2D material Detector

User Manual

Model: SLG2

Sejong Scientific Instruments Inc.

Chapter 1: Background of the Product

- Two-dimensional (2D) materials are fundamental materials applicable across a wide range of industries, including the Internet of Things (IoT), flexible devices, ultra-low-power electronics, next-generation batteries, water purification filters, and even spacecraft. A two-dimensional (2D) material is defined as a substance in which atoms form a crystalline structure in a plane, with a thickness of just a single atomic layer (approximately 1 nm, or one-billionth of a meter).
- Depending on their electrical properties, 2D materials can be categorized into conductors, semiconductors, and insulators. Representative examples include graphene, which is a conductor; transition metal dichalcogenides (TMDCs) and black phosphorus, which are semiconductors; and hexagonal boron nitride (hBN), which is an insulator.
- Graphene, a representative 2D material, was discovered through a method known as mechanical exfoliation, where layers of atoms are peeled off from a graphite block by repeatedly applying and removing adhesive tape. Despite its simplicity, this method is still widely used by researchers today. Although mechanical exfoliation has a very low yield and is unsuitable for large-area production, it remains the best method for obtaining the highest-quality 2D materials.
- However, after mechanical exfoliation, the process of manually identifying monolayer 2D materials using an optical microscope is time-consuming. Additionally, prolonged exposure to air during this process can lead to sample oxidation. Moreover, the yield is extremely low, with only one or two monolayer flakes (crystals) typically found per square centimeter. The 2D material inspection equipment has been developed to address these challenges.
- This manual provides instructions on how to use the 2D Detector, a device that automatically identifies and records the locations of mechanically exfoliated 2D materials.

Chapter 2: Instructions for Use

(Powering on the device)

Turn on the power switches of the stage controller and the LED illuminator. The brightness of the LED illuminator can be adjusted using the knob, and a setting between 40 and 50 is generally appropriate. The USB cable connected to the camera must be plugged into a USB 3.0 port on the PC. Additionally, another USB cable must connect the back of the controller to the PC for the system to function properly.

(Mounting the sample and adjusting the height)

Place the sample so that its lower-left corner is positioned near the origin. The origin can be identified by turning on the illuminator and increasing the intensity until the white light source appears under the objective lens—this spot is considered the origin. In other words, if the light is illuminating the lower-left portion of the sample, the placement is appropriate.

The working distance of the objective lens is 2 cm, meaning the approximate focal distance from the bottom of the objective lens to the sample surface should be adjusted to 2 cm. This adjustment is made manually by rotating the lever or the Z-axis motor knob connected to the microscope.

