# **XENOS XPG2 Ebeam patter writer SOP**



### **1. EBL sample preparations:**

Photoresist: PMMA A2 or A4

Spin Coater: program 7 for 60s at 3000 RPM

Hot plate: 1 hour at 180 C.

Scratch the corner of the sample to indicate the orientation of the sample.

Control and pattern file preparation: refer to the ECP manual online (user information=> cleanroom SOP) and off line software can be requested for writing and drawing files (contact cleanroom manager for getting one)

#### 2. Load the sample onto the EBL sample holder (small samples)

The offset of this EBL sample holder is 5.5 mm. Make sure input it into the sample holder offset in SEM setting.



#### **3. EBL operation steps:**

1. Turn on the XPG2 switch at the back of the console. The beam blanker should be on already and it should show "PCD /Beam blanker OUT"



2. Click "ECP" icon to start the



3. The XPG2 console should connect to the computer and beam blanker. It will show the "Current clock: 39999 KHz". The "Active" and "The beam blanked" light should be on. The beam blanker should show "Beam blanking ON".

Beam blanking ON		Contrast	Content clocks	Active	Beam blanker (
PLATE POSITION OUT PCD BLANK SETUP PLATE BEAM STATUS ON OFF BLANK ENTER PLATE ON OFF BLANK ENTER	ач • оч • оч •		XENOS XPG 2		#

4. Go to "EBL" => "Beam Control" to turn the electron beam on.

Mark Calibrate	EBL	System Extras Help	
	//■ 【↓ 総部	SEM Image Stage Control Expose	
	17	Beam Control	
		Field Size Line Scan Load Stage Configuration	ECP - Bea Control Blanker Control Beam On Beam Off PCD Position PCD
			Out Current:

5. Follow SEM SOP to find focus of your sample at high Magnification and the reference spot (normally the scratched area).

6. "File"=>"Open" your control file \*.ctl. The file commands will be displayed on the left window and the pattern will be in the right window.

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☆ Favorites	Name	Date modified	Туре	Size	
🚺 Downloads	Lyvers_Antennas.pat	10/9/2014 3:44 PM	PAT File	1 KB	
🔛 Recent places	Abbas_nanoantenna.ctl	10/9/2014 3:27 PM	CTL File	1 KB	
🗥 SkyDrive	Lyvers_fishnet300nmw80_110nm.ctl	10/9/2014 11:30 AM	CTL File	1 KB	
📃 Desktop	Lyvers_grating330nm.ctl	10/9/2014 11:18 AM	CTL File	1 KB	
	Lyvers_grating2um.ctl	10/9/2014 11:11 AM	CTL File	1 KB	
🌉 This PC	Lyvers_grating10um.ctl	Type: CTL File	1	1 KB	
📔 Desktop	Lyvers_FNandG_10_09_14.pat	Size: 632 bytes Date modified: 10/0/20	14 11-11 AM	1 KB	
Documents	gmtest_wdc.ctl	10/9/2014 9:52 AM	CILFIE	1 KB	
🚺 Downloads	gmtest.ctl	10/9/2014 9:05 AM	CTL File	1 KB	
🚺 Music	Lyvers_fishnet_10_08_14_02.pat	10/8/2014 6:23 PM	PAT File	19 KB	
📔 Pictures	lines.ctl	10/8/2014 4:49 PM	CTL File	1 KB	
📔 Videos	Lyvers_fishnet_10_08_14_double.pat	10/8/2014 4:30 PM	PAT File	1 KB	
🚢 OS (C:)	Lyvers_fishnet_6.ctl	10/8/2014 2:20 PM	CTL File	1 KB	
👝 Recovery Image i	Lyvers_fishnet_5.ctl	10/8/2014 11:58 AM	CTL File	1 KB	
	Lyvers_fishnet_4_high.ctl	10/8/2014 11:43 AM	CTL File	1 KB	
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7. Go to "Tools"=> "Map Exposure Origin" to have the stage reference location (X and Y value on SEM page) as the origin position in the control file. The "+" and "-" sign in SEM is opposite to the ones in ECP software.



8. Locate the area where you pattern will be in SEM. Then go to "Calibrate"=> "Working Distance Correction" on XPG 2. Choose three locations and adjust the SEM to get the best focus at each point. First to move away from reference spot to locate spot #1 and click "Submit". Second to move back to reference spot as spot #2 and click "Submit". Then move up to spot #3 and click "Submit". An example is shown below. Make sure the pattern will be within the area defined by the three spots.



