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:

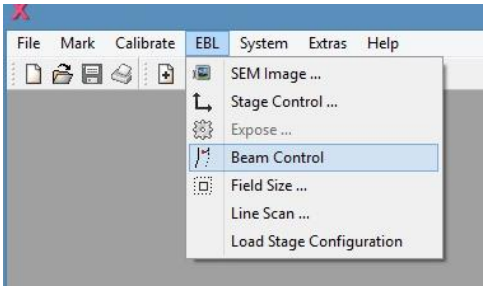
1. Turn on the XPG2 switch at the back of the console. The beam blanker should be on already and it should show “PCD /Beam blanker OUT”

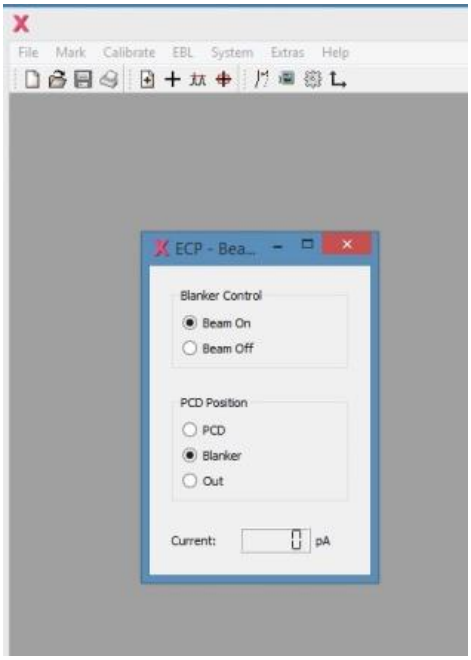
2. Click “ECP” icon to start the 

software

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”.

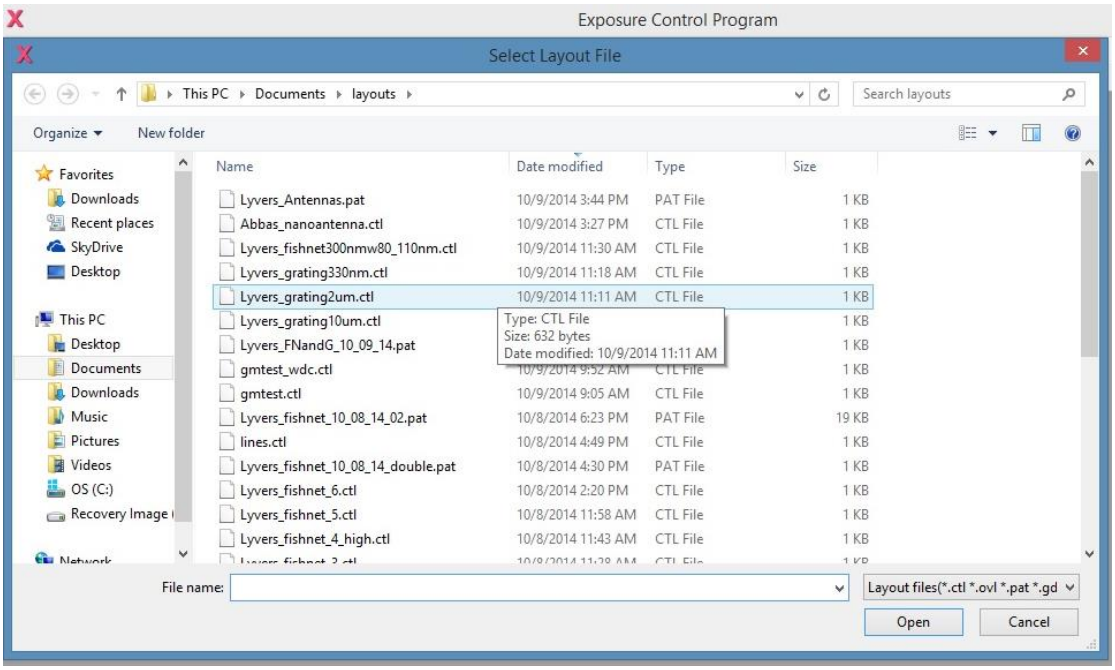
4. Go to “ EBL” => “Beam Control” to turn the electron beam on.



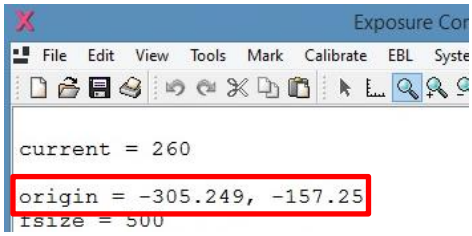


5. Follow SEM SOP to find focus of your sample at high Magnification and the reference spot (normally the scratched area).

