

MLA 150

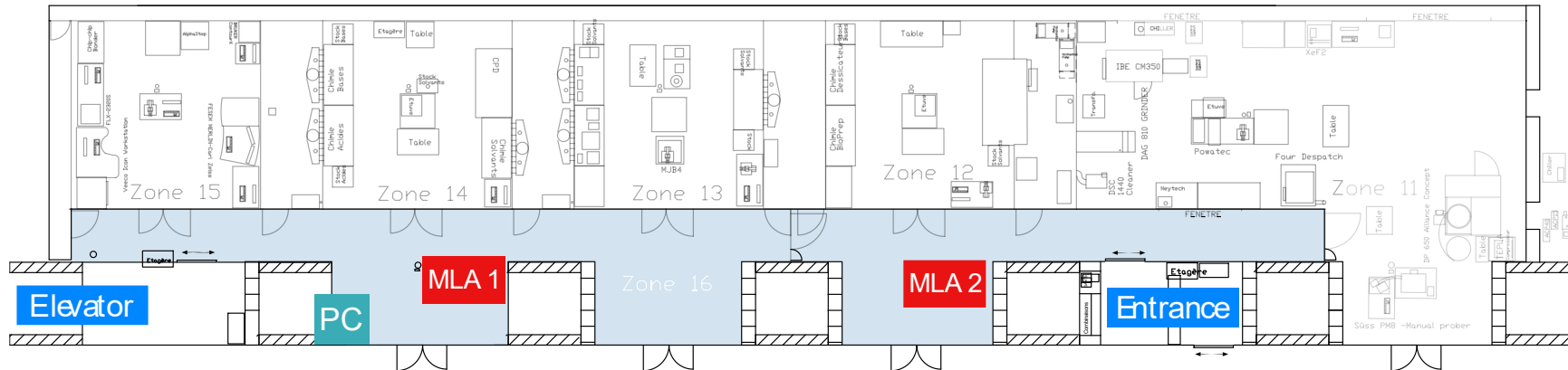
User manual

1. Exposing with MLA 150
 - A. Start
 - B. Setup job
 - C. Expose
 - D. End
2. Design conversion (wafer and mask)
3. Troubleshooting main error/issues - to be added
4. Greyscale - to be added
5. MLA 150 into more details

1.Exposing with MLA 150

1. A – Start

Level +1



1. log in on CAE PC

i	Z16 Heidelberg MLA 150 - MaskLessAligner	10.11.2022	08:08:17	00:04:43 \$	
i	Z16 Heidelberg MLA 150 2 - MaskLessAligner	10.11.2022	08:04:43	00:04:17 \$	


2. Start the menu

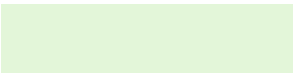
→ If not started yet, open the desktop applications (control and camera)



1.B – Setup job

- First be aware of this colour rule regarding boxes

 = input required

 = input optional

MLA150 Menu (v1.6.0) HI1416-10mm

File Tools User Info About

Setup Job

Load Substrate

Expose Job

First Exposure

Alignment

Series

Draw Mode

Inspection

Exposure Info

Job Name	Job_1502	No.	1502
Substrate Size [mm]		Height	
Design Name		Layer	First Ex
Design Type		Convert	
Design Size [mm]		Mode	
Dose [mJ/cm²]		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

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]	1.60
Chuck Vacuum [bar]	-0.86
DMD Voltage [V]	5.18
Laser Power [%]	100.0
Laser Wavelength [nm]	375

Setup Job

Job

1

Name: Job_1502 Number: 1502 Exposure Mode: Standard

New Job Restart Job Load Job Save Job

Substrate

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

2

Optional: In the chosen Layer select a Resist template.

Layer

Layer	Laser [nm]	Laser Power [%]	Design	Mode	Exposure Bitmaps	Alignment Settings	Resist	HAR	Status	Dose [mJ/cm²]	Defoc	Duration	Angle [mRad]	Date
FirstExposure								Off	Prepared					

3

Add Layer Copy Layer Delete Layer

Proceed

Load Substrate First Exposure Unload Substrate

1

Name	Number	Exposure Mode
Job_1502	1502	Standard

New Job Restart Job Load Job Save Job

2

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

- Create a new job or load one
→ when done setting a job, you can save it (please give it a specific name, jobs without one will be deleted)
- Chose the exposure mode :
 1. Standard : Expose the design once
 2. Series : Expose the design N times with different parameters for dose and defoc
→ how to determine optimal parameters for your project
 3. DrawMode : Use the camera to expose designs (bitmap format) in specific location
 4. Inspection : To inspect the loaded substrate with the camera

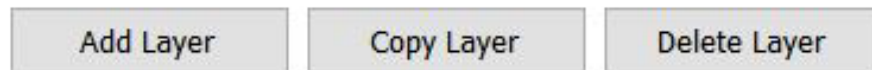
- Double click on the orange box to chose your substrate :
 - *Wafer X inch* or *Mask X inch* (X = diameter [in])
 - *Small* : if your sample is smaller than 50x50mm
 - *_Automatic X template* : if you are not sure about the dimensions of your substrate

→ Thickness value is not important

3

Job layers

- Each layer is determined by : design + laser parameters for the exposition (Dose and focus are set later in the process)
- Each lithography step of your process flow can be represented by a layer (In this case save your job and reload it [see slide 5] when performing further steps)
- You can add, copy or delete layers



- It exist 2 types of layer :

- First Exposure = no alignment
- Layer 2, 3,... = with alignment

Job parameters

- Laser : choose between *375nm* and *405nm*

375nm : 15nXT, AZ 40XT / nLOF, SU8
405nm : AZ 1515 / 3007 / 3027 / 10XT
- Laser power : *100%* (filter is used for Greyscale)
- Design : Choose from the list of converted design
→ See Chapter 2 to convert your design
- Exposure bitmaps : to add extra bitmaps image to be exposed in specific positions
- Resist :
 1 - LargeDefoc = to extend focus range from [-10;10] to [-25;25] → used with 20 to 100um thick resist
- HAR (High Aspect Ratio) : increase the depth of focus → require higher dose
 Large → for 100 to 300um thick resist
 X-Large → for >300um thick resist

3 Alignment Settings

→ Can be set only for non-FirstExposure layers

→ Load an alignment setting or create one :

a) Name : to find the settings later in the list

b) Top or Back side alignment (see next slide for more information about backside alignment)

c) Position of the marks : enter the coordinates of your marks

d) Camera for alignment : the one used during the procedure

e) Alignment Correction Options :
- Rotation : minimum **2** marks
- Scaling and Shearing : minimum **3** marks

→ After creating/editing settings, save, and refresh the list if needed

The screenshot shows the 'Alignment settings' dialog box. It has a title bar 'Alignment settings'. Below the title bar is a text input field for the name, annotated with 'a'. Below that is a dropdown menu for 'Top Surface', annotated with 'b'. Below the dropdown is a table with columns 'Pos', 'X [μm]', and 'Y [μm]'. The table has 4 rows, with the first row containing '1', '0', and '0'. The table is annotated with 'c'. Below the table is a 'Positions' label and the value '1'. Below the table is a section 'Camera for Alignment' with two radio buttons: 'Low Resolution' (selected) and 'High Resolution', annotated with 'd'. Below that is a section 'Alignment Correction Options' with three checkboxes: 'Rotation [mRad]' (checked), 'Scaling X / Y' (unchecked), and 'Shearing [mRad]' (unchecked), annotated with 'e'. At the bottom of the dialog is a 'Move to Zero after last position' checkbox (checked). At the very bottom are four buttons: 'New', 'Cancel Edit', 'Save', and 'Delete'.

