

Heidelberg MLA-150 Standard Operating Procedure

CORAL Name: **MLA-150**
Model: Heidelberg MLA150 Maskless Aligner
Location: TRL Photo-Au Room
Purpose: Direct-Write Lithography
Author: Heidelberg Instruments (2016), edited by K. Payer, April 2017

Introduction

The Heidelberg MLA-150 Maskless Aligner is a direct-write photolithography tool for samples ranging from small pieces (minimum 5x5 mm²) to 150mm wafers or 7" photomasks. The tool utilizes diode lasers (365 nm or 405 nm) and a high-precision stage to directly pattern photoresists from a CAD file. Both lasers can write a minimum feature size of 1 micron with alignment accuracy between layers of 500 nm. Write time will depend on the pattern, substrate size and the laser source; a small piece can be patterned in <5 minutes while a 150 mm wafer can take up to 60 minutes.

Design files should be one of the following formats: GDSII, DXF, CIF, GERBER. CAD files are converted to "Job Files" which the tool uses to write the pattern on a substrate. This document describes the procedure for exposing and aligning substrates.

Safety

Read and understand this SOP before use. Only trained personnel may operate this system. The MLA-150 uses two types of lasers: one for position measurement of the stage and one for design exposure. When the window is closed the system is a Class 1 laser. When the window is open for sample loading and unloading the stage interferometer laser is accessible and the system is a Class 2 laser.

The exposure lasers are very powerful diode lasers which are normally covered by optics covers and should not be accessible to users. If the optics covers are removed then the 405 nm (<10 W) and 375 nm (<3 W) are rated Class 4 and can be damaging to eyes and skin. The exposure lasers should not be accessed by unqualified users under any circumstances.

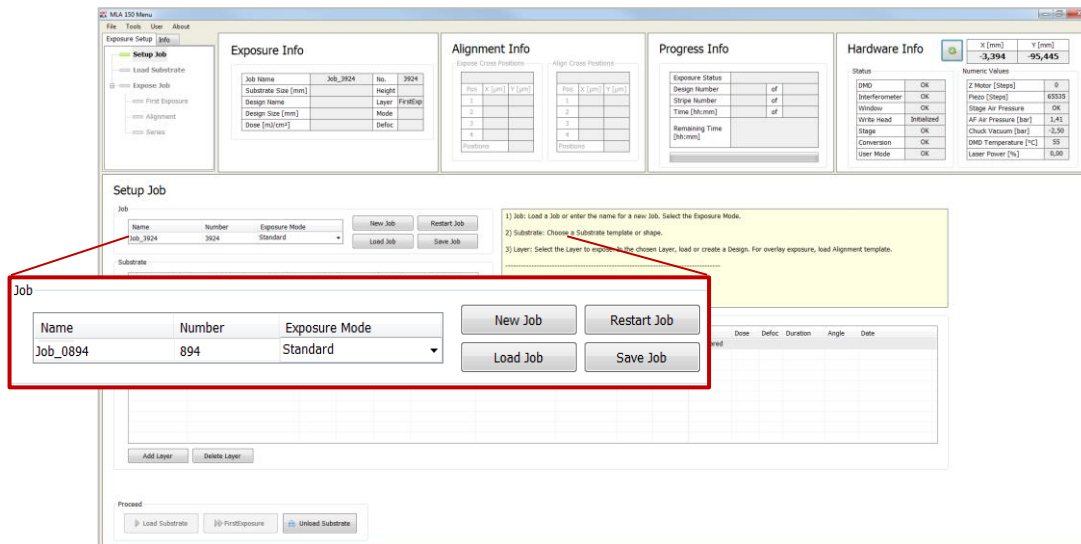
To protect the operator from hazards, interlock circuits prevent stage movement and access to laser light as soon as the window opens. A safety switch stops the stage, holds it in position, and closes the laser shutter even if an exposure has been running at the moment the window is opened. Users should observe safety labels and not make any attempt to bypass safety measures.



