Chapter 4.18

_Crestec CABL-9510CC_

High Resolution Electron Beam Lithography System
(crestec - 384)

1.0 Title
Crestec CABL-9510CC Electron Beam Lithography System

2.0 Purpose
The Crestec CABL-9510CC High Resolution Electron Beam Nanolithography System is a high precision e-beam lithography tool (writer) capable of resolving 10 nanometer features on substrate sizes ranging from 1 cm to 15.2 cm (6”) at thickness of 0.01 cm to 0.46 cm. This tool is also capable of handling mask sizes ranging from 5.1 cm (2” mask) to 12.7 cm (5” mask) at standard thicknesses.

3.0 Scope
This document describes the necessary information to prepare samples for exposure, as well as the operation of the Crestec model CABL-9510CC, a High Resolution E-Beam Nanolithography System located in the Marvell Nanofabrication Laboratory (MNL).

4.0 Applicable Documents
4.1 Crestec E-beam Writer under Equipment on the MNL Home Page website.
4.2 Crestec CABL-9000C High Resolution Electron Beam Lithography System Instruction Manual at 3M84 bay of the MNL.
4.3 Crestec Ismo Training Text (Polygon) and Training E-Manuals for editing the imported GDS file, convert and export to cpg file to be used on the Crestec.

5.0 Definitions & Process Terminology
5.1 Palette Holder - Sample holder.
5.2 Field Size Setting - Choice of exposing field size: 60 µm, 120 µm, 300 µm, 600 µm or 1200 µm.
5.3 Dot - Choice of number of dots per field: 20,000 dots, 60,000 dots or 240,000 dots on vector scan mode. 4,000 dots can only be used in vector-analog mode. Raster scan mode is fixed at 10,000 dots.
5.4 Chip - Entire design layer or exposure field. Center of the field on the layout is considered as 0, 0 for the X and Y coordinates.
5.5 Field - Part of the design area. Left bottom corner of the field is considered as 0, 0 for the X and Y coordinates.
5.6 Element - One design pattern.
5.7 CON - A condition file created based on the field pattern data.
5.8 Export - Transfer the condition file in the correct format, so that the Crestec pattern generator system can recognize it for pattern writing.
5.9 **SCH** - Schedule file is combining a list of files and exposes them in consecutive order.

5.10 **Lithography** - Open and close beam blanker.

5.11 **V1OPEN and V1CLOSE** - Open and close V1 column air lock valve.

5.12 **SCAN SELECT** - Choice of scan speed for viewing image.

5.13 **ROTATION** - Rotates SEM image.

5.14 **ASSIGNX** - Used along with X knob for fine beam current adjustment.

5.15 **ASSIGNY** - Used along with Y knob for coarse focus adjustment.

5.16 **IMAGE SELECT A** - The secondary electron detector on the Crestec E-beam system.

5.17 **SPOT** - Bring the electron beam to the center and activate the current monitor in scan mode.

5.18 **Exchange** - Move stage to load/unload position (x = 10,000 um, y = 160,000 um).

5.19 **Au** - Move to Au sample position for correcting the stigmatism (x = 31,250 um, y = 138,085 um).

5.20 **Wafer Z** - Move the specimen surface to the height sensor zero position.

5.21 **Mark Management** - Move Faraday cup position (x = 35,000 um, y = 153,778 um) to adjust the brightness and contrast output waveform.

5.22 **Custom** - Operator defines sample position and file parameters.

6.0 **Safety**

6.1 Do not bump into the transfer rod as it may cause vacuum problem or when it is bend, it will cause sample loading problem.

6.2 Never close the V5 valve when the palette holder or the transfer rod is between the gate valve. Closing V5 valve when the palette holder or the transfer rod is between the gate valve will damage the valve and cause major vacuum problem on the system.

6.3 Samples should be mounted onto the palette with metal clips and mechanical means. In the event you are unable to use mechanical mounting, a request to use Al tape may be submitted to Nanolab Staff. Requests will be approved on a case-by-case basis.

6.4 Do not use powders, pastes, or paints at any time as these contaminate the chamber and column.

6.5 To maintain vacuum compatibility and chamber cleanliness, the metal sample mounting clips are kept on the palette inside the system chamber. Ensure that all clips are secured to the pallet.