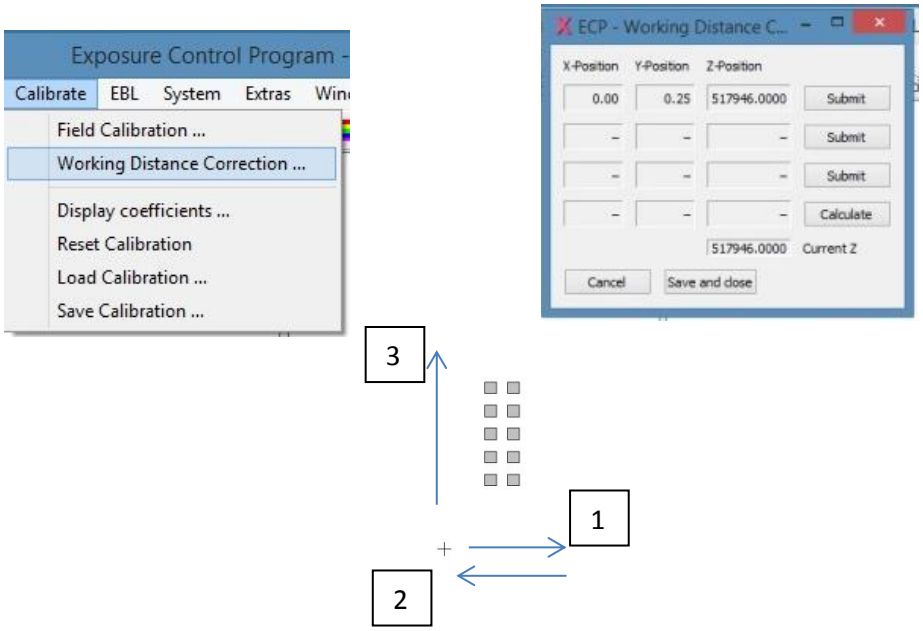
6. “File”=>”Open” your control file *.ctl. The file commands will be displayed on the left window and the pattern will be in the right window.



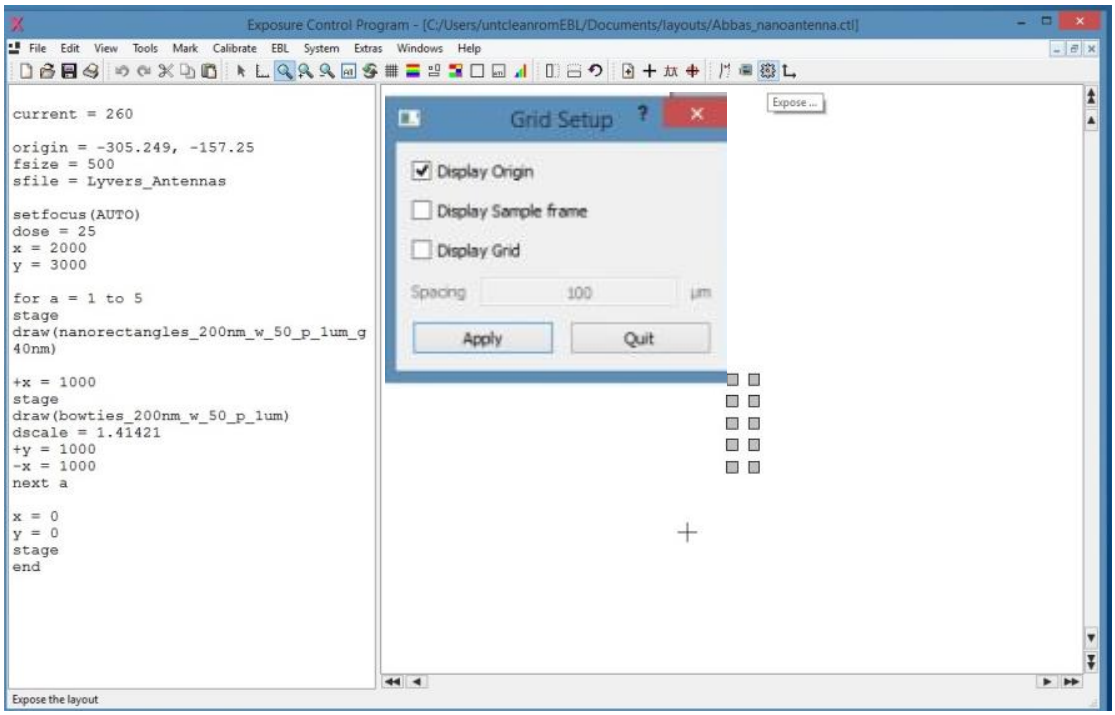
7. Go to “Tools”=> “Map Exposure Origin” to have the stage reference location (X and Y value on SEM page) as the origin position in the control file. The “+” and “-“ sign in SEM is opposite to the ones in ECP software.



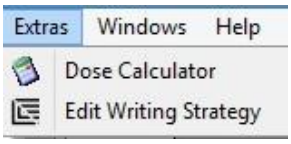
8. Locate the area where you pattern will be in SEM. Then go to “Calibrate”=> “Working Distance Correction” on XPG 2. Choose three locations and adjust the SEM to get the best focus at each point. First to move away from reference spot to locate spot #1 and click “Submit”. Second to move back to reference 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.



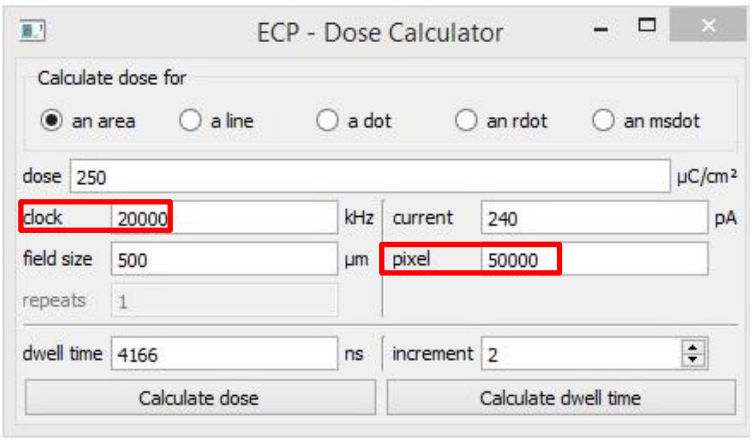
9. Go to  "Grid Setup" to choose "Display Origin". Click  "Redraw" to check where the origin is related to the rest of the pattern. If you reference origin on your sample is at lower left corner, after redraw the origin in the drawing should be at lower left corner as well as shown in the example:

