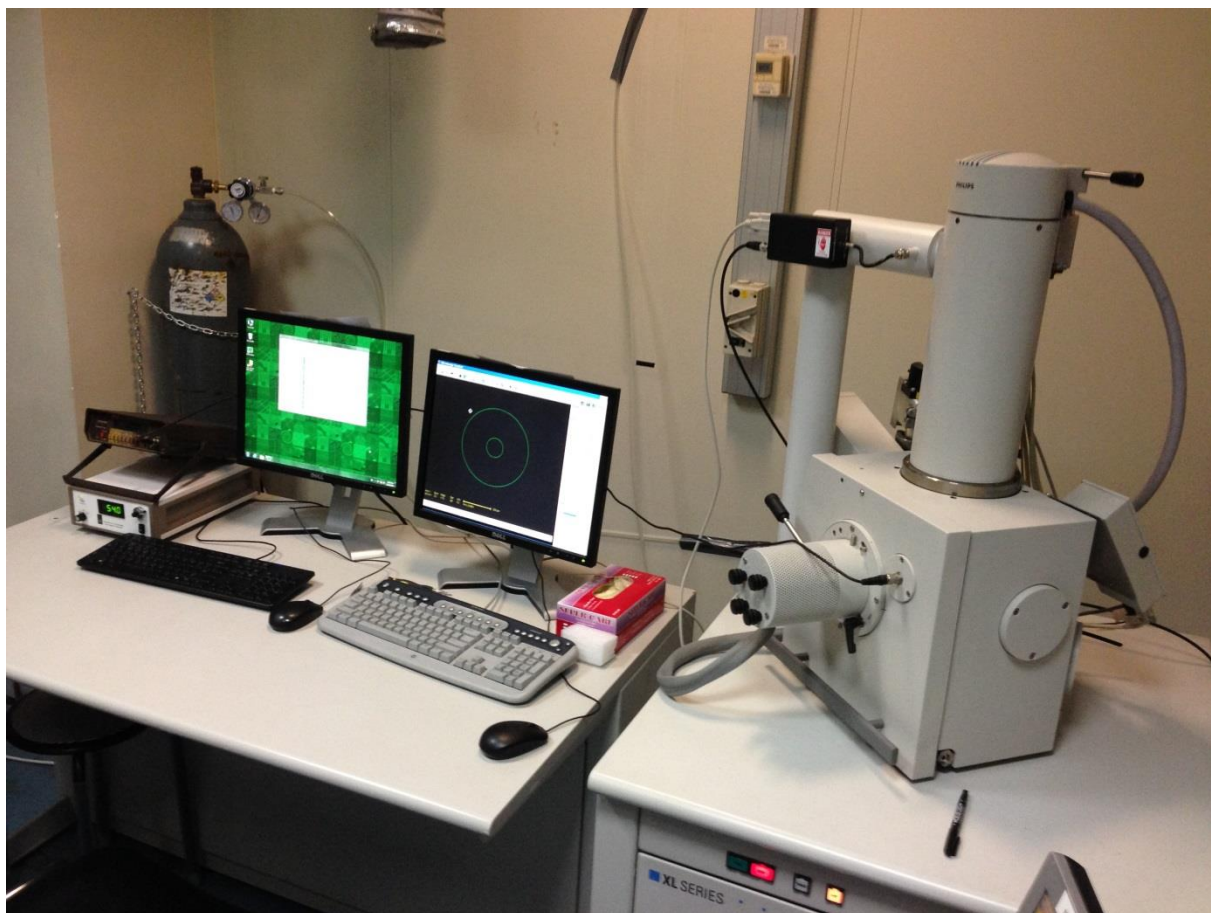


Electron Beam Writing with NPGS SOP

This is a shortened version that focuses mainly on routine operation.