MLA150
Maskless Aligner

Setting up the exposure job

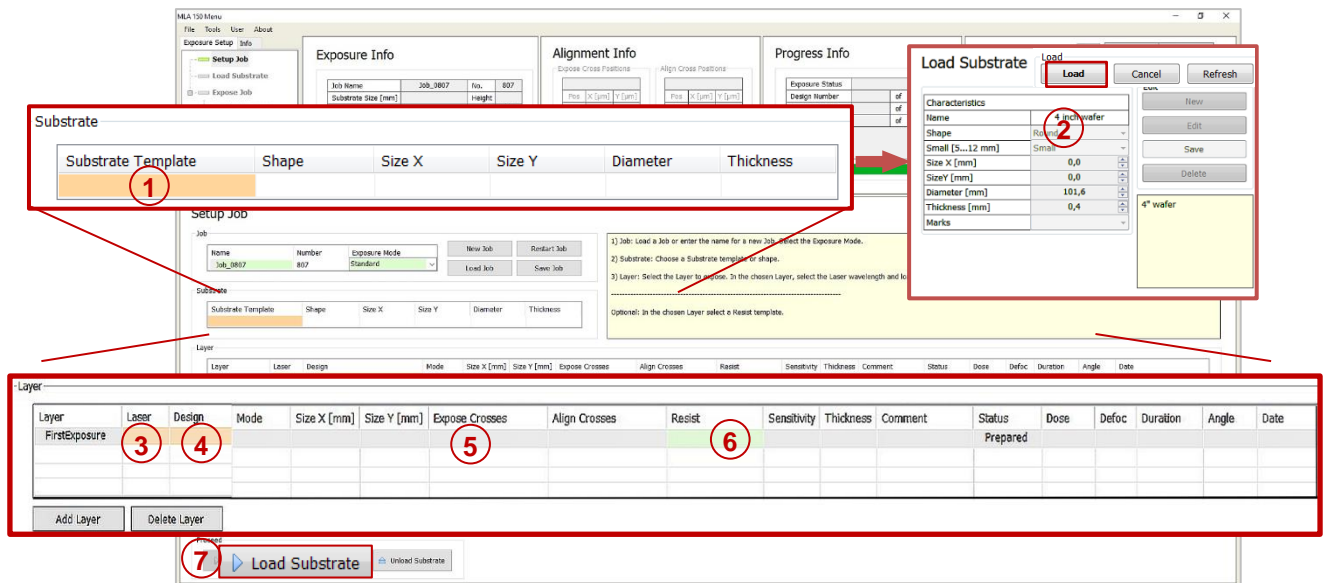
After you have clicked the shortcut icon, the wizard opens and leads you to the **Setup Job** panel, where a new job has been created automatically. This job has a **Name** and a **Number**. The name can be changed by clicking into the **Name** field. The number is fixed and auto-incrementing.



In the **Job** frame:

- To **continue or repeat** a job, click **Load Job**. A list appears from where you select the required job (for more details see related document *User Guide*.)
- 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.
- To continue the **new job**, select one of the available exposure modes:
 - Standard:** To expose a single design for each layer. Overlay (alignment) is available in this mode.
 - Series:** To expose a small test design (e.g. dosetest) several times with varying dose and/ or defoc values.
 - 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 on the layer without selecting a design.

Standard Exposure (without Overlay)



i For overlay exposures go to the section for *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 the section for *Design Conversion* in this guide.

