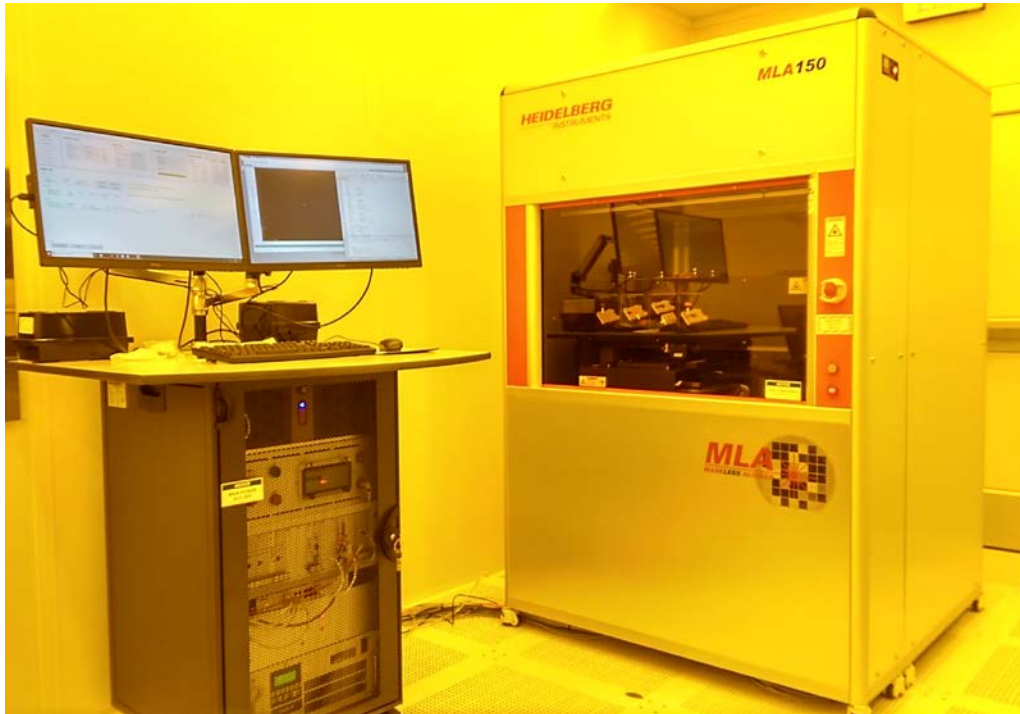


HEIDELBERG MLA150 MASKLESS ALLIGNER



MLA150 Maskless Aligner

1. Introduction

Heidelberg MLA150 Maskless Aligner is a full-scale production level laser writer which can be used to perform lithography directly on wafers as well as to create photomasks. It is equipped with both 375 nm and 405 nm diode lasers to accommodate full range of photoresists. The MLA150 Maskless Aligner will expose your layout directly to accelerate your work in the areas of life sciences, MEMS, micro-optics, semiconductors, sensors, actuators, MOEMS, material research, nanotubes, graphene, and any other application that requires microstructures.

2. Features

1. Maximum substrate size: 9" x 9"
2. Minimum substrate size: 5 mm x 5 mm
3. Substrate thickness: 0.1 to 6 mm
4. Substrate roughness $< \pm 20 \mu\text{m}$
5. Working distance of writing lens: 100 μm
6. Optical system includes highly reflective mirrors and DMD™
7. Real time air-gauge autofocus with dynamic range of 80 μm
8. Camera system for substrate inspection, automatic alignment, and basic measurement functions

Table 1: field of view of the camera system of MLA150

Camera type	Field of View (size of the substrate area that can be seen)	
	Top Surface	Back Surface
High Res	190 μm x 140 μm	-
Low Res	640 μm x 480 μm	640 μm x 480 μm
Overview	12 mm x 9 mm	top side only

9. Gray scale exposure mode with 256 intensity levels
10. Conversion software for DXF, CIF, GDSII, and Gerber files for binary exposures; and BMP, and ASCII files for gray scale
11. LED Laser Exposure Module (375 nm and 405nm)
12. Minimum structure size [μm]: 1
13. Line width uniformity [3σ , nm]: 120
14. Alignment Accuracy [3σ , nm]: 500
15. Write speed [mm^2 /minute]: see Table 2
16. Maximum write area [mm x mm]: 150 x 150

Table 2: MLA150 Specifications

Illumination Module	405nm	375 nm
Minimum Structure Size [μm]	1 μm	1 μm
Substrate Size Minimum [mm^2] Maximum	5 x 5 9" x 9"	
Exposure time [min] 50 x 50 mm^2 100 x 100 mm^2 150 x 150 mm^2	4 9 16	10 32 65
Maximum Write Area [mm^2]	150 x 150	
Alignment Accuracy* [3σ , nm] 100 x 100 mm^2	≤ 500	≤ 500
Linewidth variation [3σ , nm]	≤ 120	≤ 120
Substrate Thickness Maximum [mm] Minimum [mm]	5 0.1	5 0.1

3. Safety

Follow general safety guidelines in the lab and the specific safety rules as per follows:

1. **Laser Hazard:** This equipment utilizes Class 2 and Class 4 lasers. The unit is secured with safety interlocks so that the high power lasers will not operate when the loading window is open. **Under no circumstances users should open any optical enclosure panels.**
2. **Pinch Point Hazard:** Front loading window is operated by pneumatics. Make sure to move away before closing the window.
3. **Electric Hazard:** Fatal electrical shock and/or severe burns can be caused by the supply voltage of up to 240VAC 16A for the system. **Do not remove any covers or tamper the electronics rack.**



4. Main equipment components for user operation

There are two main components for user interface as shown in the image above:

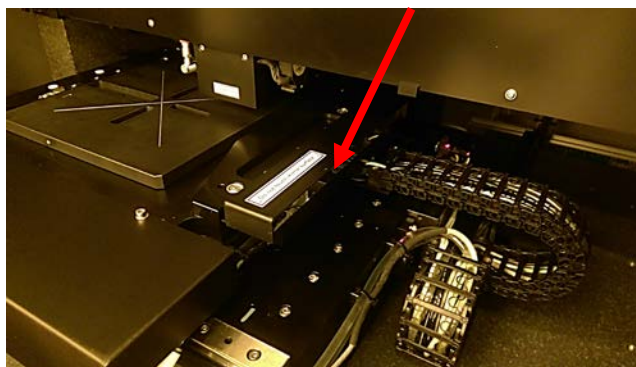
1. Main Unit
Main lithography unit in the temperature controlled cabin.
2. Electronics-Rack with the control PC
User interface PC and Control electronics

5. Available processes

Exposure conditions of all NUFAB provided photoresists are preloaded to the system. Consult staff for further assistance.

