STANDARD OPERATING PROCEDURE
RAITH EBPG 5150 EBEAM LITHOGRAPHY
1. In this document, command line entries are denoted as follows:
   i. Commands are written in *italic*.
   ii. Variables are written between <brackets>.
   iii. Shortcuts are written in *(bold)*.

2. For example, consider the command *pg substrate load* <caspos> *(subl <caspos>)*.
   i. *pg substrate load* 1 will load the holder in cassette position 1 into the chamber.
   ii. *subl* 1 executes the same command as above. *subl* is a abbreviation for *substrate load*.

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**LOGIN AND INITIAL SYSTEM CHECK**

1. In the logbook, record your name, the holder(s) you used, the beam(s) you used, and the job number(s). Additionally, document any unusual or anomalous events.
2. Run the command *ce* <your username> to enter your working environment. Alternatively, one can click on the ‘people’ icon to enter your working environment.
3. Check to see if any jobs are running in cebpg by looking under ‘status’. If a job is still running, check the logbook for instructions from the previous user.
4. Open csys from the top panel in the cebpg window.

Below: cebpg main screen.
SAMPLE LOADING PROCEDURE

1. Check the vacuum status on the csys display or *pg information vacuum*. By default, the loadlock should be pumped.
2. Vent the airlock by pressing **SET LOCK VENT** on csys.
3. Open the door when the system is ready on csys. The loadlock is vented after V8 turns off (nitrogen) and G3 displays a pressure close to atmosphere.
4. **Carefully** lift the cassette out of the loadlock. Remove the holder that you plan to use and mount onto the transfer stage. **DO NOT touch the marker block or grounding wires**. Doing so will require a complete holder recalibration and the instrument will not be useable for days.
5. Close the airlock door. Press **SET LOCK VACUUM** on csys if your loading procedure will take a lot of time. If the loadlock is vented for too long, the system will take significantly longer to pump down. You may not have enough time to complete your job.
6. Mount your sample 90° clockwise to match the stage’s coordinate system. Transfer the holder to the alignment microscope and lock it into place. Do not turn the locking screwdriver past 90°.
7. Align your sample by adjusting its rotation and height of the sample. The rotation and height must be within the system’s narrow tolerances, or your job will crash. See the alignment microscope documents or video for details on this step.
8. Focus and center the crosshairs on the Faraday Cup. Reset the system’s origin (0,0) to the center of the Faraday cup. Write down the relative location of your alignment markers. If you are not using alignment, then record the relative location for the center of your pattern. Note their order and location - they must be in the same order as they are in cjob.
9. **Slowly** reload the holder(s) into cassette (make sure to vent the airlock again if you pumped it on Step 5) by **gently** lowering the cassette into the airlock. Close Airlock door and press **SET LOCK VACUUM** on csys.
10. Wait G3 to read to at least 5.0E-6 mBar. Use *pg information vacuum (ivac)* or csys. While the system is pumping down, set up your job in BEAMER and cjob (not discussed here).
11. Run *pg information substrate (isub)* to verify that the holders are correctly loaded into the cassette.
Below: csys display.