6.6 Do not change anything on COLUMN ADJ., SCAN GENERATOR ADJUST, SCAN ADJ. pages on the CreSÉM screen as the values on these pages had been calibrated and set for optimum operation. These adjustments are to be performed by Crestec service personnel or staff only. We only need to adjust some parameters on the SEM parameter page on the CreSÉM screen.

6.7 Always wear gloves when loading and unloading samples. Avoid touching anything except sample and tweezers during loading and unloading.

6.8 Do not use gloves to touch or press on samples.

6.9 Avoid touching Au stub on palette holder at all times and especially while cleaning the palette holder.

6.10 Do not touch transfer the rod itself, except the locking knob and the handle during loading and unloading.

6.11 Always blow off particles and the V resist scratch mark on the sample before loading.
6.12 Always keep tweezers clean, supplies clean, store them in the provided box and keep the cover on.

6.13 No food or drink allowed in room.

6.14 Do not touch sample with bare hands. Hand grease and particles will contaminate the gun chamber and affect the vacuum system.

6.15 Never operate the E-beam system above 27ºC.

7.0 **Statistical/Process Data**

Pertinent information can be found in the following locations:

7.1 Problem and comments section under equipment section of Mercury.

7.2 Enable message for crestec.

8.0 **Available Processes, Gases, Process Notes**

8.1 **Crestec Capability & Specification**

The Crestec CABL-9510CC E-beam system is equipped with a thermal field emission electron gun. The TFE electron gun has the remarkable physical characteristics of virtual light source of 15 nm and the energy band of the emitted electrons is as small as 0.3 to 1.0 eV. Accordingly, the TFE gun is suitable for fine pattern writing. Since the beam current fluctuation of this source is as excellent as 1% or smaller, it is suitable to long hour continuous pattern writing. The acceleration voltage is currently set at 50 kV and the objective aperture is set at 40 um for stable fine pattern writing condition. This is a delicate and high precision equipment. Please, make sure you are familiar with the operating procedures before you use it.

8.2 The E-beam lithography system consists of several coordinated, inter-related systems including:

8.2.1 The main system which consists of illumination system, work chamber, 6” stage system, platform and evacuation system.

8.2.2 The Thermal controller unit supplies thermally controlled air to the magnetically-shielded main unit to maintain the main system in a constant temperature environment. Controller is set at 24°C currently.

8.2.3 The electronic controller is basically the operation controller. It uses the CABL-2000 software program to manage the E-beam system operation such as the load lock chamber operation, stage operation, set up the job and execute the job. Pattern data can be created here or on the other two computers in the same room. The CreSEM sets up the lithography operation here.

8.2.4 The CAD and pattern generator writing controller is to design patterns, controls the pattern generator, controls the SEM drive system during pattern writing, writes patterns and monitor the E-beam lithography.

8.3 Stage chamber operating temperature range should be 24ºC to 27ºC ± 1ºC. Crestec temperature controller unit is set at 24ºC currently. Please, do not operate Crestec e-beam writer if the temperature is out of range. It may affect the writing resolution and stage accuracy.

9.0 **Operating Procedure**

The following is a detailed outline of the general procedure to follow in using the crestec. Make sure that you are familiar with all the controls and knobs before you use the instrument.

9.1 **Load Sample**

9.1.1 Enable the system on the computer (crestec).
9.1.2 Check the valve and vacuum status on the CreSEM screen. See Figure 1.

9.1.3 Make sure V1 valve is closed and Lithography is off.

9.1.4 Double click the CABL icon on the desktop. Press the Exchange button on the CABL-2000 software main menu to move the stage to the loading position. See Figures 2 and 3. Wait for the X, Y and Z values to settle on the Sigma Tech units on the CABL-9000C electronic controller (x = 10,000 um, y = 160,000 um).

9.1.1.1 Verify the stage is in the exchange position.

9.1.5 Put on clean room gloves. Avoid touching anything except your sample and tweezers until finish loading.

9.1.6 Loosen screw knob with left hand and while the right hand holding the transfer rod in position on the main system. Pull transfer rod out and lock it with the screw knob.

Note: You should see the screw head at the end of the rod without the palette holder in the transfer window as you pull it out.

9.1.7 Press the toggle switch to the EVAC side on the main system. Gate valve (V5) will open. Display of the status is on the CreSEM screen and the OPEN LED next to the toggle switch is in green indicating the gate valve is open.