6. Process Notes



1. Your sample has to be flat. **No sample on a carrier wafer is allowed.**
2. Make sure the back side of your substrate is clean.
3. No sharp tip tweezers are allowed on the chuck.
4. After loading, make sure to wait a couple of minutes to stabilize temperature inside the cabin.
5. When loading, pay special attention to interferometer mirror and laser. **Do not block the laser or touch the mirrors.** (see the picture below)
6. Use appropriate alignment guide to center your sample on the chuck.



7. Equipment Operation

7.1 Introduction

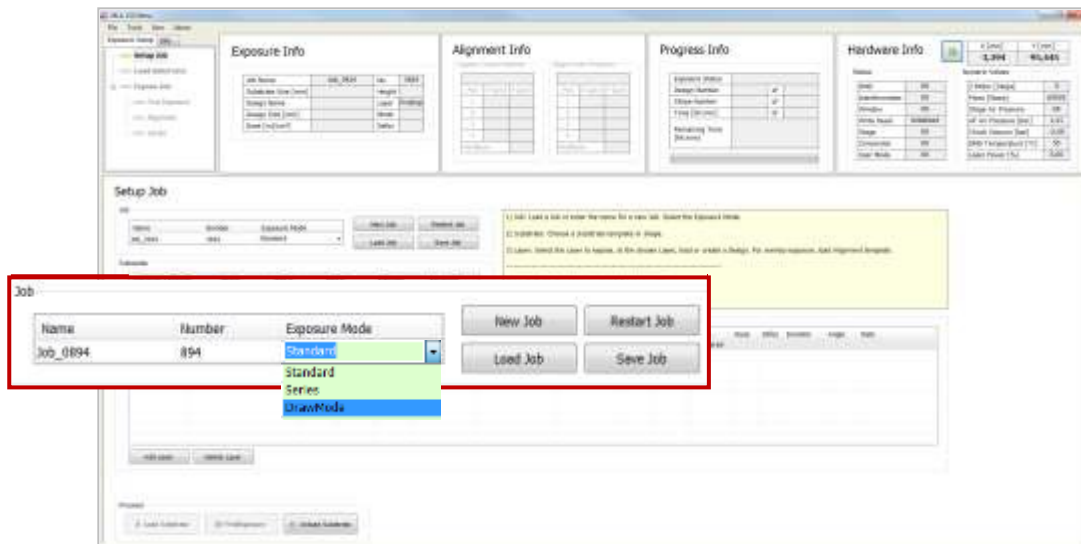
This guide gives quick instructions on how to setup and execute an exposure job with the MLA150. Follow the instructions carefully.

-  **Login in FOM.** Both monitors are interlocked by the system. They will turn on as soon as you login.
-  To load a design from an external storage media into the corresponding HIMT folder, copy the external design file to the directory: *HIMT\Designs\<design type>*.
The shortcut to the designs folder is on the DESKTOP.

7.2 Setting up the exposure job

After you have clicked the shortcut icon on the desktop of the User PC, the wizard opens and leads you to the **Setup Job** panel, where a new job has been created automatically. This job has a **Name** and a **Number**. The name can be changed by clicking into the **Name** field. The number is fixed and auto-incrementing.

From the drop-down list, select one of the available exposure modes:



Standard: To expose a single design for each layer. Overlay exposures are possible in this mode (sections 7.5 and 7.6)

Series: To expose a small test design (e.g. dosetest) several times with varying dose and/ or defocus values (section 7.7).

Draw Mode: To create boxes, circles or ellipses of arbitrary size limited only by the camera field. Used for creating connections between structures or for repairing imperfections in structures of an exposed layer. To expose crosses/shapes on the layer without selecting a design (section 7.8).

If you do not intend to use the new job, you can also choose from the following options in the **Job** frame:

- To **continue or repeat** a job, click **Load Job**. A list appears from where you select the

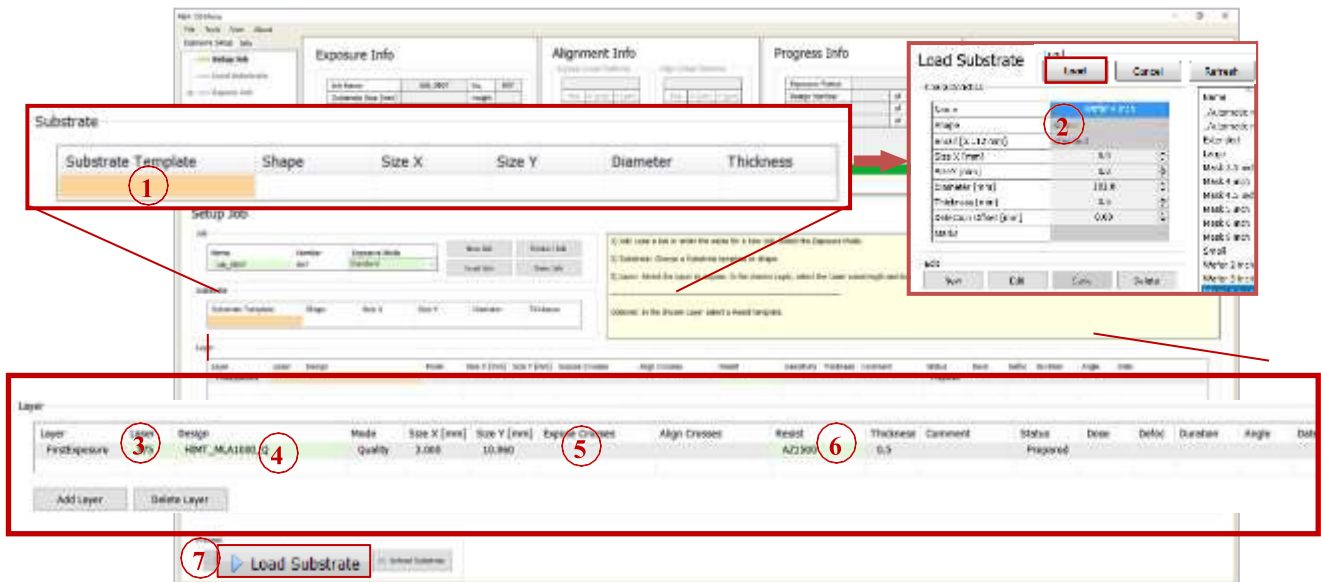
required job.

- To **repeat an exposed layer** of that job you need to copy the job with **Restart Job**. The system deletes the process data of the selected job and sets up the job with the same settings but with a new job name/number.
- To **start another new job after you have finished an exposure job**, click **New Job**. The new job has a new number and a new but editable name. Continue with the instructions for a new job.

7.3 Standard Exposure (without Overlay)

i For overlay exposures go to section 7.5 Standard Exposure with Overlay in this guide.

In the **Substrate** frame:



1. Double-click **Substrate Template**.
2. Select your substrate size or at least the shape (automatic_round or automatic_rectangular) and click **Load**.