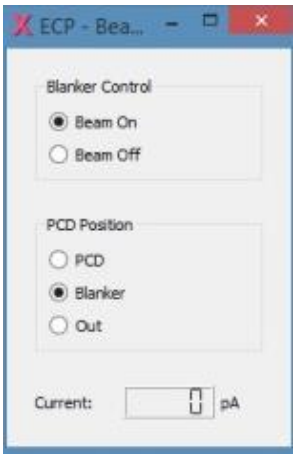


10. **Optional:** for the new pattern/sample, a series dose test is needed to determine the best dose value for the sample and patter. Go to “Extras” => “Dose Calculator”

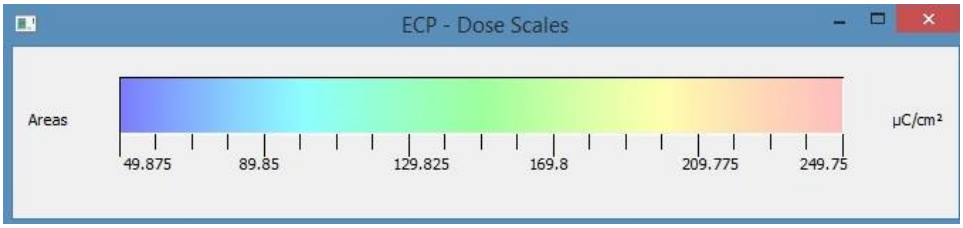


to calcate dewell time value with known dose value. Clock value is on ECP console (40000) and Pixel value is default value at 50000. At “Beam Control” to measure the PCD current by click on “PCD” and read the current valve.





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 uC/cm^3 .



11. Click  Exposure” to start the exposure process. The “Exposure” light on the console will light 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

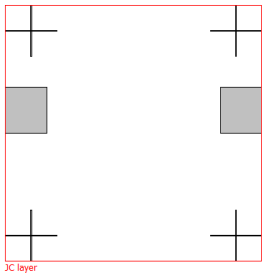
Here is an example:

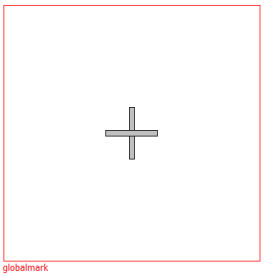
1. Write your pat files to define the patterns (eg. one for the contacts and chip cross marks and one for the global mark) and your control file for writing multiples to test out dose if needed and your global marks.

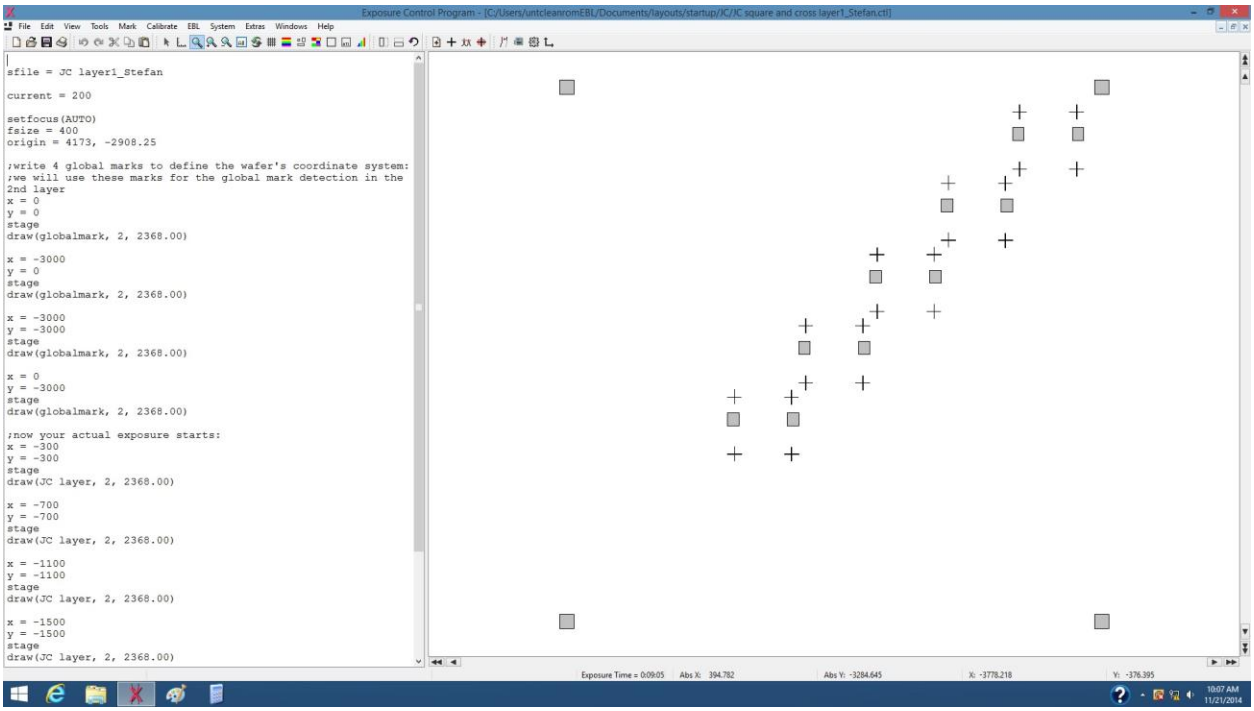
```
globalmark
JC layer
```

```
D JC layer
I 2
C 200

RECT 0,25000,8000,34000

RECT 42000,25000,50000,34000

;centre: 5000/5000
RECT 0,4900,10000,5100
RECT 4900,0,5100,5000
RECT 4900,5100,5100,10000


;centre: 5000/45000
RECT 0,44900,10000,45100
RECT 4900,40000,5100,44900
RECT 4900,45100,5100,50000



;centre: 45000/45000
RECT 40000,44900,50000,45100
RECT 44900,40000,45100,44900
RECT 44900,45100,45100,50000


;centre: 45000/5000
RECT 40000,4900,50000,5100
RECT 44900,0,45100,5000
RECT 44900,5100,45100,10000
```

```
D globalmark

I 2
C 200

RECT 20000,24500,30000,25500
RECT 24500,20000,25500,24500
RECT 24500,25500,25500,30000

end
```