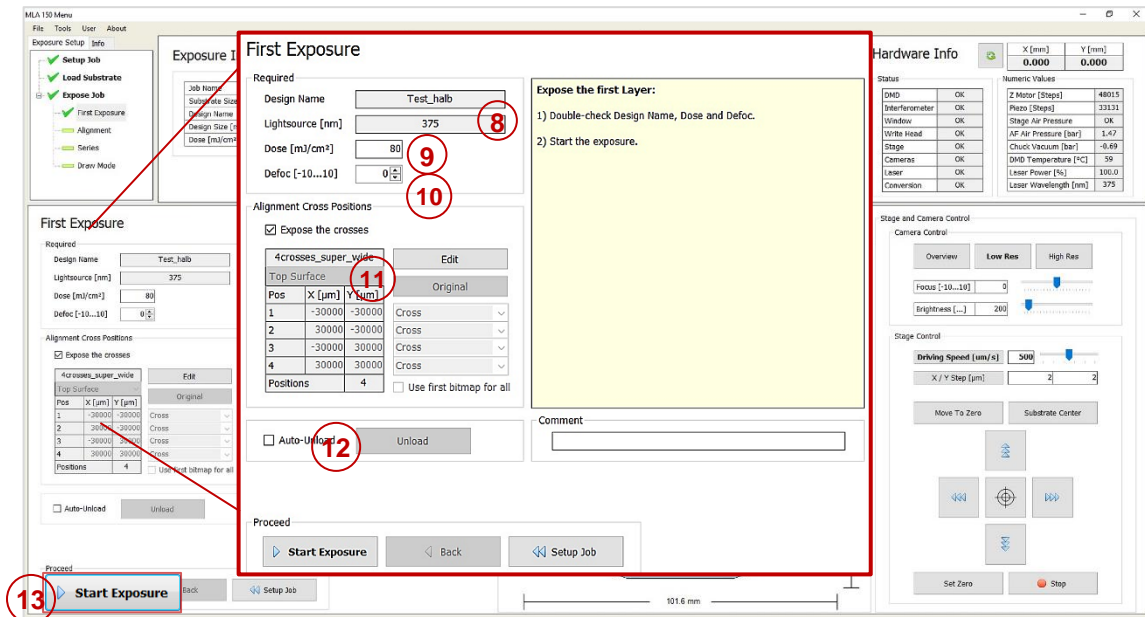
5. *Optional*: It is possible to load a template for alignment crosses which are exposed on the layer. To load this template, double-click into the value field titled **Expose Crosses** and select a bitmap template file from the list.
6. *Optional*: Double-click **Resist** and select the resist type.
 - The **Sensitivity** field automatically lists a dose value recommended for exposures on that type of resist. 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.

Note: Check for correct loading and write head position.

The system searches the center of the substrate and focusses on the center.

Standard Exposure (without Overlay)

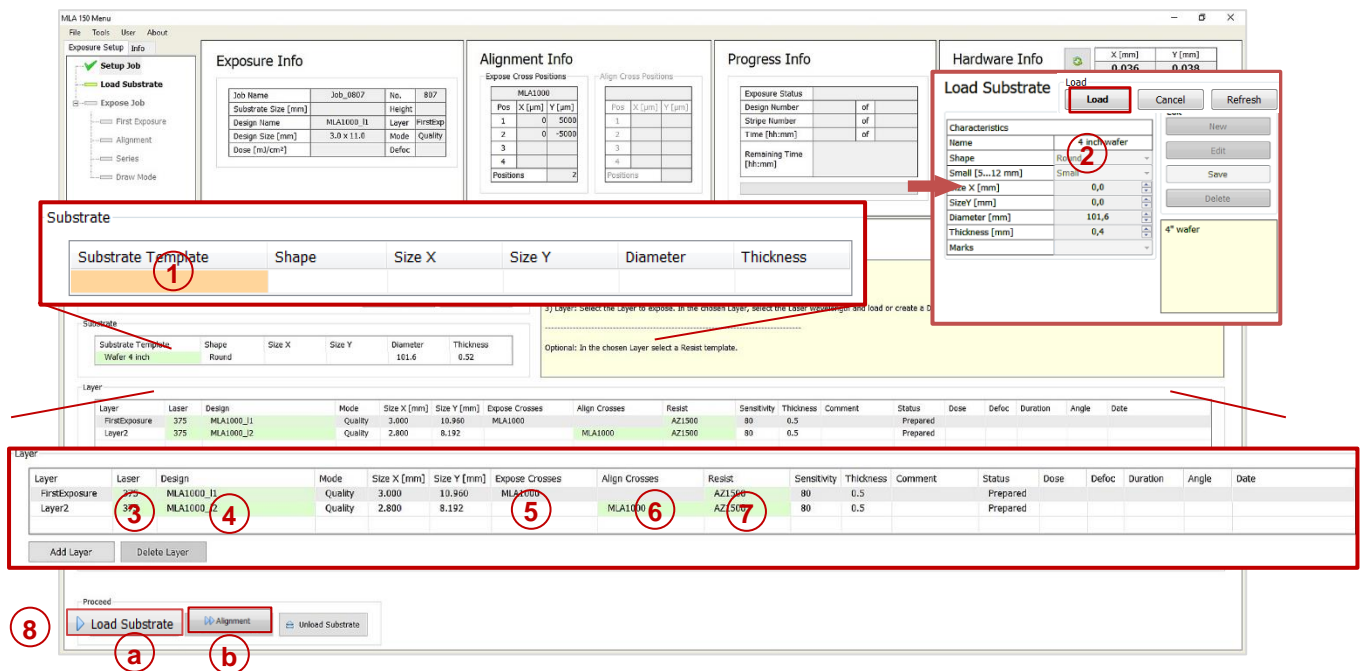
In the **First Exposure** panel:



