NANOSCOPE SYSTEMS

Confocal Microscope

NS-3500

Reference Manual

Release 1.5

Nanoscope Systems, Inc.

NS-3500

Confocal Laser Scanning Microscope

Reference Manual

Release 1.5

Knowledge of this manual is required for the operation of the software *NSWorks* and *NSViewer* to control the confocal laser scanning microscope NS-3500, and to display, measure, process, and analyze the obtained data.

Please make yourself familiar with the contents of this manual and pay special attention for safe operation of the instrument.

The specifications are subject to change anytime; the manual is not covered by an update service.

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Contents

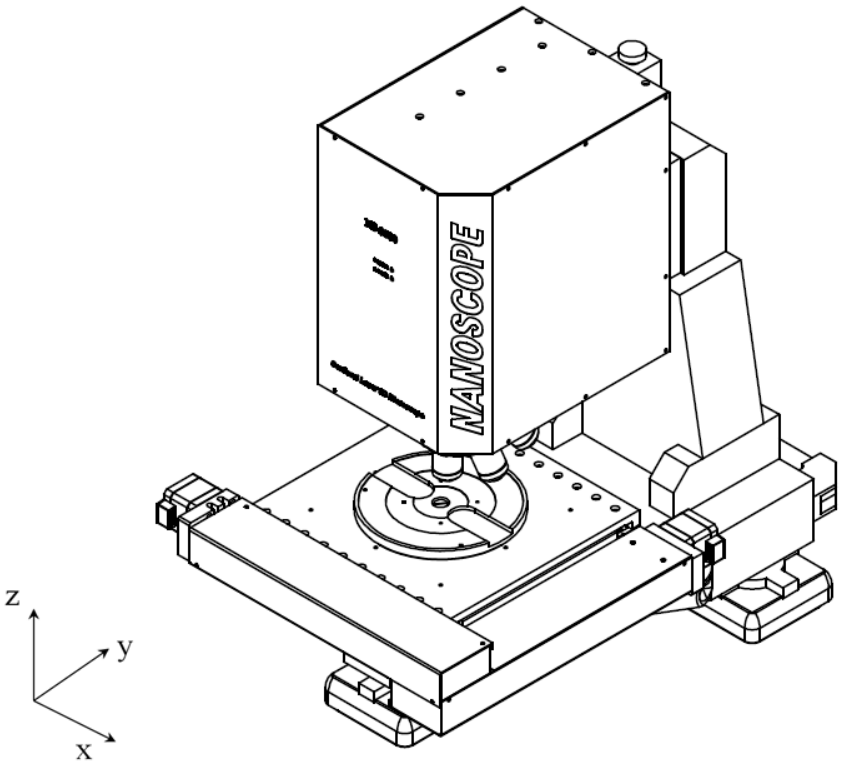
NOTICE

Before you read this manual, please make sure that all the hardware installation was successfully done.

The hardware components, such as the confocal measurement head and the controller, with the same serial numbers should be used for the installation. The tuning parameters of each confocal microscope use its own values.

> ⚠ **The hardware components with the same serial numbers should be used for the installation.**

The coordinate system used in this manual follows as shown below.



1. OVERVIEW OF *NSWORKS* AND *NSVIEWER*

NSWorks is the software for operating and controlling the confocal laser scanning microscope NS-3500 and its controller NS-3500E. By the proper operation of these, it can obtain the microscopic imaging signal from the specimen. NSViewer is the separate software, which can display the image on the other window from the obtained signal data to analyze the measurement result for the appropriate purpose with convenience.

For the first installation of NSWorks, the serial number should be checked to set up for the hardware of same serial number including NS-3500 confocal measurement head, the controller, and its dedicated control PC.

If the dedicated control PC is not purchased with NS-3500, or the user wants to set up the individual control PC by himself, the minimum performance of PC should meet the following specifications. The lower performance of the control PC cannot guarantee the normal operation.

OS	Windows7 64bit
CPU	Intel Core 2 Duo
Memory	8 GB or more
HDD	160 GB or more
Graphic board	Geforce 8600 GT
Monitor size / Pixels	24 inch / 1920×1080

Execution of the program NSWorks after the hardware installation is recommended as it checks the connection status of hardware.

All the necessary commands for the measurement including the operation of laser, the control of scanner, and the data acquisition of the imaging signal is entered from the control panel of NSWorks. The main functions provided by the NSWorks control panel are as below.

- Display of the CCD brightfield image
- Display of the live confocal image
- User interface for ROI (region of interest)
- User interface for assigning 3D measurement range
- Auto-Focus

And the many other functions for 3D measurement are available from NSWorks.

NSViewer is the analysis software dedicated for the resultant data from NS-3500. It displays the 3D imaging data acquired from NS-3500, and it provides the many convenient tools for the measurement and the data processing. The main functions provided by the NSViewer are as below.

- Display of 3D height image
- Display of 2D intensity image
- Display of sectional image
- Display of surface map and sectional profile
- Defining various ROI
- Tools for imaging process for height and intensity image
- Tools for measurement of surface analysis
- Tools for roughness measurement

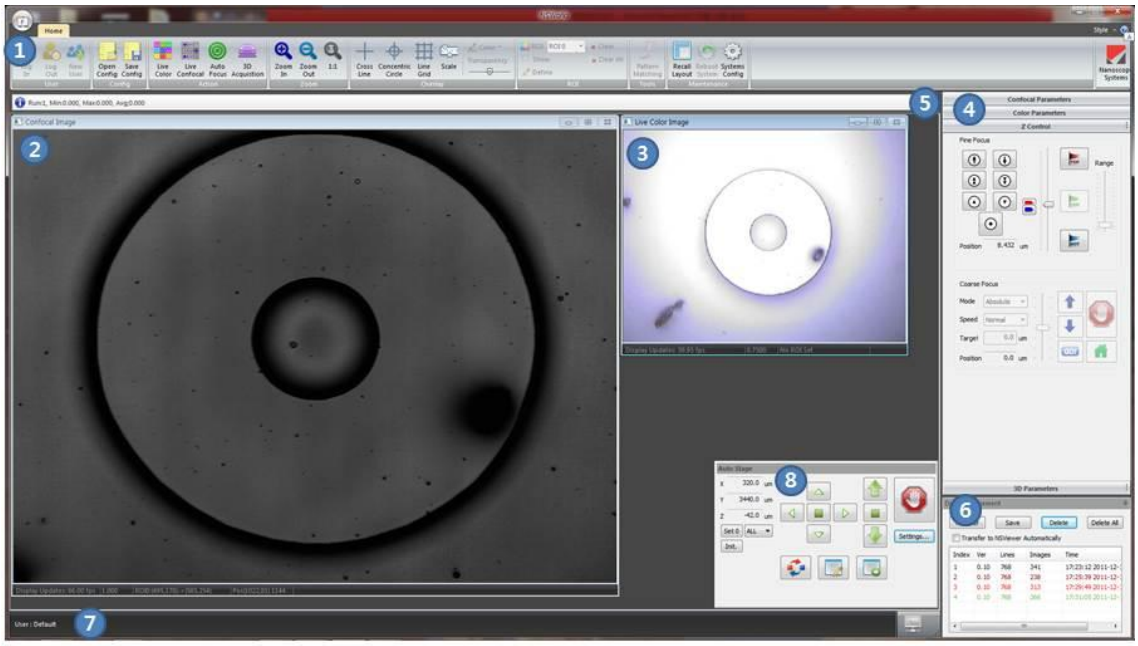
NSViewer can run independently without the connection of the confocal system NS-3500. However, the PC of the same specification as mentioned above is required for its normal performance.

2. OPERATION SOFTWARE NSWORKS

2.1. Constitution of NSWorks

When the installation of program is successfully done, the icon of NSWorks is created at the desktop of the control PC. By double clicking the NSWorks icon, or by executing NSWorks from Start menu of Windows, the main frame of NSWorks and its control panel will come out.

The hardware components of NS-3500 will be initialized with the execution of NSWorks.



<NSWorks main window display>

The main window of NSWorks displayed on the monitor is as shown above figure. NSWorks is developed with the .NET framework. It is constituted with the 8 sub-windows. (However, the constitution of sub-windows can be changed depending on the options)

Tools for user management, setting management, and the measurement execution are in the Main menu (①) on the top. Refer the section 2.2 of this manual for details of menu. Caption bar (⑤) is located at the below of the main menu, and Status bar (⑦) is located at the bottom side of the window. These are for the display of the quick report of the current measurement status. If it judges that the current condition is not good enough for the normal

measurement, the error message is reported on this window to help the user find the proper condition of the measurement. One example of the bad measurement condition is when the measurement range is far from the actual position of the specimen. Reading the resultant value displayed on these status bar may be the fast and convenient way, if the user wants to know the height measurement value, which is the most important data from 3D measurement device, as quickly as possible.

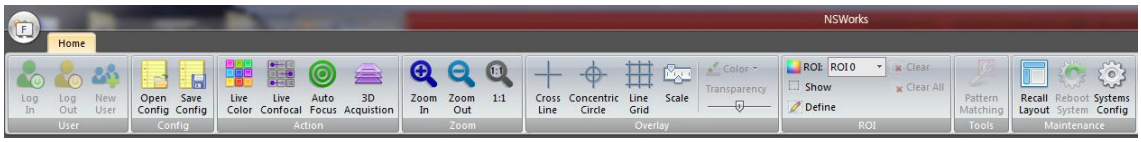
Live confocal microscope image (②) is displayed on the central part of the window, and the brightfield CCD image (③) is displayed on the right side of it. These displays can be shown individually or simultaneously for the case.

Buttons to control the parameters for the confocal microscope image and the brightfield CCD image are in windows (④) at the right side. The user can set the system to acquire 2D or 3D image optimally for his specimen, by controlling the axial scanner and the lateral scanner, and by adjusting the laser output power and the PMT (photo-multiplier tube) gain from these buttons. The user can re-arrange the placement by floating /docking the window for the axial scanner and the window for the confocal parameters.

Data management window (⑥) on the right lower corner is for saving, deleting, and transferring the measured data to the analysis software, NSViewer.

NSWorks contains various necessary tools for controlling NS-3500. More details of NSWorks and the operation of NS-3500 will be described from next section.

2.2. Main Menu



<Main Menu>

Main menu is positioned at the top of the screen. It is categorized as User, Config, Action, Zoom, Overlay, ROI, Tools, and Maintenance.

User can recall the control parameters used for the past works by Open Config, or save the current control parameters by Save Config. When the program starts, the default control parameters are called from the file **C:\ProgramFiles\Nanoscope Systems\NSWorks\config\DefaultParam.ini.**

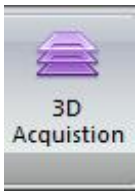
It is the button for turning on and off the live CCD image. By using the White Power LED as its light source, user can see the conventional wide field color optical microscope image. From CCD image, user can find the specific position in the specimen more conveniently, which is to be measured by confocal image with higher accuracy.

It starts the optical lateral scanning. By clicking this button, the live 2D confocal image is acquired and displayed in the monitor. Clicking this button again will stop the optical lateral scanner, and the live 2D confocal image will be paused.

It is the button for auto-focusing, which finds the best-focused position, and moves the objective lens to that position. Auto focus function is performed by analyzing the extracted data from confocal signal obtained from the specimen.

Executing auto focus, it scans the full range of axial scanner (normally the scanning range of PZT, or the effective scanning range of the objective lens), and move the objective lens to the best-focused position within the scanning range. The acquisition of 2D or 3D image can be performed more easily with the help of auto focusing function. After completion of auto focusing, the objective lens is moved to the best-focused position found, and Top and Bottom position is automatically set to be +/-10μm (the range can be set differently depending on the specimen) from this focused position. So it is ready to start the 3D scanning.