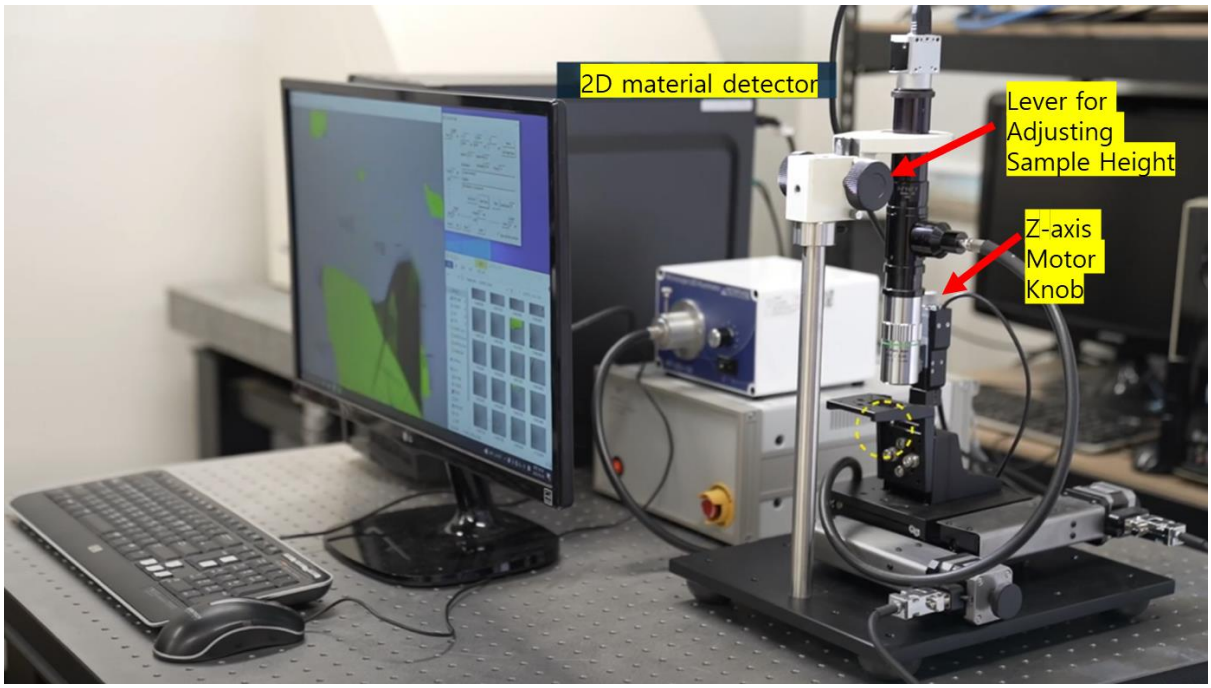

Figure 1 Overall photo of the equipment

(Launching the Program)
On the control PC, double-click the SLG64 icon to launch the program.

(Focusing)
On the main window, a live microscope image will appear, and a Control Panel will be visible on the right side. If the microscope image appears blurry, use the coarse or fine buttons located at the bottom left to automatically adjust the focus.

The coarse button is used when the focus is significantly off, providing a rough adjustment, while the fine button is for precise focusing. When either button is pressed, the motor attached to the Z-axis will automatically adjust the height to bring the sample into focus.

If the image is too far out of focus, manual adjustment may be required. After roughly adjusting the height with the coarse or fine buttons, press the focus button to perform precise autofocus.

When focus is achieved at the origin point, the current height is saved in the Z depth field next to the Origin button. This Z-value is then used as the reference height during scanning, serving as the basis for tilt correction.

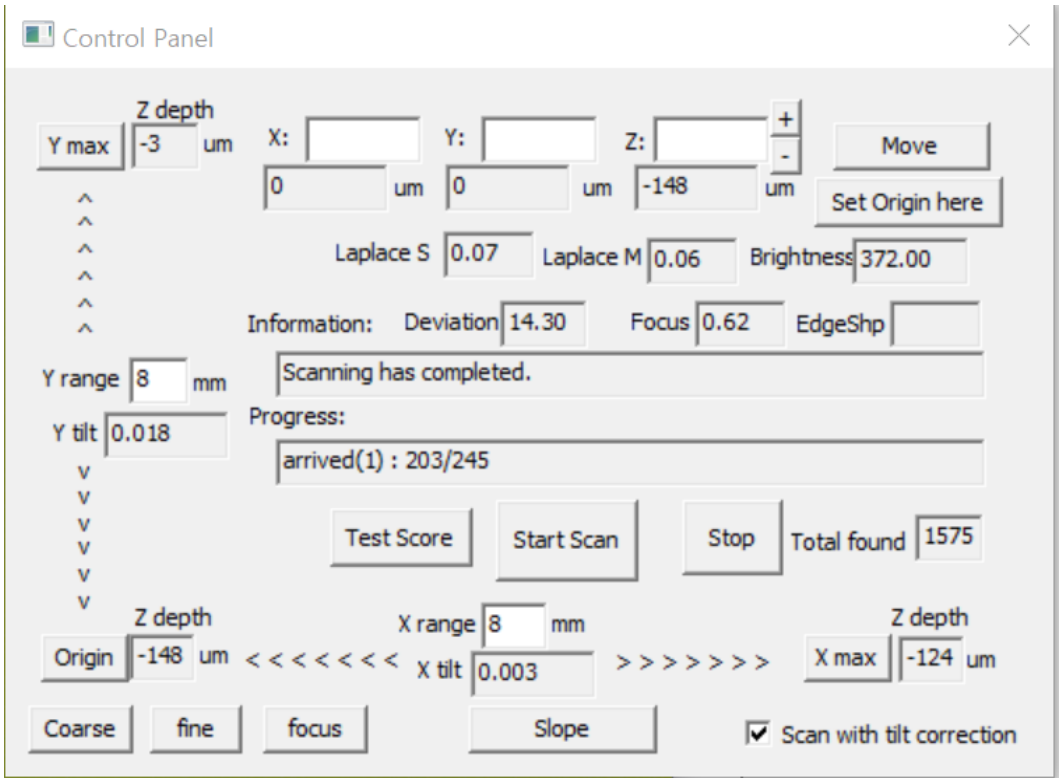

Figure 2 Control Panel

(Adjusting the Scan Range)
Check whether the default values for X range and Y range in the Control Panel are appropriate. The range can be set between a minimum of 1 mm and a maximum of 50 mm, and should be adjusted according to the size of the sample.

