KEYENCE

96M16933

Using the VK-X3000 Series for the First Time

3D Surface Profiler

Quick Start Guide

- Gathering New Film Thickness Data -

KEYENCE CORPORATION

Introduction

Thank you for your purchase of the VK-X3000 Series 3D Surface Profiler.

This manual describes the measurement method for film thickness, such as permeable films and glass, as well as transparent coatings.
Note that there are two methods for measuring film thickness: laser confocal and spectral interference.

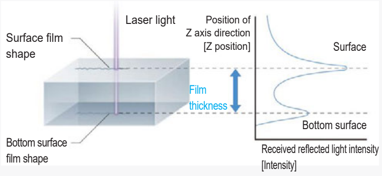
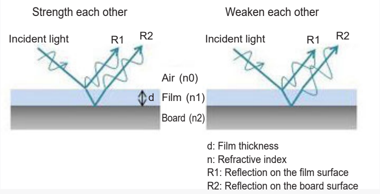
Contents

Chapter 1

Before Starting Operation

1-1 Understanding the Difference of the Measurement Methods

There are differences between the laser film thickness and spectral film thickness as follows.

<table>
<tr><th>Film thickness measurement method</th><th>Laser film thickness</th><th>Spectral film thickness</th></tr>
<tr><td>Principle</td><td>If the object is a transparent target, the transmitted light will penetrate the surface and reflect off of the bottom layer. As the result, the thickness of the transparent target can be determined by calculating the difference between the two surfaces.

</td><td>When illuminating a transparent target with light, there are two reflections that occur; light that reflects from the surface of the film (R1) and light that refracts inside the film and reflects off of the bottom layer (R2). R1 and R2 overlap and experience constructive and destructive interference.


Spectral film thickness then calculates the film thickness using this interference pattern, understanding that this interference changes depending on the thickness of the film.</td></tr>
<tr><td>Film thickness to be measured</td><td>Approx. 2 μm -
The film thickness that can be measured depends on each lens magnification.
<table>
<tr><th>Model</th><th>Objective lens</th><th>Measurable film thickness value</th></tr>
<tr><td>VK-X3100</td><td>50x</td><td>2μ -</td></tr>
<tr><td></td><td>20x</td><td>12μ -</td></tr>
<tr><td></td><td>10x</td><td>50μ -</td></tr>
<tr><td>VK-X3050</td><td>50x</td><td>3.5μ -</td></tr>
<tr><td></td><td>20x</td><td>20μ -</td></tr>
<tr><td></td><td>10x</td><td>80μ -</td></tr>
</table></td><td>Approx. 0.1 μm - 5.0 μm</td></tr>
<tr><td>Recommended objective lens</td><td>10x, 20x, 50x
*Objective lenses other than those listed above can be used as well, however, check their performance before using them.</td><td>10x, 20x, 50x
*Objective lenses other than those listed above can be used as well, however, check their performance before using them.</td></tr>
</table>

- **Spectral film thickness**
  Spectral film thickness is an optional function that can be purchased. VK-T300 hardware is required.

1-2 Understanding the Operation Flow

The operation flow of the laser film thickness measurement is as follows.

Preparation for Measurement

- Launch the Viewer Application

Setting of the Measurement Method

- Switch to laser film thickness mode
- Adjusting the magnification and focus

Measure/Save

- Laser film thickness measurement
- Saving the measurement result

1-2 Understanding the Operation Flow

The operation flow of the spectral film thickness measurement is as follows.