Pos	X [μm]	Y [μm]
1	0	0
2		
3		
4		

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

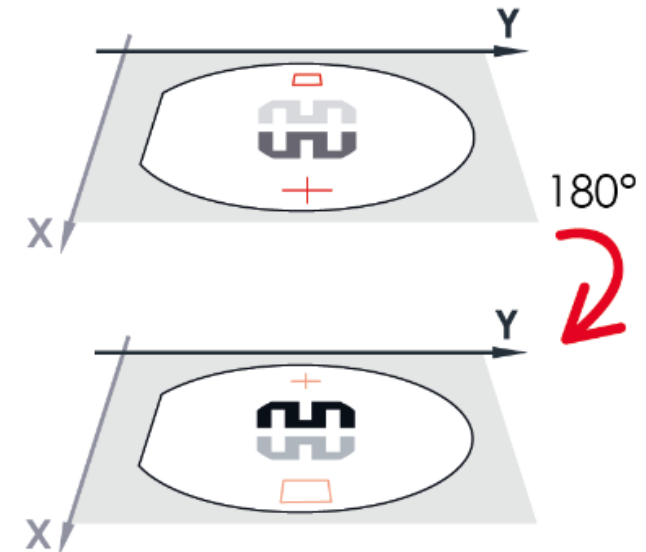
Edit

New Cancel Edit Save Delete

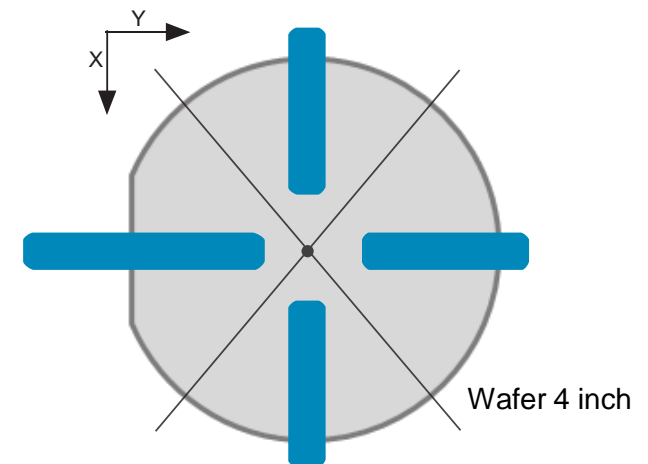
3

Alignment Settings – Information for backside alignment

- The coordinates on the MLA always refer to the substrate side that is currently the upper surface (e.g. if an alignment mark is exposed at the position [X: +20 mm], the alignment mark will be at position [X: -20 mm] for the backside alignment).
- The alignment marks need to be in a specific area. See blue zone on the image or **layer 65** in the *CMi layout template* for exact positions. Example of correct positions :



Wafer size	Mark 1	Mark 2	Mark 3	Mark 4
2 inch	X: +20 mm Y: 0	X: -20 mm Y: 0	X: 0 Y: +20 mm	X: 0 Y: -20 mm
3 inch	X: +28 mm Y: 0	X: -28 mm Y: 0	X: 0 Y: +28 mm	X: 0 Y: -28 mm
4 inch	X: +40 mm Y: 0	X: -40 mm Y: 0	X: 0 Y: +40 mm	X: 0 Y: -40 mm
5 inch	X: +44 mm Y: 0	X: -44 mm Y: 0	X: 0 Y: +44 mm	X: 0 Y: -44 mm



1.C Expose

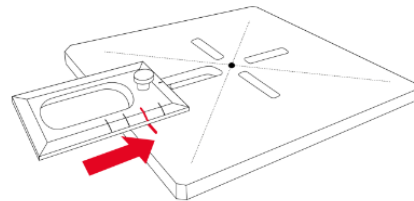
→ When your job is ready, select the layer to be exposed and click on

▶ Load Substrate

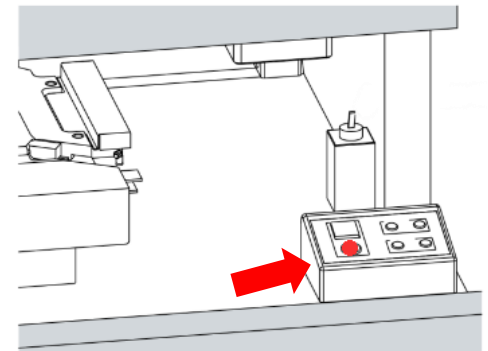
→ **For wafer :**

1. open the window

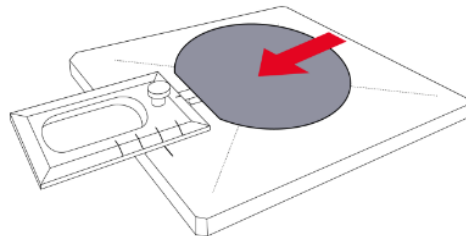
2. Place the guide according to your wafer size



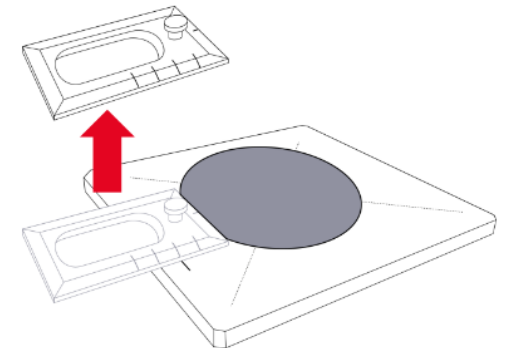
4. Activate the Vacuum



3. Place and centre the wafer against the guide



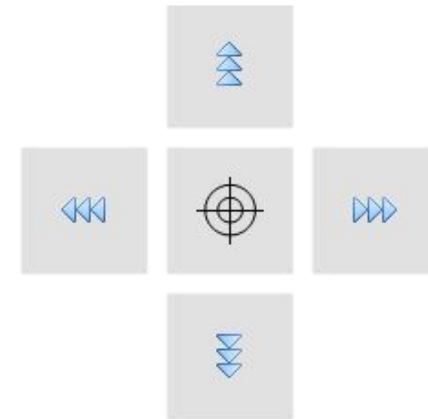
5. Remove the guide, close the door and follow screen instructions



1.C Expose

→ For small samples :

- 1. Open the window 2. Place your sample in the **centre** of the chuck (best to align it in X and Y directions) 3. activate the vacuum 4. close the door → Follow screen instructions
- You will need to determine the centre of your sample. Move with the arrows or the target tool to go manually to the centre of your sample (Target tool is always enable at beginning, simply click on the substrate where you think is the middle, you will be able to fine tune the position later)
- **Validate the position only when you are at the centre of the substrate !**



→ Next steps depend on your job :

1) Standard [s.12]

2) Standard with alignment [s.13]

3) Series [s.15]

1) Standard

- a) Set a dose and focus according to the Resist Table (Desktop) or from your own experience
- b) The design can be tilted based on the rotation of your substrate measured by the machine
- c) Enable the exposition of bitmaps you set previously
- d) Delay the exposure [hour:minutes]
- e) Auto-unload the substrate if you want to expose only one layer

Be aware that MLA-1 and MLA-2 have different Resist Tables

First Exposure

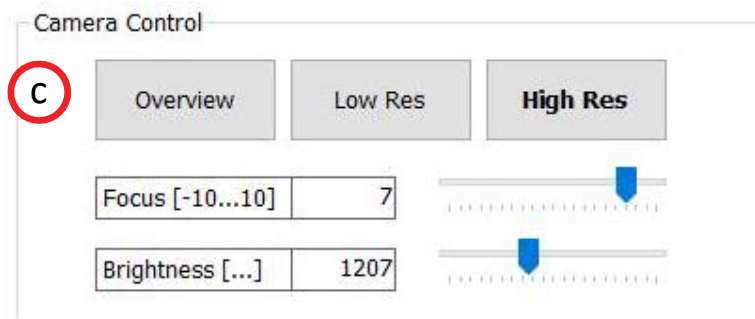
Exposure Settings	
Design Name	job_001
Laser [nm]	375
Laser Power [%]	100%
High Aspect Ratio	Off
Dose [mJ/cm ²]	500 a
Defoc [-10...10]	10
<input type="checkbox"/> Expose with Substrate Angle (8.51 mRad)	b
<input type="checkbox"/> Expose the Bitmaps	c
<input type="checkbox"/> Delay Exposure [hh:mm]	0 0 d
<input checked="" type="checkbox"/> Auto-Unload the Substrate e	
Comment <input type="text"/>	

Expose the first Layer:
1) Double-check the Exposure Settings.
2) Optional: Expose the Design with the found Substrate angle.
3) Optional: Expose Bitmaps.
4) Optional: Delay the Exposure.
5) Start the exposure.

