

FEI Nova NanoSEM 430

The FEI Nova NanoSEM 430 is a state-of-the-art SEM that utilizes a field emission electron source and immersion lens technology to obtain resolution below 1 nm. The NanoSEM is capable of imaging from 8X to 300,000X, working distance permitting. Accelerating voltage can be varied from 50V (with beam deceleration) to 30kV. It features a motorized XYZ stage with full 360° rotation and -10° to 90° tilt and can hold a full 4" wafer.

Prerequisites for operating the FEI Nova NanoSEM 430:

- a) Obtain a NRF ID (if you do not already have one) by completing the [NRF Lab Use Request Form](#).
- b) Receive “one on one” training and certification from NRF Staff. Discuss your process with a staff member.

Safety

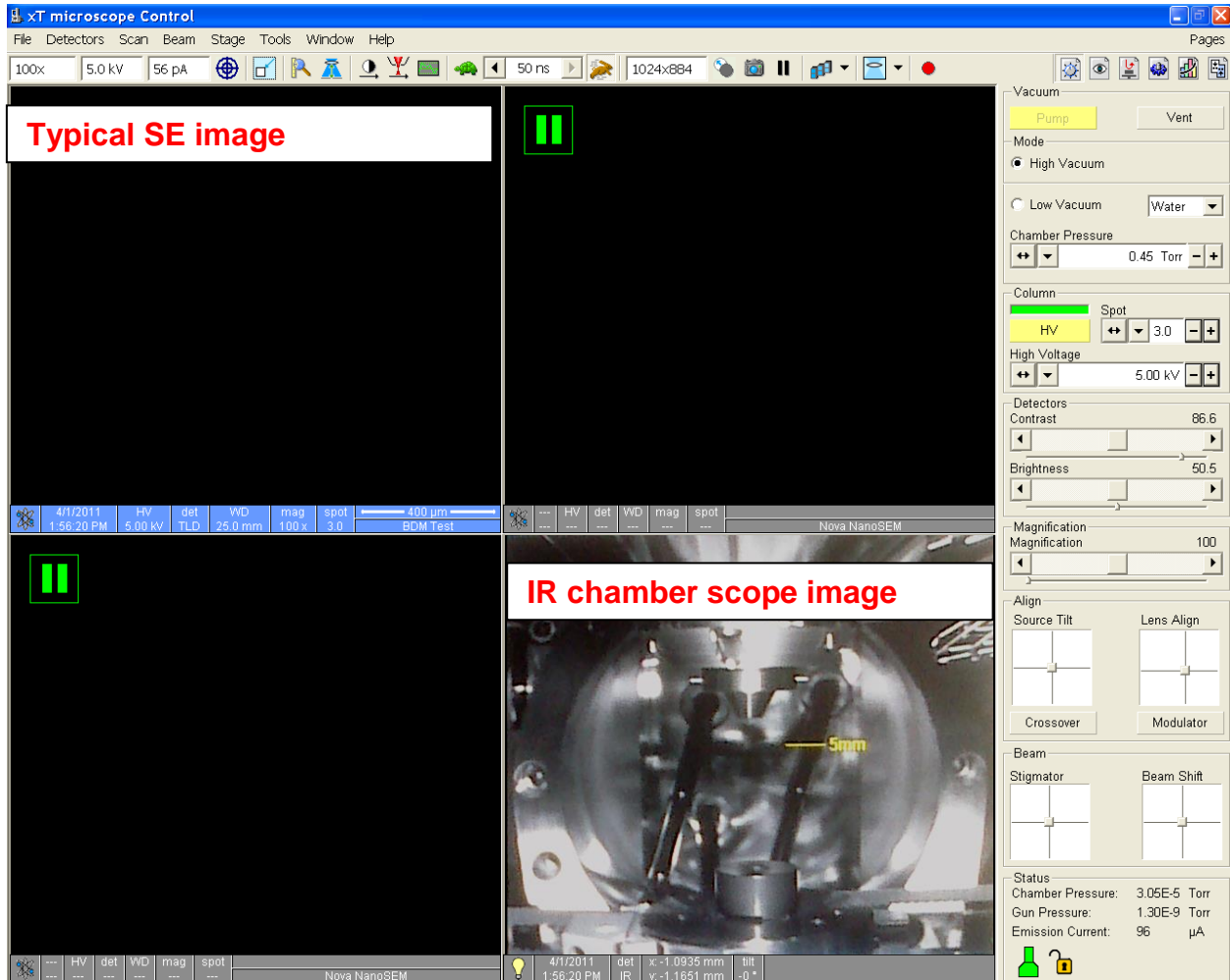
- **High Voltage** - High Voltage is used throughout the system. System maintenance may only be performed by the FEI service rep or NRF Staff. Do not remove any tool covers or defeat any interlock on this system.
- **Moving Components** - The User must observe caution when opening and closing the chamber door to ensure sample and stage clearance. Any neglect in sample loading/unloading will result in damage to the SEM column.
- **Pinching Hazard** – the door to the SEM chamber can pinch fingers when closing. Use caution.