1. After G3 displays a pressure below 5.0E-6 mBar, load the holder onto the stage. To do this run the following command: `pg substrate load <caspos>` (subl <caspos>).
2. Select the holder by running `pg select holder <holderid>`. Loading the holder into the system does not select the holder.
   Alternately, click the **bold arrow** in cebpg (cassette and holder status) next to the cassette position that your holder is in. This will load the substrate and select the holder in one operation.
3. Run the command `mvm`. This will move the holder to its marker block. Run `semon` and then `semoff` to verify that the beam is above the marker block. You should see a grid of pos20 alignment markers.
4. Restore the beam that you want to use for your job. For a list of available beams, use the command `pg information archive beam`. Restore the beam by running `pg archive restore beam <beam_name>` (arcr be <beam_name>).
5. Focus the beam with the command `pg adjust focus automatic (afa)`. If there is no message displayed in the command line, the beam is in focus. If it is not in focus, it will output a number of DAC steps, and the beam will have to be refocused. Contact the superuser if you are not comfortable with this procedure.
6. Run the command `mcur` to move to the Faraday cup and measure the beam current.
7. If your job does not require alignment, move the stage to the position where you plan to write by using the command mpos \(<x, y>/r\).
   i. The field \(x,y\) is in microns by default. If you want to use millimeters, the notation is use \(x\text{mm},y\text{mm}\).
      • \(mpos 1000,1000/r\) will move 1000 microns in \(x\) and \(y\), relative to the current position
      • \(mpos 1\text{mm},1\text{mm}/r\) will move 1 millimeter in \(x\) and \(y\), relative to the current position.
   ii. The option \(/r\) makes the field \(x,y\) relative to the current position.
8. If your job does require alignment, find your alignment markers.
   i. Manual method (not recommended - you will expose your resist - although sometimes this is your only option):
      a) Use the command \(mpos <x,y>/r\) to move near your alignment marker.
      b) Decrease the SEM field of view and turn on the crosshairs in cmon, and then run cmon. Manually locate your marker. Run semoff.
      c) Run the command \(pg\ get\ tab\) to print out the absolute stage coordinates. Write down the marker’s location.
      d) Repeat this procedure for each alignment marker.
   ii. Automatic method (recommended).
      a) Use the command \(pg\ move\ marker <x,y> --rel <ident>\). The field \(x,y\) is in the same convention as \(mpos\). The field \(ident\) will tell the system to look for a marker of that classification. For instance, the ident \(p20\) will search for a positive 20x20 micron rectangle. This command will automatically search for the center of any valid \(ident\) marker. If \(ident\) is found, then the system will print nothing and release control to back to the command line.
         ➢ The command \(pg\ info\ marker\ ident\ \ast\) will print a list of all available markers. If your marker \(ident\) is not there, read the manual about JOY markers and the command \(pg\ marker\ create\).
         ➢ If the marker search failed, you may need to change the \(ident’s\ contra, mlvtol, blvtol, or israd\, depending on the returned error. Only do this if you are comfortable, otherwise use the manual method.
      b) Run \(pg\ move\ marker 0,0 --rel <ident>\) to verify that the stage is positioned at the center of the marker.
      c) Run the command \(pg\ get\ tab\) to print out the absolute stage coordinates. Write down the marker’s location.
      d) Repeat this procedure for each alignment marker.
9. Measure the substrate height with \(mpgm height\). Do this in the location where you plan to write or near an alignment marker.
10. When you are ready to submit your exposure job in cebpg, click on the \# next to the cassette position of your holder.
11. Select the .job file name.
   i. In the parameters field, enter in the coordinates that you recorded in steps 7 or 8.
      a) Make sure to use a preceding -f for relative coordinates.
      b) Alignment marker coordinates must be listed to match their order in cjob. List the coordinates as \(<x_1,y_1> <x_2,y_2> <x_3,y_3> <x_4,y_4>\). The unit convention is the same as in mpos.
   ii. Double check the holder number, your email address, and if you want to unload the holder after the job.
   iii. Double check if the height pre-check enabled in cjob. The job will crash if the height check is not passed.

12. In the written logbook, the minimum information that must be written is the date, your / partner / trainer name (if any), holder(s), beam current(s), and job entry number(s). If there are any unusual issues that come up while you are using the EBPG, please record those as well.

13. In the logbook, record your name, the holder(s) you used, the beam(s) you used, and the job number(s). Additionally, document any unusual or anomalous events.

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**CLOSING DOWN**

1. After the exposure finishes, make sure that the holder is returned to the airlock. This can be done by pressing the **bold arrow** in cebpg next to the cassette position of interest, or with \( \text{pg substrate unload <caspos>} \) (\text{subu <caspos>}) from the command line.
2. Vent the airlock (press SET LOCK VENT on csys)
3. Follow the steps above to remove the substrate holder and get your sample(s).
4. Return the holder(s) to the airlock and pump it back down (press SET LOCK VACUUM on csys).

<table>
<thead>
<tr>
<th>Contributors</th>
<th>Revised Date</th>
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<tbody>
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