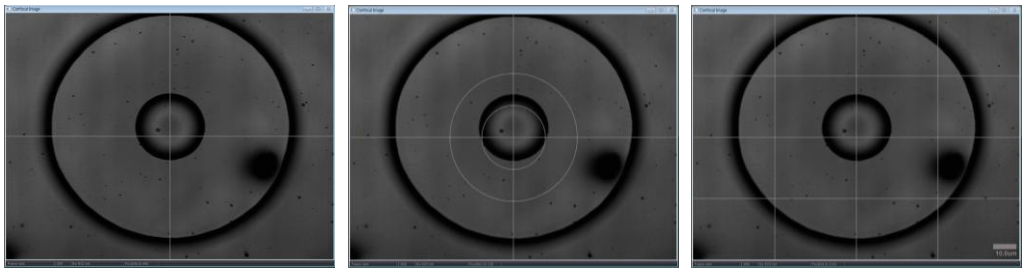
For the proper functioning of Auto Focus, the focus plane of the specimen should be within the axial scanning range. Thus, user should be roughly set the focal plane to be close enough within the scanning range by adjusting the coarse Z stage for head movement or by manual positioning of the specimen. Then by clicking Auto Focus, it will find the accurate focus plane. If auto focus function is not working well, check first whether the surface of the specimen is within the axial scanning range.



It is for executing the confocal 3D data acquisition by 3D scanning of the defined measurement volume. User can stop the 3D scanning by clicking again during the 3D measurement.

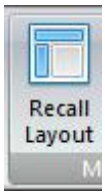
User can zoom-in or zoom-out the confocal image or color CCD image by this button. Note that it is a digital zoom, which changes the monitor display only and there is no change in FOV (field of view).

Some useful overlay can be showed on the live confocal image or color CCD image. It can be displayed on either display windows independently. The color and the transparency of the line can be adjusted for the current activated display window (confocal or CCD display window).



<Overlays>

User can define the region of interest by ROI button. Rectangular indicator is shown on the CSM image display window when clicking Define button, and user can set the ROI with this indicator. Up to 10 ROI can be defined at one time.

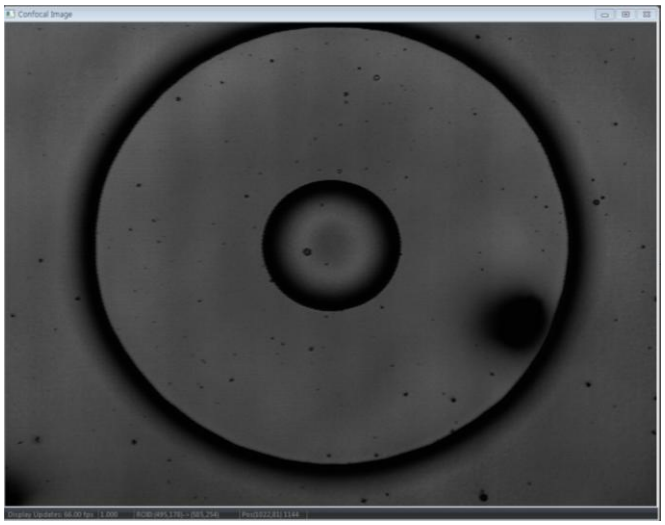


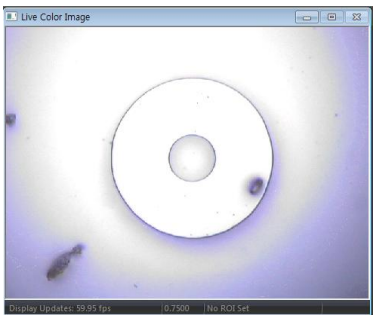
It initializes the window layout.

This button is activated when the program judges the status of system is not normal. User can reboot the system by this button.

It calls the dialog window for system configuration.

2.3. Display Panel



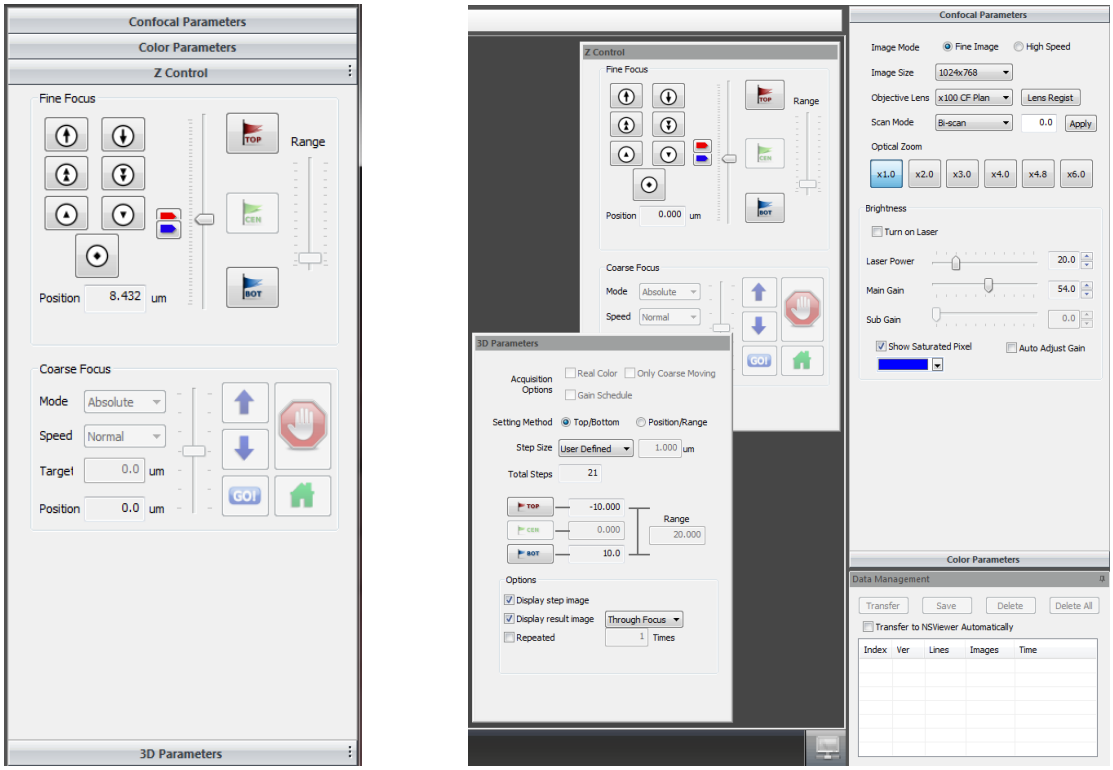


< Display panels>

NSWorks provides two display panels: CCD view at the right side, and the CSM (confocal scanning microscope) view at the left side. CCD view and CSM view can be obtained respectively or simultaneously upon user's needs.

CCD view displays the color image updated in real time at 60 frame/sec. CSM view displays the black and white image with 1024×768 pixel resolution, and it is updated in real time at 20 frames/sec for bi-directional scanning mode.

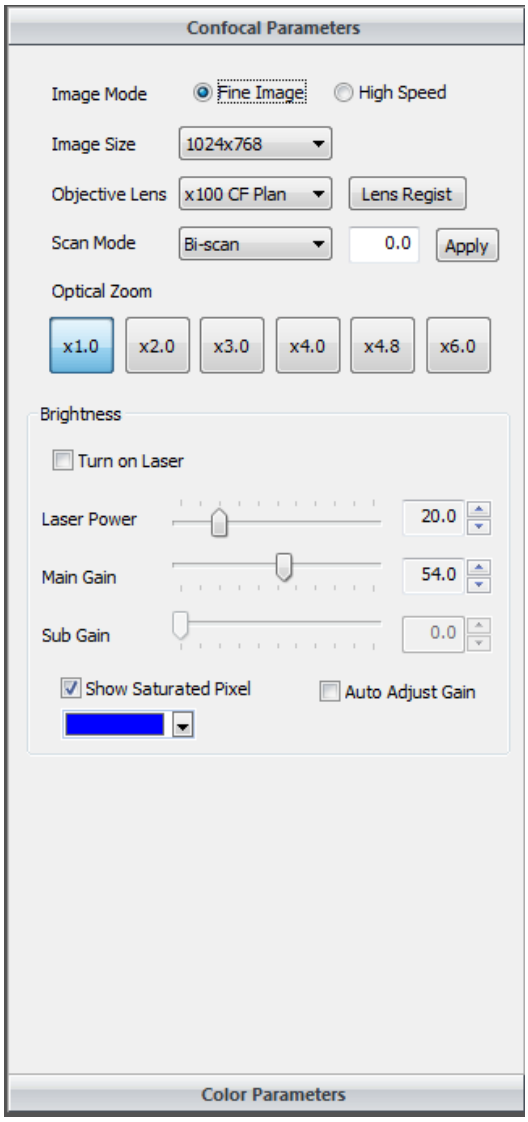
2.4. Control Panel



<Control panels>

The parameter windows are of outlook style. It consists of 4 parts: Confocal Parameters, Color Parameters, Z Control, and 3D Parameters. Z Control and 3D Parameters windows can be floated or docked to the arbitrary position.

2.4.1. Confocal Parameters

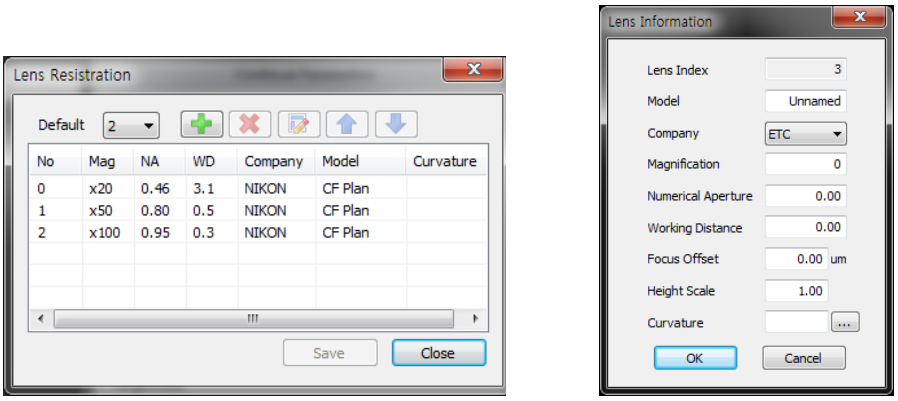


The parameters for confocal 2D imaging such as image mode, image size (or pixel size), objective lens magnification, scan mode, and etc., are set in this window.

The acquisition of CSM image can be performed in two different modes: Fine image and High speed image. The high speed image acquisition is two times faster than fine image mode.

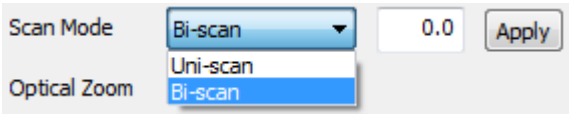
The pixel size of CSM image is provided as 1024×768, 1024×384, 1024×192, 1024×96, and 1024×48 (horizontal×vertical pixels). With the decrease of vertical pixel size (Y-direction), the field of CSM image in vertical direction also decreases, and it will increase the frame rate of CSM image. Considering the image size and measurement speed of CSM, user can set the measurement parameters suitable for the target specimen.

Objective Lens parameter should be set to be same as the currently imaging objective lens. The scale information of 2D or 3D image will be used as set in this parameter selection. *NSWorks* provides the objective lens information of ×10, ×20, ×50, ×100, and ×150 as a default option. If the user wants to use the objective lenses other than these, the additional registration in the data base of objective lenses should be made.