Preparation for Measurement

1. Connect the spectrometer
2. Launch the Viewer Application

Setting of the Measurement Method

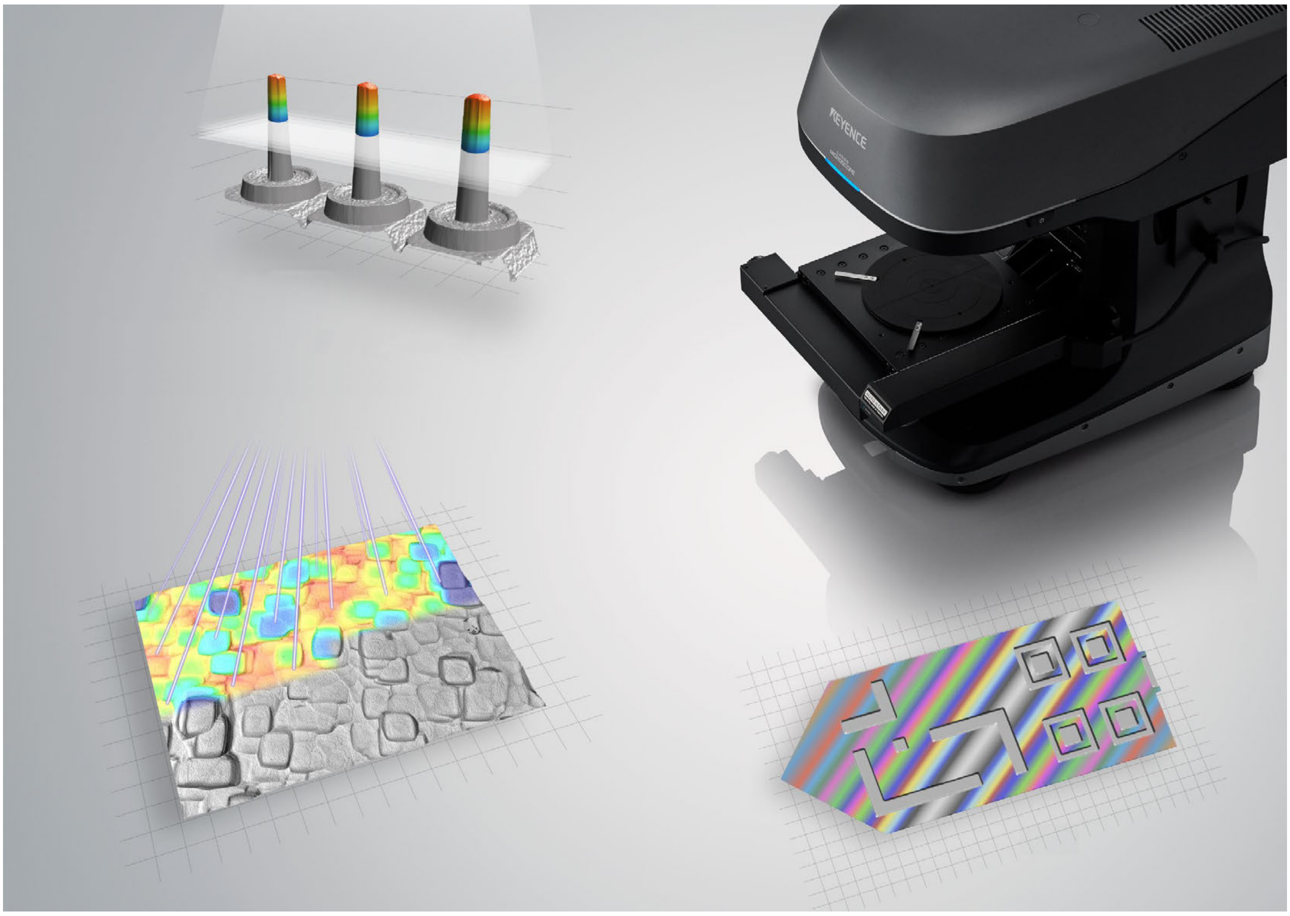
1. Switch to spectral film thickness mode
2. Remove the objective lens to be used for the measurement
3. Mount the spectroscopy interference adapter
4. Remount the objective lens
5. Reference & dark adjustment
6. Adjust the focus

Measure/Save

1. Spectral film thickness measurement
2. Saving the measurement result

Chapter 2

Preparation for Measurement



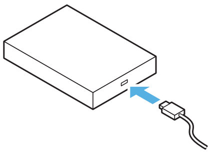
2-1 Connecting the Spectrometer

To perform the spectral film thickness measurement, connect the spectrometer first.

1. **Remove the spectrometer out of the case.**

When using laser film thickness, this step is not required.

2. **Connect the USB cable to the Micro-B connector of the spectrometer.**



3. **Connect the USB cable to the USB connector on the back of the control PC.**

Point

Perform the connection of the spectrometer before starting the Viewer Application.

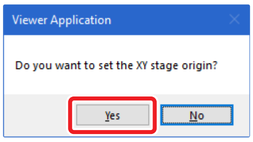
2-2 Starting the Viewer Application

To obtain new data, click the icon on the desktop to start [VK-X 3000 Viewer Application].