*For more detailed instructions, please refer to the
user manual “XL-30” and “Nanometer Pattern Generation System”*



1. Scope

- 1.1 This document provides operating procedures and requirements for electron beam lithography. Please refer to “FEI XL30 Scanning Electron Microscopy” manual for imaging procedure.
- 1.2 System description

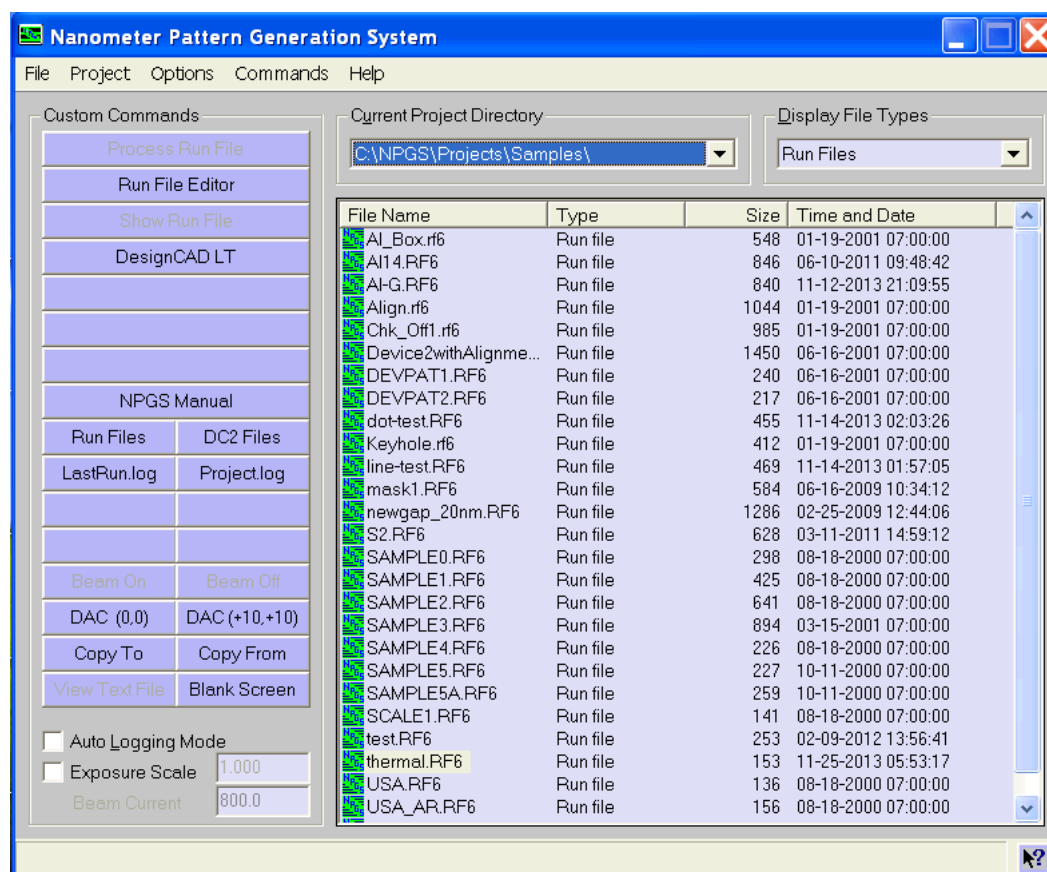
The FEI XL30 SEM uses the Nanometer Pattern Generation System for Electron Beam Lithography Writing. An SEM lithography system is a tool which can be used in a wide variety of applications. The basic lithography process allows patterns to be defined on a flat surface. The subsequent processing, such as metal evaporation or etching, will determine the final structure. NPGS is unique in that it provides a very flexible system which is ideally suited to the wide range of activities in basic research and R&D activities.

