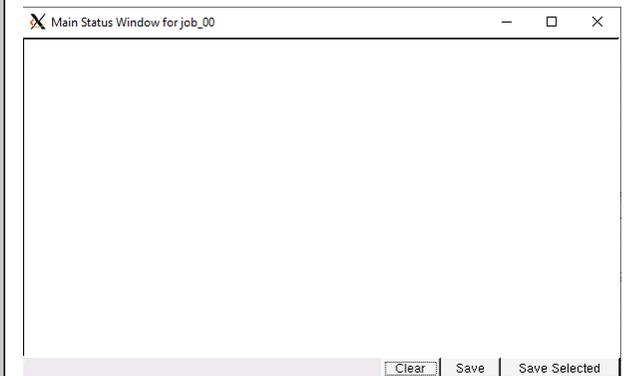
Input your file name, if you want.  
Click Ok for moving forward

1. From the popped up window, Click 'new' icon or in the menu, File – new
2. A new small window. Input your file name and click Ok.
3. Extended window, click 'Add' button and select the file type you brought from the Window system.

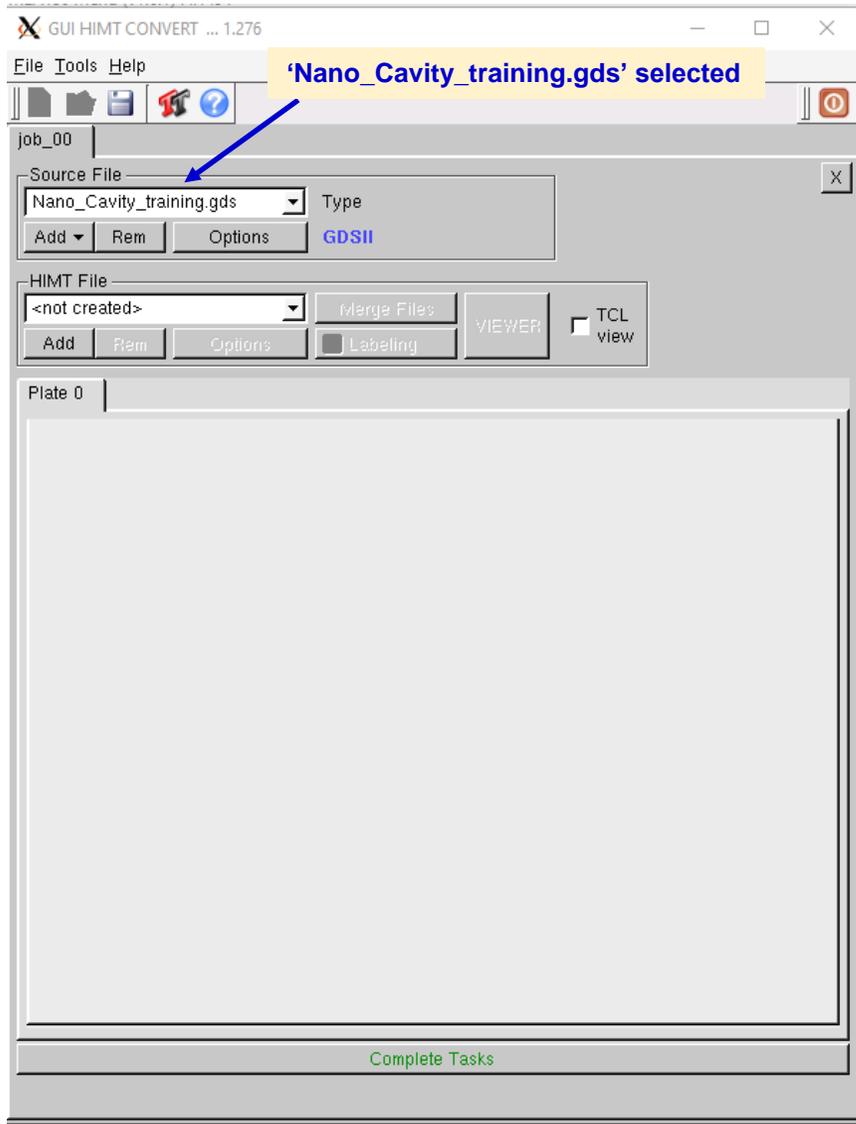


3. Click 'add' and select your extension type

Message window



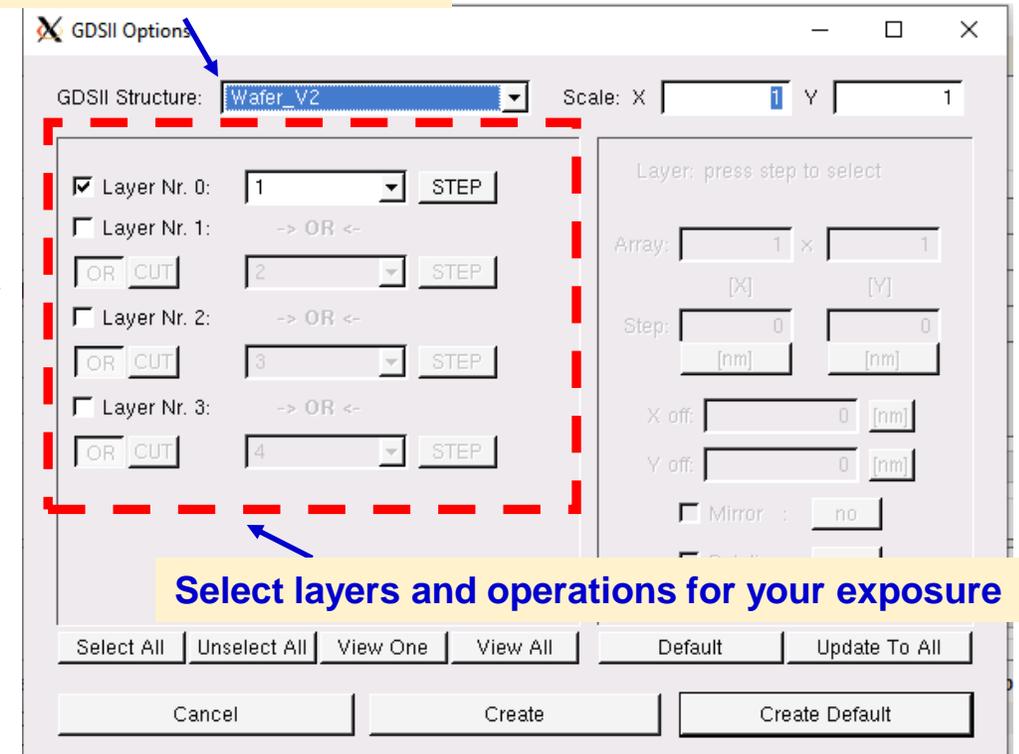
# Continued (example with .gds file)