1.0 Pre-Operation

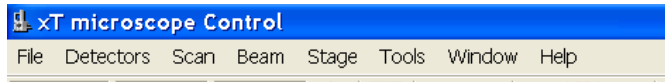
- 1.1 Tool Reservations may be made via the NRF Reservation Page. <http://nimet.ufl.edu/servicecenter/resources/default.asp>
- 1.2 Change gloves. WARNING No solvents or liquids are allowed near the machine, change your gloves before operation!! Wear gloves while handling the samples and sample holders to reduce contamination.
- 1.3 Log into the TUMI computer in room 125 to access the instrument.

2.0 Software Navigation

The FEI Nova NanoSEM 430 is a menu intensive system. The main screen (below) consists of a top menu bar, top tool bar and right side tool bar. The right side tool bar consists of 6 different tool boxes, of which 3 are used in basic operation. The right side tool bar changes with the selected icon on top.



Menu Bar



Top Tool Bar



Right Side Tool Bars – these are selected to control the electron column (labeled Beam Control), stage (labeled Navigation) and measurement tools (labeled Processing).

2.1 Right side tool bar

2.1.1. Beam Control

This toolbar is to control the electron beam parameters.

Vacuum – the user selects “Pump” or “Vent”

Mode – High Vacuum Mode ONLY

CAUTION



CAUTION

Do not select Low vacuum mode. This detector is only installed and operated by NRF staff.

Column – user enables the high voltage “**HV**”. User selects the spot size and accelerating voltage.

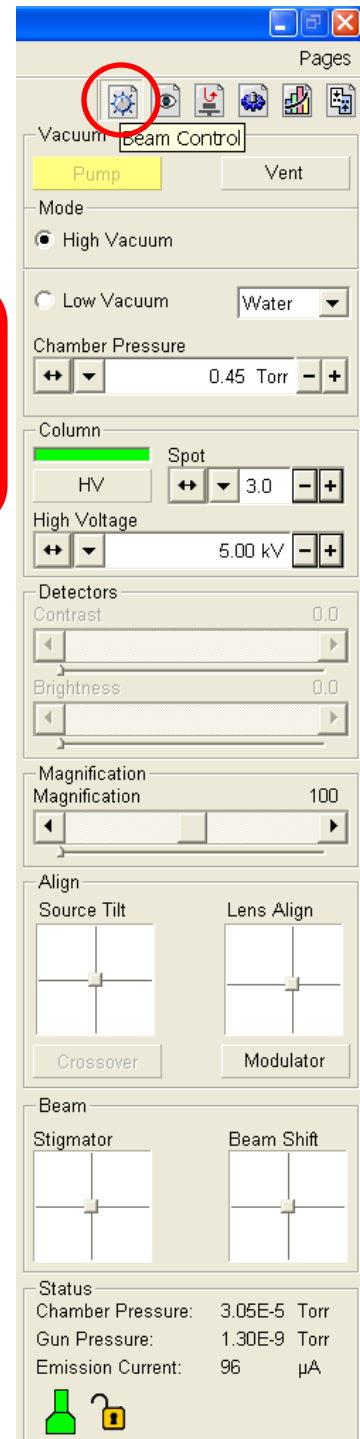
Detectors – User sets the contrast and brightness to desired levels

Magnification – User selects the desired magnification value.