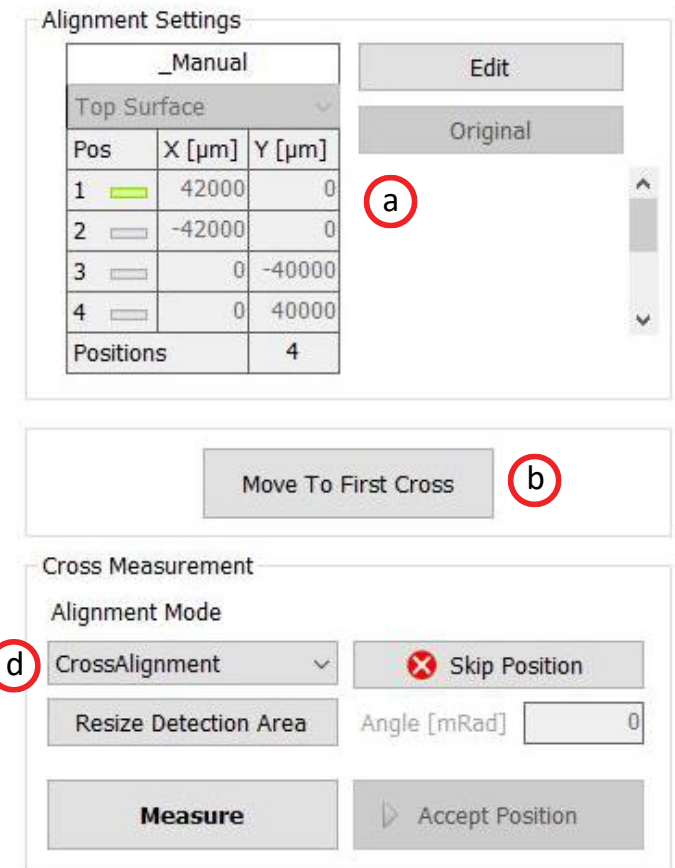
The Design will be exposed at the zero position of the stage.
To set the current stage position to zero, click the 'Set Zero' button.

2) Standard with alignment

- Control if alignment positions are correct and edit if needed
- Click to start alignment procedure
- Overview and Low Res camera → move to your mark
High Res → for the measurement
- Chose measurement mode :
 - Automatic : CrossAlignment or RectangleAlignment
 - Manual : ManualAlignment

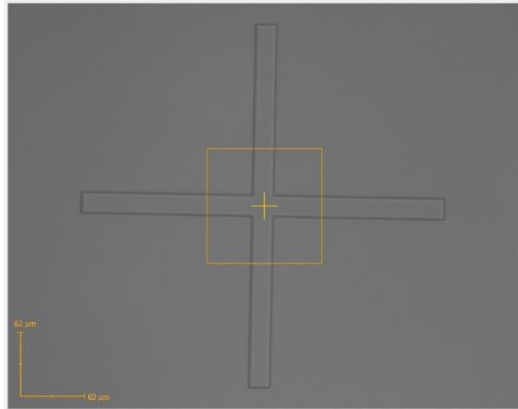


Alignment



2) Standard with alignment

e) For automatic detection, please make sure the feature to analyse is in the Detection area (Orange square). If you can't see it, press on *Resize/Maximize Detection Area* and select a zone on the camera window or slide the sides of the rectangle.



f) Measure:

- **automatic** detection of the feature
- **manual** selection of the position with the target tool

→ *Remeasure* or *Accept Position*

→ Repeat c-f for all the marks

Alignment

Alignment Settings

_Manual		
Top Surface		
Pos	X [μm]	Y [μm]
1	42000	0
2	-42000	0
3	0	-40000
4	0	40000
Positions		4

Edit

Original

Move To First Cross

Cross Measurement

Alignment Mode

CrossAlignment

⊗ Skip Position

e

Resize Detection Area

Angle [mRad]

0

f

Measure

▶ Accept Position

Camera Control

Overview

Low Res

High Res

Focus [-10...10]

7

Brightness [...]

1207

2) Standard with alignment

- g) Set a dose and focus according to the Resist Table (Desktop) or from your own experience
- h) Define which correction based on alignment you want to apply
- i) Enable the exposition of bitmaps you set previously
- j) Delay the exposure
[hour:minutes]
- k) Auto-unload the substrate if you want to expose only one layer

Be aware that MLA-1 and MLA-2 have different Resist Tables

Alignment: Exposure

Exposure Settings	
Design Name	D100_getter_wells
Laser [nm]	405
Laser Power [%]	100%
High Aspect Ratio	Off
Dose [mJ/cm ²]	260 g
Defoc [-10...10]	-2

Alignment Correction Options	
Rotation [mRad]	-19.501 <input checked="" type="checkbox"/> Use
Scaling X / Y	0.952387 / 1.000046 <input type="checkbox"/> Use h
Shearing [mRad]	-0.025 <input type="checkbox"/> Use

<input type="checkbox"/> Expose the Bitmaps i
--

3-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.

Comment	
<input type="checkbox"/> Auto-Unload the Substrate j	
<input type="checkbox"/> Delay Exposure [hh:mm] k	

3) Series

- a) Choose parameters to test :
dose / focus / dose + focus
- b) Define starting value, step and how many lines (# of fields) should contain the matrix
- c) Distance between 2 dyes in the matrix (stay orange if overlapping)
- d) Label at the bottom left of each dye containing Dose and Focus
- e) Delay the exposure [hour:minutes]
- f) Auto-unload the substrate if you want to expose only one layer

Series

Parameters

Design Name

Laser [nm]

Series Mode

Dose Series

Number of Fields	11
Start Value [mJ/cm ²]	450
Step Size [mJ/cm ²]	25
End Value [mJ/cm ²]	700
Fixed defoc value [-10...10]	0

Defoc Series

Number of Fields	9
Start value [-10...10]	-4
Step Size	1
End value [-10...10]	4
Fixed Dose Value [mJ/cm ²]	80

Expose a Series of Designs:

A Series of just one parameter will be exposed horizontally, centered around the zero stage position. You can set the "Number of Rows".

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 Exposure Settings.
- 2) Select the Series 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 in X and Y.
- 5) Optional: Check 'Expose Labeling' to expose the current Dose and Defoc values under each design.
- 6) Optional: Delay the Exposure.