9.1.8 Hold on to transfer rod, release screw knob and slowly insert the rod into the palette holder. Turn the knob on the rod clockwise slowly for 3 full turns. There shouldn’t be any gap between the big disc attachment on the loader and the small disc on the transfer rod.

Note: Do not force it in. Do it slowly and gently. Pull rod out a little and redo if it doesn’t insert smoothly.

9.1.9 Pull palette holder all the way out and lock it.

Note: You should see the brass/bronze tab on the edge of the palette holder connecting to the end of the transfer rod in the transfer window on the load lock as you are pulling it out. Never close the V5 valve when the palette holder or the transfer rod is between the gate valve. Closing V5 valve when the palette holder or the transfer rod is between the gate valve will damage the valve and cause major vacuum problem on the system.

9.1.10 Press bottom toggle switch to CLOSE on the main system. This will close the gate valve.

Note: Make sure the rod is locked in place before closing the gate valve.

9.1.11 Press the top toggle switch to VENT for venting the L/L chamber. Vent light will light up.

9.1.12 Pull open load lock chamber on the edge of the door when it is vented.

9.1.13 Mark a small v on the top center edge of your photoresist sample with a pair of fine tip tweezers and blow off the particles on the sample with the N2 gun.

9.1.14 Load sample/samples on palette holder and keep track of the position. Select the appropriate length metal clips to securely hold the sample down on two opposing sides. See Figure 12.

9.1.14.1 To maintain vacuum compatibility and chamber cleanliness, the metal clips are kept on the palette inside the system chamber. After mounting a sample, it is important to verify that all clips are secured to the pallet.

Note: X and Y coordinates of 0, 0 mm are the left bottom stage position. The X and Y coordinates on the top left position of the sample holder screw hole, which
wasn’t drill all the way through, is at 54 mm, 120 mm (X = 54 mm and Y = 120 mm). See Figure 13.

9.1.15 Push close L/L chamber and hold it in place with your hand.

9.1.16 Press the toggle switch to EVAC. Make sure transfer rod is all the way out or evacuation procedure will not start.

**Note:** When you hear the vacuum pump sound and feel the vacuum pulls on the chamber door, you can let go your hand.

9.1.17 Verify the stage is in the exchange position (x = 10,000 um, y = 160,000 um).

9.1.18 When the gate valve opens (check the vacuum monitor or the green LED light), loosen the screw knob. Push the transfer rod all the way in slowly. Turn the rod counter-clockwise at least 4 full turns to disengage the rod from the palette holder. Definitely it will not hurt to turn the transfer rod counter-clockwise 2 more turns if you are not sure how many times you turned.

9.1.19 Pull the transfer rod all the way out and lock it in place.

**Note:** Make sure you see the screw head at the end of the rod without the palette holder in the transfer window as you pull it out. Never close the V5 valve when the palette holder or the transfer rod is between the gate valve. Closing V5 valve when the palette holder or the transfer rod is between the gate valve will damage the valve and cause major vacuum problem on the system.

9.1.20 Press the bottom switch to CLOSE. This will close the gate valve.

**Note:** Make sure the rod is locked in place before closing the gate valve.

9.1.21 Insert the transfer rod back in mid way and lock it in position so hopefully nobody will bump on it.

### 9.2 Adjust The Beam Current On The Faraday

9.2.1 Click the Faraday button on the CABL-2000 Main Menu (x = 35,000 um, y = 153,778 um).

9.2.2 Click the V1 button on the CreSEM screen to open the valve for middle chamber and electron gun chamber.

9.2.3 Click the Lithography button on the CreSEM screen to open the beam blanker.

9.2.4 Start with the magnification at 100X. Click the Display button on the top menu bar. Click cursor.

9.2.5 Choose a hole in the center and bring it to the center of the screen with the X and Y joystick. Keep the hole in the center as you zoom in. This should be done with the FRAME button lit under SCAN MODE. See Figure 4.

9.2.6 Adjust magnification to 300 KX and click the SPOT button under SCAN MODE. X mark will show on the screen.

9.2.7 Adjust beam current to desire value now for exposing your wafer/sample later. Use arrow buttons, slider button, ASSIGNX button along with the EXTRA button and X knob on the controller box to tune the beam current to the desire value.

9.2.8 Change from SPOT back to FRAME on SCAN MODE.

### 9.3 First Focus & Level Wafer/Sample

9.3.1 Click the Custom button on the CABL-2000 Main Menu.
9.3.2 Input the X and Y coordinates to approximately where the v mark is on your sample or click line 1 coordinates as Figure 5 and click the GO button. Left top hole on the palette holder is a good position to start. See Figure 6.