Align – User adjusts the “**Source Tilt**” to center illumination in the cross mark and “**Lens Align**” to minimize image wobble.

Beam – User adjusts the “**Stigmator**” for optimum focus and can move the scan field with “**Beam Shift**” at high magnification.

Right clicking in these alignment boxes will open a short user menu for course/fine adjustment and zeroing the settings.



2.1.2. Navigation

This tool bar is to control stage movement. Several buttons from “Beam Control” are replicated and serve the same function.

Stage – user inputs values for stage movement and position. There are 3 tabs on this section, Coordinates is the most useful. The user can select to lock a coordinate and use actual or relative positions.

When entering stage position values, execute the stage action by selecting the [Goto] button. This button becomes a [Stop] button during the stage movement and is very useful to stop movement if an error occurs.

The type of movement must be selected. “Actual” and “Relative” are commonly used modes. “Actual” moves the stage to that actual position. “Relative” moves the stage relative to the current position.

It is a good procedure to have the IR chamber view in operation during stage movement to avoid the sample/column collision.

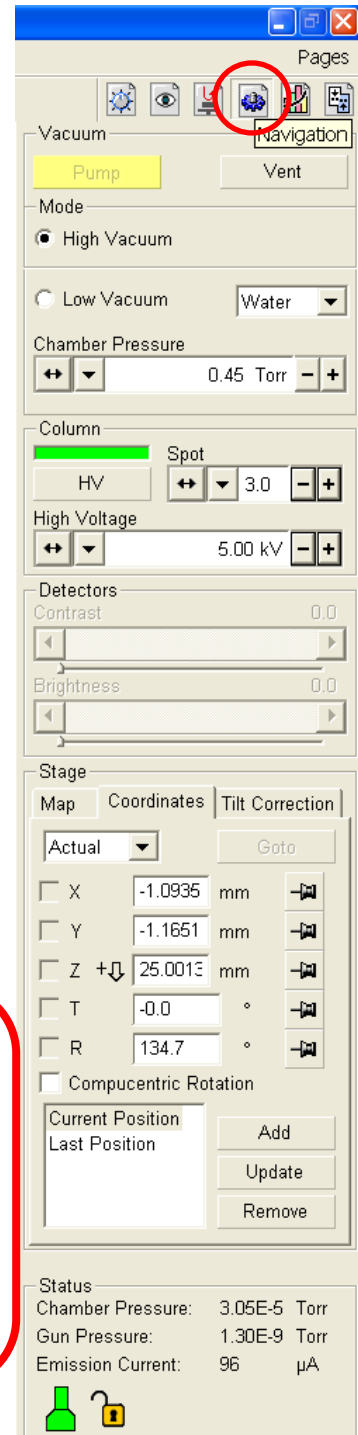
CAUTION CAUTION

The Z axis motor moves very fast. Use caution when moving the sample within 10mm of the end of column.

Never use Compucentric Rotation while the stage is tilted. This will crash stage into column.

The user can also move the axis knobs on the stage motors to position the sample.

On the active image, the user can double left click on a feature to move it into the center of the image or press and hold the scroll button to drag the sample in any direction.