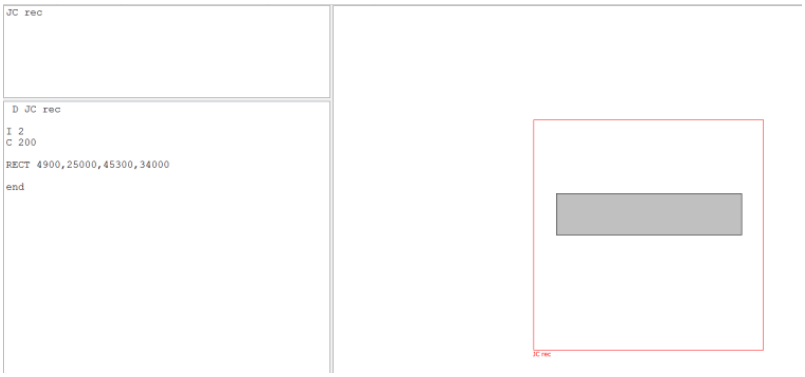


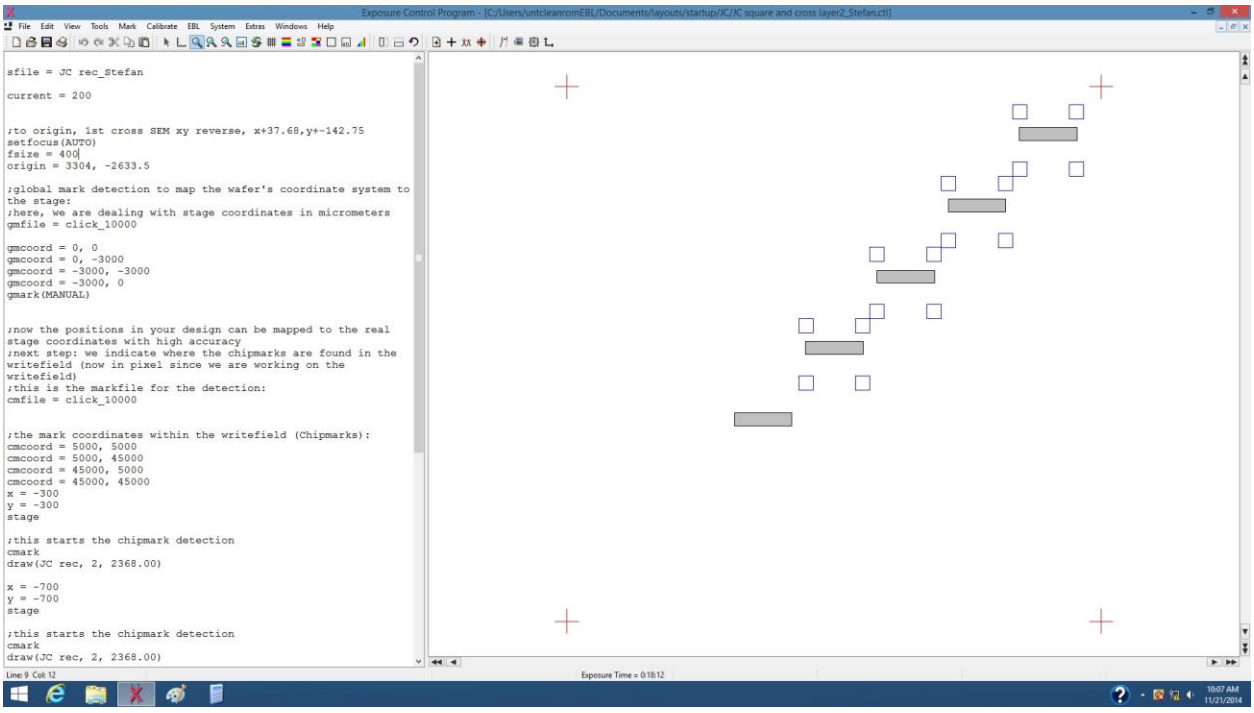




2. follow EBL instruction to have your 1st layer exposed=> developed=>metalized=>lift-off=> coated with PMMA=> baked

2. 2nd layer file writing: pat file for pattern for the 2nd layer. eg. Insulator area overlaps with the contacts area in the 1st 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"