<Lens registration window>

⚠ **If the user wants to replace or add the objective lens which is not included with NS-3500 package, new calibration for this new objective lens is necessary. Please contact to the technical support person.**



Uni-scan(uni-directional scanning) or Bi-scan(bi-directional scanning) mode can be used.

Uni : Uni-directional scanning mode

If Uni-scan mode is selected, the CSM image is made in raster scanning manner, in which the acquisition of point imaging data is made only when the scanning mirror scans in the clockwise (CW) direction.

Bi : Bi-directional scanning mode

If Bi-scan mode is selected, the acquisition of point imaging data is made when the scanning mirror scans in both clockwise (CW) and counterclockwise (CCW) direction. The image acquisition speed of Bi-scan mode is about twice faster than Uni-scan mode. However, the compensation of misalignment between CW and CCW scanning should be preceded to get the correct confocal image. This

misalignment is due to the phase difference of scanning direction, and it can be compensated, but if the accuracy matters more than the measurement time, Uni-scan mode is recommended.

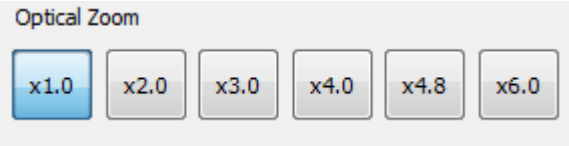
The live CSM imaging display should be paused before changing the scan mode.

⚠ **The change of Scan Mode should be performed after stopping the live CSM 2D imaging.**

⚠ **Pixel misalignment may happen in Bi-scan mode. In this case, user can adjust the calibration value in Main Menu to correct it.**

2.4.2. Zoom

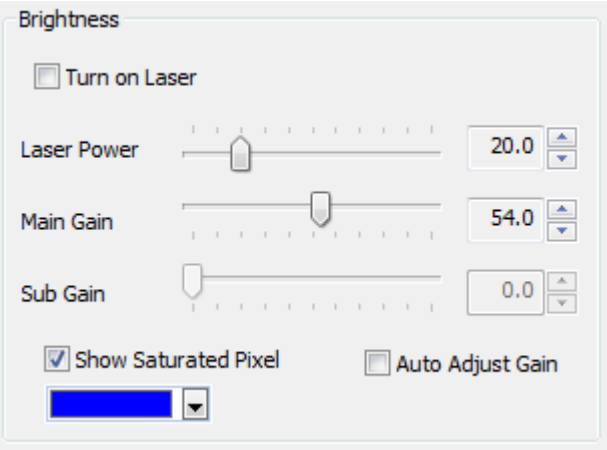
NSWorks provides the optical zoom function. Optical zoom is realized by precise control of the scanning angle of the optical scanner. By the optical zoom function, the magnified or demagnified CSM image can be obtained without the switching of the objective lens.



Optical Zoom

Default setting of the optical zoom is ×1 optical zoom at which the optical zoom is not actually working. More detailed image with higher resolution can be obtained by optical zoom function with the pre-defined optical zoom magnification of ×2, ×3, ×4, ×4.8, and ×6. It is done only by simply clicking the button. The change of optical zoom is possible during the live CSM imaging

2.4.3. CSM Brightness



Laser Power

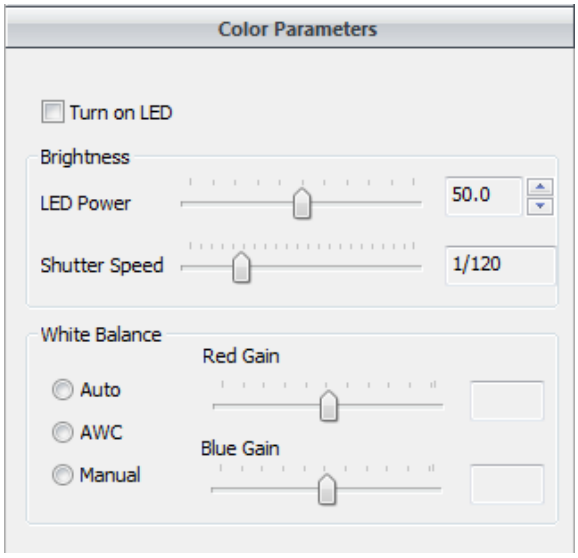
It is for setting the appropriate laser power for CSM image acquisition. The user can control the laser power suitable for the various samples. The laser power can be set from 0 to 100%. If the user unchecks the check-box, the laser does not lase. Unchecking is convenient when the exposure of laser beam to the sample is to be avoided.

PMT Gain

It is for setting the gain value of detector. The confocal imaging signal of NS-3500 is obtained by PMT (photo-multiplier tube), which is of low-noise, of high-sensitivity, and of high-dynamic range. By adjusting PMT gain value, 2D image in higher contrast and 3D profiling data in higher accuracy, can be obtained even for the specimen with low reflectivity. User can change the PMT gain from 0 to 100%.

Acquisition of the image as brightly as possible will be a help to get the measurement result with higher accuracy if the image is not in the saturation region. Checking Auto Adjust Gain, PMT gain automatically decreases if the saturated pixel is contained in the current 2D CSM image. (Note : PMT gain is not automatically increased although the CSM image is dark.)

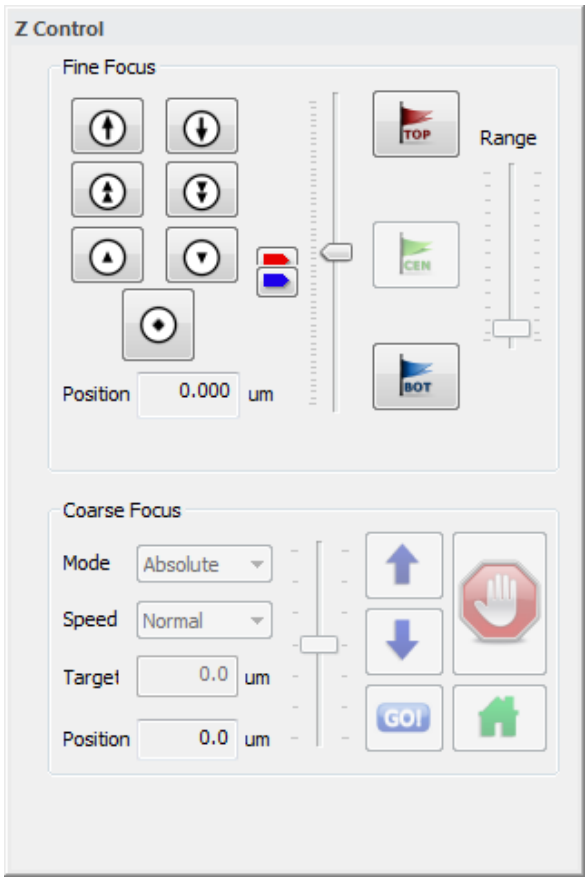
2.4.4. Color Parameters



The power of LED light, CCD shutter speed, and white balance for color imaging can be set. Unchecking the Turn on LED check-box, LED light does not emanate. The LED power can be set from 0 to 100%.

By changing the shutter speed, the brightness of color CCD image can be adjusted.

2.4.5. Z Position



The axial scanning is performed by moving the objective lens up and down in vertical Z direction. PZT scanner is used as a fine actuator, and stepping motor is used as a coarse actuator. The composition of the axial actuator differs by the model and the option. Movement of Z position can be done either by clicking the buttons or by wheeling the slide-bar.

Normally, the moving range of PZT scanner is from -100 μm to +100 μm. (Total stroke is 200 μm). To measure the height more than the stroke with the fine scanning mode, the PZT scanner with the longer stroke should be used. (PZT scanner of more than 200 μm stroke is optional)

The position of slide-indicator is

corresponding to the current position of PZT or objective lens from the reference position.

Fine Focus

PZT movement is performed by these buttons. 3 sets of up-down buttons with arrow shape are set for the different moving speed of PZT. The button with diamond shape moves the PZT at the zero position. Once the target surface is within the scanning range of PZT, focusing by PZT is fast and convenient. PZT position is also controlled by slide-bar.

Position

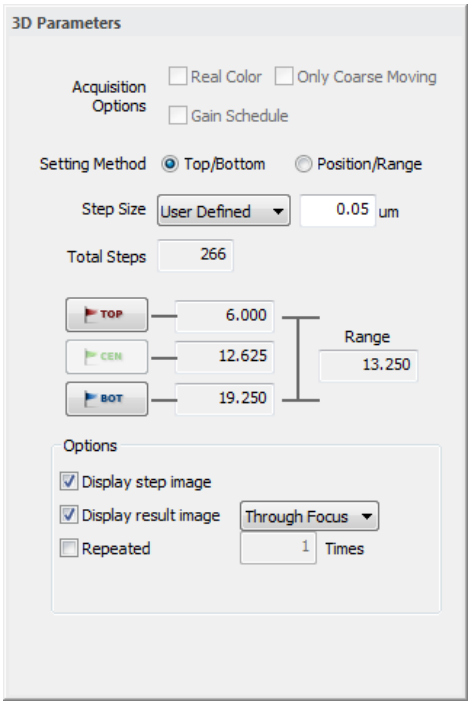
Position indicator shows the current position of PZT in *μm* scale.

Coarse Focus

It is optional function.

2.4.6. 3D Parameters

Once the Z scanning range is defined by Top and Bottom, the number of sections for 3D measurement should be set. It is for setting the number of optical sectioning planes.



Acquisition Options

It is not serviced yet.

Total Steps

The number of plane 2D images is shown. From these sliced 2D images, the 3D image is constructed. This number is automatically calculated and shown after the Top and Bottom of the measurement scanning range and the Step size is defined.

Step size

Step size means the vertical distance between the adjacent 2D sliced plane images. The smaller step size results in the more sliced optical sectioning 2D images, which enables more accurate measurement. However, the smaller step size results in the longer 3D measurement time as it has to obtain more 2D images in the same scanning range.

Range

Range displays the total scanning range in vertical direction. The total scanning range differs by the composition of actuator (scanner). When the user defines the Top and Bottom by moving the PZT at the Z Position panel, the range is automatically displayed.

Top

By clicking Top button, the current position of axial scanner is set as the upper limit of 3D scanning.

Bottom

By clicking Bottom button, the current position of axial scanner is set as the lower limit of 3D scanning.

Options

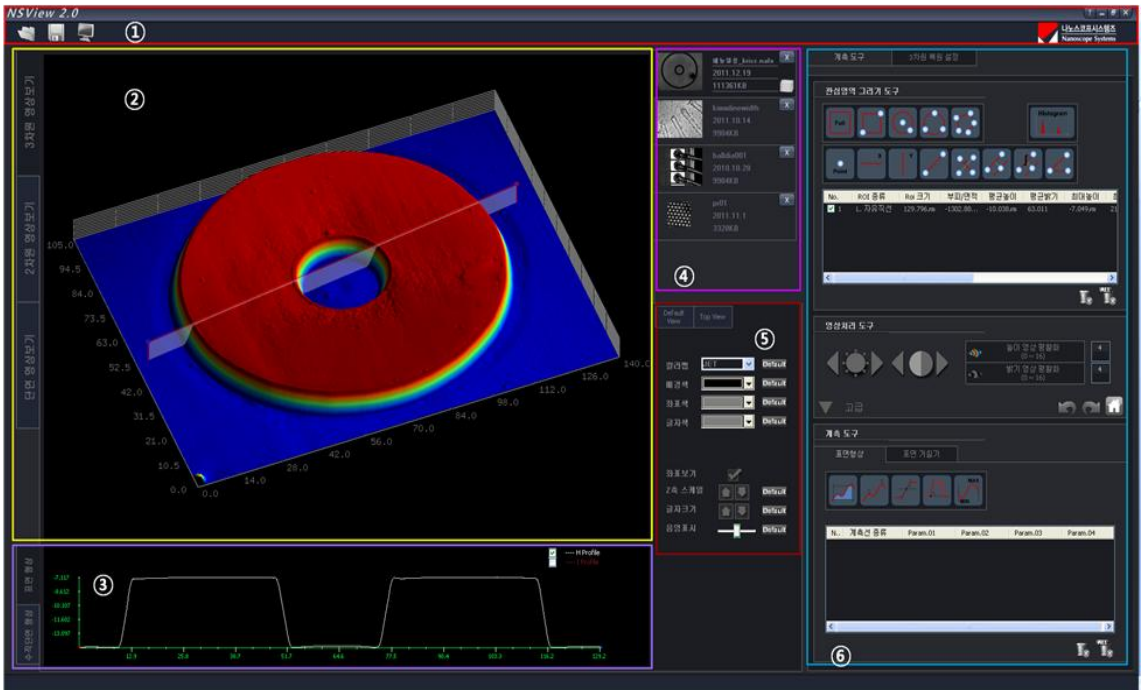
Display step image : It displays the live confocal image during the 3D scanning measurement.