1. **Double-click the [VK-X 3000 Viewer Application] icon on the desktop.**

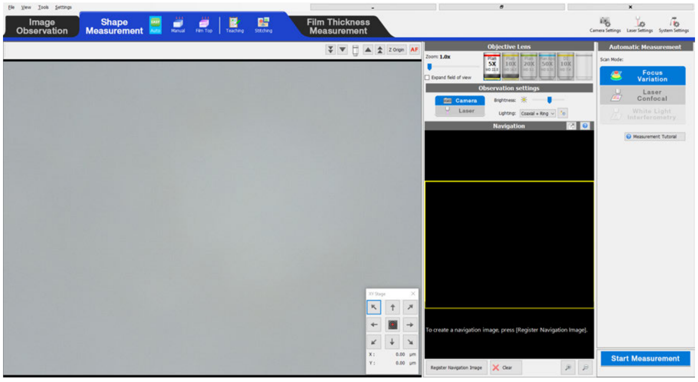
A dialog box confirming movement of the revolver and stage will appear.

2. **Click the [Yes] button.**


Viewer Application

Do you want to set the XY stage origin?

3. **The stage will return to origin, and the Viewer Application starts.**


To create a navigation image, press [Register Navigation Image].

2-3 Adjusting the Magnification and Focus

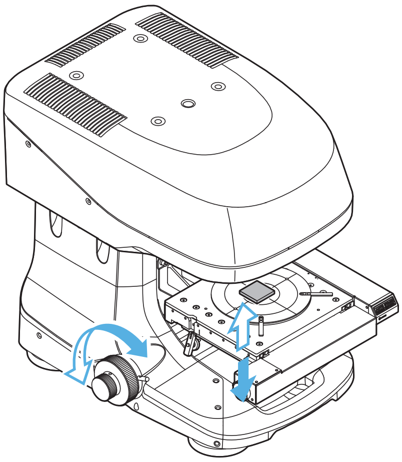
Adjust the magnification and focus so that the image of the sample appears properly in the viewing window.

- The motorized XY stage can accommodate samples up to 70 mm in height and 3.0 kg in weight.
- The standard XY stage can accommodate samples up to 70 mm in height and 5.0 kg in weight.

1. Place the sample on the XY stage.

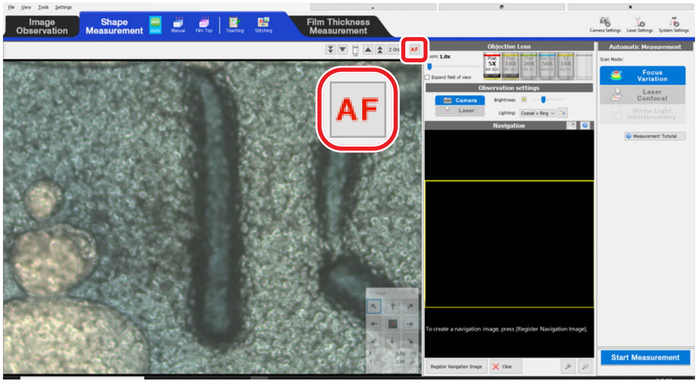
2. Adjust the height of the XY stage.

Turn the focusing handle (Coarse/Fine) to adjust the focus.



3. Focus the objective lens.

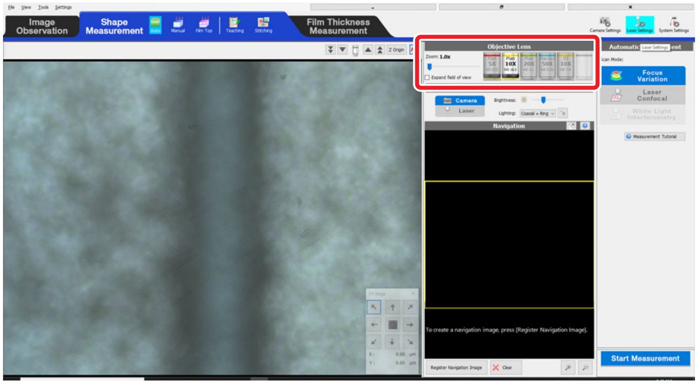
On the operation panel, click the [AF] button.



To create a navigation image, press [Register Navigation Image].