To confirm the set values, press the X max button on the right side. The X-axis motor will move to the maximum X range position. At this position, perform either automatic or manual focusing, then press the focus button to record the Z-depth (focus height) at the X max position.

Similarly, press the Y max button to move to the maximum Y range. After adjusting the focus at that point, press the focus button again to record the Z-depth at the Y max position.

To fine-tune the focus while viewing the image on the monitor, use the + or − buttons next to the Z: field. Each press adjusts the height by 1 μm, and the new value is saved as the updated Z depth.

(Performing a Scan)
There are two scanning modes: one that includes tilt correction and one that does not.
If you check "scan with tilt correction" in the lower right corner, tilt correction will be applied. If left unchecked, scanning will be performed at a constant height.

For samples smaller than 5 mm, it is acceptable to scan without applying tilt correction.

(Scanning with Tilt Correction)
To perform tilt correction, the X-tilt value (center-bottom) and the Y-tilt value (center-left) must be set. If these fields are empty and "scan with tilt correction" is checked, pressing the "start scan" button will first automatically measure the tilt and then begin scanning.

When the Z-depths at the Origin, X max, and Y max positions are all entered, you can press the slope button to calculate and display the tilt values.

Once the tilt is calculated, you can press the "start scan" button to begin scanning immediately. To stop scanning at any time, simply click on the screen with the mouse.

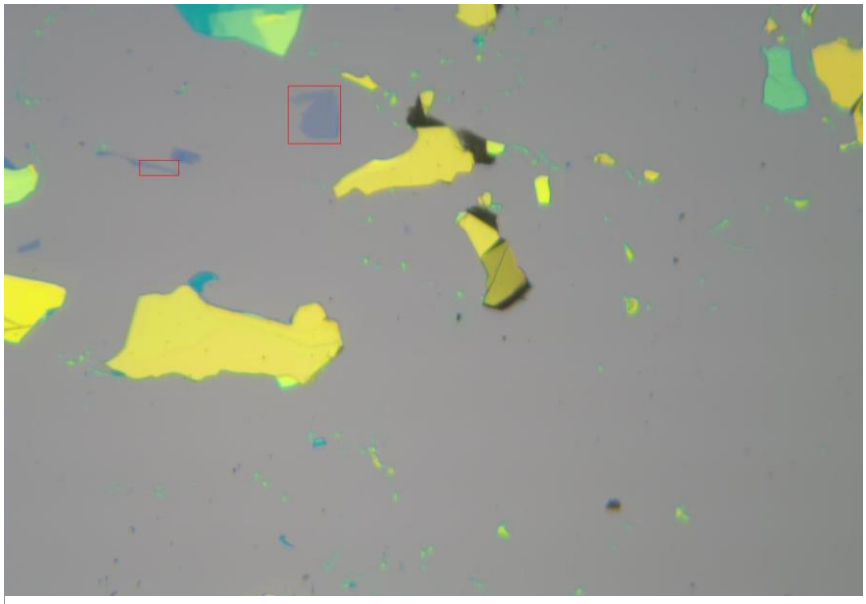

Figure 3 Saved Image

(Checking Scan Progress)
During scanning, the Information and Progress boxes located at the center of the Control Panel display the scan progress and the estimated remaining time. At the top, the X, Y, and Z fields show the current scanning position of the motors.
When the scan is complete, it automatically stops, returns to the origin, and switches back to standard microscope mode.

If you want to save the microscope image in this state, press the Enter key or select Save Image from the menu.

(Viewing Images)
Images of the 2D materials detected during scanning are automatically saved in a folder named with the current date and time inside the "image data" folder on the desktop.

The filenames indicate the sample's position coordinates. The image of the origin, labeled "(0,0)", is always saved for reference.
Detected 2D material flakes are marked with a red rectangular box in the saved images.

(Contrast Ratio Detection Settings)
To access the contrast ratio settings, go to the Analysis menu and select Configuration. In the configuration window, choose the type of 2D material and substrate, and the corresponding default contrast ratio values (for red, green, and blue) calculated theoretically will appear.