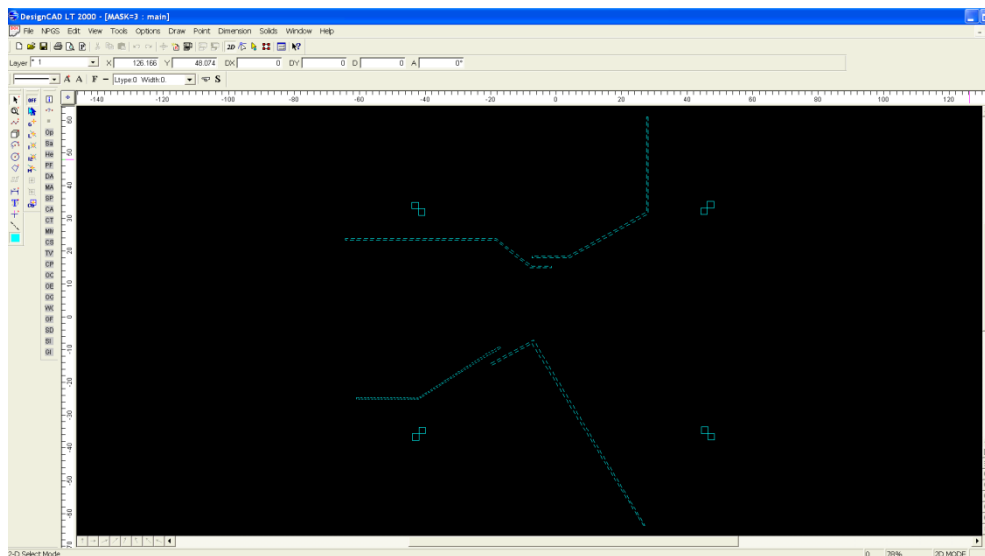
2. Before starting: Important note

- 2.1 You have to go through manual of XL30 SEM and be authorized for SEM usage before electron beam writing training.
- 2.2 You have to be authorized by Dr. Tang and properly trained by Dr. Tang's group member before operate the system.
- 2.3 This system is dedicated for electron beam writing system, which could be used to create sub 100nm fine structure. Although it can also be used for routine structure checking, **no wet, biological or other contaminating sample** allowed inside the chamber.
- 2.4 In order to keep efficient system cooling, the back panel is opened, which leads to potential electrical shock hazard. The backside of the SEM table area is restricted to authorized person only, which contain **10 kV power line**.

3. Software user interface

Two software interface are mainly used for electron beam lithography: "Nanometer Pattern Generation System" and "DesignCAD".





4. Operation instruction

I Prepare writing sample and file

Most widely used electron beam resist is PMMA which can give very high resolution ($<10\text{nm}$). The PMMA 950K A11, A7, A4 and A2 are in stock inside 8N-01 and ready for use. Spin coater and baking hotplate are also located inside 8N-01 cleanroom area. For spin condition of PMMA resist please consult <http://www.microchem.com/Prod-PMMA.htm>. Other electron beam resist such as ZEP and HSQ can also be used inside this system.

Before writing session, it is recommended that user pre-design the CAD file with DesignCAD in DC2 format.

II Load sample and beam current measure

1. Load sample with spring loaded holder similarly as imaging process. It is helpful to scratch on four corners of your sample for latter focus.
2. After pumping to high vacuum ($<5 \times 10^{-5} \text{ mBar}$), turn on beam at 30kV.
3. Image and focus on the edge of F-cup. Move the stage height to $\sim 7.5\text{mm}$. **(It is very important to tell the machine where your sample is by focus and click Z→Fwd . Skip this step could result crashing the stage into lens and severely damage the microscope!! Every time after stage move to a sample with different Z height, it is crucial to do another Z→Fwd to prevent crashing!!)**



4. Move to the center of F-cup and increase magnification to zoom at the way inside, so that the SEM screen is completely black. This will insure all electrons are collected by F-cup.
5. Read the beam current from pico-ammeter. Switch beam blanker ON/OFF and record the difference as beam current value on log book and your run file. Make sure measure all beam current of the beam spot you are going to use.

Spot size 2	~10pA
Spot size 3	~35pA
Spot size 4	~130pA
Spot size 5	~550pA
Spot size 6	~2400pA

6. (Optional) Move to Gold standard and check and correct the astigmatism at Z height ~7.5mm. Gold standard sample has many small gold particles with size 10~100nm, which is very useful for image quality optimization.

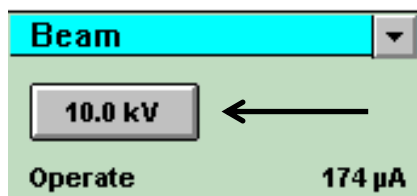
II Electron Beam Writing

1. Move to your sample and align sample with appropriate X axis by using align X (or align Y) inside stage menu.
2. Focus on the corner of your sample, after Z → fwd adjust height to ~7.5mm.
3. Move to the area where you want to write your pattern on. Switch to beam blanker to external, the SEM screen should be blanked (Important, if it is not blanked, a big hole will be created in the middle of your sample).
4. Switch the SEM scan to EXT mode by selecting from scan submenu.
5. Process run file from NPGS computer, the beam writing will start. An estimated time will show on the screen as well.
6. Once the writing is finished, quickly switch scan mode to full frame and spot size back to 2. This will minimize the potential beam exposure from the blanker leakage current. During writing, check the current reading from picoammeter, the current should be ~80% of your measured beam current.

