**Heidelberg MicroPG 101-2 Pattern Generator SOP**

1. **Scope**
	1. This document provides the operating procedures for the Heidelberg Pattern Generator with Version 3.12.5 software.
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1. **Reference Documents**
	1. **Referenced within this Document**
		1. None
	2. **External Documents**
		1. None
2. **Equipment and/or Materials**
	1. Mask
	2. USB Drive
3. **Safety**
	1. Follow all Nanofab safety procedures
4. **Pattern Design and Conversion**
	1. **Design Data**

The μPG 101 can expose designs created in one of the following formats:

* CIF: *Caltech Intermediate Form*, easy-to-use language for direct definition of structures in a text file (recommended format)
* DXF: Standard AutoCAD format
* BMP: Standard MS-Windows® Bitmap format. This is the only format useable for grayscale exposures (3D resist structuring)
* GDSII: Standard format for dense binary (2 dimensional) designs

NOTE: To get the correct results, certain rules have to be followed when creating the design.

* 1. **General Design Rules**
		1. **Minimum feature size for the MicroPG – 2 is 2.5 um in write mode II and 0.9 um in write mode I**.
		2. Maximum CAD design size is 125 mm x 125 mm for write mode II (2.5 um) and 90 mm x 90 mm for write mode I (0.9 um).
		3. Use polygons or circles that enclose areas, these may overlap and will be combined for exposure with an OR function.
		4. Defined enclosed areas will be exposed by default (you can select darkfield or lightfield later in the μPG program).
		5. Do not use special characters (spaces, punctuation marks, umlauts ..) in the design name.
		6. It is recommended to center the design (0, 0 at center of pattern), however the μPG program can calculate offsets using max and min x and y and center the design.
	2. **DXF Specific Design Rules (AutoCAD)**
		1. Use a 100% AutoCAD compatible editor.
		2. The design has to be created in metric units.
		3. Do not use single lines without width (must use closed polylines).
		4. All polylines must be closed (use close command for last segment). Keep in mind interiors of polyline structures will be filled out completely, covering any structures within.
		5. Do not cross polylines, or create doubled vertices (vertices with no distance between them). This will create data error.
		6. As far as possible, only use the structure types “rectangle”, polyline”, “circle”, and “text”.
		7. Only one text font is provided. This will replace any other font used in the design creation. The only supported text attributes are “rotated”, “mirrored”, and “scaled”.
		8. Try to use as few layers as possible. All exported layers will be merged via an OR operation.
			1. Layers can also be combined using an XOR command, but contact staff prior to running XOR for your mask.
		9. Do not use special characters in the layer names.
		10. Polylines with width must not change their width (no tapered lines).
		11. When inserting blocks, the same scaling has to be used for x and y.
		12. External blocks are not supported.

NOTE: Zoom Extents will find any unexpected features outside normal design viewing window.