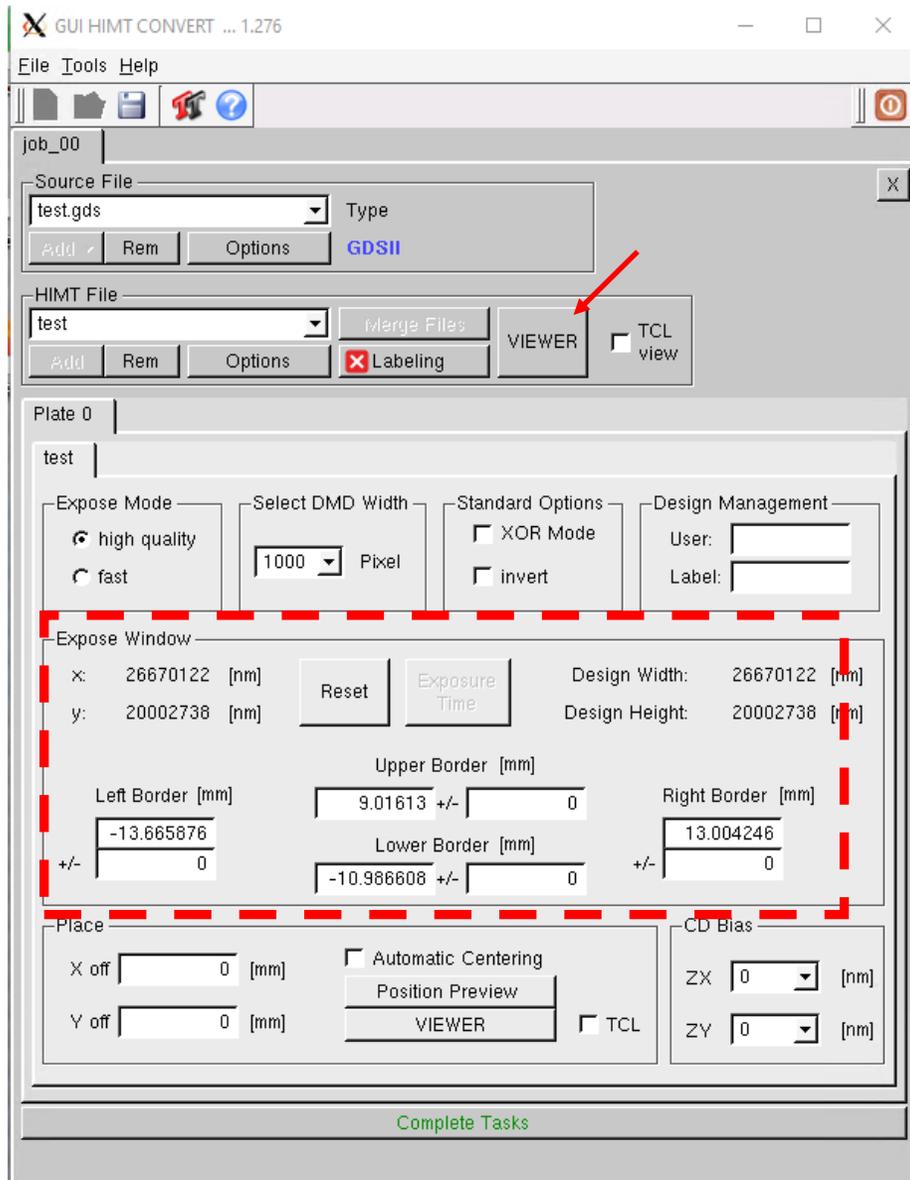
1. For .gds, both the cell and the layer should be selected properly.
2. The cell can be selected on the drop down menu of 'GDSII Structure'
3. In the red dashed box, the layer can be selected.
4. Complete by 'Create' or 'Create Default'