8. Double-check the design name and the laser wavelength.
9. Set the **Dose** value by entering the value into the text field.
10. Set the **Defoc** by selecting the value with the spin buttons (range -10 to 10).
11. Optional: It is possible to expose crosses 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.
12. If desired, activate **Auto-Unload**. The system executes the unloading procedure automatically.
13. Click **Start Exposure**.

Standard Exposure with Overlay

In the **Substrate** frame:



i For alignment at least the second layer has to 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.

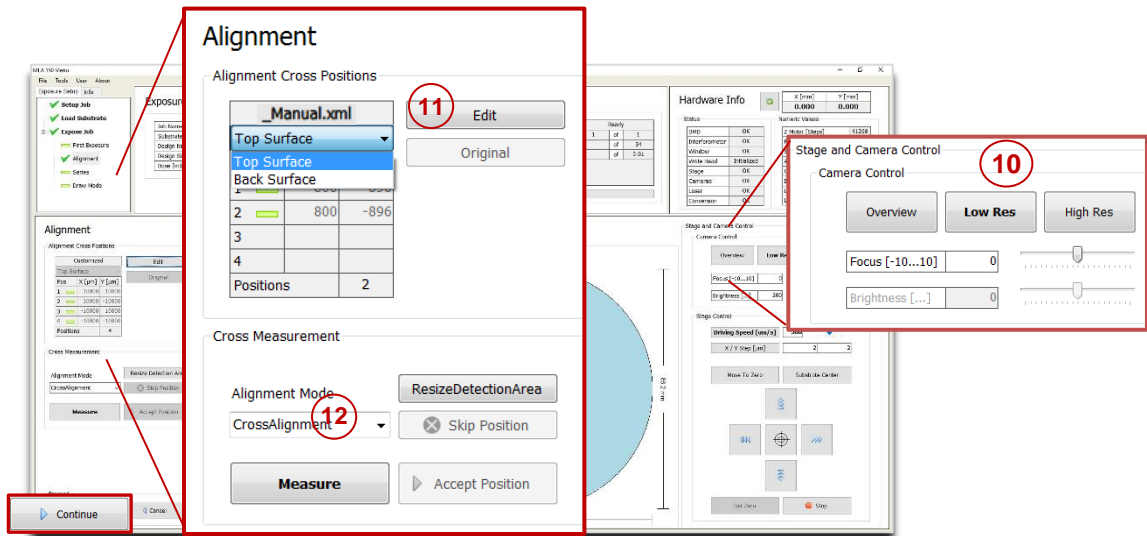
i For instruction on how to convert a new design, refer to the section for *Design Conversion* in this guide.