In the **Layer** frame:

3. If available, select a laser from the **Laser** dropdown list.
4. Double-click **Design** and load the design file.
- i** For instruction on how to convert a new design, refer to 7.8 Design Conversion in this guide.
5. It is possible to load a template for alignment crosses or shapes which are exposed on the layer. To load this template, double-click into the value field titled **Expose Crosses** and select a bitmap template file from the list.
6. Optionally, double-click **Resist** and select the resist type.
- i** In the **Thickness** field, the thickness of the resist is displayed.
7. Click **Load Substrate** and load the substrate according to the on-screen instructions displayed in the **Load Substrate** panel. For details see section 7.4.

7.4 Loading Substrate

After you have chosen the appropriate substrate, selected a substrate template and loaded a design, you can place the substrate on the chuck. The following instructions guide you through the loading procedure. You also get on-screen instructions inside the yellow **Info Box**.

The chuck is designed to facilitate the manual loading process. It has an indentation surrounding one of the four viewing slots for backside alignment. This indentation makes substrate handling on the chuck easier as it offers space for putting the adjustment aid inside.

ADJUSTMENT AID

The guide bar at the bottom of the adjustment aid is equipped with rest positions corresponding to the different wafer sizes that are possible to be loaded on the chuck.



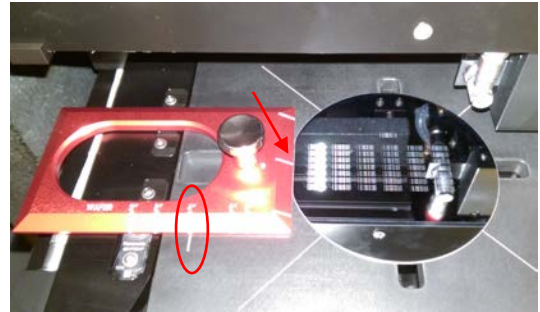
These rest positions are made visible on a measuring scale.

On the other edge, some marks help to center the wafer flat. There are two adjustment aids for up to 6 inch wafers and masks.

In the example, the chuck is loaded with a 4" wafer as it can be seen on the measuring scale matching the mark at the chuck.

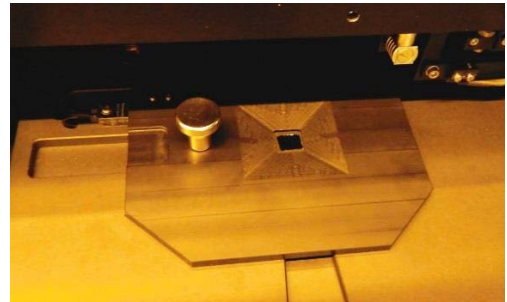
Keep in mind to remove the adjustment aid from the chuck before starting an exposure.

To avoid possible damage caused by this adjustment aid, the system is equipped with a monitoring function based on a sensor. The exposure function stays blocked until the tool is removed from the chuck.



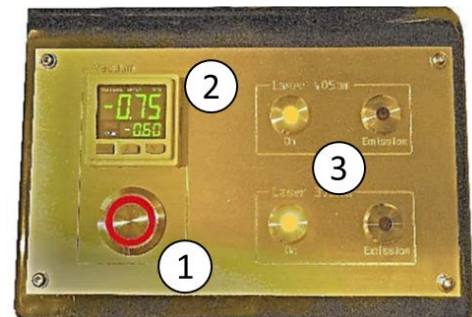
SMALL SUBSTRATES ADJUSTMENT AID

Take the adjustment tool for small substrates and put it onto the chuck so that it fits into the designated recesses. Put the substrate into the hole in the middle of the adjustment tool. Remove the tool from the chuck and switch on the vacuum.



OPERATOR PANEL

The operator panel has a push button (1) that opens the vacuum inlet to fix the substrate on the chuck. For observing the vacuum status, a display (2) shows the current vacuum status. However, it is not necessary to observe the status because the wizard informs about vacuum supply problems. The panel also contains two or four LED lights (3) indicating the status of the laser(s). The lights are on throughout the whole exposure procedure. When the window is open, the lights are off indicating that the laser(s) is (are) off



EMERGENCY SHUT OFF, WINDOW OPEN AND CABIN LIGHT BUTTONS

These buttons are on the right-hand side of the cabin.

In case of an emergency you can cut the electrical power to the whole system by pressing the EMO switch (1).

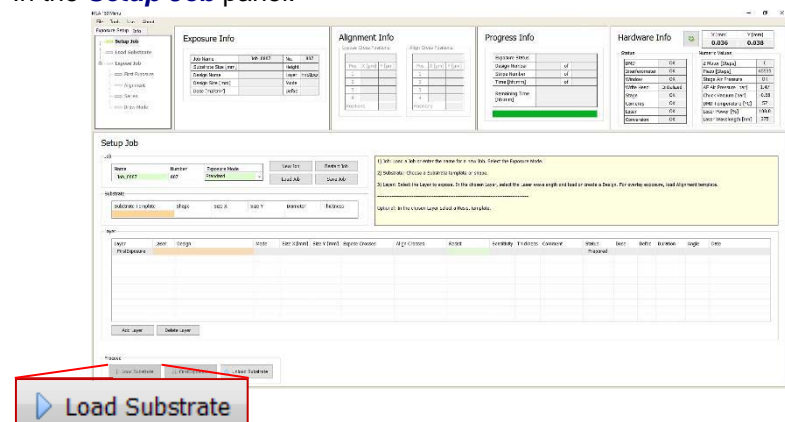
Cabin light can be activated by pressing (2). It is safe to turn on the light even with an unexposed photoresist present in the cabin.

Window open button (3) is used to open the loading window when the button is lit. During exposure, system locks the window to prevent accidental opening of the window.



STEP-BY-STEP SUBSTRATE LOADING

In the **Setup Job** panel:

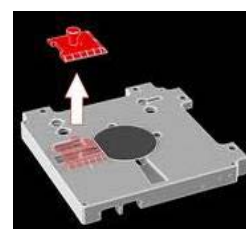
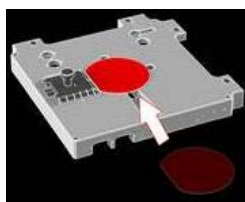


1. Click **Load Substrate**. The stage moves to loading position.

 The wizard moves on to the **Load Substrate** panel. Wait until the movement has stopped.

At the lithography main unit:

2. Push the window button and release it again. The window opens.
3. Place the adjustment aid so that the guide bar at the bottom fits into the indentation at the chuck.
4. Adjust the auxiliary tool's position to the substrate size.



- 5.** Use a tweezer to grab the substrate and place the substrate on the chuck.

6. **Note:** Check for correct loading and head position.
7. At the operator panel press the vacuum button.
8. Make sure that the substrate is held tight by the vacuum.
9. Remove the adjustment aid from the chuck.
10. Check the substrate's orientation
11. Close the window by pushing and releasing the button. Go back to the User PC.
12. In the **Load Substrate** panel, click **Continue**.