* + 1. Save file as .dxf, use LinkCAD to convert to .cif or gdsII., see following section Convert to CIF format
			1. DXF files can also be loaded but, LinkCAD can detect and repair most errors without taking up any run time.
	1. **CIF Specific Design Rules**
		1. Use only one layer. If several layers exist in a design file, only the layer with the most references will be written.
		2. Maximum definition or reference depth is 50.
		3. The subroutine with the highest number definition will be taken as main routine.
	2. **BMP Specific Design Rules**
		1. Maximum image file size is 4 GB.
		2. For grayscale exposures, use 8-bit format. The 256 gray values will be interpolated down to 100 gray values.
		3. For the Heidelberg 3 μm, designs needed to be rotated to align correctly on the stage. For the newer Heidelberg PG 101-2, such rotations are not necessary. The BMP designs will align as is.
		4. At 2.5 or 3μm, 1 pixel = 1μm
		5. At 0.9μm, 1 pixel = 0.4μm
	3. **GDSII Specific Design Rules**
		1. No Inclusions:Do not include other GDII files or text libraries, they will be ignored.
		2. No nodes:Node statements in GDSII are ignored.
	4. **Convert to CIF format**
		1. Start LinkCad software on cad station.
		2. Select import format (i.e. DXF) from dropdown list.
		3. Select Export format CIF, then click on next.
		4. Check Units and scaling factor and adjust for input drawing, try using defaults for ARC Precision and Layer Options, if text is in design remove check to ignore text.
		5. Click Next
		6. Try using defaults for CIF Export Options, click Next
		7. Select your import file for conversion in the browsing window, click Open
		8. Note error Log Messages if present and click Next (not shown if no errors)
		9. Check correct Layers included in File Structure screen, click Next
		10. Click Save to use same name with CIF extension, then Quit
		11. Find the saved .CIF file and double click to launch in viewer
		12. Confirm conversion was successful, note origin, design size and offsets
		13. Exit .CIF viewer
1. **µPG Normal Operations**
	1. **Reserve and Enable µPG in Coral**
		1. Reserve time for the Pattern Generator on the Coral computer reservation system.
			1. Reserve the MicroPG – 2 2.5um or MicroPG-2-0.9 um in Coral before beginning operation, depending on which write mode you need.
			2. A typical 5” mask (for 4” diameter wafers) takes about 5 hours to produce in write mode II (2.5 um), and about 24 hours in write mode I (0.9 um)
			3. Notify staff of your reservation so that they can ensure that the correct write head is installed beforehand.
		2. Enable the MicroPG – 2-5 um or MicroPG-2-0.9 um in Coral before beginning operation, depending on which write mode you need.
		3. Keep track of the following data to input into the Coral log:

|  |  |
| --- | --- |
| **1.** | **Substrate** |
| **2.** | **Photoresist Type** |
| **3.** | **Design file name** |
| **4.** | **File type** |
| **5.** | **Laser power** |
| **6** | **Pixel energy** |
| **7.** | **Size-X** |
| **8.** | **Size-Y** |
| **9.** | **Inverted Y/N** |
| **10.** | **X offset** |
| **11.** | **Y offset** |
| **12.** | **Number of Stripes** |
| **13.** | **Alignment No/Auto/Manual** |
| **14.** | **Total exposure time** |

* 1. **Setup PC**
		1. Go to the µPG PC
		2. Click on labuser icon to get to the desk top
		3. Copy design file onto the PC
			1. Insert flash drive
			2. Go to the Utah Users folder on the desktop
			3. Find your directory or create a new folder titled ‘your name’
			4. Copy your design file(s) into this folder
		4. Start Exposure Wizard. *See* *Figure 1, Exposure Wizard Icon*

**Figure 1 Exposure Wizard Icon**

* + 1. Wait for system initialization, lid must be closed for initialization or stage movement
		2. Make sure the write mode displayed on the bottom of the Welcome screen is the correct write mode for the minimum feature size on the CAD file you designed. (Writemode I min feature size = 0.9 um, Writemode II min feature size = 2.5 um). If it is not, you will need to contact staff to change the optics of the write head.

NOTE: Settings from previous exposure will be defaults without Advanced Options and not in standard selection menus

* 1. **Load Design**

**Figure 2, Image Preview**

Default exposes dark area

Check ‘inverted’ box to expose white space

* + 1. Select New Design, See *Figure 2, Image Preview*
			1. Select your file
			2. Enter units –
				1. 1000 for DXF if CAD file drawn in mm, 1 if drawn in um
				2. CIF units = 1
				3. For GDS, select layers to be processed
		2. Wait for preview image to process
		3. Click on image to check it and close preview after checking
			1. If not correct, either return to Load Design step and load the correct design or select EXIT to quit Wizard
			2. If the image is still not correct, refer to Troubleshooting 8.3
		4. **Make sure size x, y and offset x, y look correct.** If not, reload the design and enter the correct units.
		5. Note size and offset for Coral log
		6. Click Next
	1. **Set PG Parameters**
		1. Click on show control panel
	2. **Load Mask**

**Figure 3, Check Options – Expose Window**

Always check ‘Automatic Centering’ unless the design is already centered.