5. *Optional*: It is possible to load a template for alignment crosses 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. For selecting a template that contains the alignment crosses, double-click **Align Crosses** and choose from the list. To set the alignment marks manually, select the template `_Manual.xml` for manual setup.
7. *Optional*: Double-click **Resist** and select the resist type.

Standard Exposure with Overlay

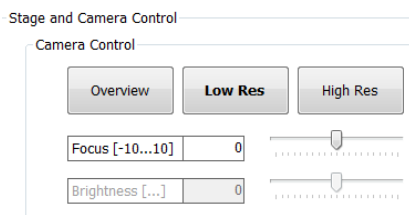
- The **Sensitivity** field automatically lists a dose value recommended for exposures on that type of resist. The **Thickness** field displays the thickness of the substrate.
8. Option a: Click **Load Substrate**, load the substrate according to the on-screen instructions. You are led automatically to the next step.
- Option b: If you have already loaded the substrate, click **Alignment**.

In the **Alignment** panel:



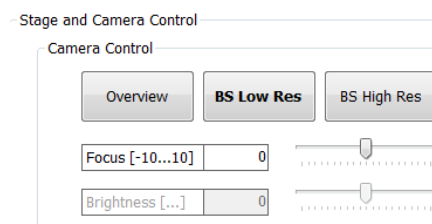
9. If the template `_Manual.xml` for manual setup of the alignment cross coordinates is chosen, select **Top Surface** for top side alignment or **Back Surface** for back side alignment from the dropdown list. The other templates already contain this information.
10. Choose a camera from the Stage and Camera Control panel:

Top Surface



	Field of view
Low Res	640 µm x 480
High Res	190 µm x 140 µm
Overview*	20 mm x 20 mm

Back Surface



	Field of view
BS Low Res	min. 364 x 274 µm
BS High Res	min. 172 x 130 µm

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

Note: Using the **High Res** camera for alignment is recommended whereas the **Overview** camera is not useful for alignment procedures.

11. Double-check the positions of the alignment crosses 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.xml` was selected, set the alignment marks manually by using the **Edit** function. For every alignment cross enter the coordinates, click **Save** and then **Accept Position**.

12. From the **Alignment Mode** dropdown list choose between **Cross Alignment** and **Manual Alignment**. 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.

Note: You can switch between continuous movement (jogging) and stepwise movement. In step mode enter the **step size** [μm] for X and Y direction into the corresponding fields. In the jogging 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. Cross Alignment 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 **Remeasure**. 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 resize the detection area again, click **MaximizeDetectionArea**.

B. Manual Alignment Mode:

- Click **Measure**. In the camera window a crosshair appears. Move the crosshair to the position in which the alignment marks should be set, and click. The crosshair turns from green to orange.

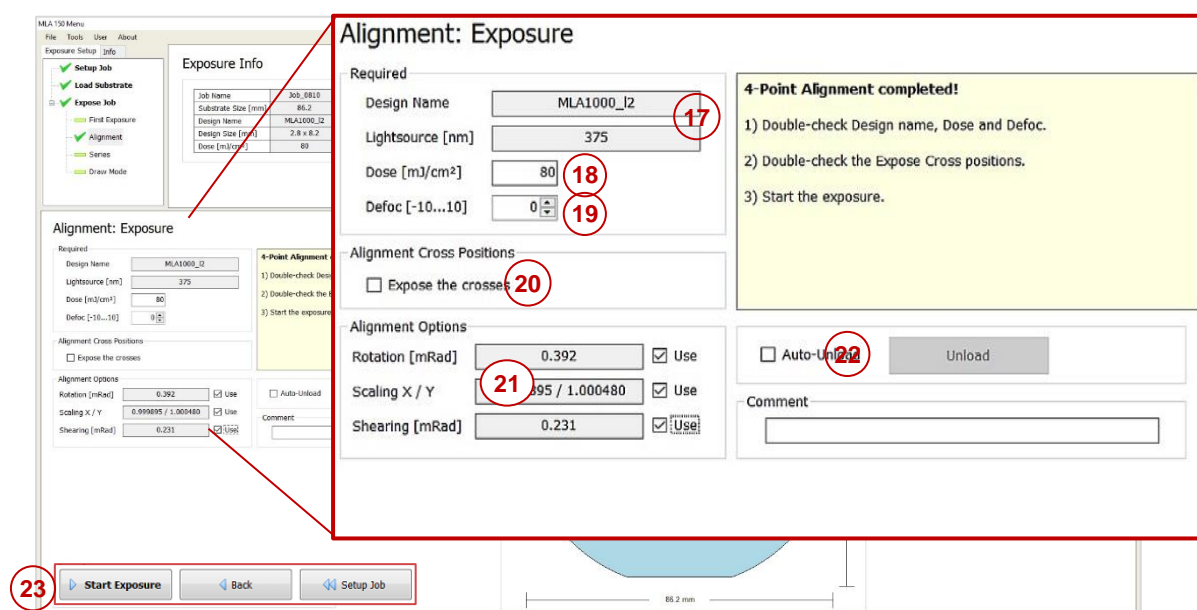
Note: For fine positioning use the arrow buttons.