Check if the substrate is placed under the write head. If not, see below. If the substrate position is correct, click **Continue**.

Note: In case the substrate is not placed under the write head, click **Cancel**. The stage moves back to loading position. Start the loading procedure again and make sure that vacuum is switched on.

Note: If the substrate size has not been completely defined in the step of substrate template selection, the system issues a dialog box. Select one of the offered options.

The system searches for the center of the substrate and gives information about the progress via a message box. If you wish to abort the **Find Plate Center** procedure, click **Stop** in the message box.

Note: For small substrates, the automatic center detection does not work. Here, the system asks the user to set the center position manually or to confirm the current position.

The system also detects the flat positions and calculates the rotation angle of the substrate. It is possible to select or deselect the angle for the exposure.

After the successful loading process, the system leads to the next panel:

- In Standard Mode with overlay alignment, the **Alignment** panel appears
- In Draw Mode, the system offers the **Draw Mode** panel for creating boxes, circles and ellipses
- In Standard Mode without overlay alignment, you are led directly to the **Exposure** panel
- In Series Mode the **Series** panel shows up offering the exposure procedure

7.5 Setting up First Exposure

In the **First Exposure** panel:

First Exposure

Required

Design Name: HJMT_MLA1000_L2

Light Source [nm]: 405

Dose [mJ/cm²]: 200

Defoc [-10...10]: 0

☒ Expose with substrate angle (~2.82 mRad)

Expose Cross Positions

☒ Expose the crosses

Top Surface: Edit

Original

Pos	X [μm]	Y [μm]
1	0	0
2		
3		
4		

Positions: 1 ☐ Use first bitmap for all

☐ Auto-Unload

Start Exposure

Expose the first Layer:

1) Double-check Design Name, Light Source, Dose and Defoc.
 2) Optional: To expose the design with the substrate angle, check 'Expose with substrate angle'.
 3) Optional: Double-check the Expose Cross positions.
 4) 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.

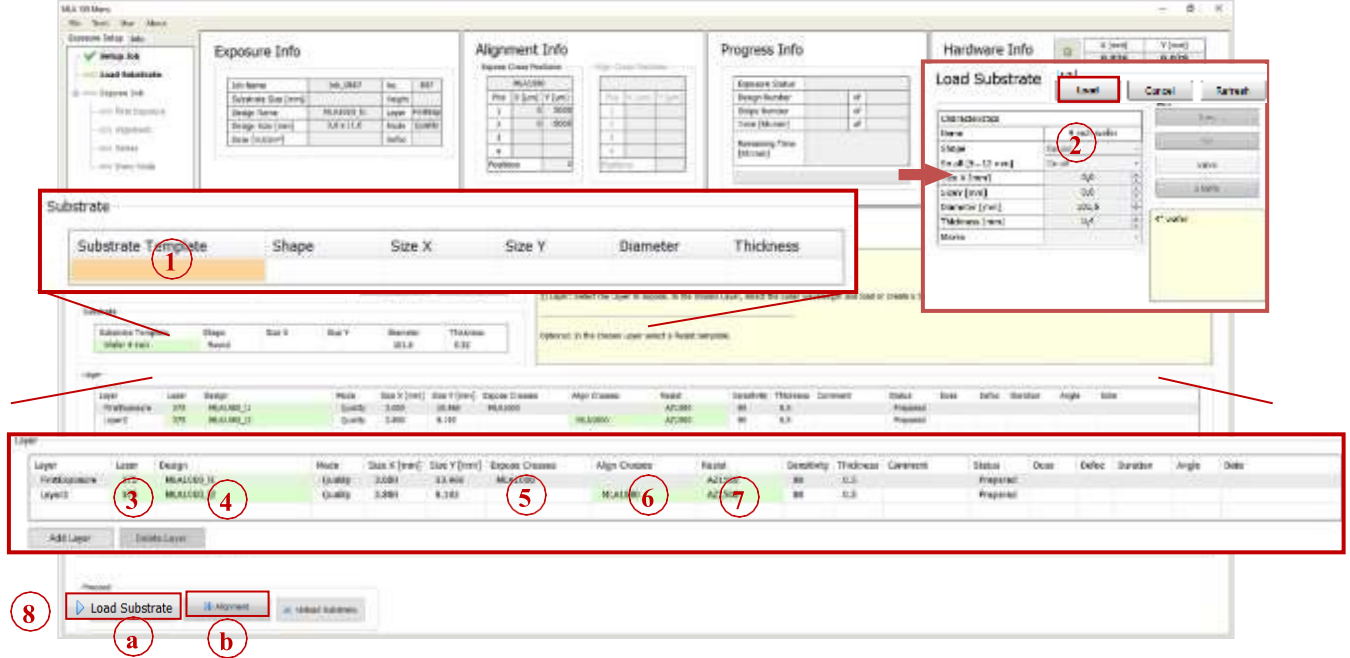
To expose the design with the found substrate angle, activate the 'Expose with substrate angle' checkbox.

Comment

13. Double-check the design name and the laser wavelength.
14. Set the **Dose** value by entering the value into the text field.
15. Set the **Defoc** by selecting the value with the spin buttons (range -10 to 10).
16. Activate the **Expose with substrate angle** checkbox if you wish to expose with the rotation angle of the substrate on the chuck.
17. It is possible to expose crosses or shapes on the layer. If not selected in the Setup panel a bitmap file can be selected for every cross position. Activate the **Expose Crosses** checkbox. Click Edit and select a template for every cross position. For selecting the same file in every position, activate the checkbox **Use first bitmap for all**. Enter the positions into the table. Click Apply again, to leave the editing mode. Use this option also for changing the cross position information.
18. If desired, activate **Auto-Unload**. The system executes the unloading procedure automatically.
19. Click Start Exposure.

7.6 Standard Exposure with Overlay

In the **Substrate** frame:



For alignment, at least the second layer must be chosen. The first row in the list is always reserved for the first expose without overlay. To leave out the first exposure row, leave it blank and click **Add Layer**.

1. Double-click **Substrate Template**.
2. Select your substrate size or at least the shape (automatic_round or automatic_rectangular) and click **Load**.

In the **Layer** frame:

3. If available, select wavelength for your application from the Laser dropdown list.
4. Double-click Design and select the design for your overlay exposure.