Another popup window. The detail depends on the cad file structures

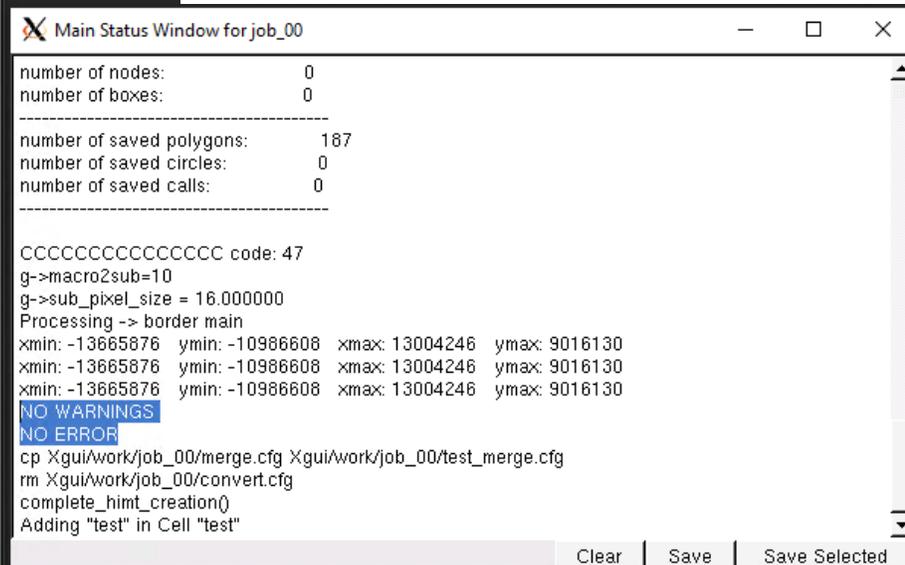
'Wafer\_V2' cell selected



# Continued



1. Check your design with 'VIEWER' if you want
2. Set parameters
3. Check your design boundary (red box)
4. Check the message window
  1. Make sure there is no error.
  2. WARNINGS mostly accepted
5. Everything is okay, click '**Complete Tasks**' and save your job file



File Tools User Info About

- Setup Job
- Load Substrate
- Expose Job
  - First Exposure
  - Alignment
  - Series
  - Draw Mode
  - Inspection

### Exposure Info

Job Name	Job_0428	No.	428
Substrate Size [mm]		Height	
Design Name		Layer	First Exp
Design Type		Convert	
Design Size [mm]		Mode	
Dose [mJ/cm <sup>2</sup> ]		Defoc	

### Alignment Info

Exposure Bitmap Positions

Pos	X [μm]	Y [μm]
1		
2		
3		
4		

Alignment Cross Positions

Pos	X [μm]	Y [μm]
1		
2		
3		
4		

### Progress Info

Exposure Status	
Design Number	of
Stripe Number	of
Time [hh:mm]	of
Remaining Time	

### Hardware Info

X [mm]	0.000	Y [mm]	0.000
--------	-------	--------	-------

Status

DMD	OK
Interferometer	OK
Window	OK
Write Head	Initialized
Stage	OK
Cameras	OK
Laser	OK
Conversion	OK

Numeric Values

Z Motor [Steps]	0
Piezo [Steps]	65535
Stage Air Pressure	OK
AF Air Pressure [bar]	Off
Chuck Vacuum [bar]	-0.04
DMD Voltage [V]	5.13
Laser Power [%]	100.0
Laser Wavelength [nm]	375

**You will see your design file converted to a job file.  
Click 'Refresh' may show your file.**

### Load Design

Prepare

**Convert Design**   **Load**   Cancel   Refresh

Search

Search   Clear

Show

All    Next   100   Next

Loaded: 34 / 37

#### Characteristics

Name	NanoCavity_layer1_training		
Source	Nano_Cavity_training		
Design Type	Binary		
Mode	Quality	Prepared	
Layer / Cell	CM		
Mirror	off		
XOR	off		
Inverted	off		
CD Bias [nm]	0	0	0
Size [mm]	125.000	125.000	
Borders l/r [mm]	-62.500	62.500	
Borders b/t [mm]	-62.500	62.500	
Offset [mm]	-62.500	-62.500	
Auto Centering	off		

Edit

Complete Designs   Delete Design

Comment

Name	Date	Time	Mode	Size X	Size Y	Source file	Prep Mode	Design Type	Bi Dir	Layer / Cell	Mirror	XOR	Inverted	CD bias X	CD bias Y	Auto Center	Offset X	Offset Y
NanoCavity_layer1_training	10/22/2023	2:57:37 PM	Quality	125	125	Nano_Cavity_training	Prepared	Binary	True	CM	off	off	off	0	0	off	-62500000	-62500
dose_test	10/18/2023	2:54:43 PM	Quality	18.75	18.75	dose_test	Completed	Binary	True	CM	off	off	off	0	0	off	-9375000	-93750
NanoCavity1	10/17/2023	4:19:01 PM	Quality	86	86	Nanocavity1	Completed	Binary	True	CM	off	off	off	0	0	off	-43000000	-43000
m1a_50	10/16/2023	4:18:44 PM	Quality	50	49.152	MLA1000_50mm	Prepared	Binary	True	CM	off	off	off	0	0	off	-25000000	-24576
FAT_100mm_L1	10/13/2023	12:23:04 PM	Quality	100	98.304	MLA1000_100mm	Completed	Binary	True	CM	off	off	off	0	0	off	-50000000	-49152
FAT_100mm_L2	10/13/2023	12:38:33 PM	Quality	99.8	98.304	MLA1000_100mm	Prepared	Binary	True	CM	off	off	off	0	0	off	-49900000	-49152
					8.192	MLA1000	Prepared	Binary	True	CM	off	off	off	0	0	off	-1400000	-40960
					10.96	MLA1000	Completed	Binary	True	CM	off	off	off	0	0	off	-1500000	-54800
					103.051113	MLA320_Version0	Completed	Binary	True	CM	off	off	off	0	0	off	-48479998	-49999
Test200mm	8/16/2023	5:33:53 AM	Quality	200	200	MLA320_Version0	Completed	Binary	True	CM	off	off	off	0	0	off	-99999999	-10000
DoseDefoc	8/16/2023	3:30:01 AM	Quality	0.64	1.62	MLA320_Version0	Completed	Binary	True	CM	off	off	off	0	0	off	-1600000	-12000
Extendedarea_200x200F	8/16/2023	2:31:52 AM	Fast	200	200	MLA320_Version0	Prepared	Binary	True	CM	off	off	off	0	0	off	-100000000	-10000
Extendedarea_200x200	8/16/2023	2:26:47 AM	Quality	300	200	MLA320_Version0	Prepared	Binary	True	CM	off	off	off	0	0	off	-200000000	-10000
newUEA	8/15/2023	9:54:45 AM	Quality	200	200	MLA320_Version0	Prepared	Binary	True	CM	off	off	off	0	0	off	-99999999	-10000
200mm_UEA	8/15/2023	8:00:44 AM	Fast	200	200	MLA320_Version0	Completed	Binary	True	CM	off	off	off	0	0	off	-100000000	-10000
Test_200mm	8/15/2023	7:47:07 AM	Fast	200	200	MLA320_Version0	Prepared	Binary	True	CM	off	off	off	0	0	off	-99999999	-10000
Longlines	8/15/2023	3:53:36 AM	Fast	15.750625	120.3	longlines	Completed	Binary	True	CM	off	off	off	0	0	off	-5000625	-60150
job_01	8/15/2023	3:18:16 AM	Quality	1.075	2.066	pfn800	Prepared	Binary	True	CM	off	off	off	0	0	off	-537500	-52100
FAT_L1_Quality	8/11/2023	7:22:04 AM	Quality	118	117.999998	MLA320_Version0	Completed	Binary	True	CM	off	off	off	0	0	off	-58999999	-58999
HIMT_Pyramids	8/11/2023	4:17:39 AM	Quality	1.02	3.825	4pyras_dxf	Completed	Grayscale_8_Bit	True	CM	off	off	off	0	0	off	-510000	-20400
HIMT_Lenses	8/11/2023	4:15:38 AM	Quality	0.12	0.48	MLA_convex.bmp	Completed	Grayscale_8_Bit	True	CM	off	off	off	0	0	off	-60000	-24000