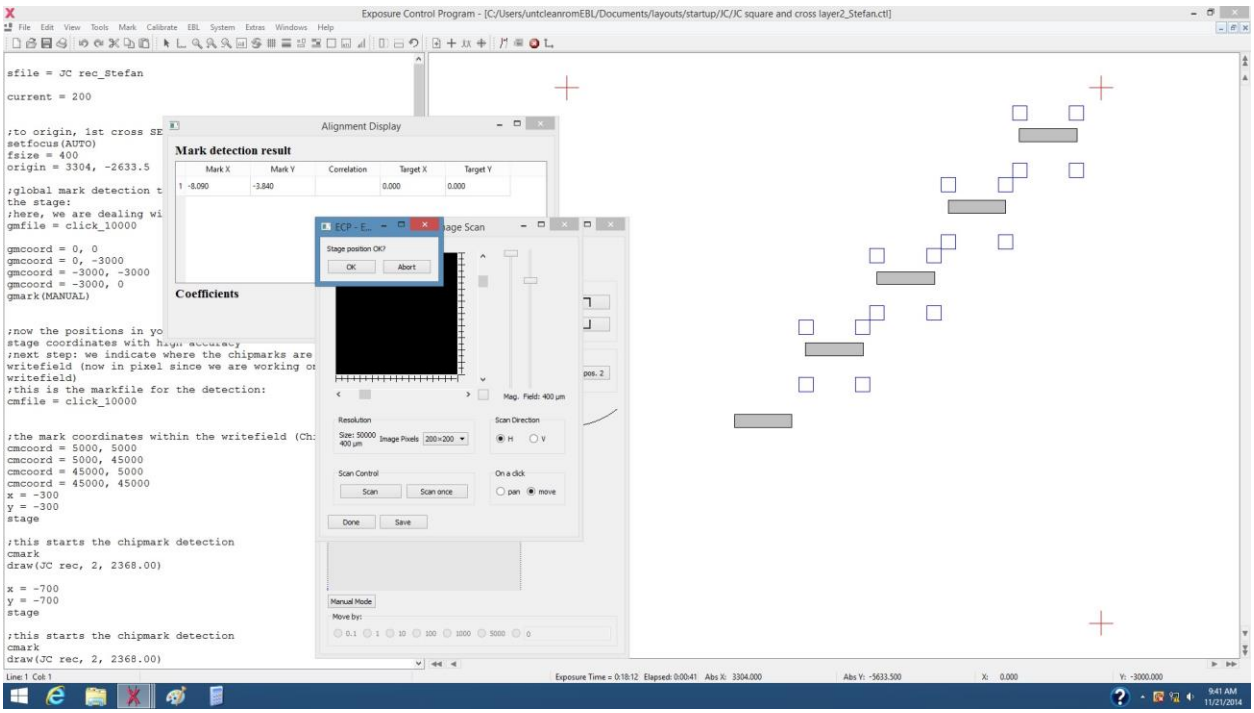


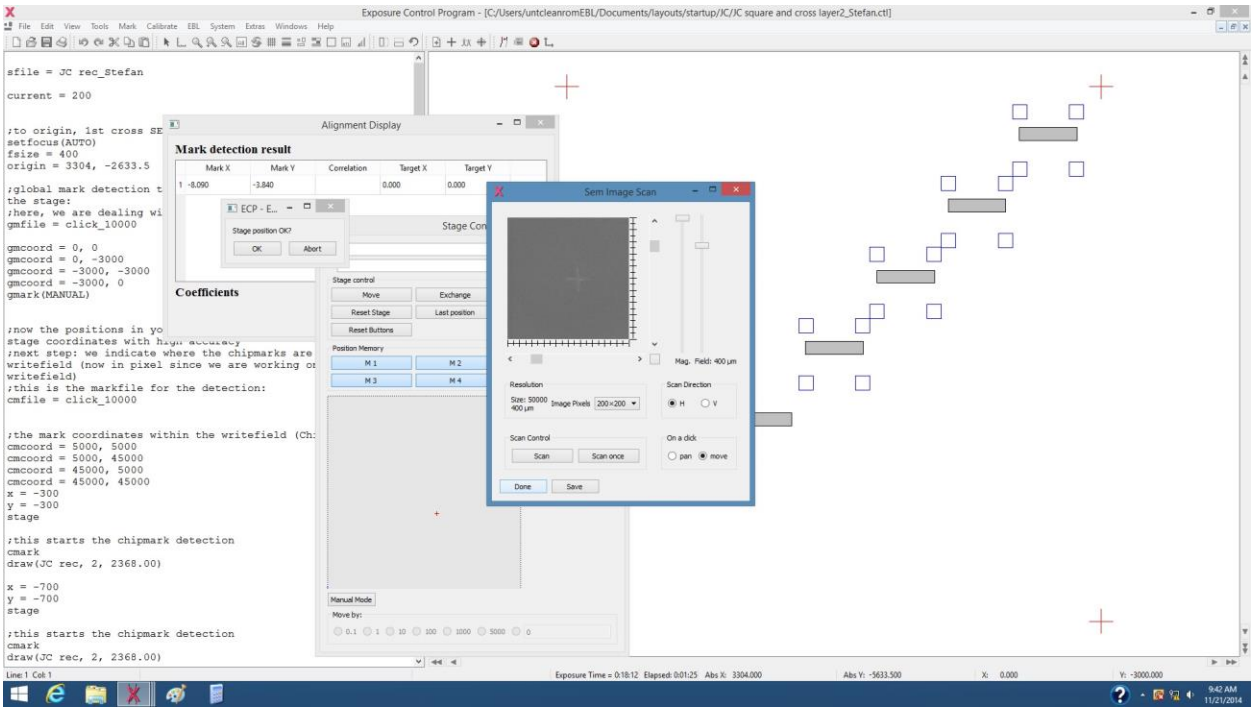

```
writefield)
;this is the markfile for the detection:
cmfile = click_10000


;the mark coordinates within the writefield (Chipmarks):
cmcoord = 5000, 5000
cmcoord = 5000, 45000
cmcoord = 45000, 5000
cmcoord = 45000, 45000
x = -300
y = -300
stage

;this starts the chipmark detection
cmark
draw(JC rec, 2, 2368.00)

x = -700
y = -700
stage

;this starts the chipmark detection
cmark
draw(JC rec, 2, 2368.00)

x = -1100
y = -1100
stage

;this starts the chipmark detection
cmark
draw(JC rec, 2, 2368.00)

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
```