These values can also be adjusted manually. The tolerance value, which defines the acceptable margin of error, can also be changed. A higher tolerance may lead to more noise, while a lower tolerance might result in missing faint 2D material.
Though the tolerance can be set automatically, a general rule is to set it to about half the highest contrast ratio value among R, G, and B.

To check if the current settings are appropriate, press the "Test Now" button. You will see the detected 2D material boundaries highlighted, along with the classification result.

(Size Range Setting)
To define the size range of flakes, enter the desired minimum and maximum values in the fields next to Size (μm²).
Ensure that the maximum value is greater than the minimum value for the setting to be applied properly.

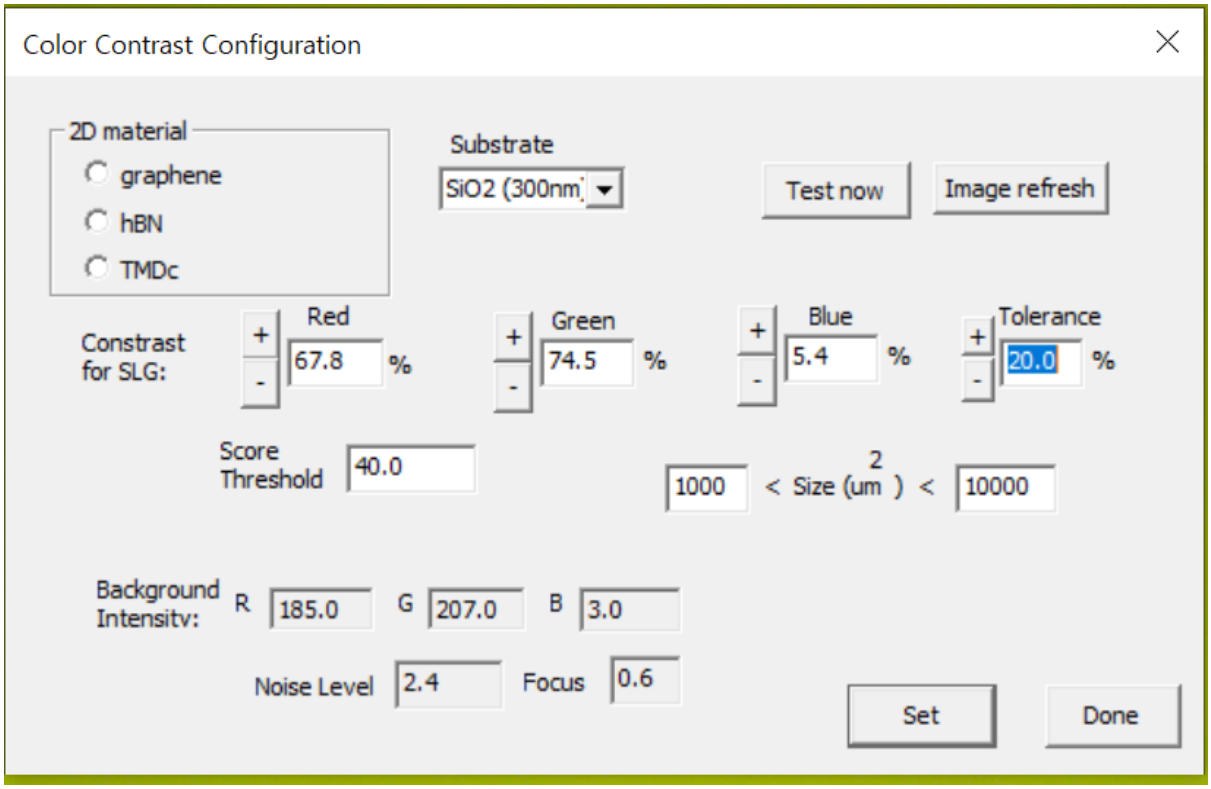

Figure 4 configuration window

(Adjusting Sample Position Using Keyboard and Mouse)
You can move the sample up, down, left, or right in 400-micron steps by pressing the arrow keys on the keyboard. If the focus becomes blurry, you can adjust the height using the PgUp and PgDn keys.

Alternatively, you can use the joystick window located at the bottom right of the screen. Clicking the buttons in this window with the mouse allows you to move the stage one step at a time. To change the step size, simply adjust the step value accordingly.