Display result image : It displays the resultant confocal image after 3D scanning measurement.

Repeated : The 3D measurement is repeated with the same parameter setting as much as set value.

3. ANALYSIS SOFTWARE NSVIEWER

3.1. Constitution of NSViewer



<NSViewer main window display>

When the installation of program is successfully done, the icon of NSViewer is created at the desktop of the control PC. By double clicking the NSViewer icon, or by executing NSViewer from Start menu of Windows, the main frame of NSViewer will come out. It is constituted with the 6 sub-windows as shown in the above figure. The name and the function of these sub-windows are as below.

① Main menu bar
It contains; open and/or save the image file, screen capture, maximize or minimize the windows, quit the program, and call the manual file.

② Image display window
It displays 3D height image, 2D intensity image, and cross sectional image according to the user's selection.

③ Profile / Cross section image display window
Surface profile or cross sectional image of selected ROI (region of interest) is displayed.

④ Opened file information tab
The brief description of currently opened image file is displayed. Maximum 5 image file can be displayed. User can switch the image file to analysis by clicking this tap.

⑤ Image display setting window
The user can set the color of image display, the font size, and the scale at this window.

⑥ Analysis tool and 3D parameter setting window
It is divided into the image analysis tool window and the 3D reconstruction parameter window. Tools for ROI setting, image process, and measurement are in the Analysis tool window. The parameters for 3D reconstruction can be set in the 3D parameter setting window.

3.2. Main Menu Bar

Main menu bar is positioned at the top of the NSViewer. The buttons of Open, Save, and Screen Capture are in the left side, and the buttons for calling the manual, maximizing/ minimizing the window, and closing the program are in the right side. There is Nanoscope Systems' logo button as well.

It is for opening the image file. NSViewer opens the image file with the extension of *.naf and *.nafx. In *.nafx file, all sliced sectioning images are saved. 3-dimensional height image and 2-dimensional intensity image is reconstructed from the sectioning images in *.nafx file and displayed. In *.naf file, 3D height image and 2D intensity image are saved. There's no sectioning image in *.naf file.

It is a button for saving the reconstructed 3D height image and 2D intensity image as *.naf file format.

> ⚠ ***NSViewer* can generate only *.naf file**
> ***.nafx is made from NSWorks.**

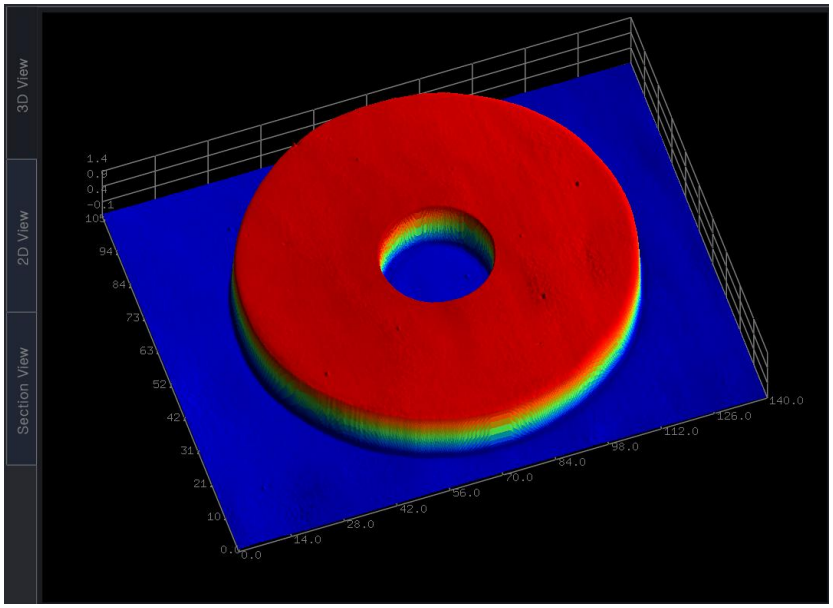
It is button to capture the current screen. The captured image is saved in the designated folder as a bitmap image file

Question mark calls the program manual. Buttons for minimizing the window, maximizing the window, and closing the window follow.

It is the logo of maker, Nanoscope Systems. Clicking it, it shows the window asking the password to convert NSViewer to manager mode.

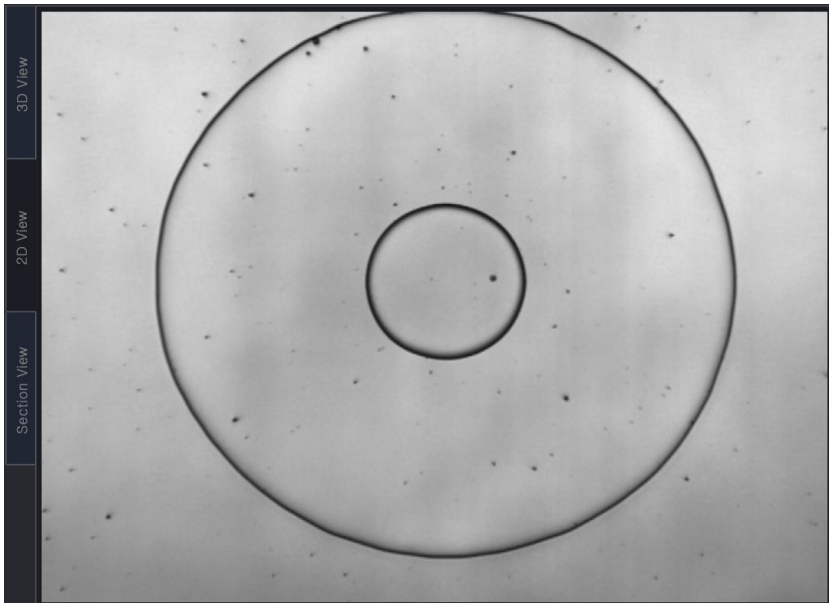
3.3. Image Display Window

The largest area of NSViewer is allocated to the image display window. Image display window can show the maximum 1024×768 pixel size image. The tabs for selecting the image display mode are at the left side of the image display window. The image display mode can be chosen among 3D View, 2D View, and Section View image.



It is the image displayed when 3D View mode is clicked. The height information of the measured specimen is displayed in the 3D graph.

The image is zoomed in and out by rolling the mouse wheel. The 3D image is rotated by clicking the mouse wheel button and dragging. The image is shifted by clicking the right button of the mouse and dragging.



It is the image displayed when 2D View mode is clicked. Zoom in, zoom out, and shifting

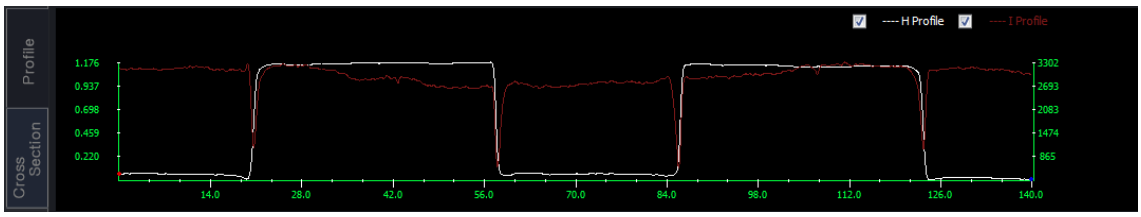
the image can be done by the mouse operation as in the 3D height image mode,

When the Section View mode is clicked, the sliced images at each axial scanning position can be display by using the control bar at the lower position of window.

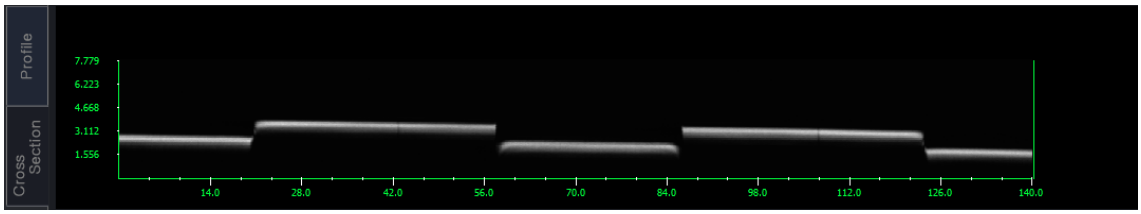
3.4. Profile / Cross Section Image Display Window

Profile / Cross section image display window is at the lower side of NSViewer. Tabs for switching the display mode are at the left side of the window. The display mode is switched between Profile mode and Cross Section image mode

> ⚠ **The measurement result in Profile / Cross Section display window is displayed only when ROI (region of interest) is defined. It displays the profile or cross section image along the line which is defined by ROI.**



It is the image displayed when Profile mode is clicked. The white line shows the height profile and the red line shows the intensity profile. By clicking the check-box at right-up position, each line can be shown or disappeared. By clicking right mouse button on the graph, user can capture the graph image or export the data to excel format.

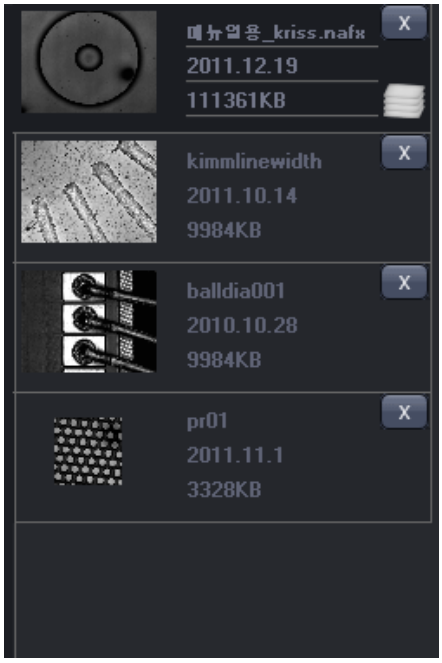


It is the image displayed when Cross Section mode is clicked. It shows the XZ plane image, or the vertically sliced image of the 3D reconstruction image. By clicking right mouse button on the image, user can capture the cross section image or export the image data to excel format.

3.5. File Information Tab

File information tab is positioned at the right-top of image display window. Displayed tab increases one by one when an image file is opened. Up to 5 tabs can be displayed.

When 6th image file is opened, the first tab is closed, and replaced with new one. The file name, the date file made, and the file size are shown. By clicking tab, the displayed image currently under analysis is changed. It is a convenient tool for comparing the measurement results.