9.3.3 Change magnification to the lowest and find the right inner side of the v mark on the sample.

9.3.4 Adjust the focus to the best by pressing the ASSIGNY button with the EXTRA button lit and the Y knob for coarse focus adjustment on the controller box. Use the focus knob on the controller box to adjust the fine focus.

9.3.5 Press the Wafer Z button on the CABL-2000 Main Menu to set the wafer leveling to within .0010 mm on the IWATSU ST-3708E Laser Displacement Meter.

9.3.6 Click Custom button on the CABL-2000 Main Menu. Click memory position line such as 10. Click the Position Read button and then the Save button.

9.4 Adjust Stigmatism

9.4.1 Close beam blanker.

9.4.2 Press the Au button on the CABL-2000 Main Menu (x = 31,250 um, y = 138,085 um).

9.4.3 Open beam blanker.

9.4.4 Set magnification to 40 KX or 60 KX. This is probably the best magnification to see the Au particles at the beginning. Use the Z joystick on the stage controller box to bring the Au particles into focus.

9.4.5 Correct the stigmatism with the X and Y stigmatism knobs as you increase the magnification until 300 KX. Adjust focus with Z joystick when necessary. Can use fine focus knob to do a little fine focus tuning as needed, but do not use the coarse focus knob to adjust focus. Note: The coarse focusing should be done with the Z joystick. The fine focusing should be done with the fine focus knob. For optimum stigmatism correction, a perfect focus is mandatory. Since the fine focusing is done in a later step, the deviation from the original focal plane should be acceptable.

9.5 Adjust Fine Focus

9.5.1 Close beam blanker.

9.5.2 Click Custom button, find memory line such as number 10 with the v mark coordinates and press GO button to move back to the reference position.

9.5.3 Open beam blanker.

9.5.4 Find the resist v mark scratch.

9.5.5 Fine tune the focus and the stigmatism. Make sure the wafer Z level reading is still within 0.0010 mm. If not, press wafer Z again.

9.5.6 Press the FREEZE button next the ASSIGNX and ASSIGNY.

9.5.7 Close beam blanker.

9.6 Mark Management

9.6.1 Click the MARK MANAGEMENT line on the CABL-2000 Main Menu.

9.6.2 Click on Acquisition tab. See Figure 7.

9.6.3 Enter the size of the writing area to 600 um or 1200 um to acquire correction data for scanning width and scanning direction.
9.6.4 Click the EXECUTE button to start the Orientation and Width Acquisition program. Stage will move to the mark position to get ready to start a number of automated alignment steps to correct the writing field distortion.

9.6.5 When the message Set LITH Mode OFF and Move Mark to Center of CRT. Then Adjust Contrast and Brightness. Finally Set LITH Mode ON., press the Lithography button OFF (SEM mode ON).

9.6.6 Center one of the hole in the center of the SEM screen at ~1600 X after the stage moves to the Mark position.

9.6.7 Click X-LINE button on SCAN MODE frame. The waveform of the secondary-electron detector output is shown at this point. This is obtained by scanning the beam on the center part of the SEM image along the horizontal direction.

9.6.8 Adjust the CONTRAST and BRIGHTNESS sliders until the SDI waveform output is enlarged on both sides without saturation as it crosses the zero level line on the center. See Figure 8.

9.6.9 Press the Lithography button ON (SEM mode OFF) and then click the YES button on the message Set LITH Mode OFF and Move Mark to Center of CRT. Then Adjust Contrast and Brightness. Finally Set LITH Mode ON. The program will start acquiring the correction data.

9.6.10 Correction data acquisition will finish in about 10 minutes. When it is finish, click the QUIT button to exit mark management menu.

9.7 Expose Wafer/Sample

9.7.1 Plug in USB flash drive in the computer which is located on the right side of the CreSEM screen.

9.7.2 Create your folder under desktop Users folder.

9.7.3 Transfer your folder which contains the CON, CCC and CBC files of your mask design on your flash drive to the desktop Users folder.

9.7.4 Set mask size and resolution dot as your design using Field Size Setting on CABL-2000 Main Menu and press Save button. See Figure 9.

9.7.5 Click Custom button, find memory line such as number 10 with the v mark coordinates and press GO button to move back to the reference position.