9. Go to "Grid Setup" to choose "Display Origin". Click "Redraw" to check where the origin is related to the rest of the pattern. If you reference origin on your sample is at lower left corner, after redraw the origin in the drawing should be at lower left corner as well as shown in the example:



10. **Optional:** for the new pattern/sample, a series dose test is needed to determine the best dose value for the sample and patter. Go to "Extras" => "Dose Calculator"



to calcate dewell time value with known dose value. Clock value is on ECP console (40000) and Pixel value is default value at 50000. At "Beam Control" to measure the PCD current by click on "PCD" and read the current valve.

<u>.</u>	ECP	- Dose	Calculat	or ·		c i	🕺 ECP - Bea 🗖 🎫
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	Calculate dose		1	Calculate dwel	l time		Current: DA

Go to to show the exposure dose. Example: a serise of pattern to be written to determin the optium dose. Dose scale shows  $50-250 \text{ uC/cm}^3$ .



11. Click Exposure" to start the exposure process. The "Exposure" light on the console up and "Beam blanked" light will blink. The ECP software will give an estimate time at the bottom of the window for the exposure process.



11. Once the exposure process is over. Click Beam "OFF" to shut off the Ebeam on the SEM.

12. Turn off the ECP console (switch on the back) and close the software. Take the sample out by following SEM procedures.

## 4. EBL multi-layer alignment: global and chip mark

Here is an example:

1. Write your pat files to define the patterns (eg. one for the contacts and chip cross marks and one for the global mark) and your control file for writing multiples to test out dose if needed and your global marks.



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write 4 global marks to define the wafer's coordinate system:							- 1	- L-	
e will use these marks for the global mark detection in the						1	1		
d layer						T	T		
= 0									
= 0									
age						320	5		
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2. follow EBL instruction to have your 1<sup>st</sup> layer exposed=> developed=>metalized=>lift-off=> coated with PMMA=> baked

2. 2<sup>nd</sup> layer file writing: pat file for pattern for the 2<sup>nd</sup> layer. eg. Insulator area overlaps with the contacts area in the 1<sup>st</sup> layer. The control file includes the "gmcoord" to confine the pattern area, "gmark (MANUAL)" for finding global marks, chip mark "cmfile" to define the chip mark, "cmcoord" to locate the chip marks in each pattern, "cmark" to confirm the chip marks before pattern draw. To create "Mark" file, go to "Mark"=> "New Mark" => fill out the parameters to create the chip mark "cmfile"

JC rec		
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2 00 100	r	
I 2 C 200		
RECT 4900,25000,45300,34000		
end		
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File Edit View Tools Mark Calibrate EBL System Extras Windows Help     B B G 10 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0			c and score of the station of t		_ # ×
sfile = JC rec_Stefan					*
current = 200	+			+	-
<pre>&gt;to origin, 1st cross SEM xy reverse, x+37.68,y+-142.75 setfocus(AUTO) fsize = 400 origin = 3304, -2633.5</pre>					
/global mark detection to map the wafer's coordinate system to the stage: /here, we are dealing with stage coordinates in micrometers gmfile = click_10000					
gmccord = 0, 0 gmccord = 0, -3000 gmccord = -3000, -3000 gmccord = -3000, 0 gmark(MANUAL)					
<pre>;now the positions in your design can be mapped to the real stage coordinates with high accuracy ;next step; we indicate where the chipmarks are found in the writefield (now in pixel since we are working on the writefield) ;this is the markfile for the detection: cmfile = click 10000</pre>					
;the mark coordinates within the writefield (Chipmarks): cmccord = 5000, 5000 cmccord = 5000, 45000 cmccord = 45000, 5000 x = -300 y = -300 stage					
;this starts the chipmark detection cmark draw(JC rec, 2, 2368.00)					
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draw(JC rec, 2, 2368.00)		Size of mark	10000		
A = -700 y = -700 stage		Increment	20		
;this starts the chipmark detection cmark draw(JC rec, 2, 2368.00)		Dwell time	10000		
x = -1100 y = -1100 stage		Detect	Cancel Save	& Exit	
<pre>/this starts the chipmark detection cmark draw(JC rec, 2, 2368.00)</pre>					
x = -1500 y = -1500 stage					
/this starts the chipmark detection cmark draw(JC rec. 2, 2368.00)					
x = -1900 y = -1900 stage					
draw(JC rec, 2, 2368.00) x = 0					
y = 0 stage end					

3. In SEM, find best focus of the surface and find the  $1^{st}$  global mark (defined as 0,0 in your gmcoord). In the eg., the upper right corner one is the 0,0. Center the image at the  $1^{st}$  global mark in SEM, go to "Tools"=>"Map Exposure Origin" to have the stage reference location (X and Y value on SEM page) as the origin position in the control file.

4. click to start "expose"

5. the global mark detection page will pop out for each global mark. Use the "SEM Image Scan" to find the cross mark. Click "Done". Then "stage position ok?" click "OK". In "Detect Mark" window, move the cross to the center of the global mark cross then click " Mark OK". Repeat the process for getting 4 global marks' coefficients.