**Double click your file or click 'Load'**

# Load your sample

1. To move forward, click 'Load Substrate' and follow instructions in each step.
2. Load your substrate

## Setup Job

Job

Name	Number	Exposure Mode	New Job	Restart Job
Job_0428	428	Standard	Load Job	Save Job

Substrate

Substrate Template	Shape	Size	The Design file selected	
Wafer 4 inch	Round	100	0.5	

Layer

Layer	Laser [nm]	Laser Power [%]	Focus Mode	Design	Mode	Exposure Bitmaps	Alignment Settings	Resist	Status	Dose [mJ/cm <sup>2</sup> ]	Defoc	Duration	Angle [mRad]	D
FirstExposure	375	100%	Pneumatic	NanoCavity_layer1_training	Quality				Prepared					

Proceed

Load Substrate First Exposure Unload Substrate

1) Job: Load a Job or enter the name for a new Job. Select the Exposure Mode.  
2) Substrate: Choose a Substrate template or shape.  
3) Layer: Select the Layer to expose. In the chosen Layer, select the Lightsource wavelength and load or create a Design. For overlay e  
Optional: In the chosen Layer select a Resist template.

# Continued

1. Load your substrate on the stage: open the window and follow the instructions in the PC or visual guide on the machine.
2. At the end of configuration, DO NOT FORGET to input **Dose** & **Defoc**

**Alignment: Exposure**

**Exposure Settings**

Design Name: job\_00

Laser [nm]: 375

Laser Power [%]: 100%

Focus Mode: Pneumatic

Dose [mJ/cm<sup>2</sup>]: 400

Defoc [-10...10]: 0

**Alignment Correction Options**

Rotation [mRad]: -27.845  Use

Scaling X / Y: 0.999971 / 1.000006  Use

Shearing [mRad]: -0.012  Use

Auto-Unload the Substrate

Delay Exposure [hh:mm]

Comment:

Expose the Bitmaps

**4-Point-Alignment completed!**

- 1) Double-check the Exposure Settings.
- 2) Select the Alignment Correction Options.
- 3) Optional: Expose Bitmaps or expose as Field Alignment.
- 4) Optional: Delay the Exposure.
- 5) Start the exposure.

**Substrate**

Y: 21.1 mm

X: 20.7 mm

Design

Camera

**Proceed**

Start Exposure Back Setup Job

## 2<sup>nd</sup> layer exposure (overlay exposure)

- Alignment marker information
- Finding and accepting markers on a substrate

# Standard exposure – 2<sup>nd</sup> layer (overlay exposure)

1. Start existing or new job and fill the Substrate Template
2. Click 'Add Layer' to bring a new layer
3. Put your design
4. Fill out the 'Alignment Settings'

Setup Job

Job

Name	Number	Exposure Mode
Job_0428	428	Standard

New Job Restart Job  
Load Job Save Job

Substrate

Substrate Template	Shape	Size X [mm]	Size Y [mm]	Diameter [mm]	Thickness [mm]
Wafer 4 inch	Round			100	0.5

Layer

Layer	Laser [nm]	Laser Power [%]	Focus Mode	Design	Mode	Exposure Bitmaps	Alignment Settings	Resist	Status	Dose [mJ/cm <sup>2</sup> ]
FirstExposure	375	100%	Pneumatic	NanoCavity_layer1_training	Quality				Prepared	
Layer2	375	100%	Pneumatic						Prepared	

Add Layer Copy Layer Delete Layer

Proceed

Load Substrate Alignment Unload Substrate

1) Job: L  
2) Substr  
3) Layer: Select the Layer to expose. In the chosen Layer, select the Lightsource wavel  
Optional: In the chosen Layer select a Resist template.