9.7.6 Open beam blanker.

9.7.7 Click the EXPOSURE EXECUTION (VECTOR) line on the CABL-2000 Main Menu. Choose EXPOSURE EXECUTION (RASTER) is an option if you want to control your exposure with the beam blanker.

9.7.8 Find the resist tip of the v mark scratch.

9.7.9 Click Position Read button. This is helpful for you to decide where you want to start your exposure.

9.7.10 Click the INITIALIZE button to clear all old files on the command list on the Exposure Information tab.

9.7.11 Click No. 1 command line. When it turns yellow, right click with mouse and find the EXPOSURE.CON file that you wish to import from your folder.

9.7.12 Click No. 2 command line. When it turns yellow, right click with mouse and find the second EXPOSURE.CON file that you wish to import from your folder. Note: You can combine all the CON files by pressing the Save button to save them as one schedule file. You can bring up this schedule to run it anytime.
9.7.13 Set x-y coordinates, exposure times, dose multipliers and define matrices if desire on all CON files. Note: Click the Save button under Schedule File, Latest vector. This will combine all the CON files on the command list into one file and save it as one schedule file in your folder so you can load all the CON as one schedule file next time you want to use it. See Figure 10.

9.7.14 Set Exposure Condition as follow:

9.7.15 Scan Mode = DIGITAL or ANALOG

9.7.16 Orientation and Width = ON

9.7.17 Laser = ON

9.7.18 Height Sensor = ON

9.7.19 Height Sensor Offset = 0.00 um

9.7.20 Specimen Thickness = 0.50 mm

9.7.21 Reg. Alignment = OFF (for no alignment)

9.7.22 Beam Compensation = OFF

9.7.23 ZigZag Coef. = 0

9.7.24 Execution Wait = 0.0 h

9.7.25 DFB Control Max Length = 1000.00 um.

9.7.26 Click EXPOSURE tab.

9.7.27 Click Field Load button.

9.7.28 Put a check mark next to Display Element and click Element Load button. All the elements on each field will display for you to check before exposure. See Figure 11.

9.7.29 Close beam blanker.

9.7.30 Press the green EXPOSURE button to start the exposure. A dialog box with pattern writing condition will pop up. If the condition is set as desire, click the YES button. If not, make corrections on the Exposure Information tab. Go back to the EXPOSURE tab, click Field Load button, click Element Load button and press the green EXPOSURE button to expose your wafer/sample. Click Yes to start exposure. Exposure run time will be displayed.

9.8 Unload Wafer/Sample

9.8.1 When exposure is finished, close V1 valve. By default, beam should be in blanked mode after exposure. If V1 valve is open, close it.

9.8.2 Press the Exchange button on the CABL-2000 software main menu to move the stage to the loading position. Wait for the X, Y and Z values to settle on the Sigma Tech units on the CABL-9000C electronic controller (x = 10,000 um, y = 160,000 um).

9.8.3 Put on clean room gloves. Avoid touching anything except your sample and tweezers until finish loading.

9.8.4 Loosen screw knob with left hand while the right hand holding the transfer rod in position on the main system. Pull transfer rod out and lock it with the screw knob.

9.8.5 Press the toggle switch to the EVAC side on the main system. Gate valve (V5) will open. Display of the status is on the CreSEM screen and the OPEN LED next to the toggle switch is in green indicating the gate valve is open.

9.8.6 Hold on to transfer rod, release screw knob and slowly insert the rod into the palette holder. Turn the knob on the rod clockwise slowly for about 3 to 4 turns. There should
not be any gap between the big disc attachment on the loader and the small disc on the transfer rod.

**Note:** Do not force it in. Do it slowly and gently. Pull rod out a little and redo if it doesn’t insert smoothly.

9.8.7 Pull palette holder all the way out and lock it.

**Note:** You should see the brass/bronze tab on the edge of the palette holder connecting to the end of the transfer rod in the transfer window on the load lock as you are pulling it out. **Never close the V5 valve when the palette holder or the transfer rod is between the gate valve.** Closing V5 valve when the palette holder or the transfer rod is between the gate valve will damage the valve and cause major vacuum problem on the system.

9.8.8 Press bottom toggle switch to CLOSE on the main system. This will close the gate valve.

9.8.9 Press the top toggle switch to VENT for venting the L/L chamber. Vent light will light up.

9.8.10 Pull open load lock chamber on the edge of the door when it is vented.

9.8.11Unload sample/wafer.

