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**

<table>
<thead>
<tr>
<th>No.</th>
<th>Equipment Description</th>
<th>Date</th>
<th>Time</th>
<th>Duration</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Z16 Heidelberg MLA 150 - MaskLessAligner</td>
<td>10.11.2022</td>
<td>08:08:17</td>
<td>00:04:43</td>
<td>$</td>
</tr>
<tr>
<td>2</td>
<td>Z16 Heidelberg MLA 150 2 - MaskLessAligner</td>
<td>10.11.2022</td>
<td>08:04:43</td>
<td>00:04:17</td>
<td>$</td>
</tr>
</tbody>
</table>

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:
  
  - Orange = input **required**
  - Green = input **optional**

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**Setup Job**

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 exposures, load alignment templates.
• 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**
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
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
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:

<table>
<thead>
<tr>
<th>Wafer size</th>
<th>Mark 1</th>
<th>Mark 2</th>
<th>Mark 3</th>
<th>Mark 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 inch</td>
<td>X: +20 mm</td>
<td>Y: 0</td>
<td>X: -20 mm</td>
<td>Y: 0</td>
</tr>
<tr>
<td>3 inch</td>
<td>X: +28 mm</td>
<td>Y: 0</td>
<td>X: -28 mm</td>
<td>Y: 0</td>
</tr>
<tr>
<td>4 inch</td>
<td>X: +40 mm</td>
<td>Y: 0</td>
<td>X: -40 mm</td>
<td>Y: 0</td>
</tr>
<tr>
<td>5 inch</td>
<td>X: +44 mm</td>
<td>Y: 0</td>
<td>X: -44 mm</td>
<td>Y: 0</td>
</tr>
</tbody>
</table>

Wafer 4 inch
1.C Expose

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

→ For wafer :

1. open the window

2. Place the guide according to your wafer size

3. Place and centre the wafer against the guide

4. Activate the Vacuum

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

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
2) Standard with alignment

a) Control if alignment positions are correct and edit if needed

b) Click to start alignment procedure

c) Overview and Low Res camera → move to your mark  
   High Res → for the measurement

d) Chose measurement mode:
   - Automatic: CrossAlignment or RectangleAlignment
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
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
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
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:

![Start Exposure]

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
(≈ 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
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.
**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 approximatively 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.