(Manually Adjusting Detection Settings for 2D Materials)

When working with a new material or a new substrate, it may be difficult to estimate the appropriate contrast ratio values. In such cases, you can manually search for 2D materials by visually inspecting the microscope image.

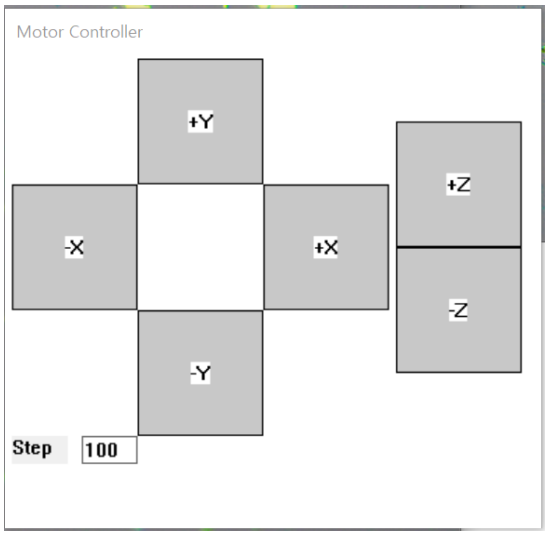

Figure 5 joystick window for stage position control

If a flake that appears to be a 2D material is found, press the Enter key to save the image. Then, left-click on the suspected 2D material area with the mouse. A message box will appear, showing the R, G, and B contrast ratios of the selected pixel.

You will be prompted to confirm whether you want to use these values as the contrast ratio settings for 2D material detection. If you click Yes, the contrast ratios of the selected pixel will be applied.

If this was done by mistake, you can return to the Configuration menu and revert to the previous settings.