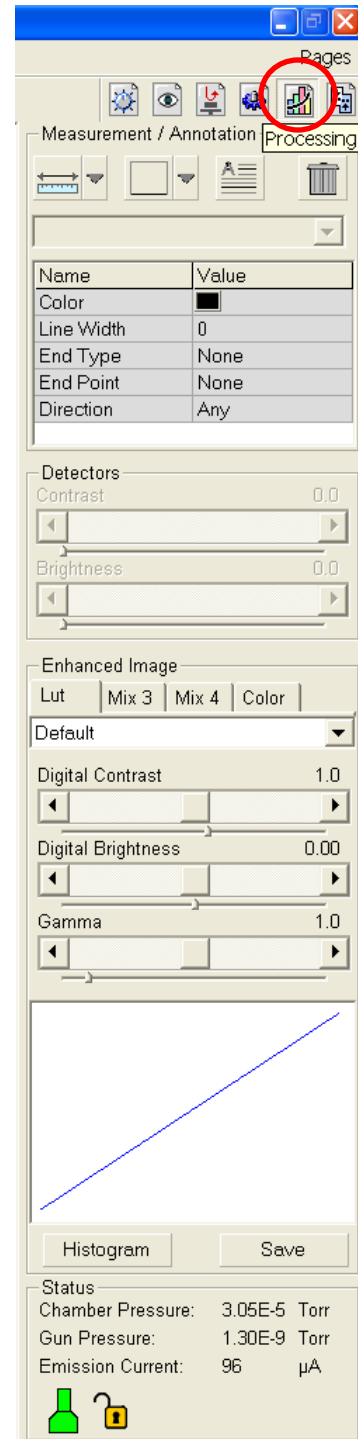


2.1.3. Process

This tool bar provides measurement tools for image analysis.

Measurement/Annotation – user selects line, area and text tool to edit image.

Enhanced Image – User selects different tools to digitally enhance the image.



Reference will be made to these menu and tool bars throughout this SOP.

3.0 Load Sample

Clean gloves must be worn while handling the sample holders and loading/unloading the samples. This reduces the amount of contamination on the holders and in the chamber, providing a longer life of the high resolution capabilities.

CAUTION  CAUTION

**BE SURE THE CL MIRROR IS FULLY RETRACTED
BEFORE LOADING OR UNLOADING SAMPLES
FROM THE CHAMBER**

To ensure the CL mirror is fully retracted, check the indicator light on the CL monochromator. If the light is **GREEN**, the CL mirror is fully retracted and it is safe to proceed. If the light is **RED**, retract the CL mirror using the mirror position knob under the monochromator.



Green LightThe mirror is fully retracted



Red light.... The mirror is partially or fully extended. Mirror position knob is circled in yellow.



- 3.1** Confirm the stage is at its lowest position, Z to **55mm** (or more) in the Navigation tool bar (**Section 2.1.2**). Set the tilt to 0° and the rotation to 120°. This places the securing screw to a convenient location. The IR chamber scope should be used to avoid a stage/column collision.

CAUTION  **CAUTION**

Z refers to the stage height read from the lower right side of the monitor.

- 3.2** Click the “VENT” button on the top of the Navigation (**Section 2.1.2**) or the Beam Control (**Section 2.1.1**) tool bars. The system will notify you of the approximate time for venting and a confirmation to continue. After 2-3 minutes, you may pull the chamber door open by using the chamber door handle.

CAUTION  **CAUTION**




Open and close the chamber door with the chamber door handle.
DO NOT use the stage control knobs as handles.


- 3.3** Mount sample in holders with screws, vise clamp design, or 4” wafer holder. You may also use carbon tape or Cu tape to attach samples.

NO CARBON PAINT, OR PAINT OF ANY KIND, TO BE USED UNLESS SPECIAL PERMISSION IS GRANTED BY THE STAFF.

- 3.4** Insert the sample mount into the SEM stage and lightly tighten the retaining screw.
CAUTION – do not over tighten this screw.
- 3.5** Push the chamber door closed by using the chamber door handle.
- 3.6** Click the “Pump” button on the top of the Navigation (**Section 2.1.2**) or the Beam Control (**Section 2.1.1**) tool bars to begin chamber pump down. This will take a few minutes for the chamber to reach the mid 10⁻⁵ Torr for operation. Then the base pressure has been obtained, the “HV” icon will become available for activation.

4.0 SEM Operation

- 4.1 Click the “HV” icon to turn on the FE gun.
- 4.2 Select the acceleration voltage and spot size from the Beam Control toolbar (**Section 2.1.1**)
- 4.3 Unpause the SE image (upper right hand image) by clicking the pause icon 
- 4.4 Make sure that the imaging averaging is set to “Live”. 
- 4.5 Adjust the contrast/brightness to obtain a grey scale image.
- 4.6 **Focus** on the top surface of your sample using the right mouse button and moving left and right. The SE image must be highlighted to the focus this image. When the **right mouse button is pressed**, the cursor will become a double ended arrow.
- 4.7 Adjust magnification with the magnification control on the Beam Control toolbar (**Section 2.1.1**), with the top tool bar magnification window, by right clicking the mouse and dragging a box around your area of interest [or by using the + - keys on the keyboard](#). Use a magnification of 1000 or more and refocus the image.
- 4.8 Set the actual sample height by using the “link Z to FWD” icon on the top tool bar . This will set the top of the focused sample and provide an accurate working distance for stage navigation.