# Standard exposure – 2<sup>nd</sup> layer

## Load Alignment Settings

Alignment settings

Top Surface

Pos	X [ $\mu\text{m}$ ]	Y [ $\mu\text{m}$ ]
5		
6		
7		
8		

Positions 1

Camera for Alignment

Low Resolution

High Resolution

Alignment Correction Options

Rotation [mRad]  Use

Scaling X / Y  Use

Shearing [mRad]  Use

Move to Zero after last position

Edit

New Copy Cancel Save Delete

Comment

Load

Search

Show

Load Cancel Refresh

Search Clear

All Next 100 Next

Loaded: 15 / 15

Name ^	Date	Time	X1	Y1	X2	Y2	X3	Y3	X4	Y4	X5	Y5	X6	Y6	X7	Y7	X8	Y8	#Positions	Camera Mode	Camera
_Manual	5/7/2018	2:49:50 AM	0	0															1	Frontside	Macro
001	3/29/2024	10:32:11 AM	-8500	0	8500	0	0	8500	0	-8500									4	Frontside	Macro
111	2/23/2024	4:21:48 PM	-40180	0	39800	0													2	Frontside	Macro
3inchall	1/22/2024	12:18:56 PM	-35000	-9500	35000	-9500	-10800	32500	9000	-35500									4	Frontside	Macro
Cap_V2	2/12/2024	2:50:09 PM	-8500	0	0	8500	8500	0	0	-8500									4	Frontside	Macro
dielectric	1/18/2024	1:12:17 PM	-3500	4000	-3500	-3700	3500	-3700	3500	4000									4	Frontside	Micro
Dwayne_layer2	12/14/2023	2:49:42 PM	-9000	9000	9000	9000	-9000	-9000	9000	-9000									4	Frontside	Macro
gratingcover	1/21/2024	4:45:41 PM	8000	0	-8000	0	0	8000	0	-8000									4	Frontside	Macro
Job0641_L1	1/21/2024	4:59:22 PM	8000	0	-8000	0	0	8000	0	-8000									4	Frontside	Macro
Job0642_L1	1/22/2024	12:28:58 PM	-27000	-1500	27000	-1500	-10800	32500	17000	-27500									4	Frontside	Macro
NanoCavity_layer2	3/1/2024	1:14:56 PM	-8500	0	0	8500	8500	0	0	-8500									4	Frontside	Macro
new	3/28/2024	3:19:49 PM	-40180	0	39820	0													2	Frontside	Macro
Sahar	3/27/2024	12:28:17 PM	-25078.2	9355.7	30802.8	9364.2													2	Frontside	Macro
training	2/13/2024	10:48:28 AM	-40180	0	39820	0													2	Frontside	Macro
yyyy	4/30/2024	2:20:59 PM	8500	0	-8500	0	0	8500	0	-8500									4	Frontside	Macro

1. Select your file if exists.
2. Click 'New' if you need to make your file for your markers.
3. Then, put the title and your markers' coordinates, up to eight.
4. Save and Load it.

# Load your sample

## Substrate

Substrate Template	Shape	Size X [mm]	Size Y [mm]	Diameter [mm]	Thickness [mm]
chip_half_inch	Rectangular	15	15		0.5

3) Layer: Select the Layer to expose. In the chosen Layer, select the Lightsource wavelength and load or cr

Optional: In the chosen Layer select a Resist template.

## Layer

Layer	Laser [nm]	Laser Power [%]	Focus Mode	Design	Mode	Exposure Bitmaps	Alignment Settings	Resist	Status	Dose [mJ/cm <sup>2</sup> ]	Defoc	Du
FirstExposure	375	100%	Pneumatic	job_00	Quality				Prepared			
Layer2	375	100%	Pneumatic	job_00	Quality		YYYY		Prepared			
Layer3	375	100%	Pneumatic	job_00	Quality				Prepared			

Select your proper layer: Layer 3 is selected.  
Then, Load Substrate will be activated.  
Follow the instructions for loading your substrate

Add Layer

Copy Layer

Delete Layer

## Proceed

▶ Load Substrate

▶▶ Alignment

⏏ Unload Substrate

# Standard exposure – 2<sup>nd</sup> layer

## Alignment page

1. You will have options for alignments. Select one.
2. Click 'Move To First Cross'
3. Search your marker on the camera screen and 'Measure'
4. 'Accept Position' if you are satisfied
5. Repeat until you are done with your markers

### Alignment

#### Alignment Settings

Top Surface	WVY	Edit	
Top Surface		Original	
Pos	X [μm]	Y [μm]	
1	8500	0	
2	-8500	0	
3	0	8500	
4	0	-8500	
Positions	4		