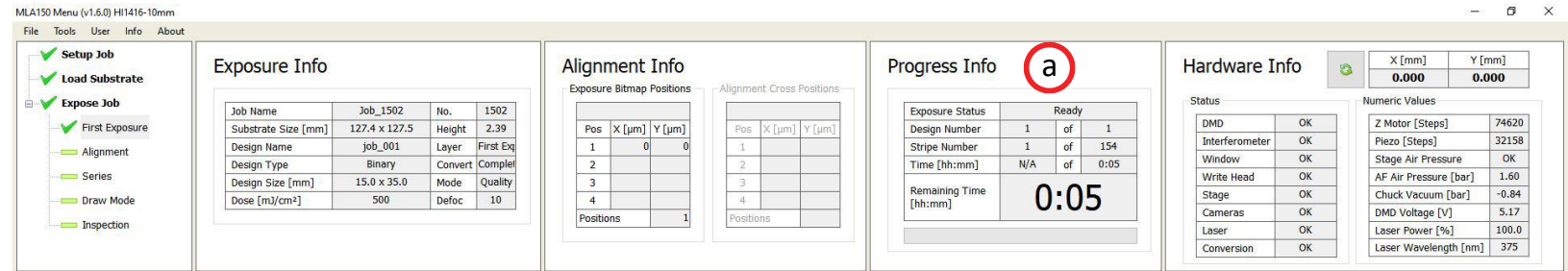
☐ Expose Labeling

☐ Auto-Unload Substrate

Comment

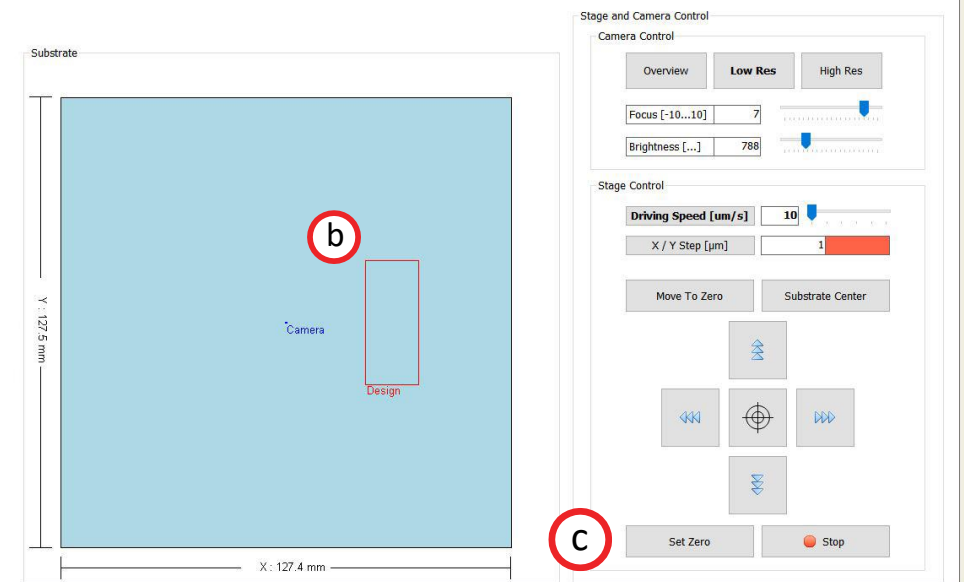
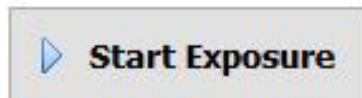
☐ Delay Exposure [hh:mm]

Exposition information and position



- a) Estimated maximum time for exposition
- b) Position of exposed design. Hold-click on its side to move it on the substrate.
- c) When using the camera to find the appropriate position for exposition, press *Set Zero* at the desired position for the design centre

→ If all information on the screen looks correct, press :

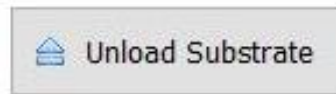


In case you have change the exposition position, an error message about not being in the centre will appear. You can acknowledge it !

1.D End

- If not automatically unloaded, you can restart your job in the main menu or expose a second layer

- If you are done, click



→ When back to the main menu:

- 1) open the windows
- 2) deactivate the vacuum
- 3) get back your sample
- 4) close the windows

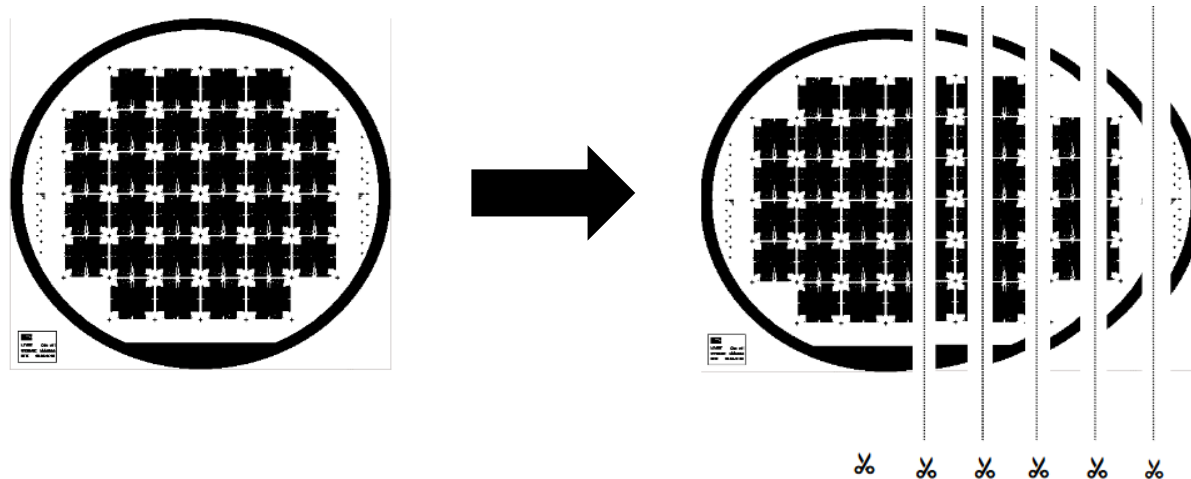
→ Press *New Job*

→ Go to the Zone PC to log out from the CAE

2. Design Conversion

2. Convert

- Goal : convert your design into a series of stripes than can be exposed by the MLA150



1. Copy your design into the corresponding file extension folder

Allowed extension : .gds , .cif , .dxf (no capital letter)

Allowed character for file name : a...z A...Z 0..9 _ (alpha numeric + underscore)



2. Convert your design

- In the job setup/Design → click on
- The GUI HIMT CONVERT will pop up



→ Press on the blank page icon to create a new job (or File/New Job)

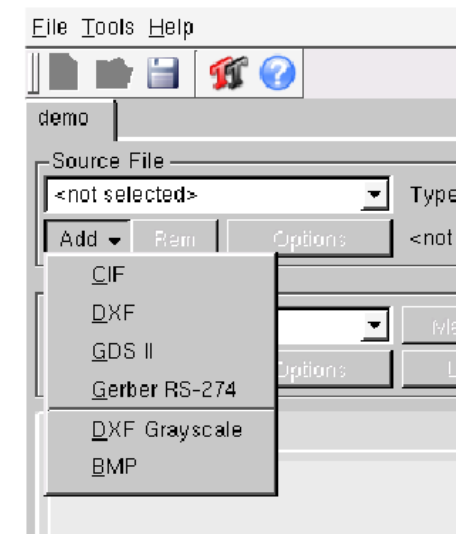


→ Give a job name

→ Click on *Add* to load your design

if you can't find your design, make sure :