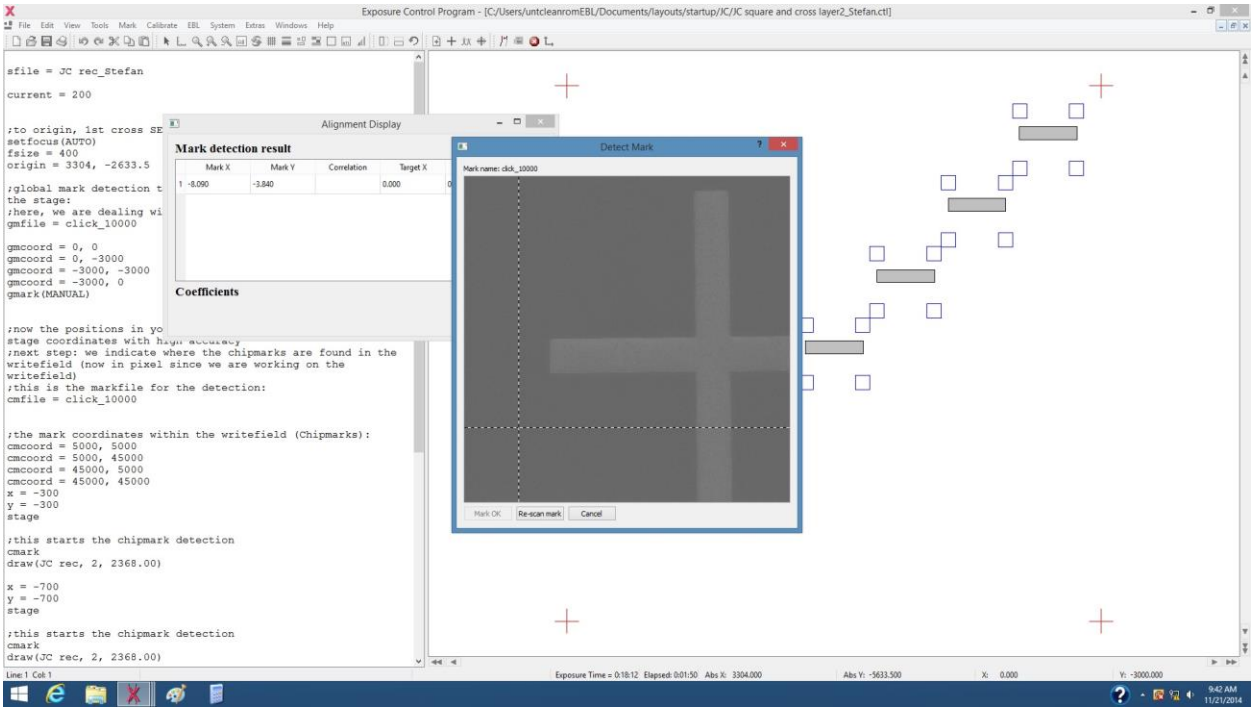
3. In SEM, find best focus of the surface and find the 1st global mark (defined as 0,0 in your gmcoord). In the eg., the upper right corner one is the 0,0. Center the image at the 1st global mark in SEM, go to "Tools"=>"Map Exposure Origin" to have the stage reference location (X and Y value on SEM page)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

4. click  to start "expose"