Use Angle (-21.72 mRad) Move To First Cross

#### Cross Measurement

Alignment Mode  
CrossAlignment Skip Position

Resize Detection Area Angle [mRad] 0

Measure Accept Position

#### Proceed

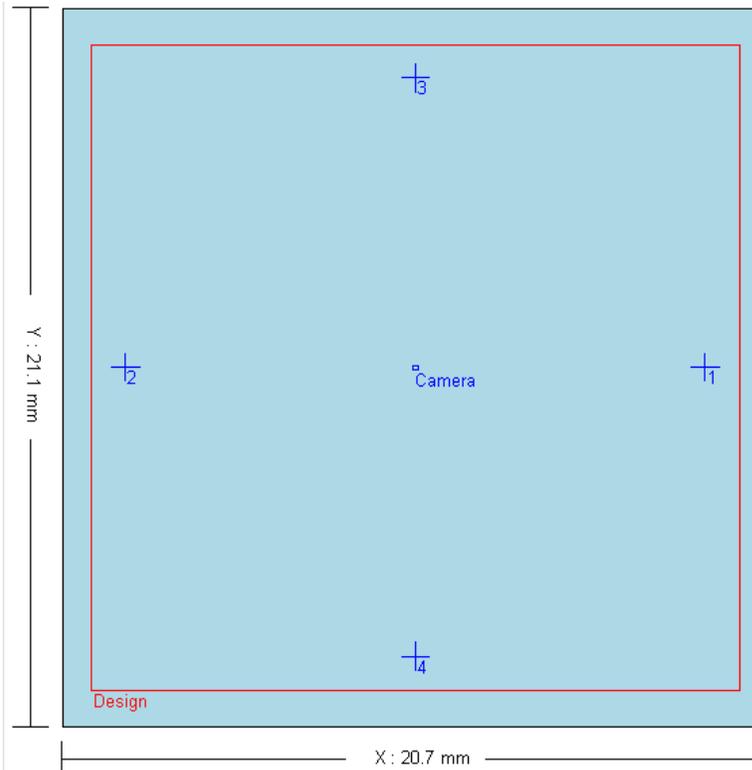
Continue Restart Setup Job

by double click the alignment cross positions.

**Find the Alignment cross positions:**

- 1) Use the Stage Control to move the **first** Alignment cross to the camera center.
- 2) If the cross is smaller than the camera window, mark it using the button **Resize Detection Area**.

Note:  
Choose lower resolution cameras to help finding the cross.  
If required optimize the camera picture with the 'Focus' and the 'Brightness' sliders.  
When skipping alignment positions, two positions must remain.



### Stage and Camera Control

#### Camera Control

Overview Low Res High Res

Focus [-10...10] 0

Brightness [...] 314

#### Stage Control

Driving Speed [um/s] 10

X / Y Step [μm] 5000 5000

Move To Zero Substrate Center

Set Zero Stop

# Continued

1. Load your substrate on the stage: open the window and follow the instructions in the PC or visual guide on the machine.
2. At the end of configuration, DO NOT FORGET to input **Dose** & **Defoc**

**Alignment: Exposure**

**Exposure Settings**

Design Name: job\_00

Laser [nm]: 375

Laser Power [%]: 100%

Focus Mode: Pneumatic

Dose [mJ/cm<sup>2</sup>]: 400

Defoc [-10...10]: 0

**Alignment Correction Options**

Rotation [mRad]: -27.845  Use

Scaling X / Y: 0.999971 / 1.000006  Use

Shearing [mRad]: -0.012  Use

Auto-Unload the Substrate

Delay Exposure [hh:mm]

Comment:

Expose the Bitmaps

**4-Point-Alignment completed!**

- 1) Double-check the Exposure Settings.
- 2) Select the Alignment Correction Options.
- 3) Optional: Expose Bitmaps or expose as Field Alignment.
- 4) Optional: Delay the Exposure.
- 5) Start the exposure.

**Substrate**

Y: 21.1 mm

X: 20.7 mm

Design

Camera

**Proceed**

# Series exposure (1/2)

## Information

✓ Setup Job

Load Substrate

Expose Job

- First Exposure
- Alignment
- Series
- Draw Mode
- Inspection

### Exposure Info

Job Name	Job_0403	No.	403
Substrate Size [mm]		Height	
Design Name	dose_test	Layer	Series
Design Type	Binary	Convert	Prepare
Design Size [mm]	18.8 x 18.8	Mode	Quality
Dose [mJ/cm <sup>2</sup> ]		Defoc	

### Series Info

Series Parameters

Name	Dose_defoc	
Step Size X / Y [mm]	0.0	0.0
	Dose	Defoc
Number of Fields	3	5
Start Value	80	-2
Step Size	20	1
End Value	120	2

### Progress Info

Exposure Status	
Design Number	of
Stripe Number	of
Time [hh:mm]	of
Remaining Time [hh:mm]	

### Hardware Info

X [mm]	0.000	Y [mm]	0.000
--------	-------	--------	-------

Status

DMD	OK
Interferometer	OK
Window	OK
Write Head	Initialized
Stage	OK
Cameras	OK
Laser	OK
Conversion	OK

Numeric Values

Z Motor [Steps]	0
Piezo [Steps]	65535
Stage Air Pressure	OK
AF Air Pressure [bar]	Off
Chuck Vacuum [bar]	-0.82
DMD Voltage [V]	5.11
Laser Power [%]	100.0
Laser Wavelength [nm]	375

### Setup Job

1 Job

Name	Number	Exposure Mode	New Job	Restart Job
Job_0403	403	Series	Load Job	Save Job

Substrate

Substrate Template	Shape	Size X [mm]	Size Y [mm]	Diameter [mm]	Thickness [mm]
Wafer 4 inch	Round			100	0.5

Series

Series Template	Series Mode	Laser [nm]	Laser Power [%]	Focus Mode	Design	Mode	Resist	Status	Duration	Angle [mRad]	Date
Dose_defoc	Dose and Defoc	375	100%	Optical	dose_test	Quality		Prepared			

1) Job: Load a Job or enter the name for a new Job. Select the Exposure Mode.

2) Substrate: Choose a Substrate template or shape.

Optional: In the Series, you can change the template or the design and select a Resist template.