4. Select the objective lens.

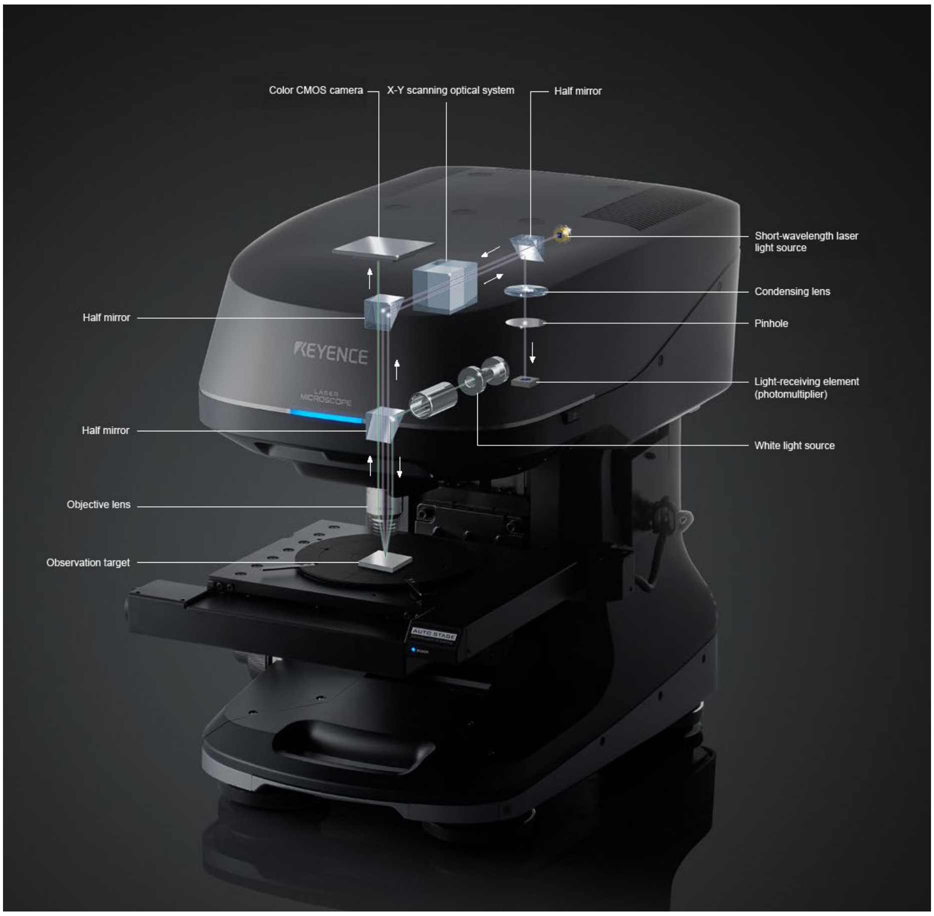
Adjust the focus with a desirable lens magnification by repeating Steps 2 to 3.



To create a navigation image, press [Register Navigation Image].

Chapter 3

Laser Film Thickness Measurement

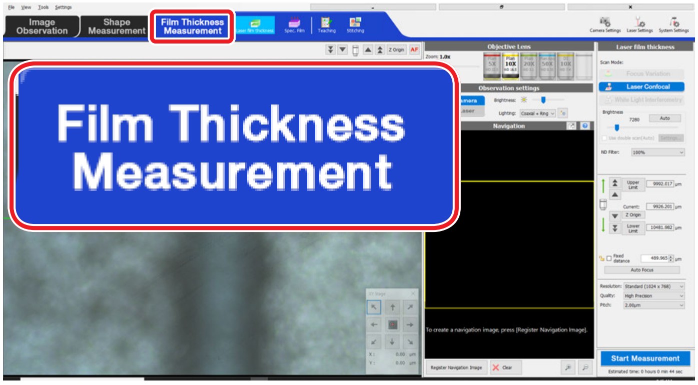


3-1 Using Laser Film Thickness

This section describes the operation procedure for laser film thickness.

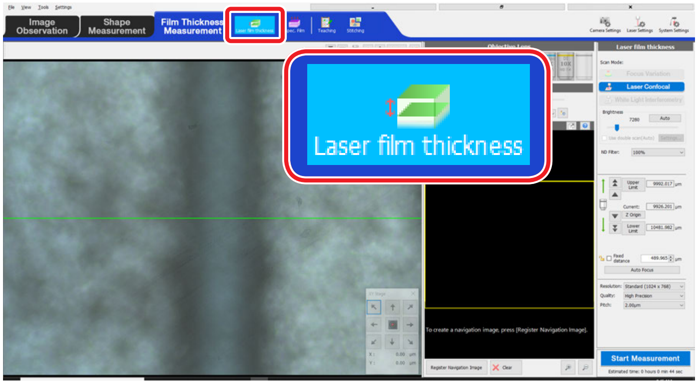
- **Laser film thickness measurement**
  Measure the thickness (film thickness of more than 2 μm) and shape of the top three layers of a transparent target.