Check for non-centered designs

* + 1. Click “To Un/Load” button in Stage Controls, see *Figure 4, Controls Window*
		2. Do not open lid until stage moves forward.
		3. Load Mask
			1. Open lid
			2. Place a 5 x5” mask against the 3 centering pins in the stage, 1 on the front edge and 2 on the left edge
				1. Contact staff if using wafers or substrates 1” or smaller, Writehead cannot auto focus with 1” or smaller size
				2. Or for other size substrates visually center on the stage
				3. If the pins must be removed to accommodate a larger substrate, contact staff

NOTE: Pins are an aid for centering the mask on the stage but not required

**Figure 4, Controls Window**

* + - 1. Check to make sure the mask is photoresist side up
			2. Turn on vacuum switch, see *Figure 5 and 6, μPG Chuck*
			3. Adjust white knobs for mask size ONLY if needed (*see figure 10*)
				1. You want to switch on all the vacuum holes under your substrate or mask to keep it flat on the stage but not have any leaks. Push on your mask to check that it is secure on the stage.
				2. If the mask is secure and problems persist, refer to Troubleshooting 8.2.
			4. For wafers or thin substrates: PULL OUT PINS \*IMPORTANT\*, if the pins protrude above substrate surface. (You don’t need to remove the pins for glass/chrome masks that are thicker than the pins.)

NOTE: The mask must not be resting on any of the stage alignment pins. If it is, you may hear the vacuum leaking and it may contact the Writehead during exposure. You will be accountable for damage to the Writehead if you improperly load your mask.

vacuum switch

**Figure 5**

**Figure 6, Vacuum Switch**

|  |  |  |
| --- | --- | --- |
|  | **WARNING****Severe damage to the Writehead could occur if pins are above mask surface.** |  |

* + - 1. Shut lid
			2. Click “To Center” on the Stage Control, the stage will move to stage center under Writehead
			3. Click “Focus” on the Writehead Control, the Writehead will move to focus and expose height above substrate

NOTE: Focus is complete when a green rectangle is present above Focus button, do not proceed until green rectangle is present, see *Figure 4, Controls Window*

* + - 1. Click “Close” in the Controls window
	1. **Set PG Parameters**
		1. Check and set Options: see *Figure 3, Check Options – Expose Window*
		2. Power in mW, see current recommendation tag on μPG101 (This is different for each different write mode!)
		3. Exposure level %, see current recommendation tag on μPG101 (This is different for each different write mode!)
		4. Energy Mode: 1x1 (default for typical masks and resist)
		5. Inverted check on = Light field (opaque/dark where features are drawn) or Inverted check off (default) = dark field (transparent where features are drawn), *see Figure 2, Image Preview*

NOTE: RIE or Wet Etch processes typically use light field mask to protect feature layer with PR. Lift-off processes typically use dark field mask for layer deposition into open areas

* + 1. Enter size of frame to expose extending outside design for inverted exposure – 0 to 10000 μm (larger number will increase write time, 1000 um recommended)
		2. Check the box next to Automatic Centering so the software centers your design on the mask
		3. Click “Next” in the Check Options window
	1. **Manual Alignment Window**
		1. If manual offsets or substrate alignment is needed, contact staff for training. Some instructions are provided in Section 9 Alignment Options

Figure 7, Manual Alignment

* + 1. Click NEXT

NOTE: Exposure is rotated in relation to front of Heidelberg, See *Figure 8, Stage Coordinates*