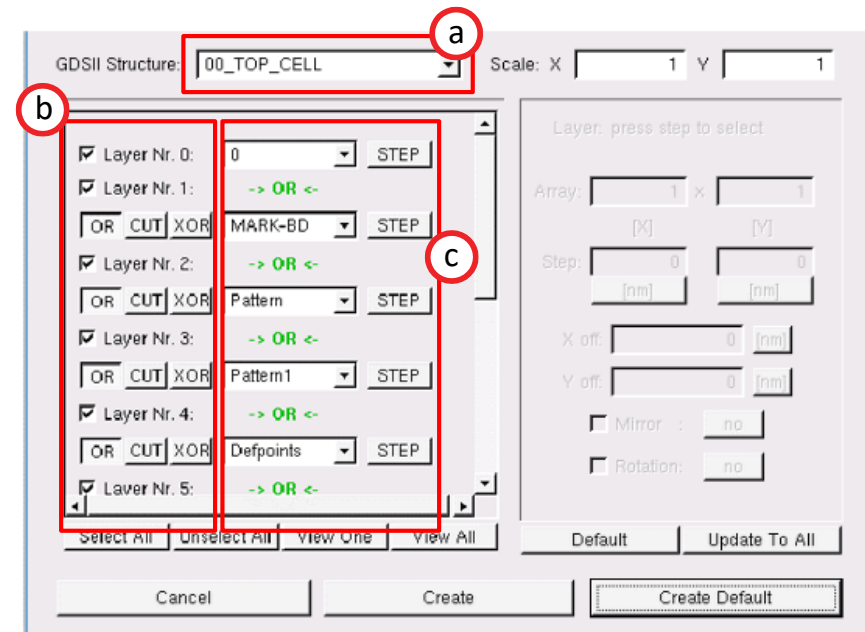
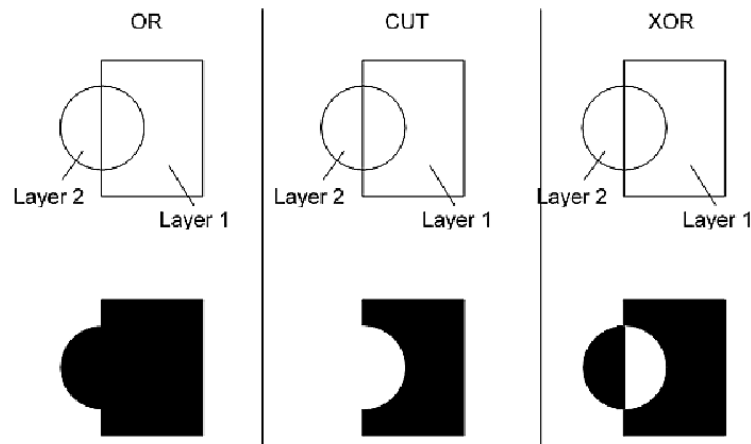
- 1) The design is in the right folder
- 2) Extension without capital letters (i.e. ".gds", not ".GDS")
- 3) File name contain only accepted characters



Following instruction are for GDSII files. Procedures with DXF and CIF are relatively similar but don't hesitate to contact a CMI staff if you have any doubt.

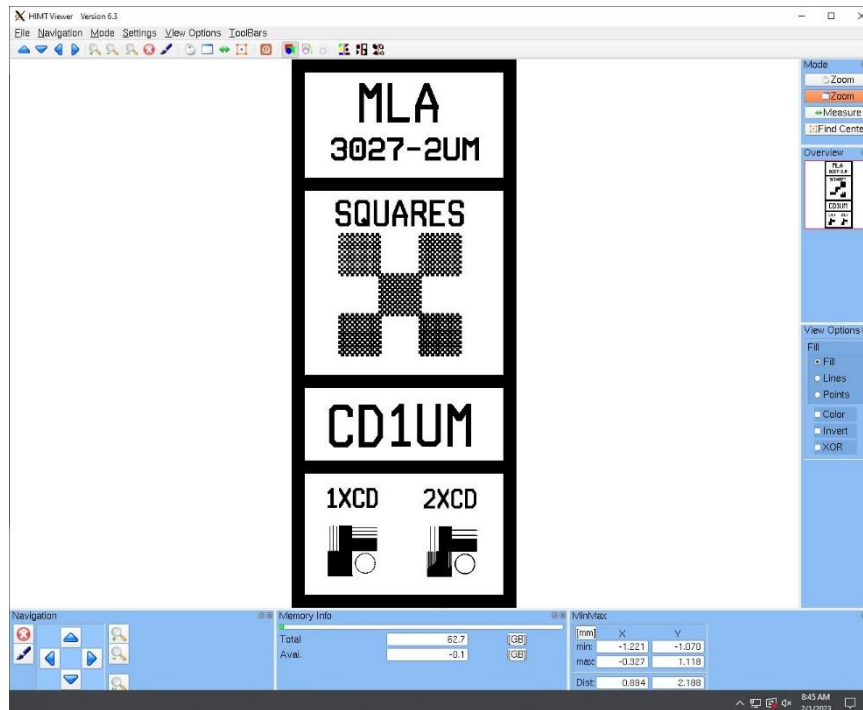
a) Select which cell from your design should be exposed

b) Select how many layers you want to expose

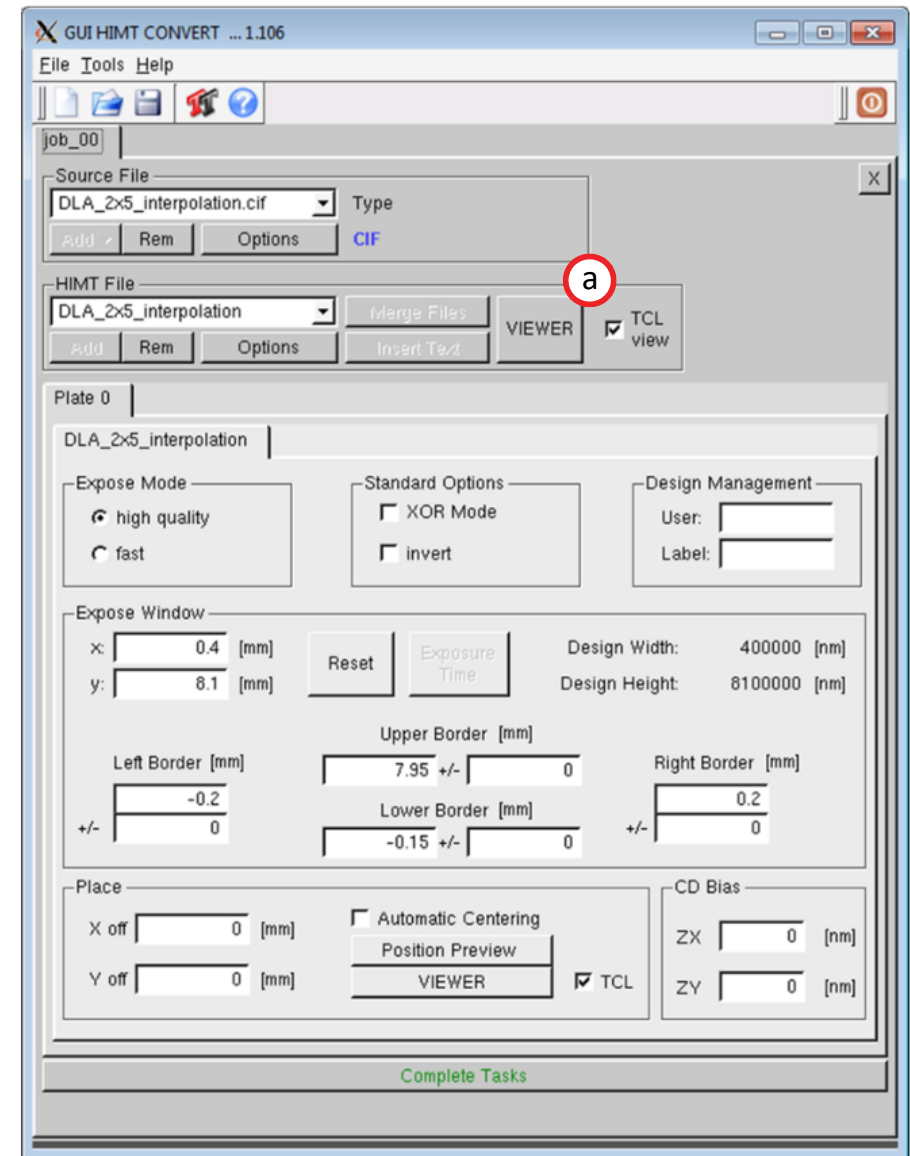


c) Select corresponding layers from your design

- a) Open the Viewer to check if your design/layer have been loaded correctly

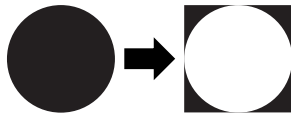


→ The laser will expose every black pixel



- b) Expose mode :
High quality = bigger overlap of the strip
($\approx 1.5x$ slower)
Fast = lower overlap of the stripe

c) Invert :