1. **On the toolbar, click [Film Thickness Measurement].**



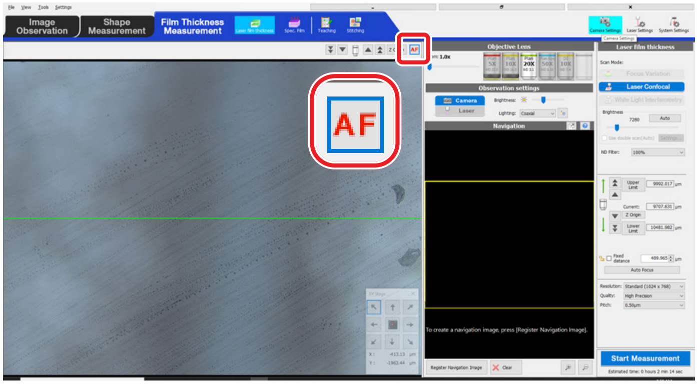
2. **Click the [Laser film thickness] button.**

It will switch to the laser film thickness of the film thickness measurement mode.



3. **Adjust the focus using the appropriate lens.**

Select the objective lens to be used for the measurement. Next, on the operation panel, click the [AF] button to execute the auto focus.

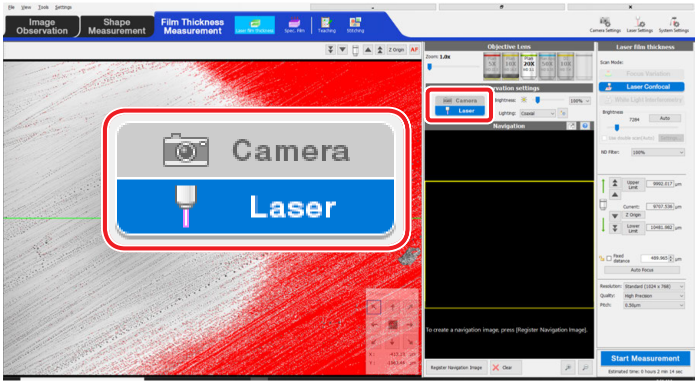


Point

When the screen goes dark completely by switching the display image from [Camera] to [Laser], click the auto focus button.
The screen brightness is optimized.

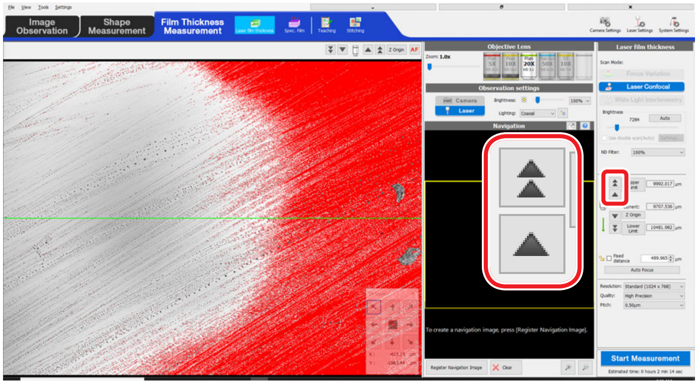
4. Adjust the brightness of the laser.

Switch the displayed image from [Camera] to [Laser].



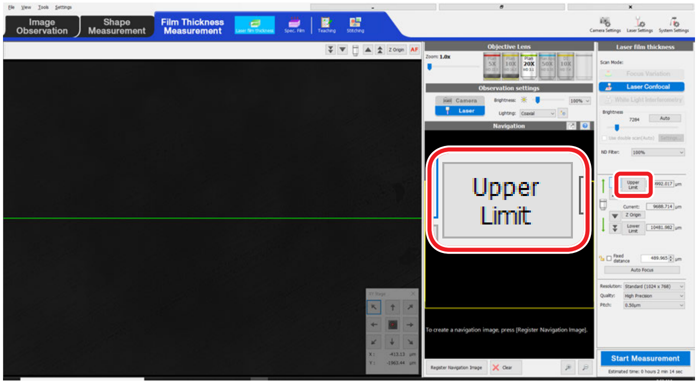
5. Next, click the vertical position buttons for the objective lens to move the objective lens upward.

Move it upward past the top surface of the film to be measured, until the laser image turns black and disappears.