9.8.12 Wet Texwipe with acetone, clean palette holder with acetone, clean acetone residue with IPA and blow dry with N2 gun. **Avoid touching the Au stub on the palette holder during this cleaning process.** The Au stub is next to the wafer guiding pins on the top of the palette holder. See Figure 12.

9.8.13 Push close L/L chamber and hold it in place.

9.8.14 Press the toggle switch to EVAC. Make sure transfer rod is all the way out or evacuation procedure will not start. **Note:** When you hear the vacuum pump sound and feel the vacuum pulls on the chamber door, you can let go your hand.

9.8.15 When the gate valve opens (check the vacuum monitor or the green LED light), loosen the screw knob. Push the transfer rod all the way in slowly. Turn the rod counter-clockwise at least 4 full turns to disengage the rod from the palette holder. Definitely it will not hurt to turn the transfer rod counter-clockwise 2 more turns.

9.8.16 Pull the transfer rod all the way out and lock it in place.

**Note:** You should only see the screw head at the end of the rod without the palette holder in the transfer window on the L/L as you pull it out. **Never close the V5 valve when the palette holder or the transfer rod is between the gate valve.** Closing V5 valve when the palette holder or the transfer rod is between the gate valve will damage the valve and cause major vacuum problem on the system.

9.8.17 Press the bottom switch to CLOSE. This will close the gate valve.

9.8.18 Insert the transfer rod back in mid way and lock it in position to prevent people from bumping it.

### 9.9 Shutdown Procedure

9.9.1 Make sure to close V1 valve.

9.9.2 Make sure to close beam blanker.

9.9.3 Make sure the transfer rod is half way in.

9.9.4 Log off Mercury.

**Note:** Ensure that the Crestec is in the above state before you log out.
10.0 Troubleshooting Guidelines

10.1 If the gate valve doesn’t open or close, make sure the transfer rod is not in the way.

10.2 If the stage hits the limit or it freezes, press the Initialize button on the CABL-2000 Main Menu.

10.3 If there is no SEM image after switching to SEM mode, check that V1 valve is open.
11.0 Figures & Schematics

Figure 1 - Main CABL-2000 SEM Screen

Figure 2 - Main CABL-2000 Menu Screen

Figure 3

Figure 4

Figure 5

Figure 6
Figure 7

Figure 8

Figure 9

Figure 10

Figure 11

Figure 12
12.0 Appendices

PMMA (polymethyl methacrylate) is a versatile polymeric material that is well suited for many imaging microelectronic applications and most commonly used as a high resolution positive resist for direct write e-beam. Standard PMMA products cover a wide range of film thicknesses and are formulated with 495,000 and 950,000 molecular weight (MW) resins in either chlorobenzene or the safer solvent anisole. 495 PMMA A2 photoresist (495,000 molecular weight type) and 1:3 MIBK:IPA developer are recommended for very high resolution and low sensitivity/throughput process.

12.1 495 PMMA Spin Speed vs. Film Thickness Curves

![Graph showing spin speed vs. film thickness for 495 PMMA C resists and 495 PMMA A resists.]

12.2 PMM EBL Resist Preparation Suggestions

<table>
<thead>
<tr>
<th>EBL Resist Preparation</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Voltage Fixed at 50 KV</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Spin Coat Condition:</th>
<th>Clean &amp; prebake on hotplate at 125C/5 min.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Special preparation</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Equipment</th>
<th>spinner1</th>
<th>svgcoat1</th>
<th>spinner1</th>
<th>svgcoat1</th>
<th>spinner1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Substrate size</td>
<td>---</td>
<td>6&quot;</td>
<td>---</td>
<td>6&quot;</td>
<td>---</td>
</tr>
<tr>
<td>Spread Cycle (R.P.M.)</td>
<td>---</td>
<td>500</td>
<td>---</td>
<td>500</td>
<td>---</td>
</tr>
<tr>
<td>Time (Sec.)</td>
<td>---</td>
<td>3</td>
<td>---</td>
<td>3</td>
<td>---</td>
</tr>
<tr>
<td>Spin Speed (R.P.M.)</td>
<td>3000</td>
<td>7000</td>
<td>3000</td>
<td>2500</td>
<td>4000</td>
</tr>
<tr>
<td>Time (Sec.)</td>
<td>45</td>
<td>60</td>
<td>45</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>Softbake Temperature (°C)</td>
<td>180</td>
<td>180</td>
<td>180</td>
<td>180</td>
<td>125</td>
</tr>
<tr>
<td>Time (Min.)</td>
<td>10</td>
<td>1.5</td>
<td>10</td>
<td>1.5</td>
<td>12</td>
</tr>
<tr>
<td>Resist thickness (Å)</td>
<td>~2400</td>
<td>~1900</td>
<td>~1000</td>
<td>~900</td>
<td>~500 to 600</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Crestec Expose Condition:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beam Current</td>
</tr>
<tr>
<td>Dose Timer (µsec)</td>
</tr>
<tr>
<td>Resist Sensitivity (µC/cm2)</td>
</tr>
<tr>
<td>Field Size (µm)</td>
</tr>
<tr>
<td>----------------</td>
</tr>
<tr>
<td>Dot (number of dots in field)</td>
</tr>
</tbody>
</table>