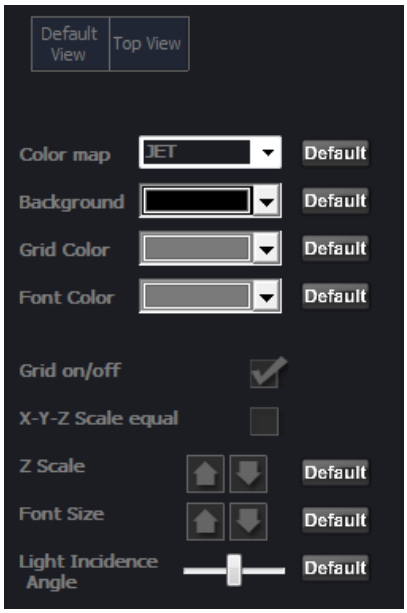
It is the buttons for closing each tab. The closed tab is disappeared and the remained tabs are re-arranged.

It is the icon to distinguish whether the opened file is *.naf file or *.nafx file. In case of *.nafx file, this icon is displayed at the right-bottom position of each

tab.

3.6. Image Display Setting Window

Image display setting window is positioned at the right-bottom of the image display window. The background color, the font size, and the other settings of image display window can be set or changed.



Default View button initialize the viewing angle, position, and scale of the image. When the user rotates or shifts the 3D display with the mouse, clicking Default View button will restore it to the originally displayed status.

Top View button displays the 3D image of viewing looking down.

Puseudo-Color Map of 3D image can be changed by clicking the arrow button. Four types of color map can be chosen among Intensity, Jet, Hot, and Cool. By clicking the

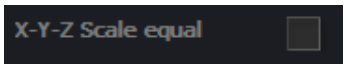
Default button, the color map of 3D image is initialized to Intensity color map.

Background color of image display window can be changed by clicking the arrow button. By clicking the Default button, the background color is initialized to black.

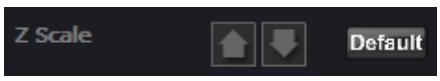
Grid color can be changed by clicking the arrow button. By clicking the Default button, the background color is initialized to gray.

Font color can be changed by clicking the arrow button. By clicking the Default button, the background color is initialized to gray.

By checking the check box or not, the grid of 3D image is showed or not.



If it is checked, the scales of X-Y-Z coordinates become same with each other. Real aspect ratio of the feature can be visualized.

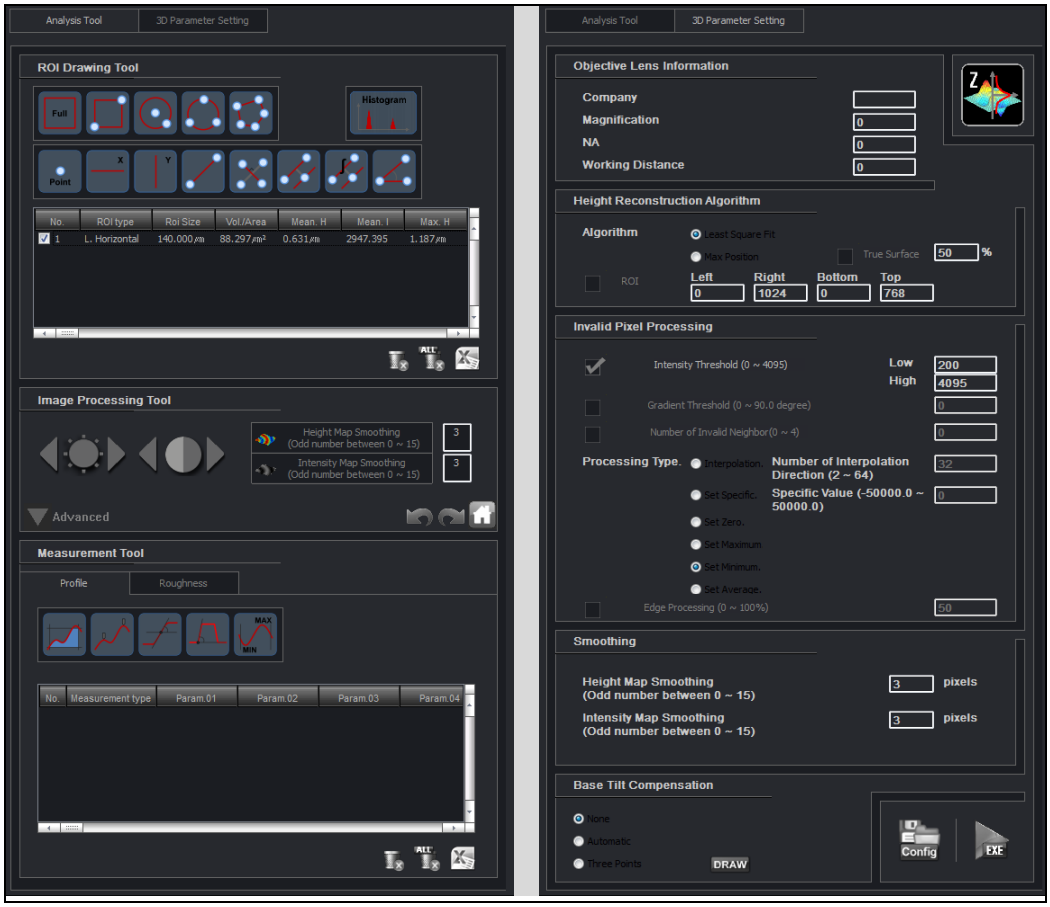


The grid scale of Z-axis is increased or decreased by clicking the arrow buttons. The Default button initializes the scale size.

The font size is increased or decreased by clicking the arrow buttons. The Default button initializes the font size.

By dragging the slide bar, the incidence angle of light illuminating the 3D image can be controlled. The Default button initializes the angle to the iso-view angle.

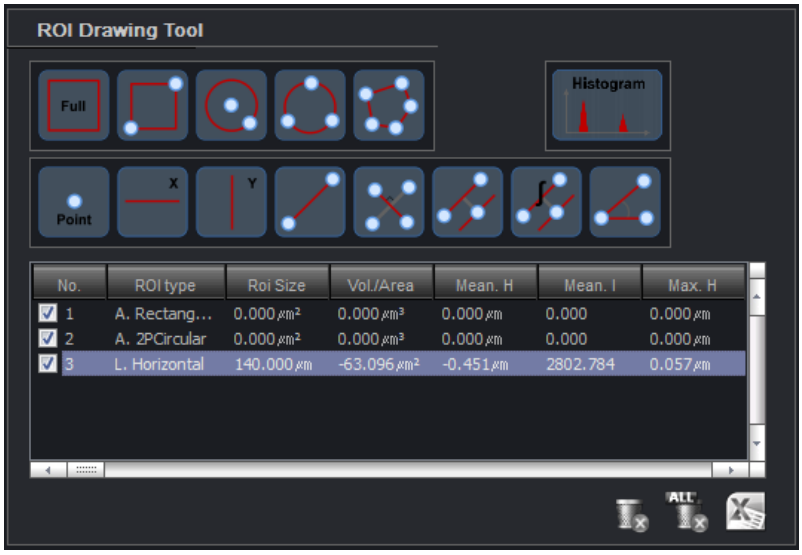
3.7. Analysis Tool and 3D Parameter Setting Window



Analysis Tool and 3D Parameter Setting Window is positioned at the right-end. User can switch to the each mode by clicking Analysis Tool / 3D Parameter Setting buttons located at the top of this window.

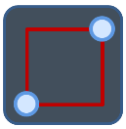
3.7.1. Analysis Tool Window

The Analysis Tool Window contains ROI Drawing Tool, Image Processing Tool, and Measurement Tool.



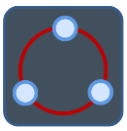
The user can draw the ROI (region of interest) on 2D or 3D image on Image display window by using the ROI Drawing Tool. If the user draws a ROI on an image, the information such as the averaged height, the maximum height, and etc. within the ROI are reported in the table below the ROI Drawing Tool icons. The line profile and the cross section image along the segment of the ROI are displayed on the Profile/Cross Section image display window.

The whole area of an image becomes a ROI.



The user can create a rectangular ROI by clicking two diagonal vertexes. The height/intensity profiles and the cross section image along the four segments of the drawn rectangular ROI are displayed on the Profile/Cross Section window.

The user can create a circular ROI by clicking a center point and a point on the circumference. The height/intensity profiles and the cross section image along the circumference of the drawn circular ROI are displayed on the Profile/Cross Section window.



The user can create a circular ROI by clicking three points on the circumference. The height/intensity profiles and the cross section image along the circumference of the drawn circular ROI are displayed on the Profile/Cross Section window.

The user can create a polygonal ROI by clicking several vertexes (less than 50 points). The height/intensity profiles and the cross section image along the segments of the drawn polygonal ROI are displayed on the Profile/Cross Section window.

The user can create a point ROI by clicking a point. The height and the intensity value of the drawn point are displayed on the image display window. Nothing is displayed on the Profile/Cross Section window.

The user can create a horizontal linear ROI by clicking a point on the image. The resulting line covers full horizontal length of the image and crosses the clicked point. The height/intensity profiles and the cross section image along the segment of the drawn horizontal line are displayed on the Profile/Cross Section window.

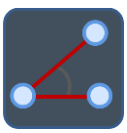
The user can create a vertical linear ROI by clicking a point on the image. The resulting line covers full vertical length of the image and crosses the clicked point. The height/intensity profiles and the cross section image along the segment of the drawn vertical line are displayed on the Profile/Cross Section window.

The user can create a linear ROI by clicking two points on the image. The drawn two points becomes vertexes of the created line. The height/intensity profiles and the cross section image along the drawn line are displayed on the Profile/Cross Section window.

The user can create a linear ROI crossing at right angles. Clicking two points on the image creates the reference line, and clicking another two points creates the line which crosses at right angles with the reference line. This line is defined as a ROI. The height/intensity profiles and the cross section image along this right-angle line are displayed on the Profile/Cross Section window

The user can create a parallel ROI. Clicking two points on the image creates the reference line. Clicking another point will create the line which is crossing the point, and parallel to the reference line. The length of line is same to the reference line length as well. The drawn two lines are defined as a ROI. The height/intensity profiles and the cross section image along the drawn two lines are displayed as overlapped on the Profile/Cross Section window.

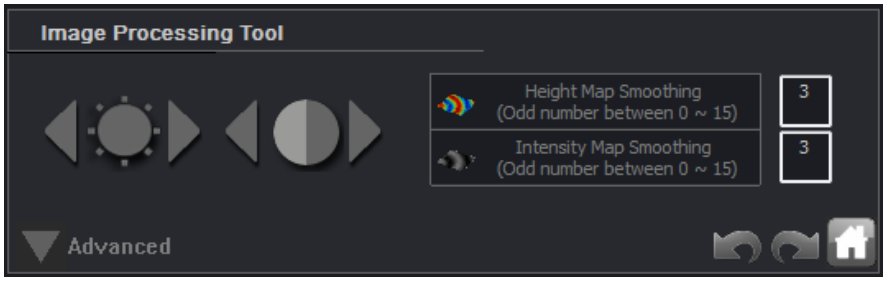
The user can create an integrated ROI. Clicking two points on the image creates the reference line. Clicking another point will create the line which is crossing the point, and parallel to the reference line. The length of line is same to the reference line length as well. The ROI is defined as the integration between two lines. The height/intensity profiles and the cross section image integrated between the drawn two lines are displayed on the Profile/Cross Section window.