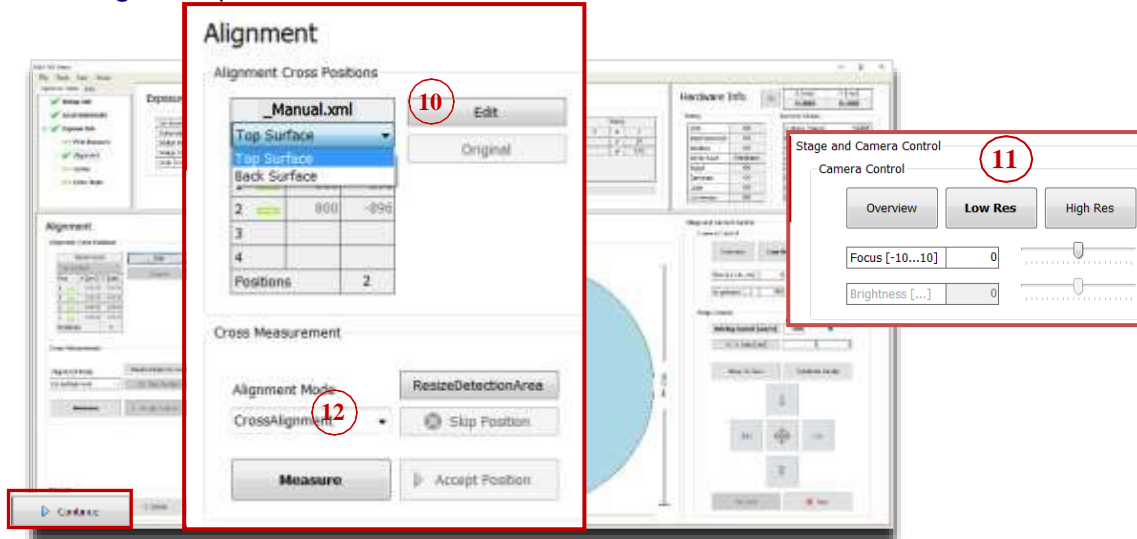
For instruction on how to convert a new design, refer to 7 *Design Conversion* in this guide.

5. It is possible to load a template for alignment crosses or shapes which are exposed on the layer. To load this kind of template, double-click into the value field titled Expose Crosses and select a bitmap template file from the list.
6. For selecting a template that contains the positions of alignment marks, double-click **Align Crosses** and choose from the list. To set the alignment marks manually, select the template *Manual* for manual setup.
7. Double-click **Resist** and select the resist type.

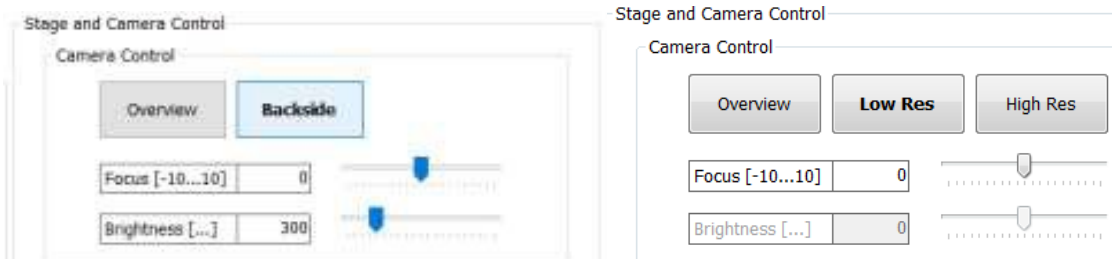
- The **Thickness** field displays the thickness of the substrate.
- 8. Option a: Click **Load Substrate**, load the substrate according to the on-screen instructions. You are led automatically to the next step.

Option b: If you have already loaded the substrate, click **Alignment**.

In the **Alignment** panel:



- 9. If the template `_Manual` for manual setup of the alignment cross coordinates is chosen, select **Top Surface** for top side alignment or **Back Surface** for back side alignment from the dropdown list. The other templates already contain this information.
- 10. Double-check the positions of the alignment marks taken from the template file.
 - To change the cross positions, click **Edit**. Enter new values and click **Save**. The positions are stored in a temporary file and turned into a permanent template after exposure start.
 - To restore the original positions from the file, click **Original**.
 - If the template `_Manual` was selected, set the alignment marks manually by using the **Edit** function. For every alignment cross enter the coordinates and click **Apply**.
- 11. Choose a camera from the Stage and Camera Control panel:



	Top Surface		Back Surface
	Field of view		Field of view
High Res	190 μm x 140 μm	Backside	640 μm x 480 μm
Low Res	640 μm x 480 μm		
Overview*	12 mm x 9 mm		

*Overview cannot access the entire surface of the substrate due to mechanical limits.

Note: Using the **High Res** or **Low Res** camera for alignment is recommended whereas the **Overview** camera might only be useful for alignment procedures with coarse structures.

12. From the **Alignment Mode** dropdown list choose between **CrossAlignment** and **ManualAlignment**. This selection can be made for every single position.

13. Use the **Stage Control** section of the **Control Panel** to move the first cross into the camera center. You can switch between the available cameras.

Note: You can switch between continuous movement and stepwise movement. In step mode enter the **step size** [μm] for X and Y direction into the corresponding fields. In the continuous mode, change the **driving speed** [$\mu\text{m/s}$] either by using the slider or by clicking into the field and entering the speed manually into the corresponding field. Alternatively, click into the slider field to use the arrow keys for setting the speed

14. Determine the alignment marks in:

A. CrossAlignment Mode:

☐ Click **Measure**. The system measures the position of the cross and moves it to the center of the camera window. Examine the positions and click **Accept Position** to confirm it. The procedure moves on to the next alignment cross. In the **Pos** field, the rectangle turns into a check.

Note: Unsatisfying measurements can be repeated by clicking **Re- Measure**. For the finding cross function to work properly it is important that the alignment cross fills the entire camera window. If this was not the case, click **ResizeDetectionArea**. Inside the camera window, a rectangle appears showing the new detection area. To enlarge the detection area, click the right bottom corner of the rectangle without releasing it and drag it to the desired size while holding down the mouse button. To enlarge the detection area again, click **MaximizeDetectionArea** in the panel.

B. ManualAlignment Mode:

☐ Click **Measure**. In the camera window, a crosshair appears. Move the crosshair to the position in which the alignment marks should be set.

☐ Press S (square) or/and C (circle) on the key board, a rectangle frame or a circular frame appear to support positioning into the center of the cross. Click the left mouse button to fix the position.

Note: The frame can be enlarged or reduced by using the mouse wheel. Pressing C or S again makes the rectangle/circle disappear. To speed up the resizing of the frame, use Ctrl+ mouse wheel.

☐ To center the position of the alignment mark inside the camera window, click **Center Cross**.