**Immerse Develop Condition:**

<table>
<thead>
<tr>
<th>Temperature</th>
<th>room</th>
<th>room</th>
<th>room</th>
<th>room</th>
<th>room</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of Developer</td>
<td>1:3 MIBK</td>
<td>1:3 MIBK</td>
<td>1:3 MIBK</td>
<td>1:3 MIBK</td>
<td>1:3 MIBK</td>
</tr>
<tr>
<td>Time (Sec.)</td>
<td>30-40</td>
<td>60</td>
<td>120</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>Rinse (Solvent)</td>
<td>IPA</td>
<td>IPA</td>
<td>IPA</td>
<td>IPA</td>
<td>IPA</td>
</tr>
<tr>
<td>Time (Sec.)</td>
<td>---</td>
<td>30</td>
<td>---</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Dry (Method)</td>
<td>N2 blow</td>
<td>N2 blow</td>
<td>N2 blow</td>
<td>N2 blow</td>
<td>N2 blow</td>
</tr>
</tbody>
</table>

**Comments:**

- 0.45 µsec/500 µC/cm² to resolve 2 µm lines
- 1-2 µsec resolves 100 nm lines.
- 50 to 55 µsec resolves 2 µm lines.
- 278 to 556 µC/cm² to resolve 100 nm lines.
- 0.3 to 0.8 µsec/µC/cm² to resolve 300 to 800 µm lines.
- 20 to 60 nm triangular tip.
- 400 to 500 µC/cm² to resolve 20 to 40 nm lines.
- 2-6 µsec for triangular shape with 100 nm base length at 6 nm dot to dot distance.

**Note 1:** Above resist parameters are for guidance only. The process may vary. Please develop your own optimal process. Please refer to MicroChem Corp. data sheets for PMMA spin curve and general process parameters.

**Note 2:** 495 PMMA A2 photoresist and 1:3 MIBK:IPA developer are provided for Crestec ebl users by the Marvell Nanofabrication Laboratory. A bottle of 250 ml. 495 PMMA A2 photoresist is stored in Y1 chemical cabinet for Crestec ebl users. If the resist in the 250 ml. bottle is low, please contact Kim Chan to refill it. A gallon of 1:3 MIBK:IPA is stored in Y1 storage bin also. Please contact Kim Chan for a new bottle also.

**Note 3:** Please contact Kim Chan at eecs dot Berkeley dot edu for Crestec training class. A class will be scheduled under staff's discretion.

**12.3 Software bugs** found by a Crestec user that can potentially cause problems for EBL

12.3.1 Pitch setting in mask design program doesn’t change writing pitch, pitch is always 1 (except for dot array feature).

12.3.2 Dosage multiplier in vector exposure program only multiplies with dosage offset.

12.3.3 X/Y pitch display swapped for vector/exposure window.

12.3.4 Mask requires absolute path, no transfer of masks from different paths.

12.3.5 Mask resolution 4,000 dots (presumably for all mask sizes) gives a totally wrong exposure time, not recommended for use.

12.3.6 4,000 dots can be used in vector- analog mode only. If used under other mode, it will have an error such as 60,000 dots/ 20,000 dots --- after approximately 14 hours. This seems to be a stage movement problem.
12.4 Table of Common X/Y Coordinates on the Stage

Occasionally pre-programmed stage positions are overwritten by users. Below is a table of locations and their X/Y coordinates.