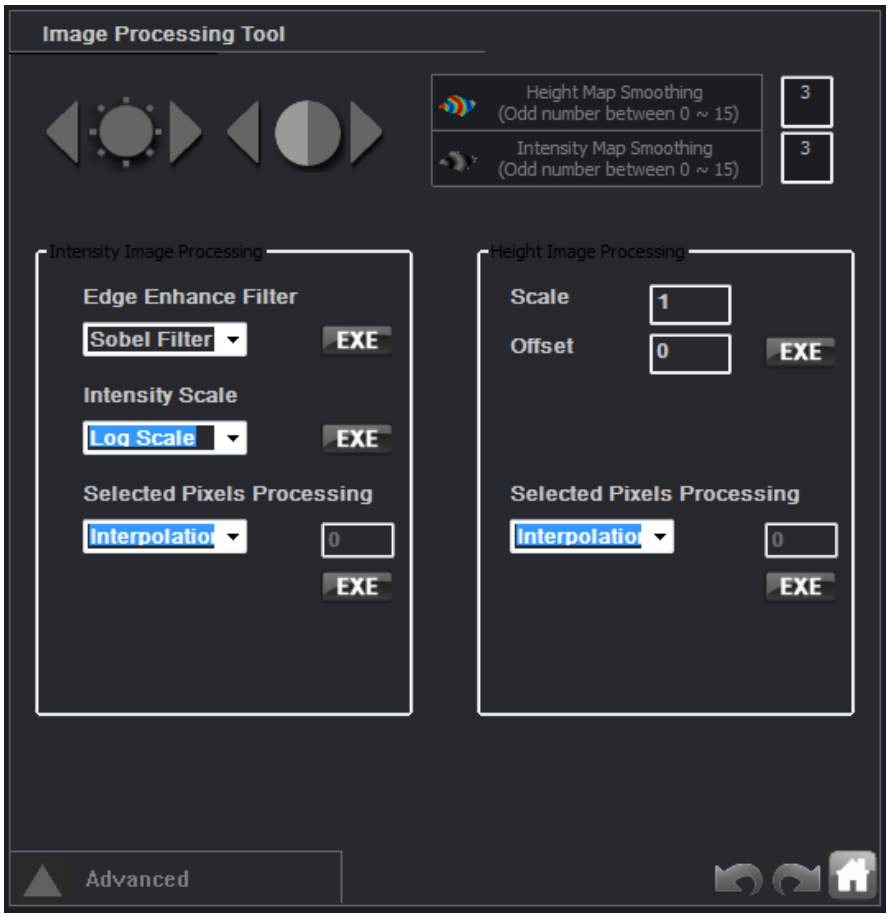
Clicking three points on the image creates a ROI define by the lines passing these points.

The angle between these two lines is displayed on the Image display window. The height/intensity profiles or the cross section image along the draw lines are displayed on the Profile/Cross Section window.

Histogram button is activated only when the ROI of area type is defined. The histogram of height and the intensity in ROI is displayed. The specific region in the histogram graph can be selected, and the pixels in this specific region can be defined as a ROI.

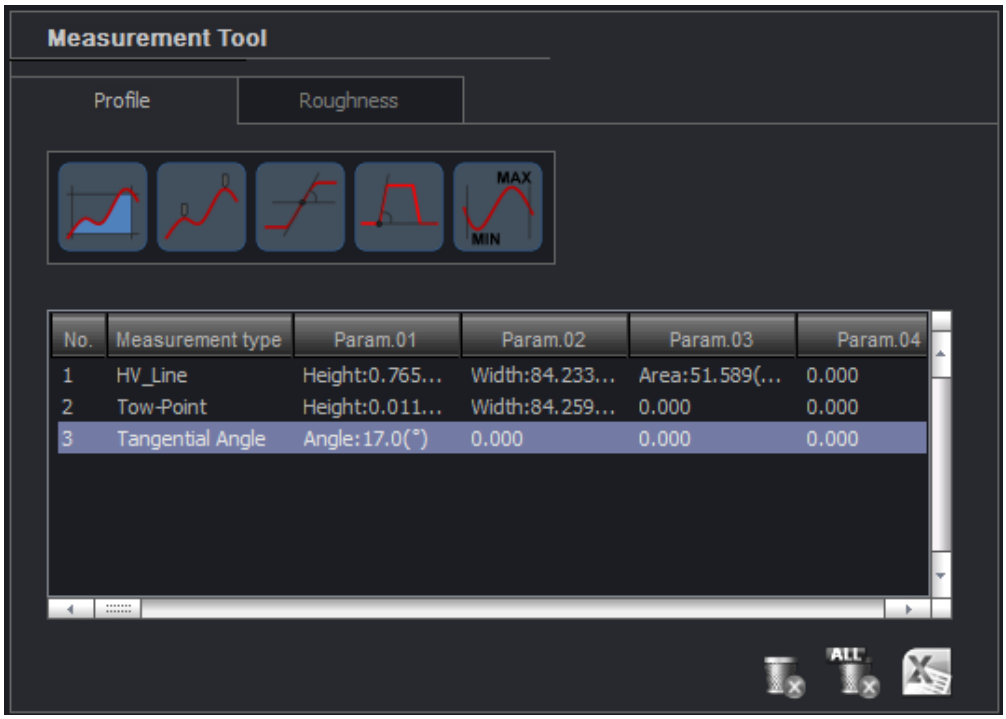


Imaging Processing Tool provides some useful tools for processing 3D height image and 2D intensity image within the defined ROI. With imaging processing tool, brightness and contrast of 2D intensity image can be adjusted, and the smoothing of height image and intensity image can be performed. Imaging Processing Tool is activated only when the ROI of area type is defined. By Undo, Redo, and Home buttons at the right-bottom side of this window, the user can cancel, repeat, or initialize the imaging process.



Clicking the Advanced button positioned at left-bottom side, the extended image processing tools are shown up.

Edge enhance filtering, intensity scale adjustment, scale and offset adjustment of height data, and some image processing tools for height data are provided in the advanced tools.



Measurement tool can be divided into the surface profile tools and the roughness measurement tools. With Profile measurement tools, the user can measure the height, the width, and the angle from Profile/Cross Section window

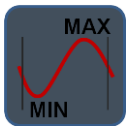
The measurement results are displayed in the table as shown above. These can be deleted by Delete or Delete All buttons.

Two horizontal lines and two vertical lines are created on Profile/Cross Section window. The height and the width can be measured by dragging these lines.

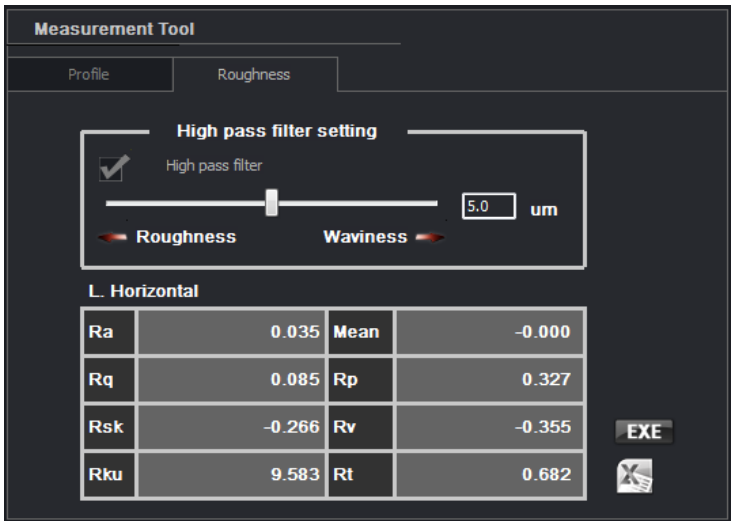
The user can measure the height and the width by clicking two points along the profile curve in Profile/Cross Section window.

By clicking one point along the profile curve in Profile/Cross Section window, the line passing through the point and tangent to the profile curve is drawn and the slope angle is measured.

The user can measure the angle of profile curve by clicking three points along the profile curve in Profile/Cross Section window.



Defining the range in Profile/Cross Section window, the user can measure the maximum and minimum value in the range.



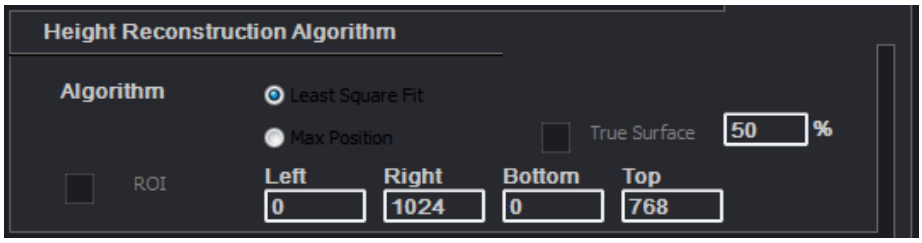
Roughness in the ROI is automatically calculated by clicking. The user can apply the high pass filter before calculating the roughness. It will remove waviness less than the

cut-off frequency, and more accurate surface roughness can be obtained if appropriate cut-off frequency is applied.

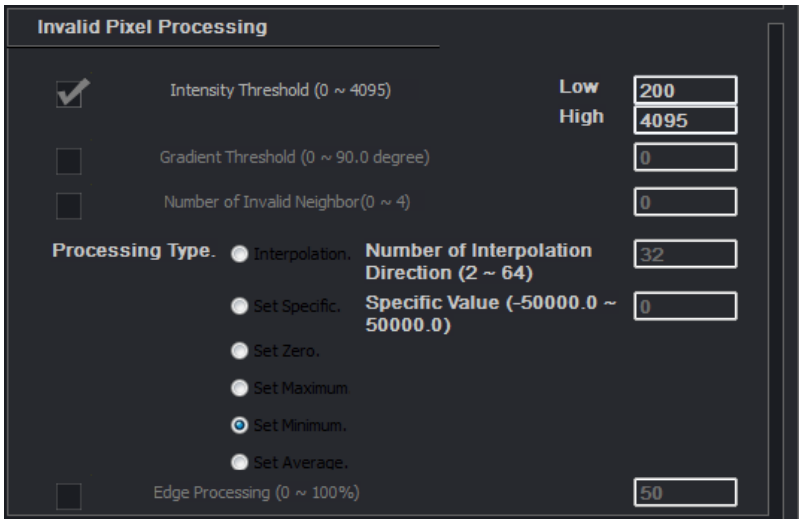
3.7.2. 3D Parameter Setting Window

The parameters for 3D image data reconstruction from the sectional images saved in *.nafx file are in 3D parameter setting window

Objective Lens Information shows the maker, magnification, NA(numerical aperture), and working distance of the objective lens used for the image acquisition.



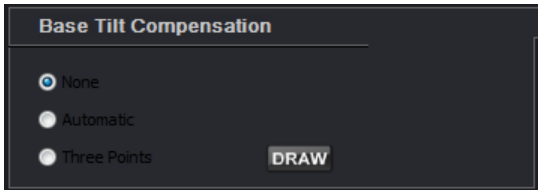
3D image processing algorithm can be selected in Height Reconstruction Algorithm. The available height reconstruction algorithm is the least square fit method and the maximum positioning method. True Surface is activated when checked. It is used for extracting the top-most surface of the specimen with the multi-layered structure.



If some region is too bright or too dark, or if the slope of the feature is too steep, the effective measurement may not be made in this region. In this case, the suspicious measurement region may be ignored and replaced with the appropriately estimated height data by Invalid Pixel Processing.

The methods to finding the appropriately estimated height data includes the interpolation using the valid data from adjacent pixels, setting specific value, setting zero value, setting maximum value, setting minimum value, and setting average value. In case of interpolation, the number of interpolation direction should be defined.