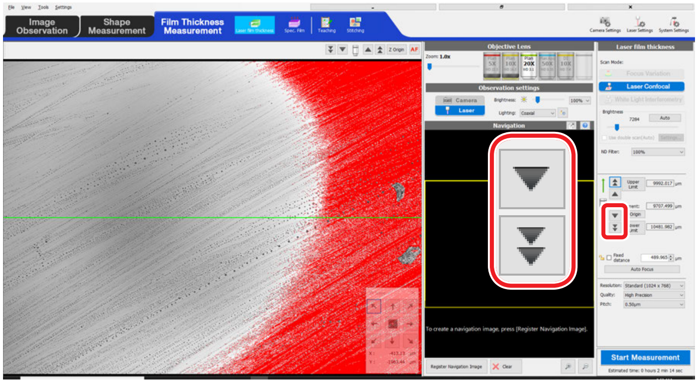
6. Click the [Upper Limit] button.

Set the upper limit value of the range to be measured.



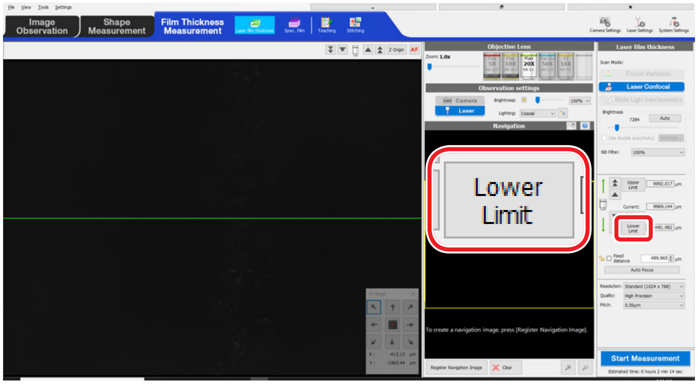
7. Click the vertical position buttons for the objective lens to move the objective lens downward.

Move it downward past the bottom surface of the film to be measured, until the laser image turns black and disappears again. Note that you may need to scroll through several reflected layers to get to the bottom surface depending on the sample.



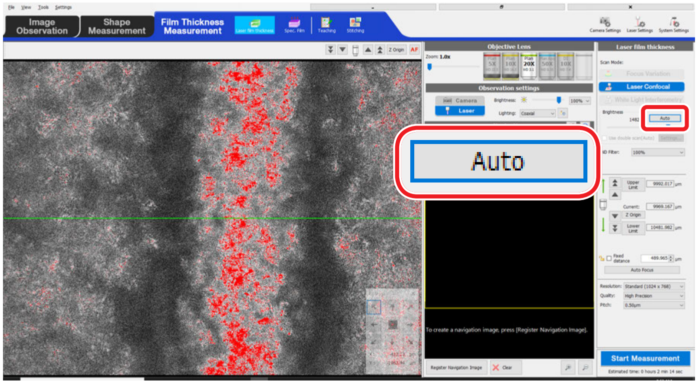
8. Click the [Lower Limit] button.

Set the lower limit value of the range to be measured.

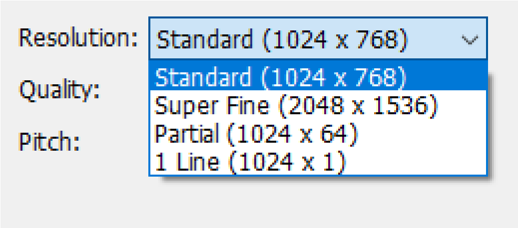


9. Click the [Auto] button.

Optimize the laser brightness within the specified measurement range.



10. Select [Standard (1024 x 768)] in the [Resolution] box.



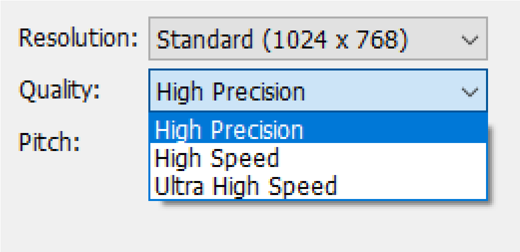
Resolution: Standard (1024 x 768)

- Standard (1024 x 768)
- Super Fine (2048 x 1536)
- Partial (1024 x 64)
- 1 Line (1024 x 1)

Quality:

Pitch:

11. Select [High Precision] in the [Quality] box.



Resolution: Standard (1024 x 768)