**1. Job name & number:** machine generates them

**2. Exposure Mode:** exposure option

**3. Selection proper substrate template**

**4. Selection or generation of dose and/or focus split test file**

**5. Focus mode:** 'Optical' or 'Pneumatic'

**6. Design:** your cad file

'Standard': standard binary exposures, single, overlay exposures

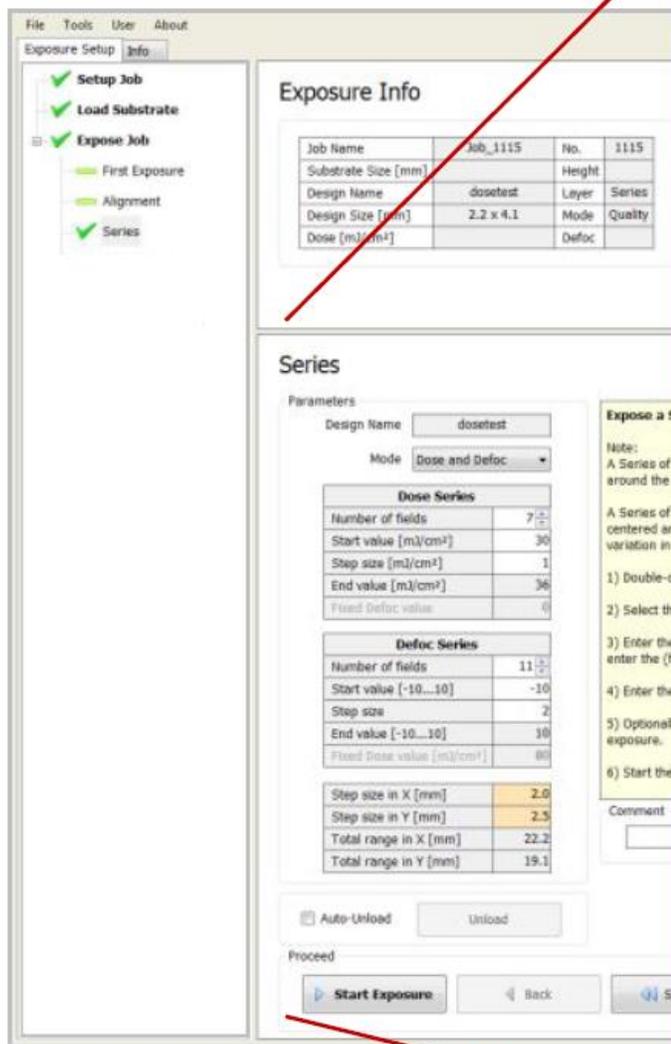
'Series': dose and focus test on a single substrate

'Draw': draw shapes onto substrate via view camera

'Optical' for high resolution (0.6 - 1 $\mu$ m features are in the design)

'Pneumatic': focusing using pressure sensing (> 1 $\mu$ m features)

# Series exposure (2/2)



## Series

Parameters

Design Name

Lightsource [nm]

Mode

**Dose Series**

Number of fields	7
Start value [mJ/cm <sup>2</sup> ]	30
Step size [mJ/cm <sup>2</sup> ]	1
End value [mJ/cm <sup>2</sup> ]	36
Fixed Defoc value	0

**Defoc Series**

Number of fields	13
Start value [-10...10]	-10
Step size	1
End value [-10...10]	2
Fixed Dose value [mJ/cm <sup>2</sup> ]	80

Step size in X [mm]

Step size in Y [mm]

Total range in X [mm]

Total range in Y [mm]

**Expose a Series of Designs:**

Note:  
A Series of just one parameter will be exposed horizontally, centered around the zero stage position.  
A Series of both parameters will be exposed two-dimensionally, also centered around the zero stage position. Defoc variation in X, Dose variation in Y.

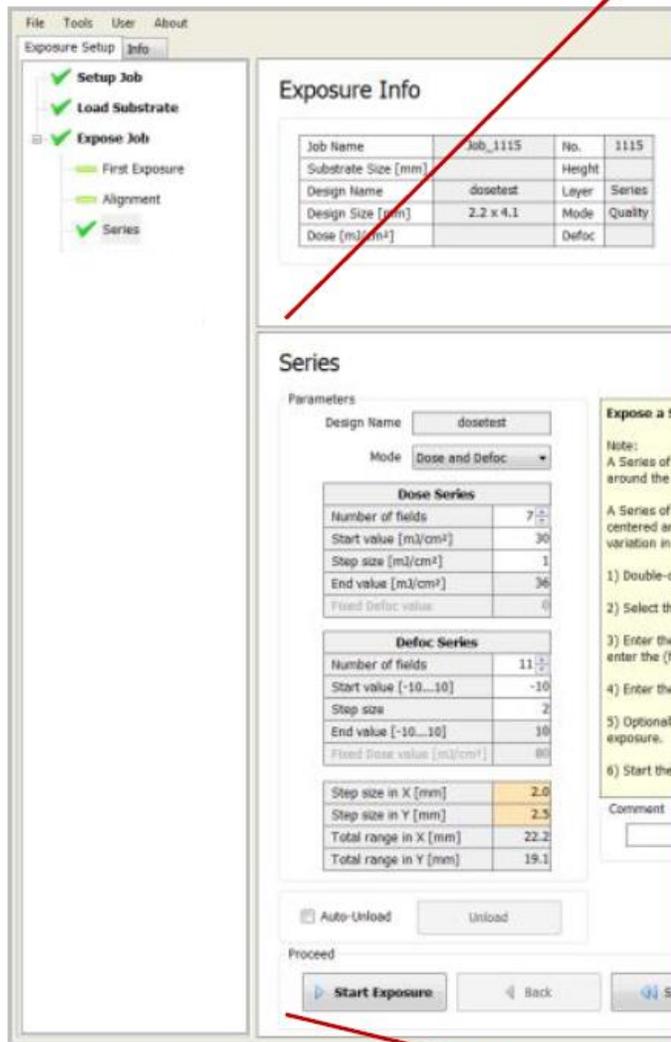
- 1) Double-check the Design Name.
- 2) Select the Mode.
- 3) Enter the Parameters. For a Series of just one parameter, also enter the (fixed) value of the remaining parameter.
- 4) Enter the step size between two adjacent Designs.
- 5) Optionally set the stage to auto-unload the substrate after the exposure.
- 6) Start the exposure.