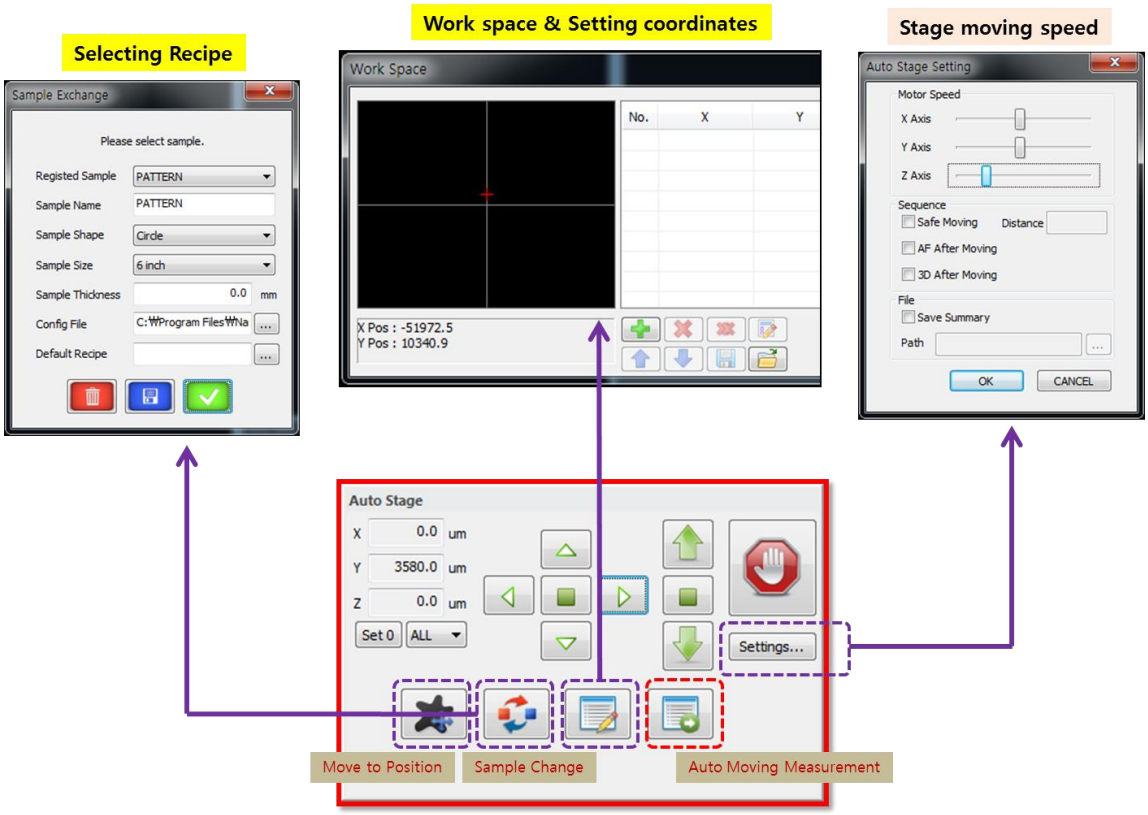
Smoothing is processed by averaging the height image and intensity image as much as the designated number of pixels when the image is reconstructed.



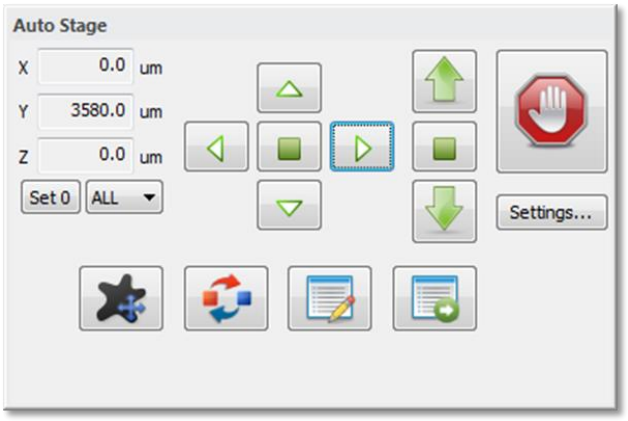
The tilting of the specimen can be calculated and compensated. Auto base tilt compensation method searches the peak point in the height histogram graph. And the height corresponding to this peak point is defined as the basement to compensate the tilt. In three point tilt compensation method, the basement is defined by three areas assigned by the user. With the plane passing through these three points (or areas), it compensate the tilt.

4. AUTOMATIC STAGE AND IMAGE STITCHING

4.1. Auto Stage Panel

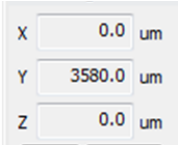


<Related sub-menu windows for **Auo Stage** panel>



Auto Stage

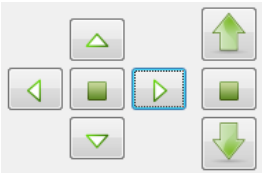
”Auto Stage” menu window is for the interface with motorized stages. The position of a stage and the moving speed of s a stage can be controlled. The batch process of the stage motion after 3D measurement can be made.



It shows the current postion of X,Y, and Z stage from the coordinate origin (0,0), which is already set.

This button sets the current postion as an origin of each axis.

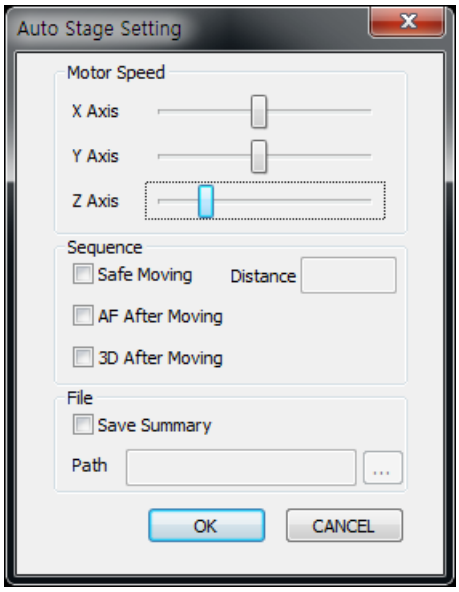
This button is expanded, and the user can choose which axis to be chosen for setting origin.



This is buttons for moving XY stage and Z stage
Retangluar button is for moving to its origin position.

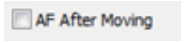
This button is for stopping all stage moving.

This is button for Auto Stage Setting. Clicking this, it will open another "Auto Stage Setting"window as below.



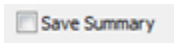
It is for adjusting the moving speed of the each stage

If checked, it moved the Z-stage up as much as the amount of written in the "Distance" while XY stage is moving. Z-stage returns down to the original position when XY stage stops.



DO NOT USE THIS for STITCHING. (If checked, AutoFocus works at each position.)

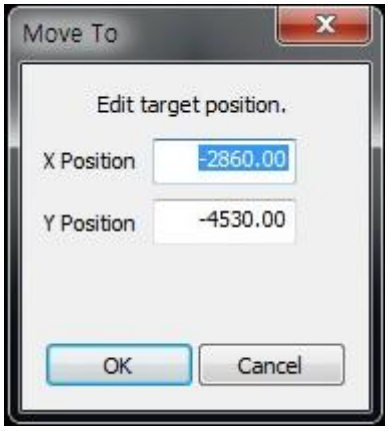
It should be checked for stitching. This is button for automatic execution of 3D measurement after XY stage moves to the next position.



*.nafx file is saved on the specified path.

[Move to Position]

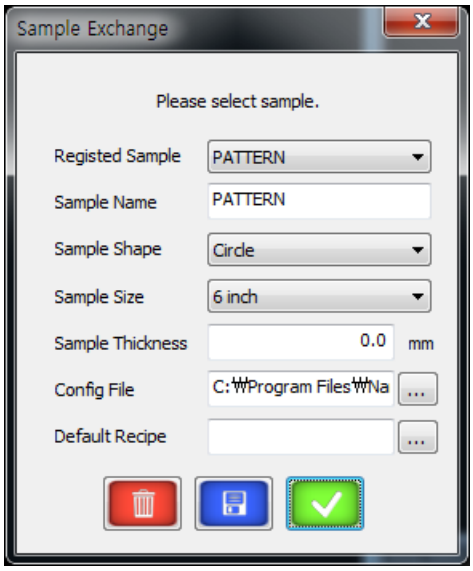
XY stage moves to the input position. Dimension is in [μm]



Input the position of X and Y, and click "OK", the stage moves to that position.

[Change Sample]

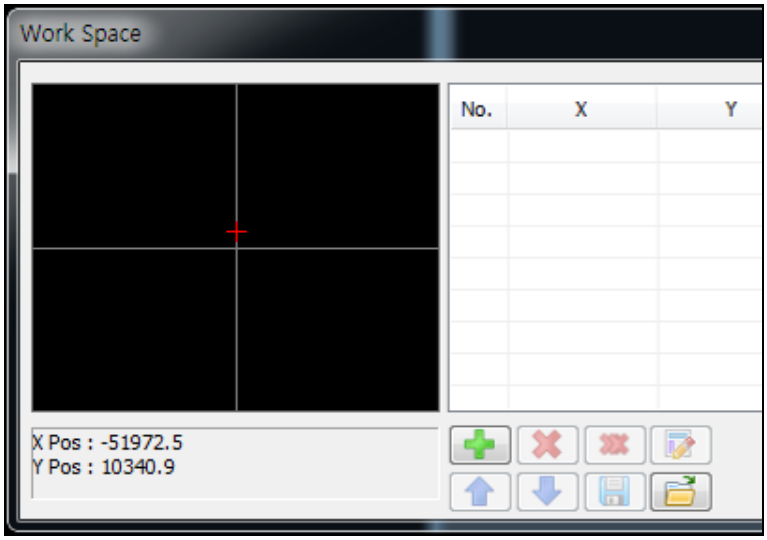
This button is useful for replacing the measurement sample, especially for the same kind of samples.



The thickness of a sample and the appropriate measurement parameters (such as a laser power) can be called when replacing the sample by this button. It is useful for the repeat measurement in mass quantity of same kind of samples.

[Edit Coordinate]

It opens the windows for entering the coordinate for automatic movement & measurement. For the consecutive measurement of the listed coordiantes, like stiching function, the coordinates should be appropriately entered. These coordinate values can be saved as a file, and loaded froma a file.

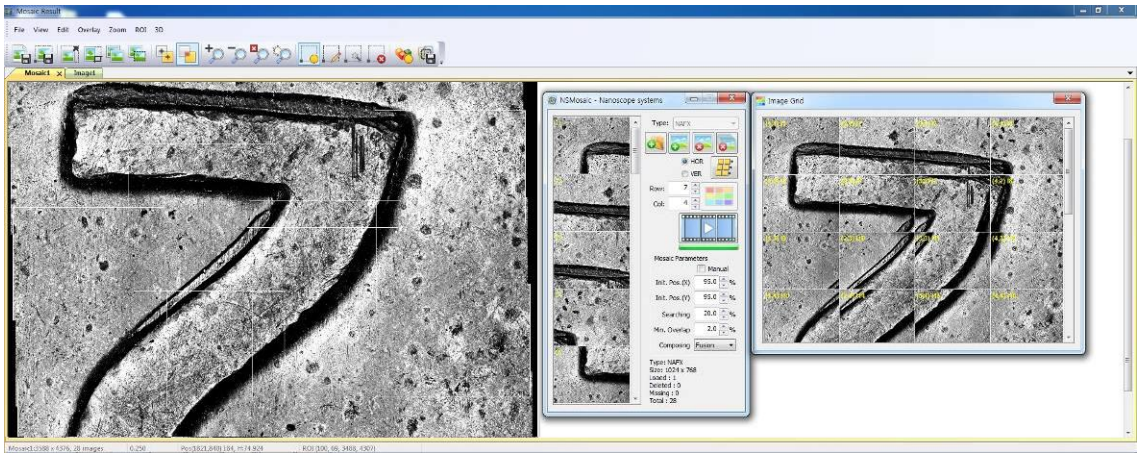


The coordinates can be added by this button.