Quality: High Precision

- High Precision
- High Speed
- Ultra High Speed

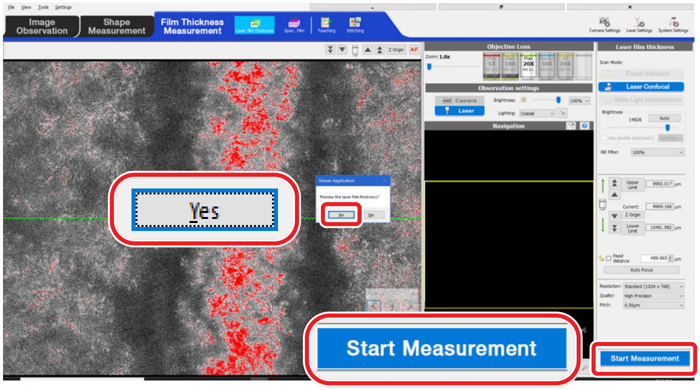
Pitch:

12. Select a pitch as needed.

Normally, the RPD (Real Peak Detection) method is used to detect the focal point position. It's recommended to keep RPD on.

13. Click the [Start Measurement] button.

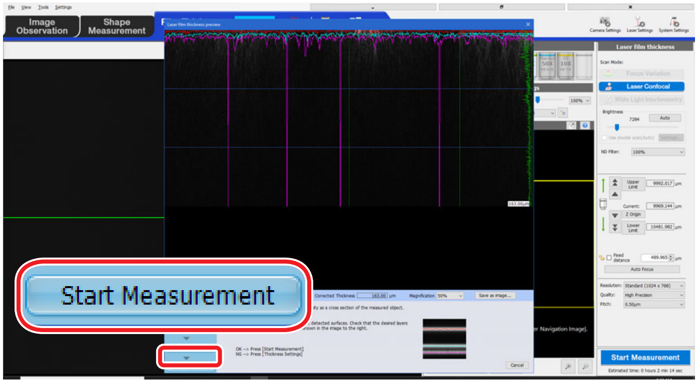
A confirmation message appears asking whether to perform a preview measurement. Click the [Yes] button.



The preview measurement starts, and the [Laser film thickness preview] window appears. Make sure that the measured layer (white signal) matches the detected layer (red, light blue, and magenta lines) before performing the measurement.

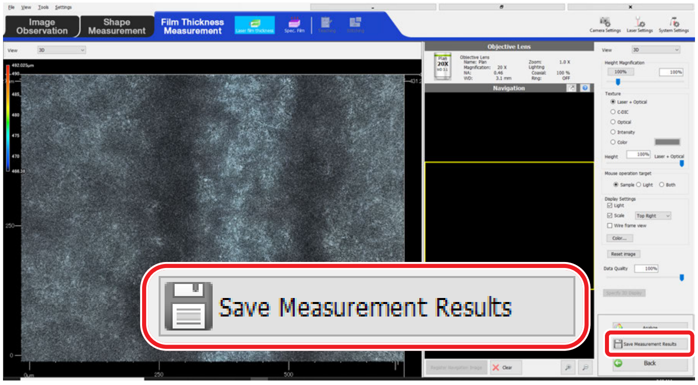
When the detected layer is not matched, refer to the 📖Chapter 7 of "Viewer Application Reference Manual".

14. **Click the [Start Measurement] button.**



The film thickness measurement results will be displayed.

15. **Click the [Save Measurement Results] button to save the result.**



Point

The [Laser film thickness preview] window appears only for the recommended objective lens with 10x, 20x, or 50x.

For other objective lenses, measurement starts at the same time as the [Start measurement] button is clicked.

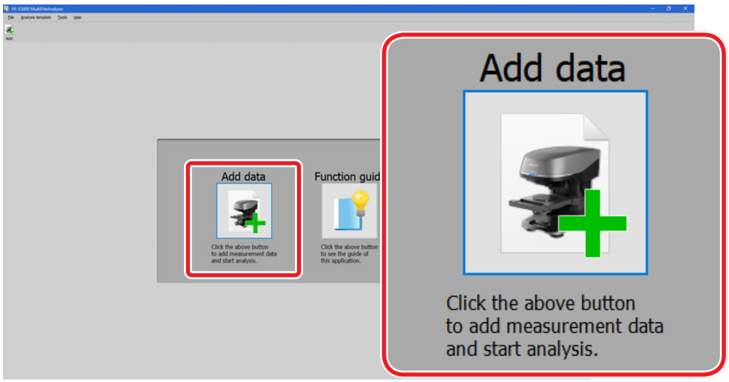
Point

Click the [Analyze] button to display the measurement results in the Multifile Analyzer.

Next, we will analyze the obtained laser film thickness data.