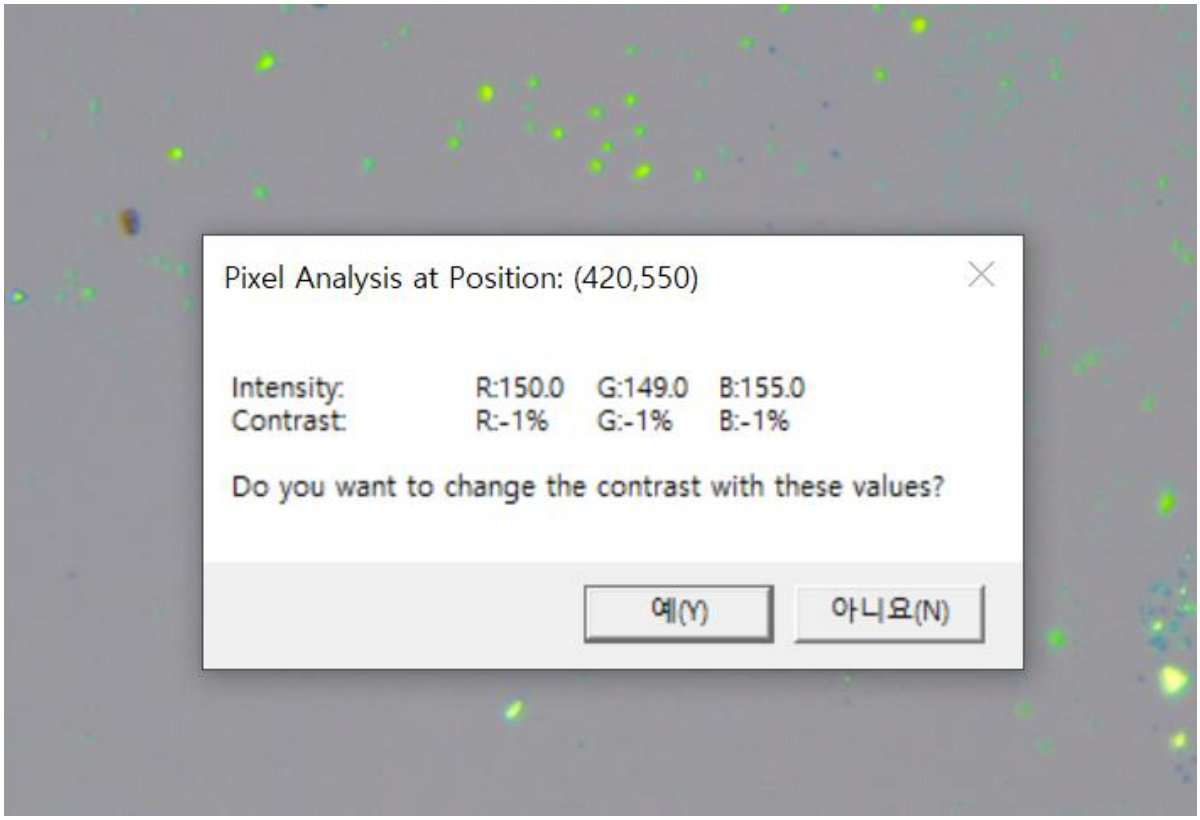

Figure 6. When the desired flake is clicked with the mouse, the RGB values at that position are displayed. By clicking the Yes **button, the corresponding contrast ratios can be set as the detection values.**

(Modifying Device Settings)

In the Device Configuration menu, if the XYZ stage (Arduino) or camera is not connecting properly, unplug and reconnect the USB cable, then click the Initialize button to restore the connection.

The serial port number for the XYZ stage can be found in the PC's Device Manager, under the Ports section next to Arduino Uno. If the wrong port number is entered, the motor will not operate. Once the correct value is entered, click the Initialize button to re-establish the connection.

The Focus Factor is a parameter used to improve autofocus performance. Since the Laplacian value varies depending on the type of sample, adjustments may be necessary. Typically, a value of 1.5 works well. For samples with few flakes or distinct features, reducing this value to around 1.0 can help. For samples with many flakes, increasing it to 2–3 often results in faster focusing.

There is no need to adjust other settings.

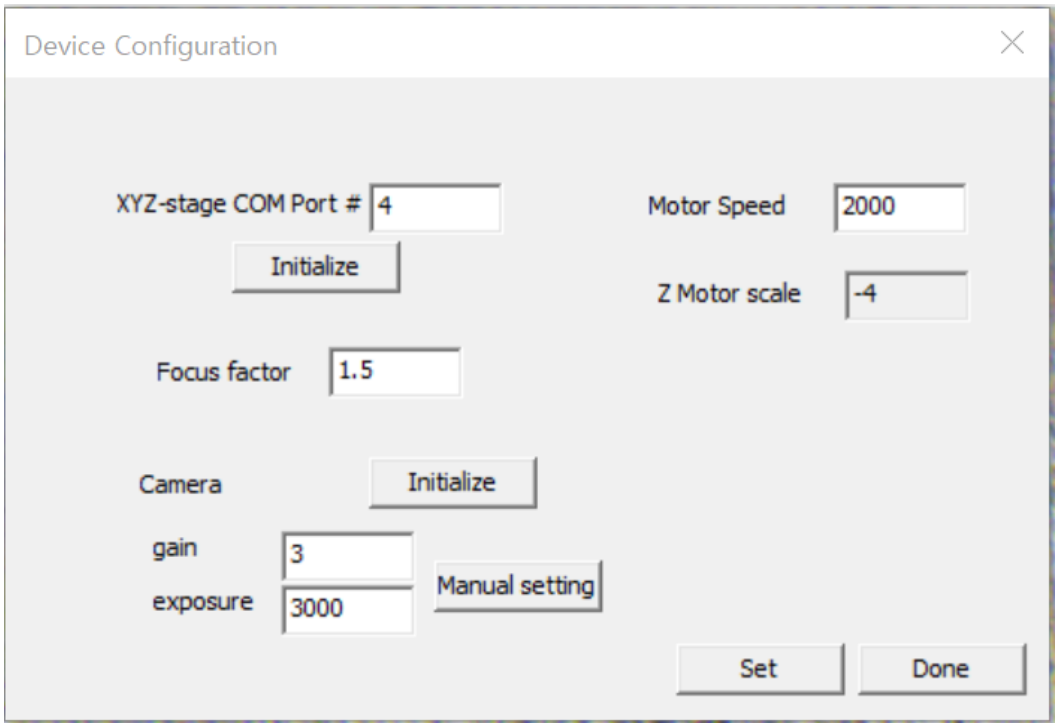

Figure 7 Device -> Configuration menu window

Chapter 3: Conclusion

This concludes the instructions for using the equipment. For further inquiries or detailed assistance regarding operation, please contact our headquarters (Sejong Scientific Instruments) for technical support.

We actively support users in modifying the system to suit their research needs, as the equipment is built with standardized components.

Additionally, a video manual is available at the following link:
https://www.youtube.com/watch?v=92kUt2Gia9c&t=112s