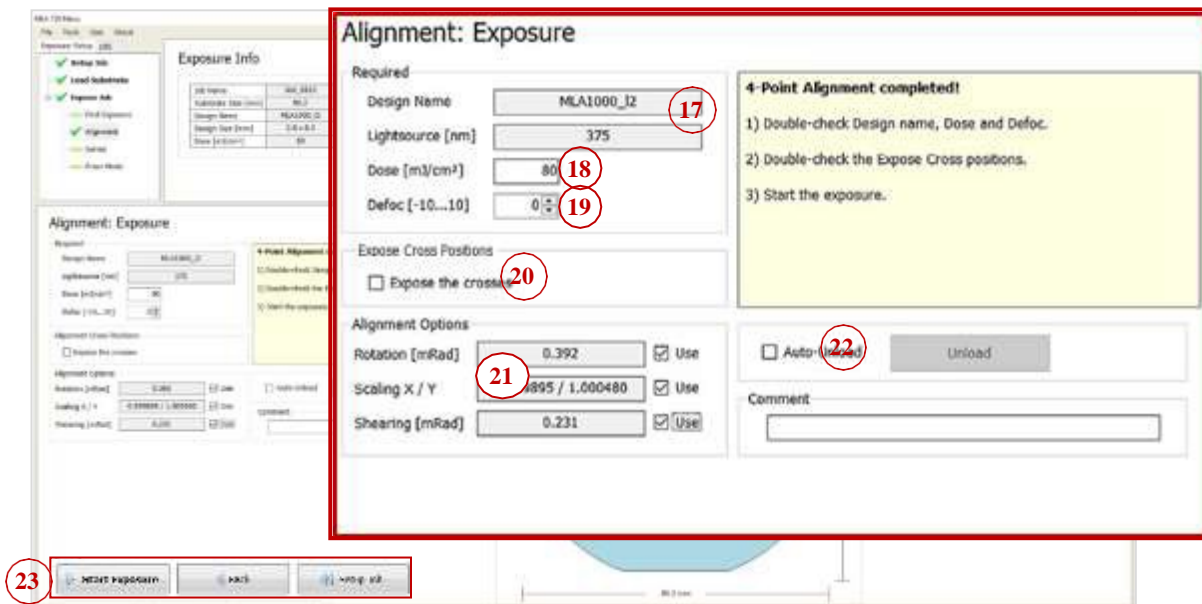
Note: It is possible to skip alignment positions by clicking **Skip Position**. This only works if more than two points are available otherwise the button is disabled. In the **Pos** field the rectangle turns red indicating that this coordinate pair was ignored Repeat the procedure for all alignment cross positions.

16. Click **Continue**.

Note: Restarting the alignment procedure is possible by clicking **Cancel**. Alternatively, with **Setup Job** the alignment procedure gets cancelled and the Exposure Wizard moves

back to the **Setup Job** panel.

In the **Alignment: Exposure** panel:



17. Double-check the design name and the wavelength.

18. Double-check or edit the **Dose** value by entering it into the text field.

19. Set the **Defoc** by selecting a value with the spin buttons (range -10 to 10).

20. It is possible to expose crosses or shapes on the layer. If not selected in the Setup panel a bitmap file can be selected for every cross position. Activate **Expose Crosses** checkbox. Click Edit and select a template for every cross position. For selecting the same file in every position, activate the checkbox **Use first bitmap for all**. Enter the positions into the table. Click Edit again, to leave the editing mode. Use this option also for changing the cross position information.

21. Choose from the Alignment Options section:

- Rotation [mRad]: If the **Use** checkbox is activated, the system includes the rotation of the substrate.
- Scaling X/Y: The system compares the distance measured during alignment with the distance given by the alignment positions. From the deviation, a scaling factor results. On this basis, the alignment design is shrunk or stretched in order to match the previous layer.
- Shearing [mRad]: The system compensates small distortions such as a rectangle that appears more like a parallelogram

22. If desired, activate **Auto-Unload**. The system executes the unloading procedure automatically.

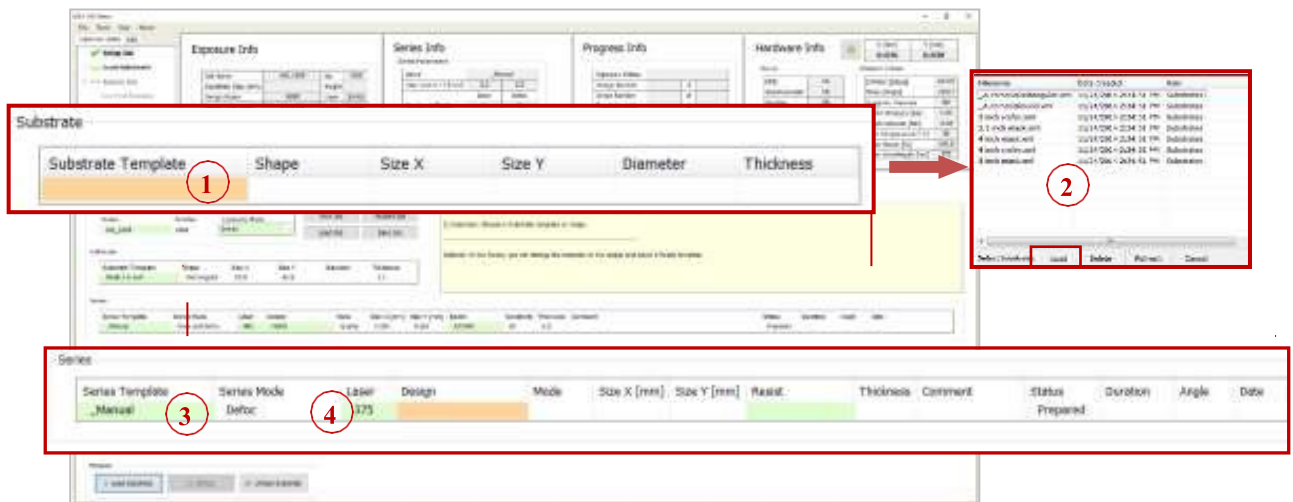
23. Click Start Exposure.

7.7 Series Exposure

By selecting **Series** from the Exposure Mode dropdown list, a template and standard test design for series exposures is loaded automatically.

In the **Substrate** frame:

Series									
Series Template	Series Mode	Design	Mode	Size X	Size Y	Resist	Sensitivity	Thickness	Comment
_Manual	Dose and Defoc	dosetest	Quality	2.000	5.826				