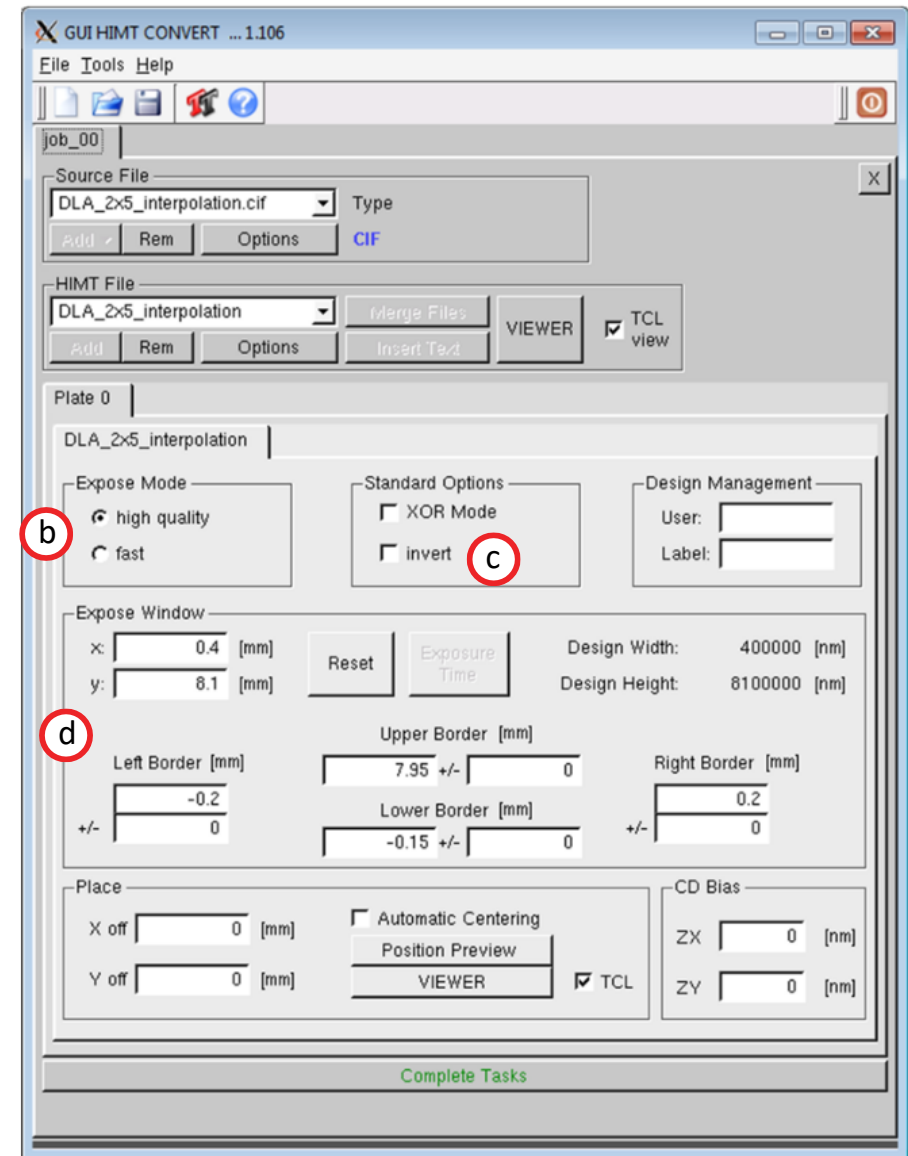
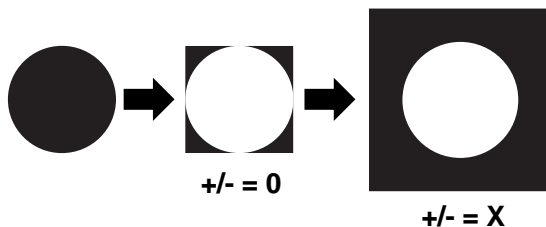


! Viewer

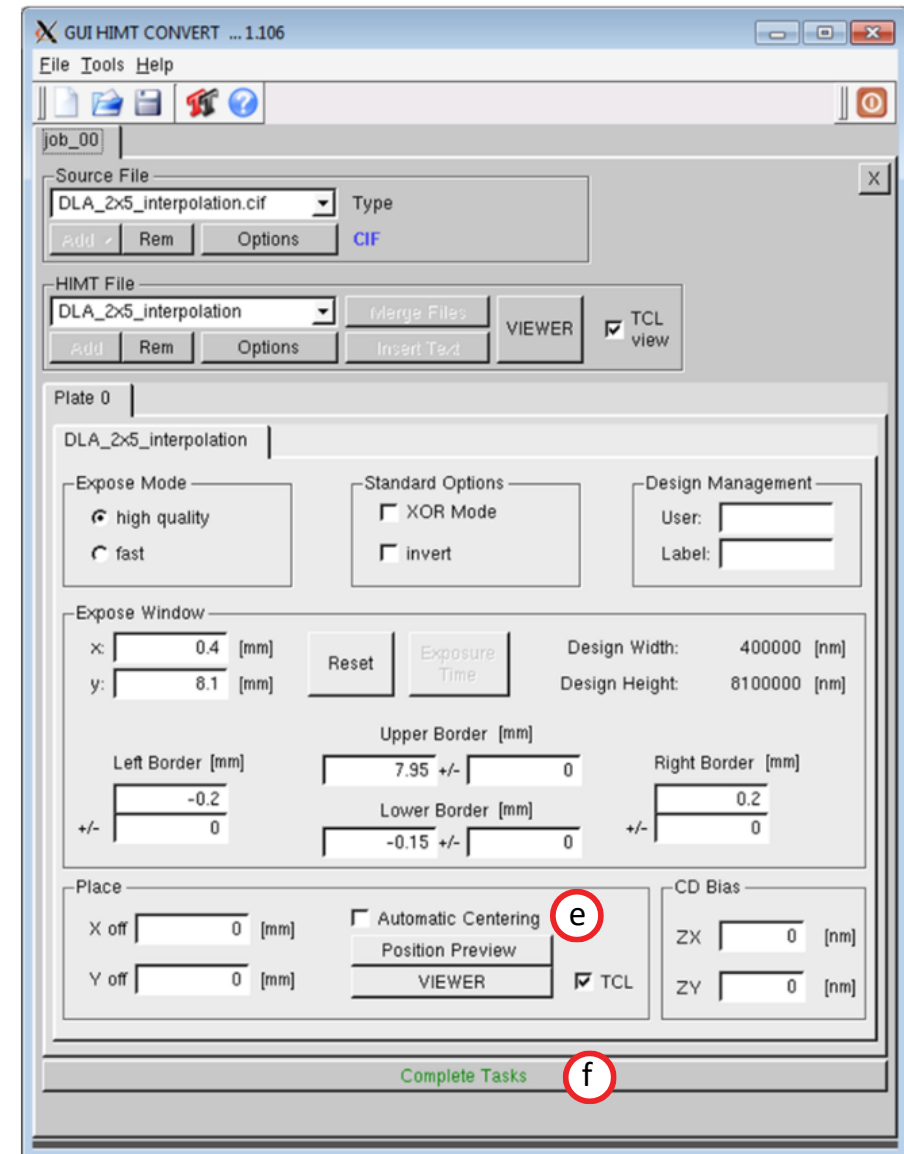
- 1) select *Invert* in the viewer too
- 2) it does not consider the boundaries of your design, but the machine does