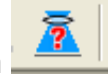
To change the working distance, enter the working distance value into the Z box on the Navigation tool bar (**Section 2.1.2**). After entering this value, click the “Go To” button to activate that position. The “Go To” button becomes a “STOP” button during stage travel. Raise the stage in increments so there will be a reduced chance of a collision with the column or other detectors. You may also highlight the IR chamber image and use the mouse scroll wheel. Hold the mouse scroll wheel down and drag the mouse up or down to move the stage. Use the IR chamber image to determine possible sample/column interference and to ensure no column touching. [Ensure chamber view image is not paused](#) . You may also manually raise the sample by turning the Z knob on top of the chamber door.

CAUTION



CAUTION

Use caution when moving the stage close to the column to avoid collision.



After a large stage movement in Z, refocus the image and “link Z” again. Check this icon often to confirm the Z value on the stage control is correct.

5.0 Image Optimization

For each change in detector or column condition, realignment of the Lens and stigmator will be required.

It is best practice to achieve the beam condition and select detector type prior to image optimization.

5.1 Find your area of interest and begin image optimization. The aperture is set to the 30 μ m aperture is already well aligned mechanically. There should be no need to adjust this aperture manually.

The stage can be moved by double clicking the left mouse button on the feature of interest or by holding the center scroll wheel down and dragging the mouse to move the stage.


5.1.1. Adjust Source Tilt by pressing Crossover radial button and aligning the green X on the screen with the circle. If the circle is not visible, increase contrast to 90%. Use the crosshairs to center the X with the circle. When done depress the Crossover button and adjust focus.

5.1.2. Align the beam within the aperture by using the Lens Align crosshair on the Beam Control toolbar (**Section 2.1.1**). It is a good practice to clear the “Beam Shift” to center the scanning beam. Turn on the “Modulator” (under the crosshairs) to begin image wobble. Drag the crosshairs to minimize the wobble, this is centering the beam with the aperture.



5.1.3. Readjust focus.

5.1.4. Adjust the stigmatism with the stigmator crosshairs in the Beam Control toolbar. Adjust one axis at the time and refocus each time.

5.1.5. Readjust focus.

Note: many times it is useful to adjust these setting while in the small area scan mode .

5.1.6. Adjust contrast and brightness.

5.1.7. You may select scan speed  and image averaging  from the top tool bar.

Note: some scan modes will default to imaging averaging which can cause confusion during image optimization. You can reset the averaging mode to “live”.

5.2 Detectors.

The system has 3 different SE detection modes, the standard ET detector, Thru Lens and Thru Lens w/immersion. The highest image resolution will be obtained with the Thru Lens w/immersion. Detectors are selected by opening the Detector menu from the top menu bar (**Section 2.0**).

To use the Thru Lens w/immersion, the following conditions must be met:

- Less than 18kV
- Above 2000x magnification
- Less than 7mm working distance

To select the immersion lens, click the Lens Selection icon  on the top tool bar and select “immersion”. If the “immersion” is not selectable