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

15. Repeat the procedure for all alignment cross positions. 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.

16. Click **Continue**.

In the **Alignment: Exposure** panel:



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

18. If no default value is given, set 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. Optional: It is possible to expose crosses 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. Chose from the Alignment Options section:

- **Rotation [mRad]:** If the Use checkbox is activated, the system calculates 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**. .

Series Exposure

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

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				

In the **Substrate** frame:

The screenshot shows the software interface with the following elements highlighted:

- 1:** A red circle around the 'Substrate Template' dropdown menu in the Substrate frame.
- 2:** A red circle around the 'Load' button in the 'Select Substrate' dialog box.
- 3:** A red circle around the 'Series Template' dropdown menu in the Series frame.
- 4:** A red circle around the 'Laser' dropdown menu in the Series 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. 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:

Series

Parameters

Design Name: rk800

Lightsource [nm]: 375

Mode: Dose and Defoc

Dose Series	
Number of fields	7
Start value [mJ/cm ²]	30
Step size [mJ/cm ²]	1
End value [mJ/cm ²]	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 ²]	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.
- 5) Optionally set the stage to auto-unload the substrate after the exposure.
- 6) Start the exposure.

Comment: Test of new resist

Auto-Unload

Proceed

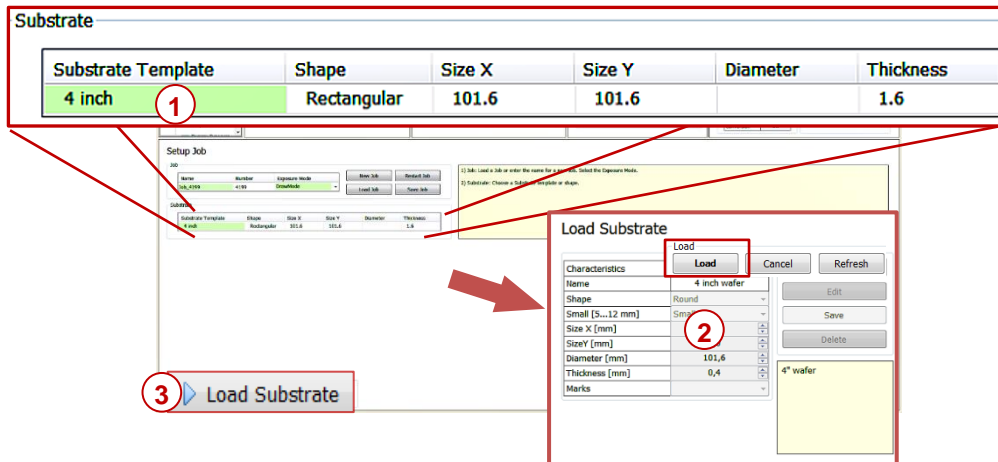
Start Exposure

5. Check the wavelength in the **Lightsource** 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.

Note: Pay attention to the value in the **Total range** fields. If the total range requires more space than available on the substrate, an error message pops up.
8. If desired, activate **Auto-Unload**. The system executes the unloading procedure automatically.
9. Click **Start Exposure**.