- d) Expose window = Position of the virtual rectangle fitting all your design

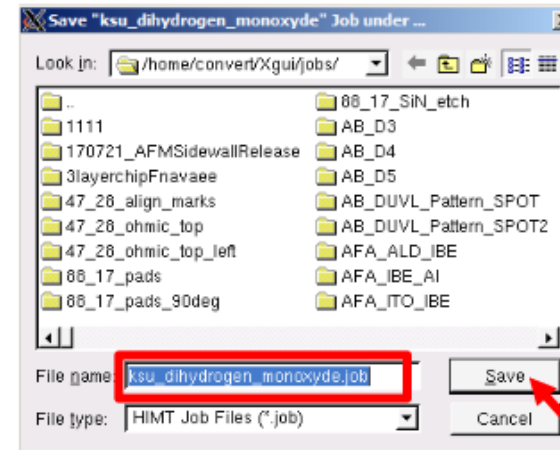
- ! if your design is inverted :
use +/- values to enlarge the frame to be exposed around your design



- e) *Automatic centering* : Centre your design at coordinate (0;0). Offset can be manually adjusted (X / Y off)
- f) If all information are correct click on *Complete task*



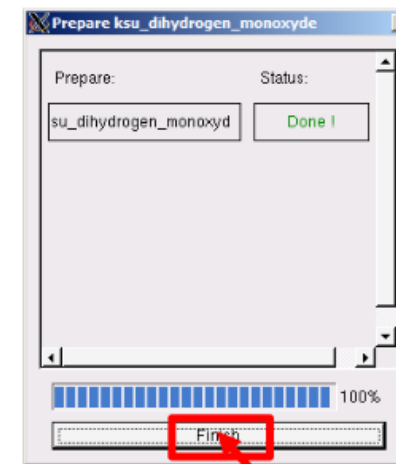
- You will be asked to save the job (no need to change the name)



- Conversion will start and end

→ do not forget to click on Finish

- If your job does not appear in the list, please *Refresh* it



Prepare

Convert Design

Load

Cancel

Refresh

Search

Search

Clear

Show

All

Next

100

Next

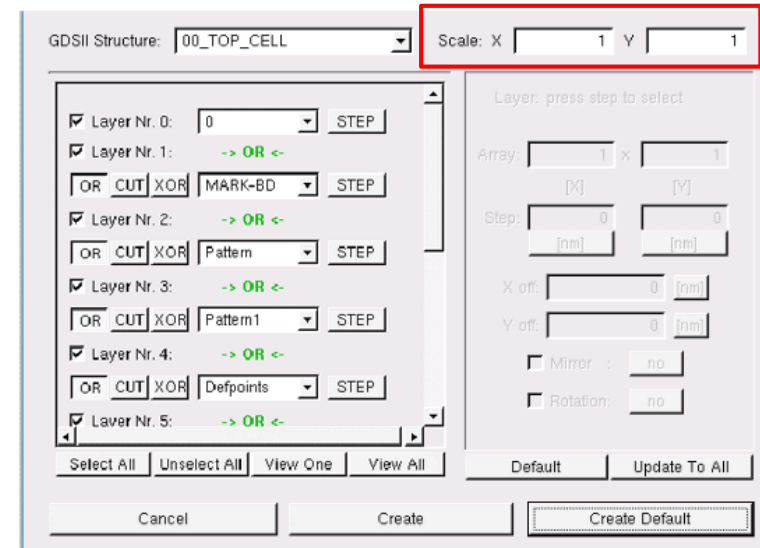
Loaded: 332 / 333

Name	Date	Time	Mode	Size X	Size Y	Source file	Prep Mode	Design Type	Bi Dir	Layer / Cell	Mirror	
job_001	10/11/2022	1:49:42 PM	Quality	14.999998	35	SFL_toplayer_300um_30um_error	Prepared	Binary	True	CM	off	
111022_DK_Toplayer_6x	10/11/2022	1:37:46 PM	Fast	74.999998	74.888788	SFL_toplayer_300um_30um_6x	Completed	Binary	True	CM	off	
111022_DK_toplayer_8x	10/11/2022	1:35:10 PM	Fast	75.787522	75.155124	SFL_toplayer_300um_30um_8x	Prepared	Binary	True	CM	off	
111022_DK_toplayer	10/11/2022	1:23:40 PM	Quality	154.62325	75.155124	SFL_toplayer_300um_30um	Prepared	Binary	True	CM	off	

Additional information for Mask fabrication

Follow the standard procedure and add these 2 extra steps if needed

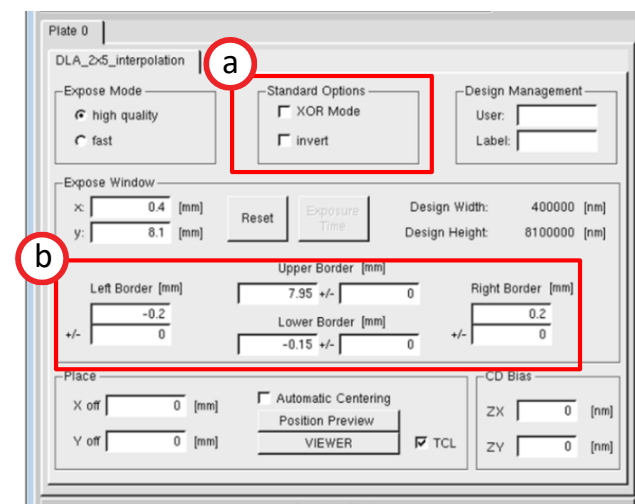
- Y mirroring : set a Y-scale of -1



- To invert the design :

a) Select invert

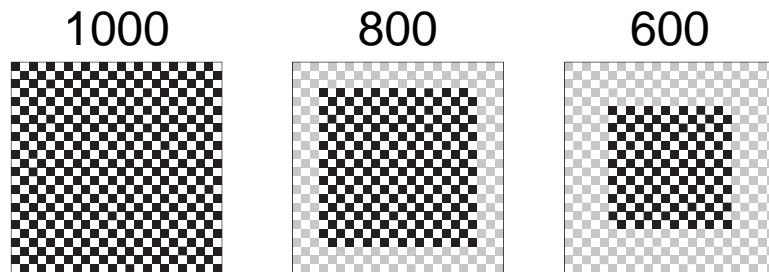
b) Use the +/- to extend your design slightly over the size of your mask