¥ ≝File Edit View Tools Mark Calibri □ 26 日 43 10 04 ≫ Do 101 1	ate EBL System Extras Windows	Exposure Control	Program - [C/Users/untcleanromEBL/Documents/layouts/startup//C//C square and cross layer2_Stefs + Jx +	an.cti]	- 0 ×
sfile = JC rec_Stefan current = 200		^	+		+
;to origin, 1st cross SE	E	Alignment Display		T.	
setfocus (AUTO) fsize = 400	Mark detection result		Detect Mark ? X		
origin = 3304, -2633.5	Mark X Mark Y	Correlation Target X	Mark name: click_10000		
<pre>;global mark detection t the stage: ;here, we are dealing wi gmfile = click_10000 gmccoord = 0, 0 gmccoord = 0, -3000 gmccoord = -3000, -3000</pre>	1 -8.090 -3.840	0.000			
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6. Once global marks are detected, the program will go to detecting chip marks and expose the patterns. Locate the cross at the center of the cross in "Detect mark" windows to get the coefficients of the chip marks. Repeat the process until all the chip marks found and patterns exposed.



7. Go back to step 11 in section 3 to close the program and turn off the console.

#### Reference pattern file and control file examples:

Eg. 1, Pattern file:

The content of one pattern file is called a pattern. Each pattern can contain many structures, each with a unique name, one structure can be composed of many shapes. Patterns are defined by simple text commands.

D structure\_name I increment C dwell time shape 1 .... shape n

END D next\_name . . . END

The shape "RECT" is a simple rectangle. The syntax is "RECT X1, Y1, X2, Y2". (X1, Y1) is the bottom left corner, (X2, Y2) is the top right corner of the rectangle. To arrange the shapes on a rectangular grid, four more numbers must be added after the shape data. They specify the period in x-direction, the period in y-direction, the number of repetitions in x-direction and the number of repetitions in y-direction.

Eg.2. Control file: A ctl-file consist of lines with text commands that control the e-beam system. You set up a number of variables like the beam current and define which pattern will be written at what position.

Current: Sets the current for the dose calculation. The current is given in picoampere (pA). setfocus(AUTO): will correct the focus for every exposure field fsize: specifies the size of the writing field in micrometers.

origin = x,y: you specify the starting point of the exposure.

x, y,z: These commands set the target for the next stage command

Stage: Moves the stage to the position defined by origin and x,y,z, \_x,y,z commands.

+x,+y,-x,-y:These command add a length to the stage move target or subtracts it.

draw (pattern-name, increment, dwell time): This command exposes the pattern on the sample.

fishnet\_p220nm\_w\_80\_110nm fishnet\_p300nm\_w\_80\_110nm gratings\_10um\_w\_130nm gratings\_2um\_w\_130nm gratings\_325m\_w\_150nm lines D gratings\_2um\_w\_130nm C 769 I 2 RECT 0, 0, 50000, 13, 0, 200, 1, 250 END D fishnet\_p220nm\_w\_80\_110nm C 160 I 2 RECT 935, 0, 1000, 50000, 1000, 0, 50, 1 RECT 0, 0, 49945, 40, 0, 110, 1, 455 END D lines C 40 I 4 RECT 1000, 0, 2000, 50000, 2000, 0, 25, 1 RECT 48000, 0, 49000, 40, 0, 110, 1, 455 END D gratings\_10um\_w\_130nm C 30 I 2 RECT 0, 0, 50000, 65, 0, 5000, 1, 10, 1 END D gratings\_325m\_w\_150nm C 30 I 2 RECT 0, 0, 50000, 75, 0, 165 , 1, 303, 1 END D fishnet p300nm w 80 110nm



sfile = Lyvers\_FNandG\_10\_09\_14 current = 240 setfocus(AUTO)
fsize = 100
origin = -1943.5, -6743.25
x = -1000
y = 1000
stage
draw(fishnet\_p300nm\_w\_80\_110nm, 4, 133.00) +x = 200stage draw(fishnet\_p300nm\_w\_80\_110nm, 4, 200.00) +x = 200stage draw(fishnet\_p300nm\_w\_80\_110nm, 4, 266) -x = 400 +y = 200 stage draw(fishnet\_p300nm\_w\_80\_110nm, 4, 333) +x = 200 stage draw(fishnet\_p300nm\_w\_80\_110nm, 4, 400) +x = 200stage draw(fishnet\_p300nm\_w\_80\_110nm, 4, 466.00) -x = 400 +y = 200 stage draw(fishnet\_p300nm\_w\_80\_110nm, 4, 533.00) +x = 200stage draw(fishnet p300nm w 80 110nm, 4, 600.00) -

+