<table>
<thead>
<tr>
<th>Location</th>
<th>X (um)</th>
<th>Y (um)</th>
<th>Z (um)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exchange position</td>
<td>10,000</td>
<td>160,000</td>
<td>variable</td>
</tr>
<tr>
<td>Faraday cup</td>
<td>34,997</td>
<td>153,410</td>
<td>variable</td>
</tr>
<tr>
<td>Au Sample</td>
<td>26,323</td>
<td>144,928</td>
<td>variable</td>
</tr>
<tr>
<td>MEM1</td>
<td>54,002</td>
<td>119,994</td>
<td>variable</td>
</tr>
</tbody>
</table>

12.5 How to Reset the Crestec CABL 9000

If you find the CRESTEC has locked up or not performing correctly (Mark Management or SEM), please use the following guideline to reset the system:

Power Down:
1. Turn the SEM off by pressing the small, Red SEM OFF button (above the monitor).
2. Close the current programs (CABL & CreSEM) if you can.
3. Shut down the computer using the START button in lower left of screen – choose Turn Computer Off, then select Turn Off.
4. Turn Off the CPG unit (small rack) with the red button in upper right of rack that says Pattern Generator O.
5. Wait for 1 minute for things to settle…

Power Up:
1. Turn ON the PC computer – located on the right side of the CRESTEC – press the ON button. Wait for system to come up then log into the computer (at the Nanolab Administrator prompt, hit Ctrl-Alt-Del twice, then log in with Username: crestec, Password: crestec).
2. Turn the SEM on by pressing the small, green SEM ON button (above the monitor).
3. Wait 15 seconds, then go ahead and start the CABL first, then CreSEM programs (one at a time).
4. Start the CPG unit (small rack) with the green button in upper right of rack (Pattern Generator I, which illuminates Green. Once DOS boots up and you see the prompt, (A:\) enter this: WIN0 & and hit Enter.
5. Using the CABL program, initialize the Stage using the XYZ option.

At this point, you should be able to open V1 and turn on Lithography (should see the white grid on the view window). You should be ok to use at this point…if not, please report the issue and disable the tool.

12.6 Pump Oil Compatibility

The following is adapted from the SPI (electron microscope supplies) web site (http://www.2spi.com/catalog/vac/santovac-5.shtml)

Nantovac (pump oil) fluids are known for their low backsteaming characteristics, which is especially important for electron microscope applications. This is the reason why it is so highly used not only in
analytical laboratory instrumentation but also in production electronics applications. However, since the product is a hydrocarbon fluid, the molecular species from the fluid, in the presence of the ionizing radiation from the electron beam, will cause polymerization, contributing to the overall contamination of the column.

For many users of electron microscopes, another alternative would be to use one of the perfluorocarbon based diffusion pump fluids, such as Fomblin® or Krytox®. While all diffusion pump fluids do have some low level of molecular species in the microscope column, the perfluorinated polyether species do not get polymerized in the presence of the ionizing radiation as is the case for hydrocarbon pump fluids. The end result of this advantage is that the column runs cleaner, longer and whatever contamination in the column that might otherwise be present is present but at much lower levels. Putting it another way, microscope downtime is greatly reduced since the column runs much cleaner for much longer periods of time.

Occasionally pump oil is used for sample mounting and preparation. Fomblin, Krytox or other perfluorinated ethers are acceptable for sample mounting, however no hydrocarbon based oils are allowed.
We have not found the root cause of Field Distortion, but please follow the instruction as below to prevent this issue.

1. In case of exposure without A/B alignment.
   Please set the Reg Alignment mode to OFF.

   And after Mark Management, please go exposure without changing any parameters on CreSEM screen like Contrast & Brightness.

2. In case of exposure with A/B alignment.

   If you see the SEM image of A/B alignment mark is distorted while observation like below,

   push LITHOGRAPHY button to go back to OFF line mode temporary to set rotation 0 → 3.
Then push LITHOGRAPHY button again to return to ON line mode.

Can you see SEM image of A/B mark in good shape?  
If so, please go ahead.

Otherwise, push LITHOGRAPHY button to go back to OFF line mode temporarily to change Contrast & Brightness, then push LITHOGRAPHY button again to return to ON line mode.

Can you see SEM image of A/B mark in good shape?  
If so, please go ahead.

Otherwise, abort exposure process and then, re-start exposure again.

End