Comment

Auto-Unload

Proceed

# Series exposure (2/2)



## Series

Parameters

Design Name:  **5**

Lightsource [nm]:  **5**

Mode:  **6**

Dose Series	
Number of fields	7
Start value [mJ/cm <sup>2</sup> ]	30
Step size [mJ/cm <sup>2</sup> ]	1
End value [mJ/cm <sup>2</sup> ]	36
Fixed Defoc value	0

Defoc Series	
Number of fields	13
Start value [-10...10]	-10
Step size	1
End value [-10...10]	2
Fixed Dose value [mJ/cm <sup>2</sup> ]	80

Step size in X [mm]	4
Step size in Y [mm]	8
Total range in X [mm]	50.0
Total range in Y [mm]	53.6

**Expose a Series of Designs:**

Note:  
A Series of just one parameter will be exposed horizontally, centered around the zero stage position.  
A Series of both parameters will be exposed two-dimensionally, also centered around the zero stage position. Defoc variation in X, Dose variation in Y.

- 1) Double-check the Design Name.
- 2) Select the Mode.
- 3) Enter the Parameters. For a Series of just one parameter, also enter the (fixed) value of the remaining parameter.
- 4) Enter the step size between two adjacent Designs. **7**
- 5) Optionally set the stage to auto-unload the substrate after the exposure.
- 6) Start the exposure.

Comment:

Auto-Unload **8**

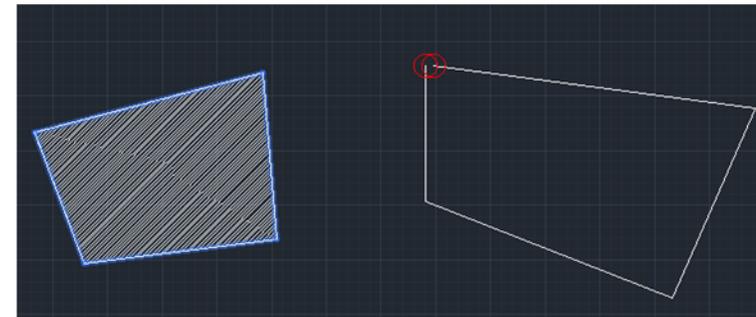
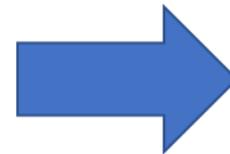
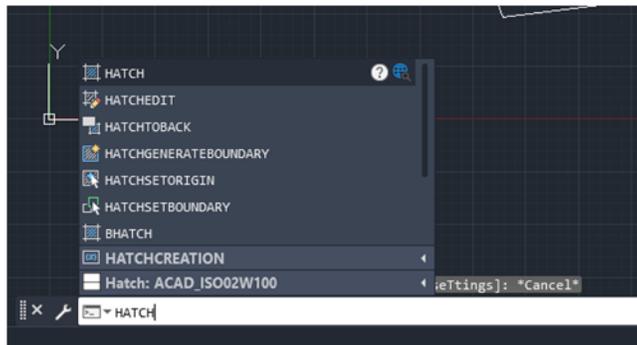
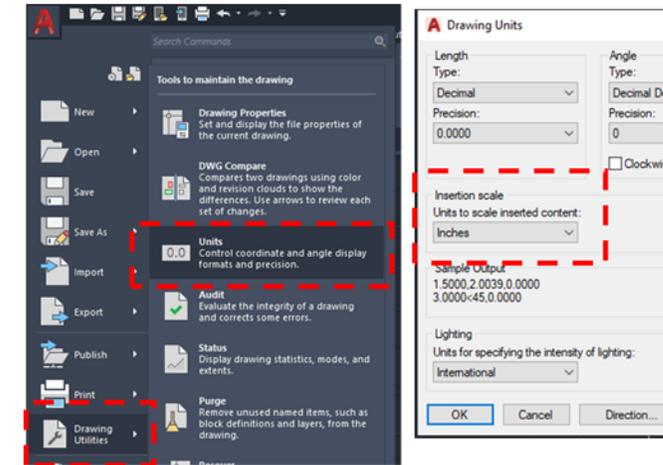
Proceed

**9**

## Draw your design

1. **Drawing units:** AutoCAD is unitless. Make sure the unit in AutoCAD is aligned with your design.
2. **Exposed area** is defined only by closed shape. If you draw lines, make sure they are joined together. Unfortunately, it is difficult to contrast exposed areas (shapes) in AutoCAD. To make it sure, it'd be better to make hatch patterns for the exposed areas (shapes)
  - 'Hatch' command
  - Select the exposed areas
  - Hatch patterns will be shown for closed shapes that will be exposed.
  - Or, warnings for not closed shapes (gap for red circles)

## Set drawing units



- 3. Remove all the lines:** the closed shapes without the hatch pattern is exposed in the Heidelberg MLA. Hatch pattern with the originally shapes result in double exposure.
4. Move the center of your design to (0,0)
5. Save as .dxf extension that is accepted.

### Recommendation

The maskless aligner manufacturer recommends to use gds file. To convert dxf to gds, you can open your dxf file in the Klayout and save as a gds file format, which is free software for 2D photomask design and can be downloaded here, <https://www.klayout.de/>.

# Revision history

## SIGNATURES AND REVISION HISTORY

1. Original author of this document: Dr. Sung Oh Woo
2. Original author Title or Role: Research Engineer
3. Date of original: 10/15/2023
4. Revision B notes: description of file locations, graphical alignment procedure, and tips for AutoCAD users are added

### Approvals:

Technical Manager Signature: *Sandra G Malhotra*

Date: 5/6/2024

Revision	Author	Date
Original Issue	Sung Oh Woo	10/15/2023
Rev B	Sung Oh Woo	5/6/2024