Draw Mode

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

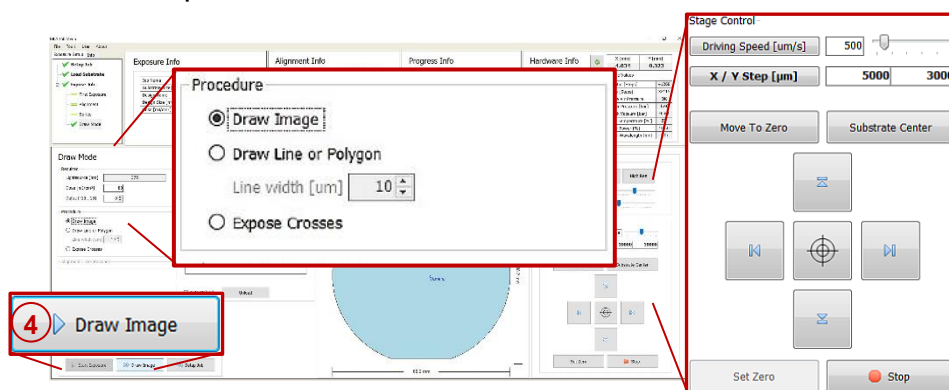


1. Double-click **Substrate Template**.
2. Select your substrate size or at least the shape (automatic_round or automatic_rectangular) and click **Load**.
3. Click **Load Substrate** and load the substrate according to the on-screen instructions displayed in the **Load Substrate** panel.

Note: Check for correct loading and head position. For small substrates the system issues a dialog box if the substrate type has not been completely defined in the step of substrate template selection.

The system searches for the center of the substrate.

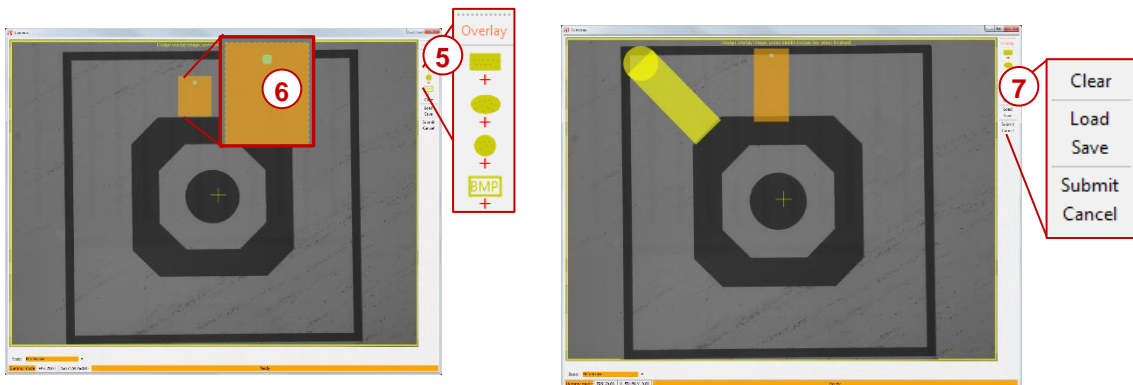
In the **Draw Mode** panel



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.

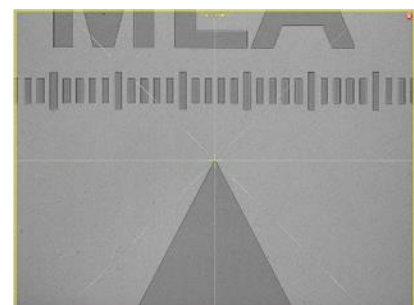
5. Click **Draw Image** and select the area for the structure on the substrate inside the camera window (use the Stage Control section for moving on the substrate).
 6. In the camera window select the shapes of the structures that should be drawn onto the substrate by clicking on the corresponding icon.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