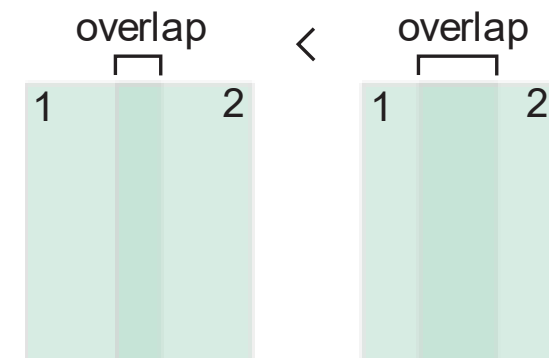
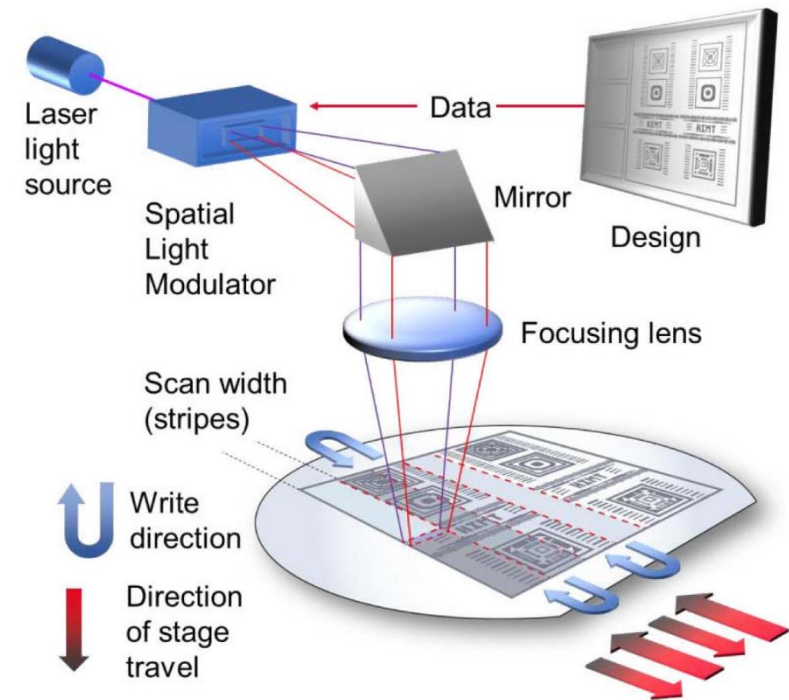
5. MLA 150 into more details

Exposure

The MLA 150 is using DMD (Digital Multimirror Device) to expose in stripes. DMD can be considered as an array of pixels (1000x1000 for the MLA150) in which each pixel can be turned on and off at every moment. The DMD modulates the write beam so that the laserlight projects and transfers a light pattern onto the positive or negative resist on the substrate surface. It is possible to use only part of the DMD width to improve homogeneity.



The writing of the stripes occurs in a bidirectional way and to avoid gaps in between, more or less overlap is present.



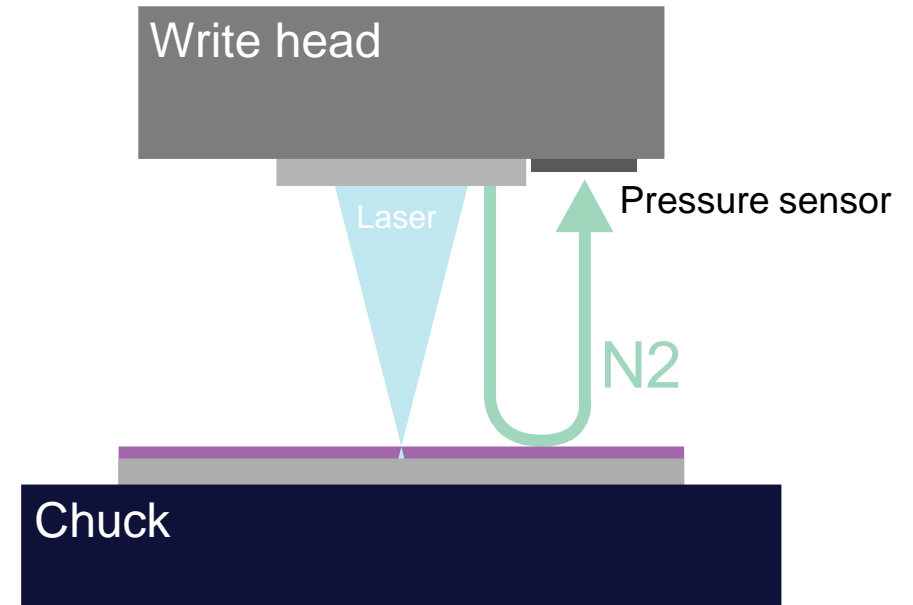
Fast mode

Quality mode

Autofocus - Pneumatic

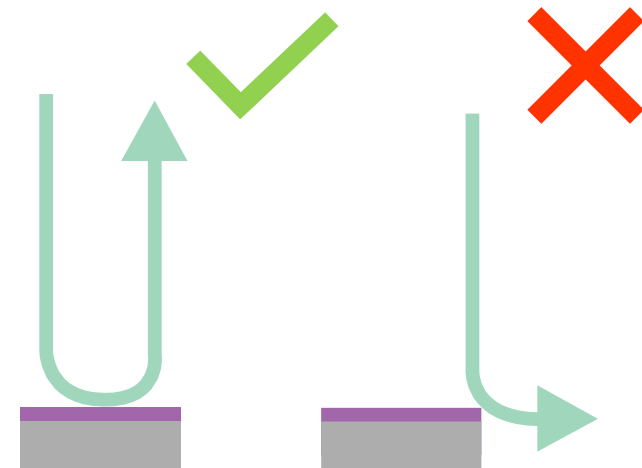
The autofocus on CMI's MLA 150 is performed pneumatically. A flow of nitrogen (N₂) is coming directly from the write head and is reflected on the sample to a pressure sensor. The height of the write head is therefore adjusted at every moment based on the pressure measured thanks to a piezo.

The nitrogen flow has a diameter of 3mm, also the focus can't be adjusted live for too small substrate (~15x15mm). In these case, the piezo at a set height for the whole exposure



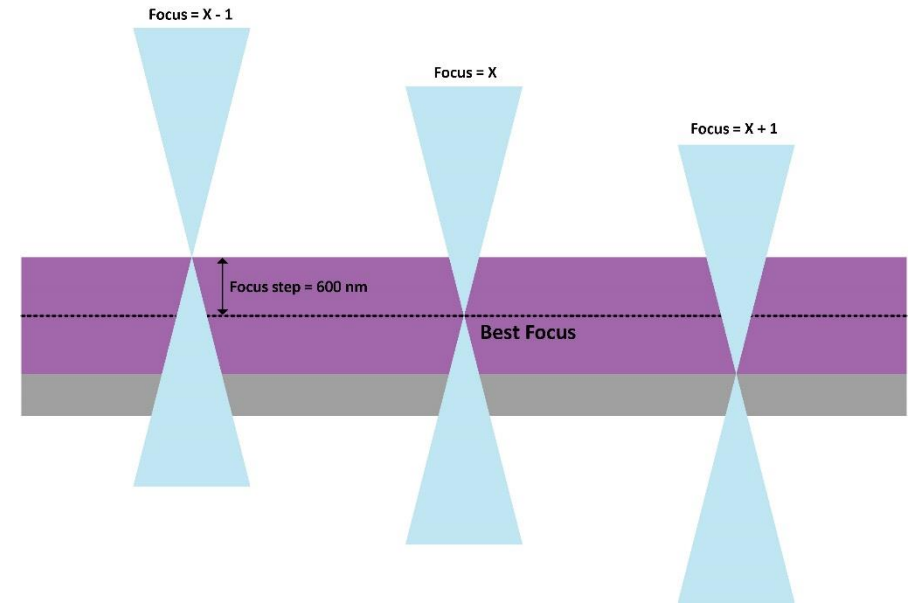
Risk with small substrates

When loading a new substrate, a first focus has to be performed to determine the substrate thickness. If the sample is not under the write head, the flow can land on the edges and be deflected sideways. The height is therefore not measured correctly anymore and the write head can crash on the substrate/chuck → The software allows the user to determine manually the centre of the substrate to prevent any crash.



Defocus

The defocus allows to shift the focus to have it in the centre of the resist instead of the top. A positive defocus will move the focus downwards inside the resist. A step corresponds to a movement of approximately 600nm.



With positive photoresists, in practice both positive and negative defocus have the same effect. See below the impact on narrow and large isolated line.