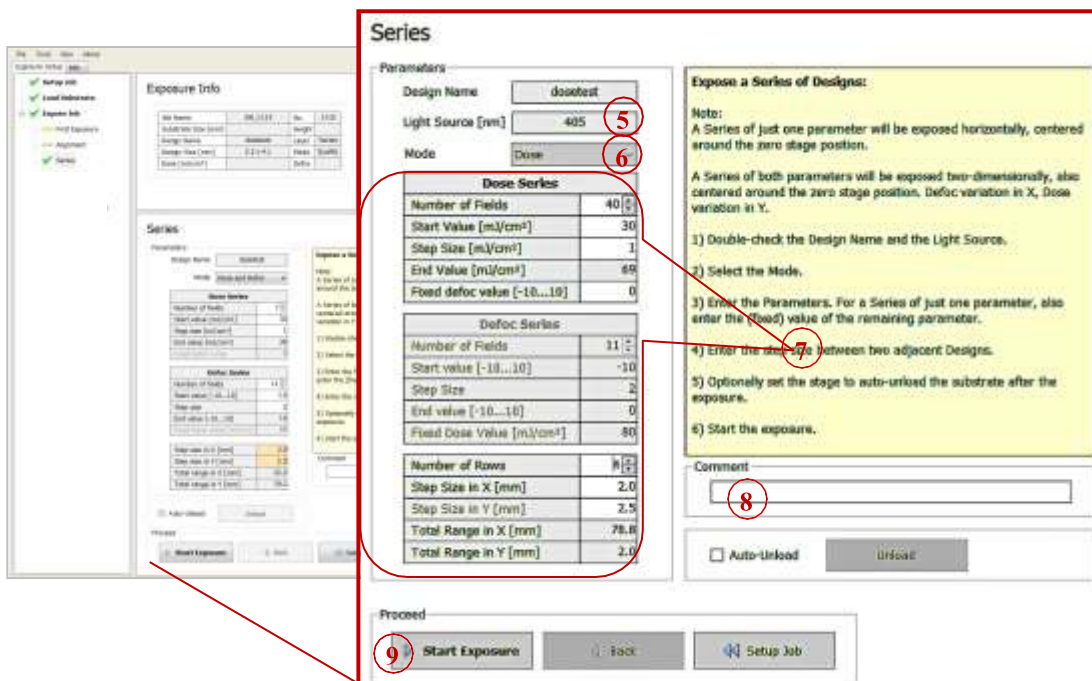


1. Double-click **Substrate Template**.
2. Select your substrate size or at least the shape (automatic_round or automatic_rectangular) and click **Load**.

In the **Layer** frame:

3. It is possible to select a different template by double-clicking **Series Template** and select one from the list. The design file can also be changed by double-clicking **Design** and selecting the design file.
4. If available, select the laser wavelength from the **Laser** dropdown list.

The wizard moves on to the next panel.



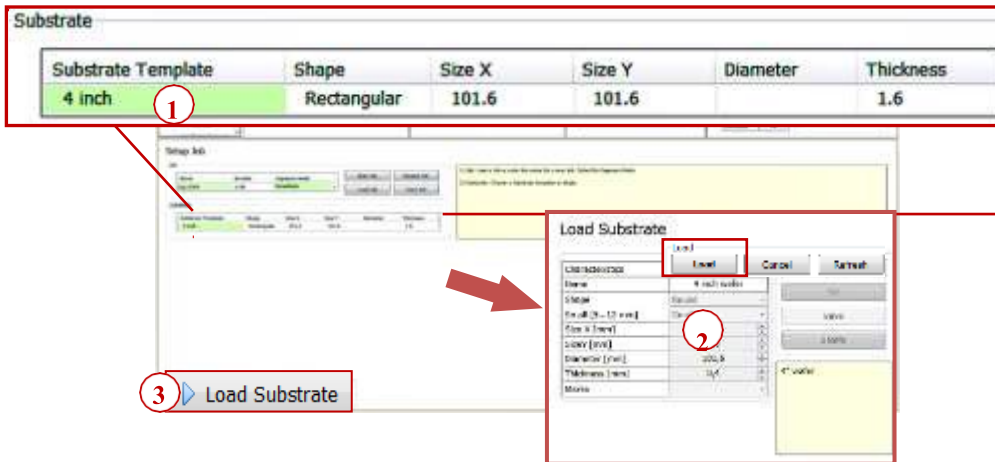
In the **Parameters** frame:

5. Check the wavelength in the **Light Source** field.
6. Select from the options in the **Mode** dropdown list: **Dose**, **Defoc** or **Dose and Defoc**.

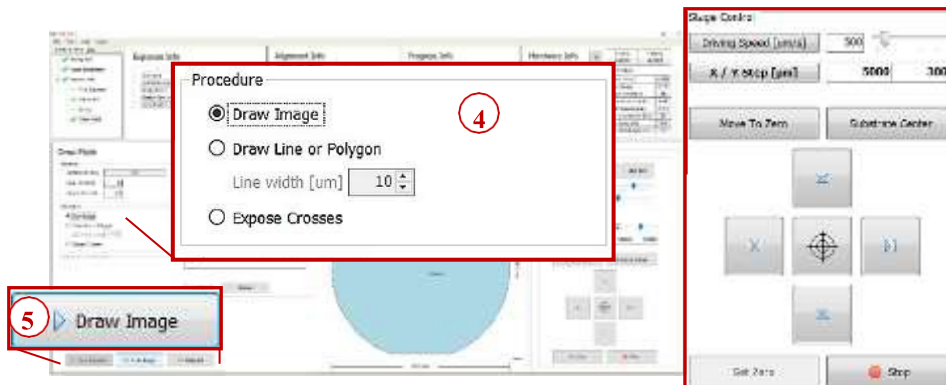
7. Set the values required for the selected mode.
8. If desired, activate **Auto-Unload**. The system executes the unloading procedure automatically.
9. Click **Start Exposure**.

7.8 Draw Mode

After having selected the Exposure Mode, you select the substrate size. In the **Setup Job** panel:



1. Double-click **Substrate Template**.
2. Select your substrate size or at least the shape (automatic_round or automatic_rectangular) and click **Load**.
3. Click **Load Substrate** and load the substrate according to the on-screen instructions displayed in the **Load Substrate** panel. The system searches for the center of the substrate.



In the **Draw Mode** panel

4. In the Procedure frame, select the kind of shape to use for image drawing by activating the corresponding radio button:

Draw Image: Activate this option to use the shapes offered in the camera window: rectangle, ellipse, circle or bitmap file.

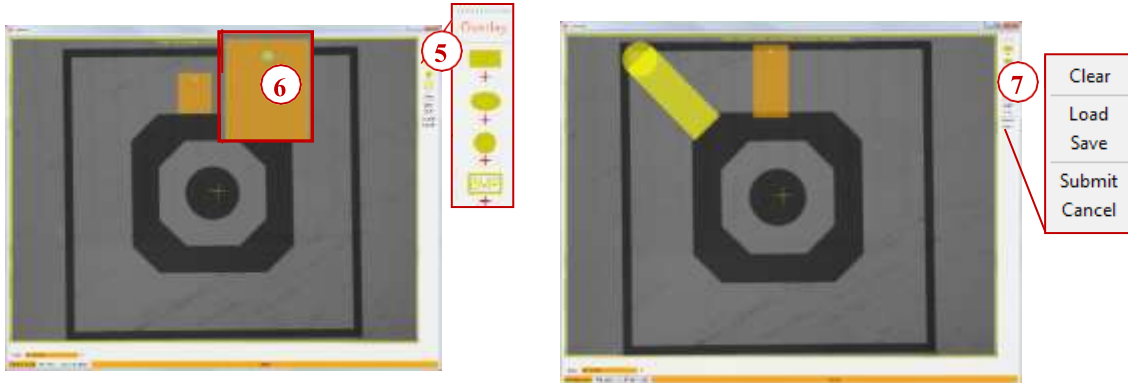
5. Click **Draw Image** and select the area for the structure on the substrate inside the camera window (use the Stage Control section for moving on the substrate)
6. In the camera window select the shapes of the structures that should be drawn onto

the substrate by clicking on the corresponding icon.