**Figure 8, Stage Coodinates**

* 1. **Begin Expose**
		1. Verify parameters (Energy, design name, parameters) see *Figure 9, Expose*
		2. Check Auto Unload after Exposure
		3. Click EXPOSE
		4. Software will estimate total mask write time, progress may be monitored remotely via the Nanofab site https://www.nanofab.utah.edu/heidelberg/
		5. Enter parameters into Coral log
		6. Recommend schedule disable. Go to the Nanofab site <https://www.nanofab.utah.edu>, under the Resources tab, click on Schedule Disable, login using your coral username and password, choose date and time, and make sure you select the right tool. If you are not planning on being in the lab by the time your process is over, leave a note and the case where your mask should be placed. (If you have questions, contact lab staff)
	2. **Unload Mask**

**Figure 9, Expose**

* + 1. Unload mask when exposure is complete
			1. Turn off vacuum
			2. Wait 10 seconds
			3. Unload mask
			4. Replace pins at 5” mask locations if removed
			5. Click OK in pop-up window
			6. Click Exit Wizard
		2. Enter information into Coral
		3. Disable MicroPG-2 in Coral
1. **Troubleshooting Problems**
	1. Terminating the Program during Normal Operation
		1. Click the blue Abort! Button
	2. Adjusting the white knobs
		1. Depending on the size of the mask being used, the white knobs controlling the vacuum reigon need to be reconfigured. To find the knobs, see *Figure 5, μpg Chuck*.
		2. Check that the knobs are in the correct positions as outlined in *Figure 10, White Knob* *Position*.
			1. Turn the knobs to the correct positions if they are out of line.

**Figure 10, White Knob Position**

* 1. Load Design Errors
		1. Check that the x and y values are less than or equal to the maximum amounts. If the values are greater than the maximum, adjust the values to fit the parameters. Refer to *Figure 2 Image Preview* to find where to adjust values.
		2. If x and y values are correct and problems continue, convert the image file into a different format.
			1. Use LinkCAD and convert file to .cif or gdsII. formats.
			2. Reload image.
			3. If it doesn’t work, try converting the file a second time and reload image.
		3. If above steps do not work, contact staff.

1. **Alignment Options**
	1. Manual Alignment Options, contact staff
		1. To confirm camera offset has been correctly adjusted, contact staff.
		2. Option - Find Plate Center
			1. Select check box fast mode and start to auto locate substrate edges and calculate offsets to center design on substrate, see (insert ref)
			2. Select accept to apply calculated offsets
			3. Select exit or cancel to exit window without offsets

**Figure 11, Find Plate Center**

**Figure 12, Setup Automatic Alignment**

* + 1. Option, Advanced Alignment - Contact staff to assist using Advanced alignment, see (insert ref)
			1. For POS enter design position of mark center in µm from design center, required for either Manual or Auto
			2. Only use Load or Create to use mark image for Auto align
			3. Check Mark 1 & Mark 2 to locate marks and calculate offsets and rotation
			4. Check Mark 1 only to locate one mark and calculate offset
			5. Select Execute alignment and use Stage Controls in Controls window to move to mark location
			6. For Manual, select POI and move crosshair to center of mark
		2. Option Manual Offsets
			1. Select Manual Offsets
			2. Enter offset value in pop-up windows for x and y offsets
		3. Option Manual Rotation
			1. Select Manual Rotation
			2. Enter offset value in pop-up windows for rotation in degrees
		4. Click Next after completing any desired positioning selections to exit Manual Alignment Window

**Figure 13, Camera View Window for Positioning & Alignment**

1. **Revision History**

|  |  |  |  |
| --- | --- | --- | --- |
| **Rev** | **Date** | **Originator** | **Description of Changes** |
| **3** | 26 Jan 2015 | Brian Baker | Copy and modify SOP from Heidelberg MicroPG-1 |
| **4** | 27 March 2015 | Christina Mottishaw | Modify SOP and update pictures. |
| **5** | 4 Dec 2015 | Sebastian Arias | Modify SOP and update pictures. |