Image Capture – FEI software

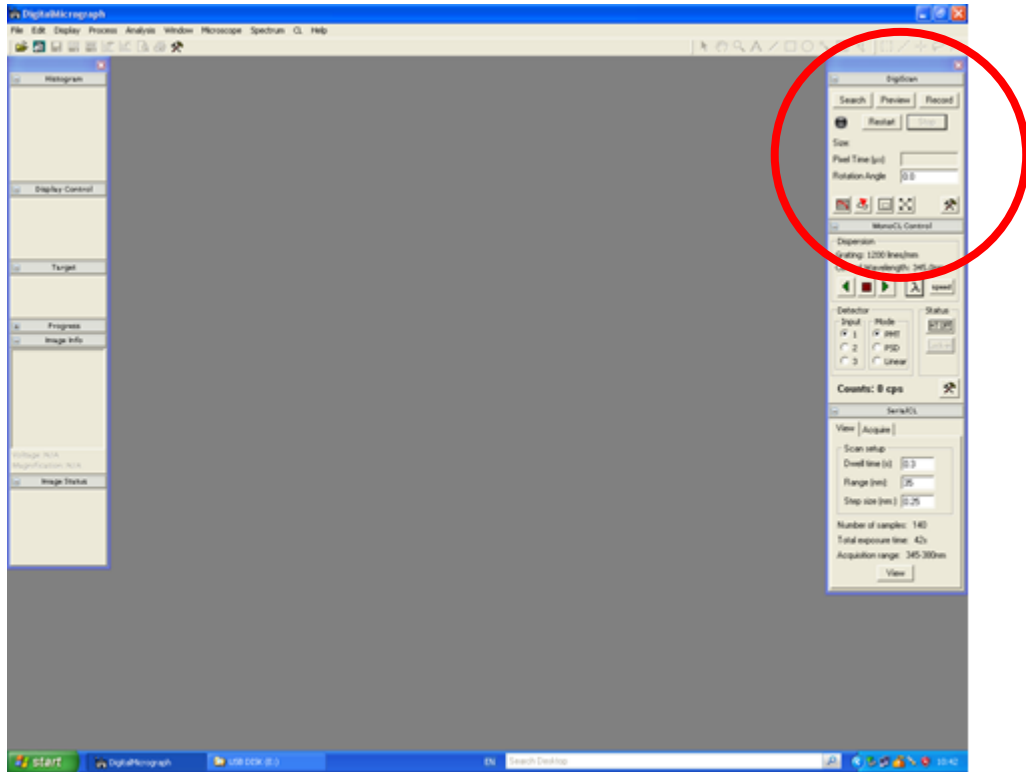
Select the image pause from the top tool bar to stop the image scan. Or press the Camera Icon on the Top Tool Bar.

Open the “File” menu on the top menu bar and select “Save As”. Save all images to the **SPC Shared Data on spc-npe102** directory found on the desktop. This will save the images to the support computer (located to the left of the main computer). The keyboard and mouse for this computer are located on the keyboard tray under the desk.

Once the samples are saved, remove them from the computer via USB stick. Only remove images from the support computer. The USB slots in the main computer are blocked and are inaccessible.

5.3 Image Capture – Gatan software

Superior images can be acquired with the Gatan Digital Microscope software. The program screen shot is below with the image capture menu highlighted.



Use the search, preview or record modes to capture your image. Each mode has a different resolution. The space bar will trigger a scan stop at the end of the image scan.

Captured images should be saved in the following format.

In the FILE pull down menu, select SAVE AS. The default format is the Gatan DigitalMicrograph format (*.dm3). It is preferred that you save the images in this format for future editing and data creation. The Gatan format stores a lot of image resolution data and this makes future image edits easier and more accurate. However only Gatan DigitalMicrograph can read this *.dm3 format.

If the image format is to be other than the Gatan format, select SAVE DISPLAY AS in the FILE menu. This will allow the user to select the type of image file format desired. Gatan DigitalMicrograph can save images in standard formats such as TIFF, GIF, BMP, and JPEG.

6.0 Unload Sample

- 6.1 Ensure the CL mirror is fully retracted.
- 6.2 Lower the Z to **60mm**, set tilt to 0°, center X and Y, set rotation to 120°.
- 6.3 Click the “HV” button to turn off the gun.
- 6.4 Click the “VENT” button on the software.
- 6.5 Loosen the retaining screw 1 turn, **do not remove the screw**. Remove the sample holder.
- 6.6 Once the sample is removed, close the chamber door and pump down the system.
- 6.7 **If you modify a sample holder, remove screws or clips, you must place it back into its original state. Other users depend on these holders to mount their samples. Please let us know by TUMI log off note if any of sample holders are taken apart or are missing parts.**
- 6.8 Log out of the TUMI computer in room 125 at the end of your session.
- 6.9 Please close the room door behind you. SEM room is limited access only.