You can also load an existing file by clicking Load and selecting the file. To load a bitmap file, click **BMP** below the structure icons.

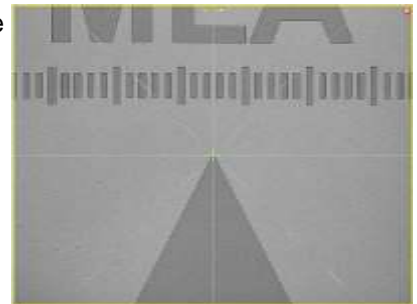
7. You can drag the structure to the desired position by clicking and moving the cursor with the mouse button held down.
8. To rotate the structure, click into the dot inside the structure and move the cursor without releasing the mouse button until the desired position has been found.
9. To confirm the drawn image, click **Submit** in the menu bar of the camera window. To clear the image, click **Clear** and start again



10. To save the image, click **Save**, insert a name for the file and save it. To cancel the entire procedure, click **Cancel**.

Polygon/ Polyline: Use this option to draw lines or polygons (lines with more than two points). Adjust the line width by using the spin control below the radio button.

5. In the camera window, move to the area near to the position of the first point of the line or polygon, so that it is visible in the camera image.
6. Click Set Point.
7. In the camera window, a crosshair appears. Move the crosshair by moving the mouse to the desired position.
8. Click the left mouse button at the position in which the first point of the line should be set.
9. Move to the next point of the line/polygon by using the arrow buttons of the Control Panel.
10. Click **Set Point**. Repeat the set point procedure.

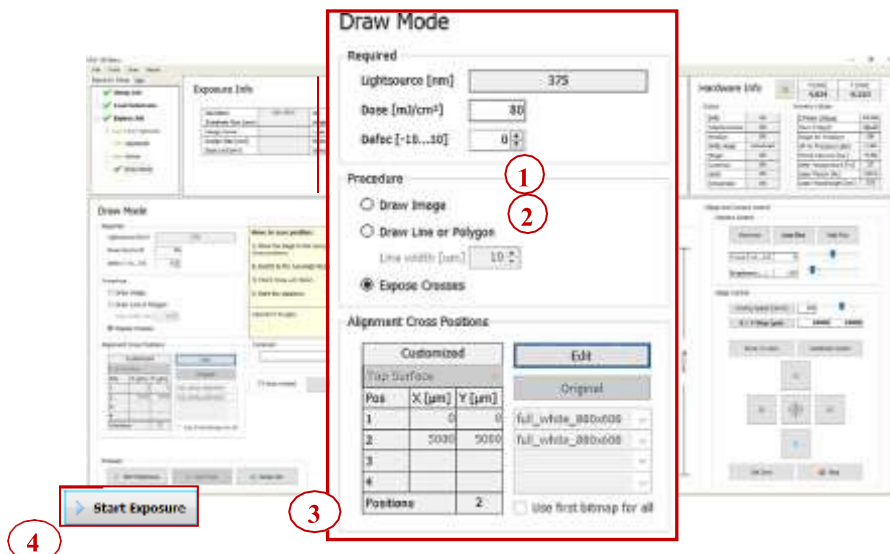


11. Check the line position in the camera window and click **Accept line**. To draw a polygon, go on with the set point procedure and click **Accept Polygon** to submit the polygon drawing.

Expose Crosses: Use this option to expose crosses or shapes for alignment orientation without the design (in Standard Mode a design has to be loaded). In the Expose Crosses table, you can load the bitmap file for cross exposure

If not selected in the **Setup** panel, a bitmap file has to be selected for every cross position:

5. Click **Edit** and select a template for every cross position. For selecting the same file in every position, activate the checkbox **Use first bitmap for all**.
6. Enter the positions into the table.
7. Click **Edit** again, to leave the editing mode.



Back in the **Draw Mode** panel

1. Set the **Dose** value by entering the value into the text field.
2. Set the **Defoc** by selecting the value with the spin buttons (range -10 to 10).
3. If desired, activate **Auto-Unload**. The system executes the unloading procedure automatically.
4. Click **Start Exposure**.

7.9 Design Conversion

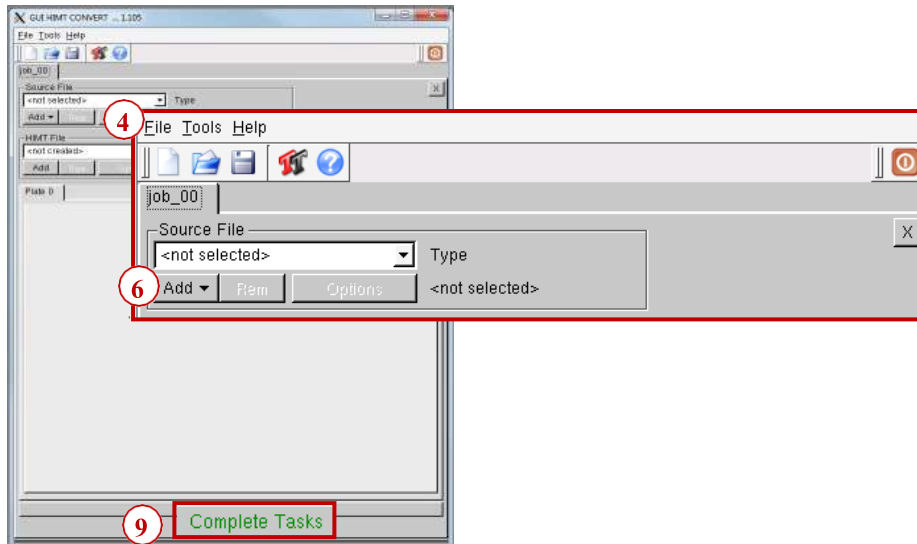
To use a new and yet unconverted design, follow these instructions: In the **Layer** frame:

1. Double-click **Design**. The **Load Design** panel containing a list of designs opens, where you normally select one of them for your exposure.
2. To upload a new design, click **Convert Design**.



3. The conversion software opens. In

the **Conversion** window:



4. From the menu bar, select **File** → **New Job**.
5. Enter a name for the job.
6. Click **Add** and select a design format. A directory opens containing the source files for the selected design format.
7. From the directory, select the file to be converted.
8. If necessary, change settings and / or use the viewer application (for details see related document *Conversion Job Manager*).
9. Click **Complete Task**. A message pops up. Wait until the message box informs about the completion of the process.
10. In the message box, click **Finish**. The conversion software closes.
11. Click into the wizard window to refresh the design list, or click **Refresh**. The new file is now listed and ready to be selected for the exposure job.