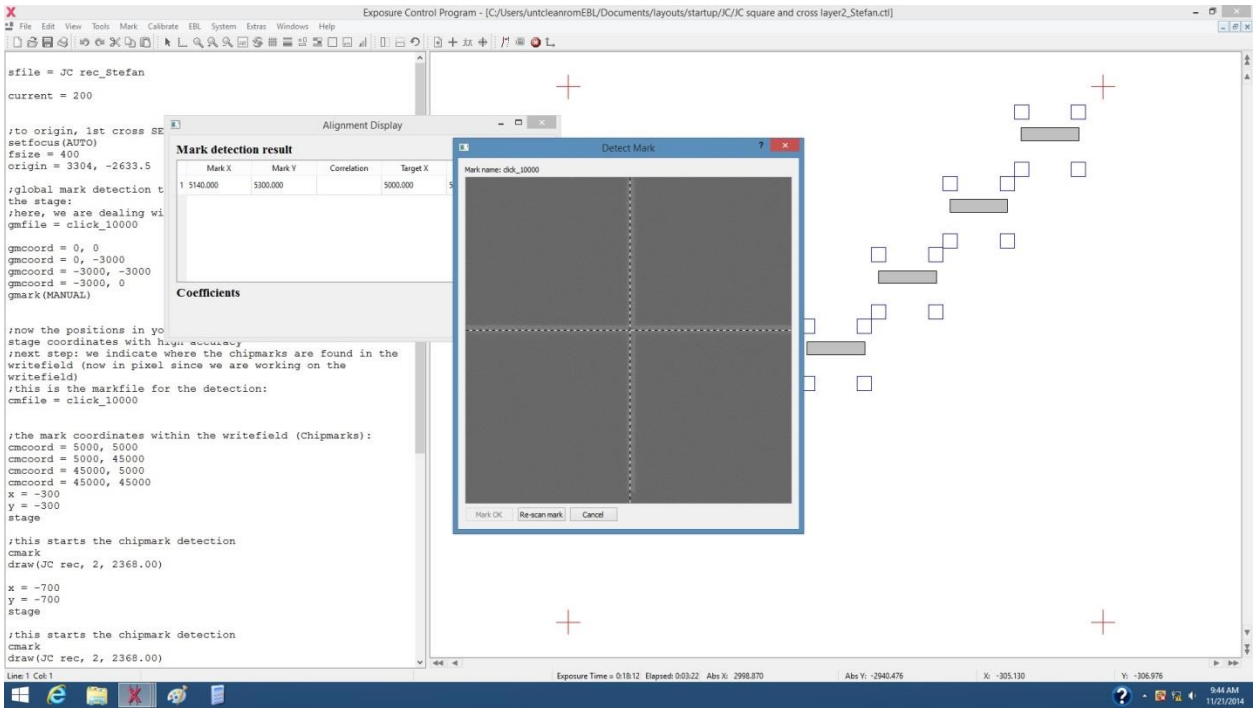
5. the global mark detection page will pop out for each global mark. Use the "SEM Image Scan" to find the cross mark. Click "Done". Then "stage position ok?" click "OK". In "Detect Mark" window, move the cross to the center of the global mark cross then click " Mark OK". Repeat the process for getting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