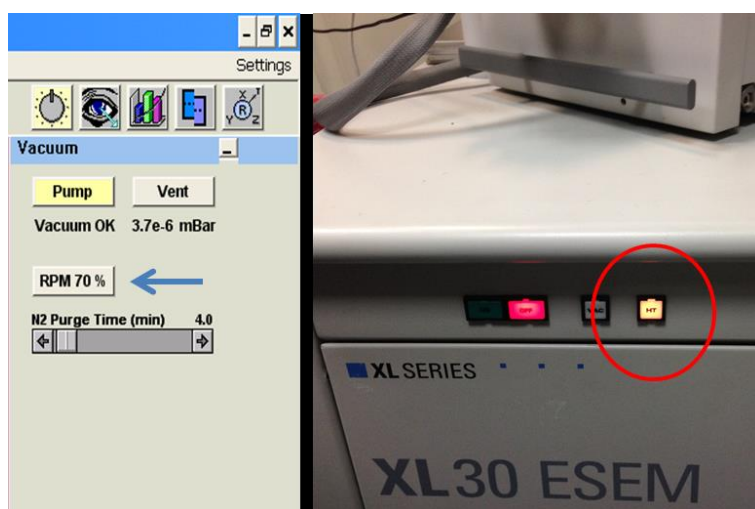
If the current is significantly lower, your writing is not correct, and you should re-measure beam current.

II Finish

1. Select F-Cup in stage control and click Goto
2. Turn-off Beam by click 30 kV



3. **Wait 5min** for filament cooling down before vent the chamber and retrieve your sample.
4. Pump system back to vacuum, wait for "Vacuum OK" before leave the room. If you are the last person who uses the SEM today, expand Vacuum control zone, and click "RPM 70%" to put pump into low speed mode. Press HT button on the SEM main console to put system into overnight mode.

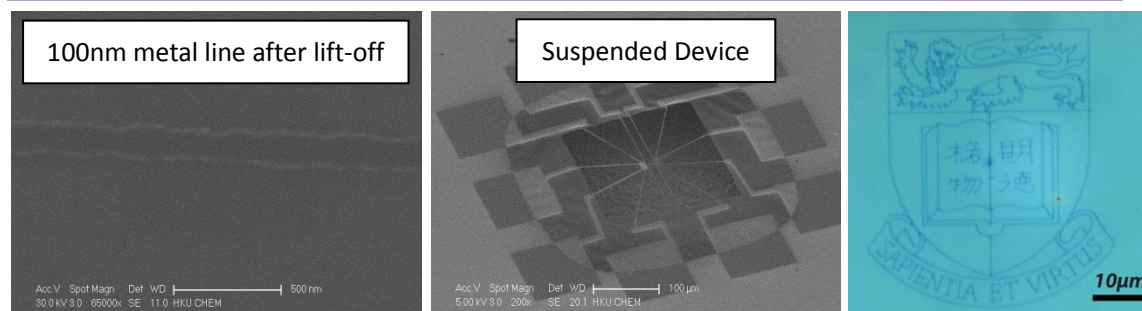


IV Record your usage status on Log book.

V Develop sample

There are two ways to develop sample with PMMA as resist. The most widely used developer is MIBK:IPA 1:3, which is in stock in 8N01 clean area. For $\sim 0.5\mu\text{m}$ line features, the dose should be $\sim 400\mu\text{C}/\text{cm}^2$.

5. Examples of beam writing



6. Trouble Shooting

A. Very blur pattern

The focus maybe far off, auto XY focus mode can be used to correct this. Consult super user for detail.

B. Hole in the middle of my pattern

Make sure blank the beam before switch to EXT scan mode, and do not unblank the beam before switch back to full frame scan mode.

C. Pattern does not come out completely or no pattern at all

Make sure the beam is not blanked from SEM side, and the dose is correct.