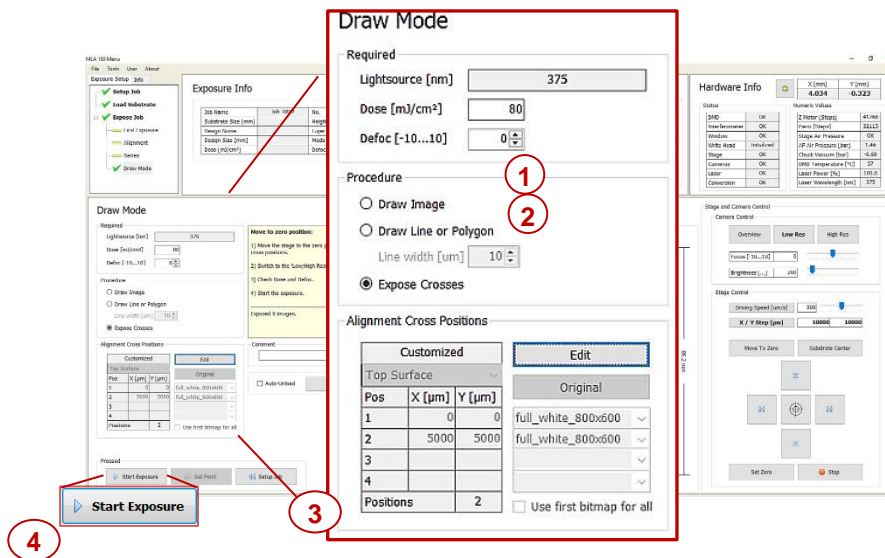
9. Move to the next point of the line/polygon by using the arrow buttons of the Control Panel.
10. Click **Set Point**. Repeat the set point procedure.
11. Check the line position in the camera window and click **Accept line**. To draw a polygon, go on with the set point procedure and click **Accept Polygon** to submit the polygon drawing.

Expose Crosses: Use this option to expose crosses 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**.

Design Conversion

To use a new and yet unconverted design, follow these instructions:

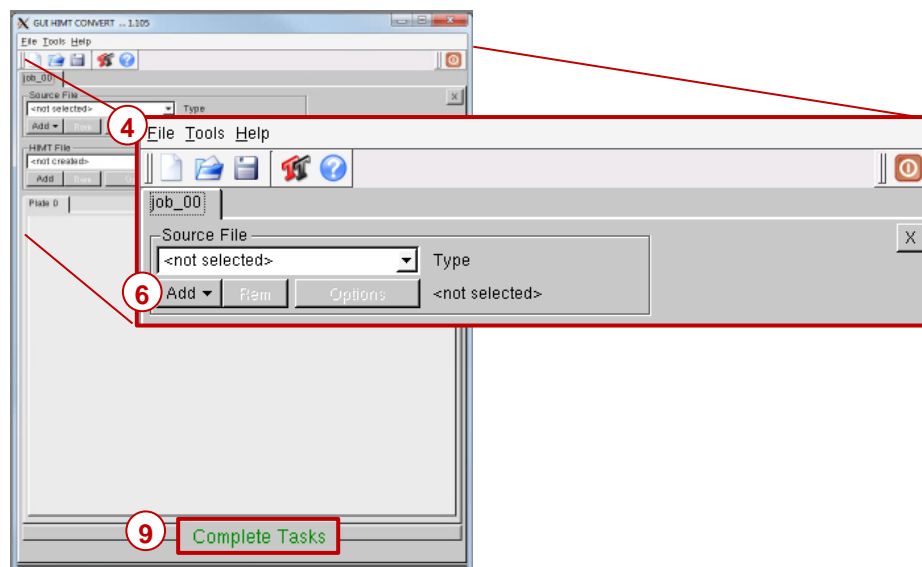
In the **Layer** frame:

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**.
11. The conversion software closes automatically.
12. Click into the wizard window to refresh the design list, or click **Refresh**.
13. The new file is now listed and ready to be selected for the exposure job.