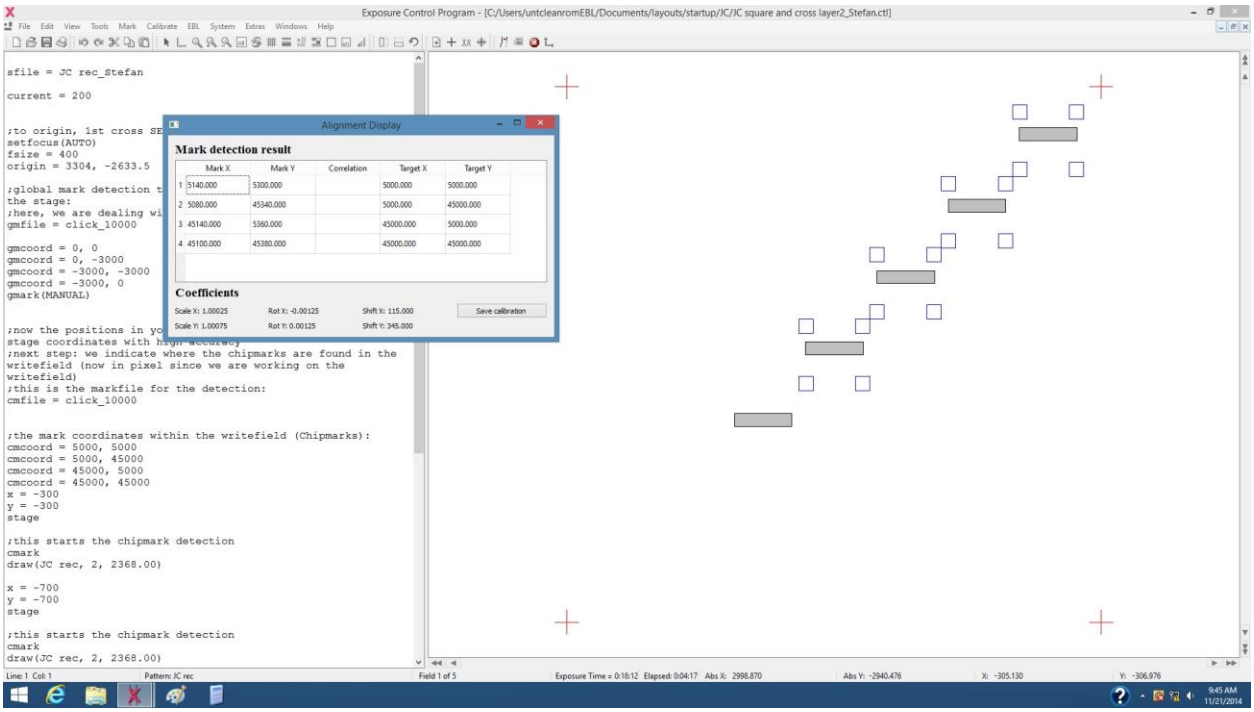



Exposure Control Program - [C:/Users/untcleanromEBL/Documents/layouts/startup/JC/JC square and cross layer2_Stefan.ctl]
File Edit View Tools Mark Calibrate EBL System Extras Windows Help
sfile = JC rec_Stefan
current = 200
;to origin, 1st cross SE
setfocus(AUTO)
fsize = 400
origin = 3304, -2633.5
;global mark detection t
the stage:
;here, we are dealing wi
gmfile = click_10000
gmcoord = 0, 0
gmcoord = 0, -3000
gmcoord = -3000, -3000
gmcoord = -3000, 0
gmark(MANUAL)
;now the positions in yo
stage coordinates with high accuracy
;next step: we indicate where the chipmarks are
writefield (now in pixel since we are working o
writefield)
;this is the markfile for the detection:
cmfile = click_10000
;the mark coordinates within the writefield (Ch:
cmcoord = 5000, 5000
cmcoord = 5000, 45000
cmcoord = 45000, 5000
cmcoord = 45000, 45000
x = -300
y = -300
stage
;this starts the chipmark detection
cmark
draw(JC rec, 2, 2368.00)
x = -700
y = -700
stage
;this starts the chipmark detection
cmark
draw(JC rec, 2, 2368.00)
Alignment Display
Mark detection result
Mark X
Mark Y
Correlation
Target X
Target Y
1 -8.090
-3.840
0.000
0.000
ECP - E...
Stage position OK?
OK
Abort
Coefficients
Stage control
Move
Exchange
Reset Stage
Last position
Reset Buttons
Position Memory
M 1
M 2
M 3
M 4
Manual Mode
Move by:
Sem Image Scan
Mag. Field: 400 µm
Resolution
Size: 50000
400 µm
Image Pixels
200×200
Scan Direction
H
V
Scan Control
Scan
Scan once
On a click
pan
move
Done
Save
Line: 1 Col: 1
Exposure Time = 0:18:12 Elapsed: 0:01:25 Abs X: 3304.000
Abs Y: -5633.500
X: 0.000
Y: -3000.000
9:42 AM
11/21/2014


Exposure Control Program - [C:/Users/untcleanromEBL/Documents/layouts/startup/JC/JC square and cross layer2_Stefan.ctl]
File Edit View Tools Mark Calibrate EBL System Extras Windows Help
sfile = JC rec_Stefan
current = 200
;to origin, 1st cross SE
setfocus(AUTO)
fsize = 400
origin = 3304, -2633.5
;global mark detection t
the stage:
;here, we are dealing wi
gmfile = click_10000
gmcoord = 0, 0
gmcoord = 0, -3000
gmcoord = -3000, -3000
gmcoord = -3000, 0
gmark(MANUAL)
;now the positions in yo
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
;the mark coordinates within the writefield (Chipmarks):
cmcoord = 5000, 5000
cmcoord = 5000, 45000
cmcoord = 45000, 5000
cmcoord = 45000, 45000
x = -300
y = -300
stage
;this starts the chipmark detection
cmark
draw(JC rec, 2, 2368.00)
x = -700
y = -700
stage
;this starts the chipmark detection
cmark
draw(JC rec, 2, 2368.00)
Alignment Display
Mark detection result
Mark X
Mark Y
Correlation
Target X
1 -8.090
-3.840
0.000
Coefficients
Detect Mark
Mark name: click_10000
Mark OK
Re-scan mark
Cancel
Line: 1 Col: 1
Exposure Time = 0:18:12 Elapsed: 0:01:50 Abs X: 3304.000
Abs Y: -5633.500
X: 0.000
Y: -3000.000
9:42 AM
11/21/2014

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
```

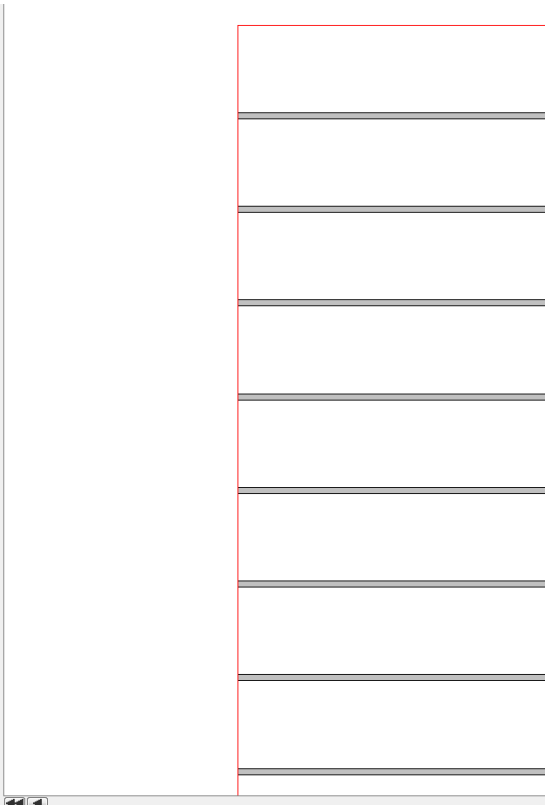
The shape “RECT” is a simple rectangle. The syntax is “RECT X1, Y1, X2, Y2”. (X1, Y1) is the bottom left corner, (X2, Y2) is the top right corner of the rectangle. To arrange the shapes on a rectangular grid, four more numbers must be added after the shape data. They specify the period in x-direction, 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 = 200
stage
draw(fishnet_p300nm_w_80_110nm, 4, 200.00)

+x = 200
stage
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 = 200
stage
draw(fishnet_p300nm_w_80_110nm, 4, 466.00)

-x = 400
+y = 200
stage
draw(fishnet_p300nm_w_80_110nm, 4, 533.00)

+x = 200
stage
draw(fishnet_p300nm_w_80_110nm, 4, 600.00)
```