[Start Sequential Measurement]

It will run the automatic sequential measurement to the positions as listed above.

4.2. Stitching Image



<Image Stitching>

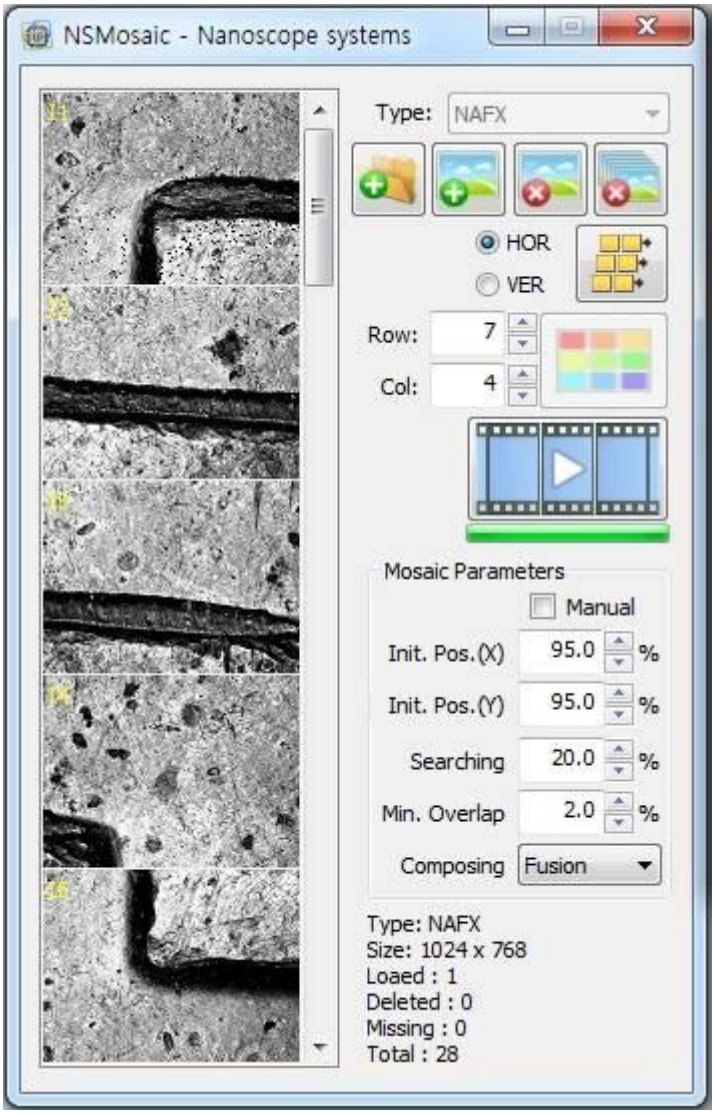
Image stitching is to get one large image by tiling a group of consecutive individual images. It is to take an image of which the size is exceed the field of view of one shot.

Select the measurement result files displayed in the right down portion of *NSWorks* result file window, and click  or 

.

Once files are loaded, there are two steps for stitching; Arrange the image and Make the file.

<Step 1> Arrange the images



The individual loaded files, which should be stitched, are shown as a column in the left side.

Select the file type to stich.

The group of files to be stitched can be stored in one folder. This button is to call all the file in the specific folder.

This is to call the file one by one.

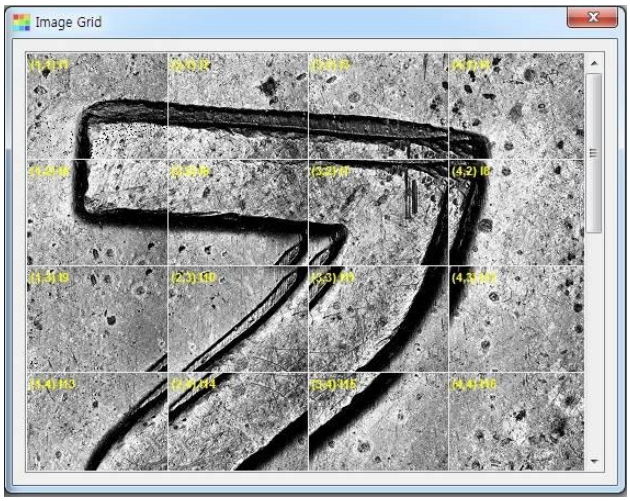
This is a button to remove one file among the opened files.

This is a button to remove all opened files

The sequence of opened files can be arranged as horizontally(HOR) or vertically(VER).

The number of row and column should be input here.

This button is for pre-view of stitched image. The pre-view image is shown as below.



Each cell of image can be moved and re-arrnaged in pre-view window by a mouse-drag.

Once the arrangement is confirmed, click this button to perform the stitching.

There are some parameters for stitching.

If checked, the specific set value in the parameter file is applied. If checked, the parameter values are inactivated.

The X, Y position of files are set here.

The matching range for searching is set here.

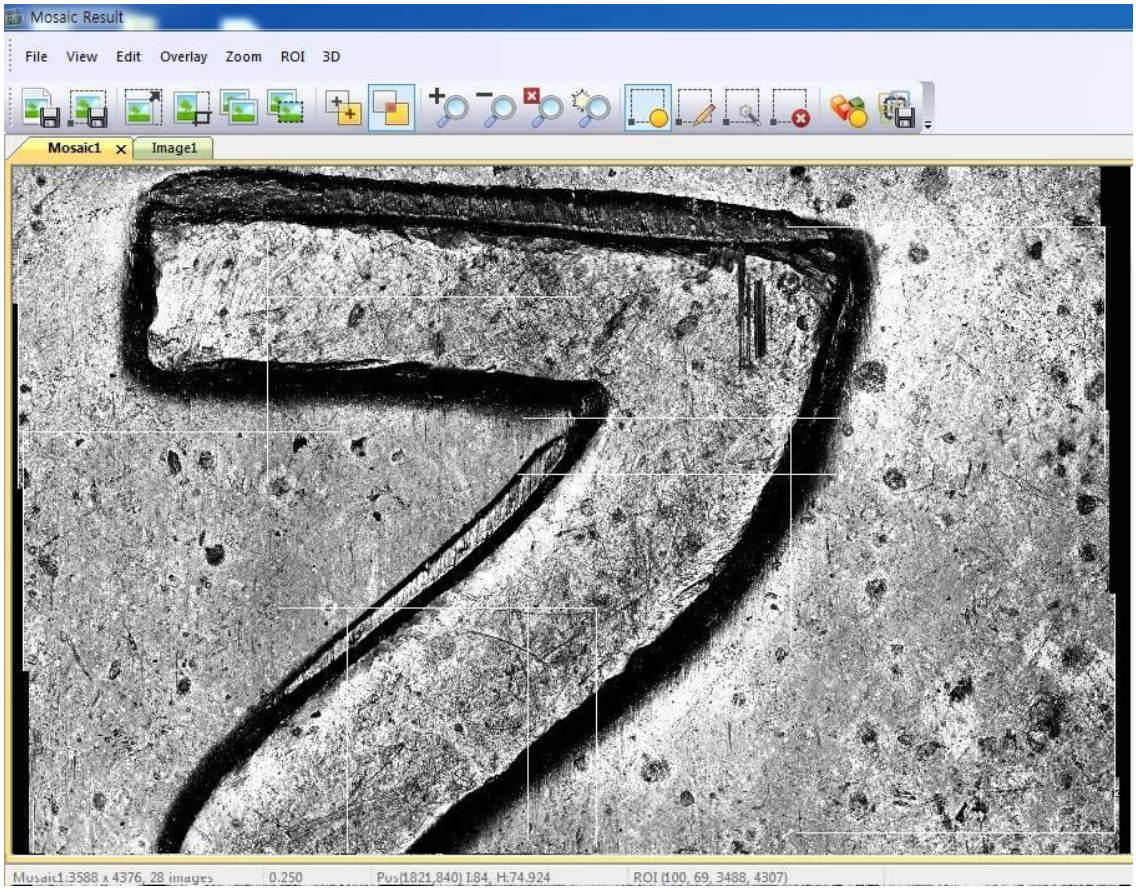
Minimum overlapped range is set here.

It is for selecting the priority of the method to combine adjacent files. There are methods such as Fusion, Average, First, and Last.

There's Information window at the right down side. Brief information for the stitched file is shown. Meaning of this captured information is that 1 image of 1024x768 size file of NAFX format will be made, and total 28 images are used for stitching and there's no deleted or missing file.

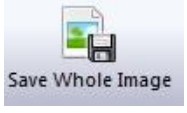
<Step 2> Make the file

After execution of stitching, the resultant stitched image is shown at the new display window as below. Simple editting should be done.



<Menu of stitched image display window>

File It is for saving as a file. The file format of stitched image is *.NMC.



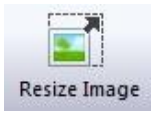
[Save Whole Image] This is to save whole image.

. 

[Save ROI]

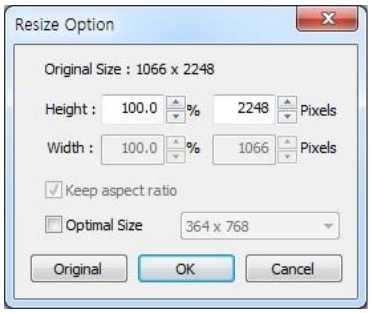
This is to save ROI region.

Some functions to edit stitched image.



[Resize Image]

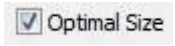
It is to change the image size.



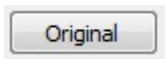
It shows the size of the original stitched image.

It shows the percent of the related pixel size.

Aspect ratio is always kept. It can not be checked. (Inactivated)



Some specific pixel sizes are proposed, and the user can choose one of these optimal size.



It is button for restoring original image size.

[Crop Image]

It is to cut the image as fit to specified ROI region.

[Copy Whole to Clipboard]

It is to copy the image, and the copied image is temporarily saved at Clipboard. It is same as “Copy” in Edit menu

[Copy ROI to Clipboard]

It is to Copy the ROI region only.

This is the menu related to the overlay

[Show Center]

It shows the center of each image.

[Show Overlap]

It shows the overlapped region of images.

[Zoom In]

[Zoom Out]

[No Zoom]

[Fit to Window]

Menus for editing ROI (region of interest).

[Show ROI]

It shows currently specified ROI

[Define ROI]

It is to draw ROI as a rectangular shape by mouse-drag.

[Fit ROI]

Click this, it assigns ROI which is best fit to the image.

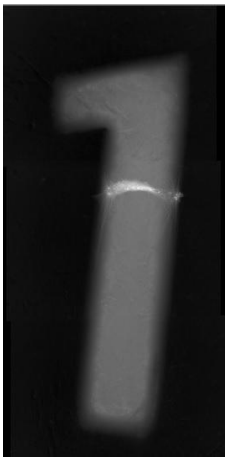
[Clear ROI]

It is to delete ROI.

It is menu for 3D function of stitched images

[Show Height map]

Display the height map of the stitched image



< Show Height Map>

[3D Export]

It is to make 3D file format of the stitched image.

The saved file format is "*.NMC"

Mosaic file is the first display of the stitched image. **Image file** is from editing Mosaic file. NMC file is made from Image file. Overlay function does not work in Image file,

Warranty

1. Warranty period

1 year after delivery.

2. Warranty limit

All breakdown caused by manufacturer would be repaired for free during the warranty period except below.

- breakdown caused by unsuitable condition, environment, handling, using.
- breakdown caused by user's equipment
- the third party's repairing
- the third party's opening the product
- breakdown caused by natural disaster