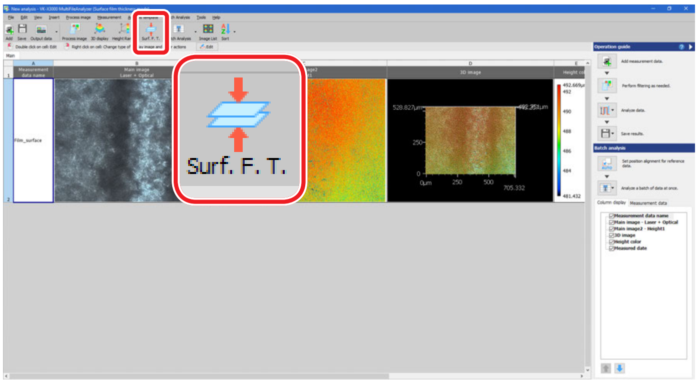
1. Click the [Add data] button, and select the saved measurement data.

The obtained laser film thickness data will appear.



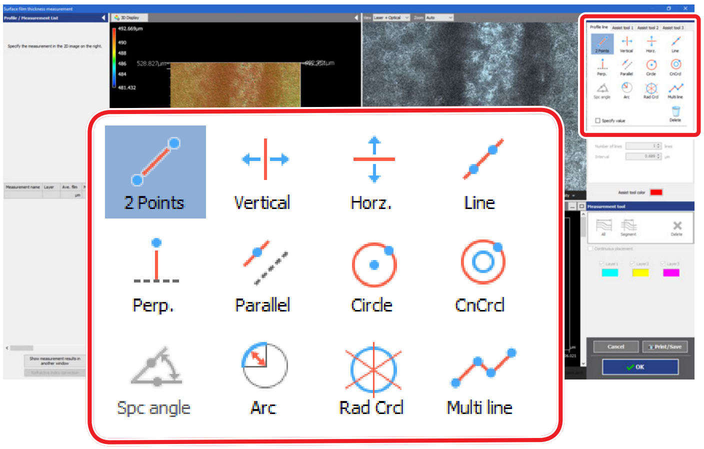
2. Select the surface film thickness.

On the toolbar, click the [Surf. F.T.] button. Alternatively, you can select [Surface film thickness measurement] from the [Measurement] menu.



3. Click to select [2 Points] in [Profile line].

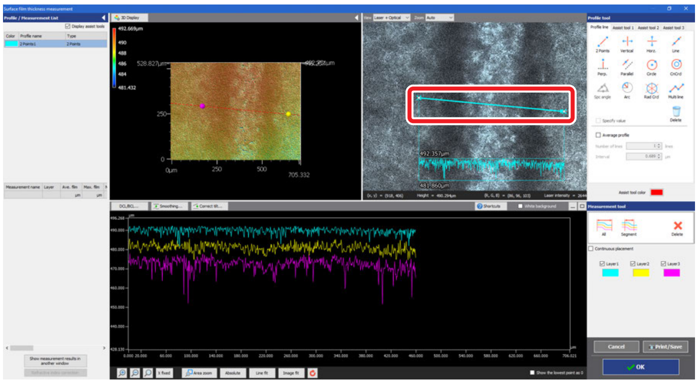
Create a cross section profile using the 12 types of profile tools that appear on the top right of the screen. In this case, select 2 points specification.



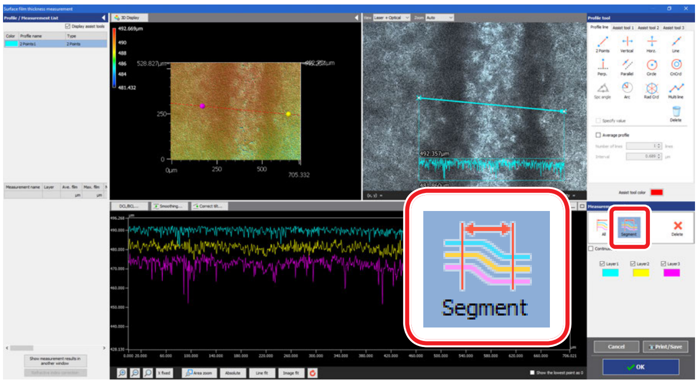
The [Area settings] window appears.

4. Click the part where you want to measure the film thickness, and draw a line.

On the top right of the screen, place the cursor over the area where you want to measure the film thickness, then click it. In the lower half of the screen, the film thickness profile at the specified place appears.

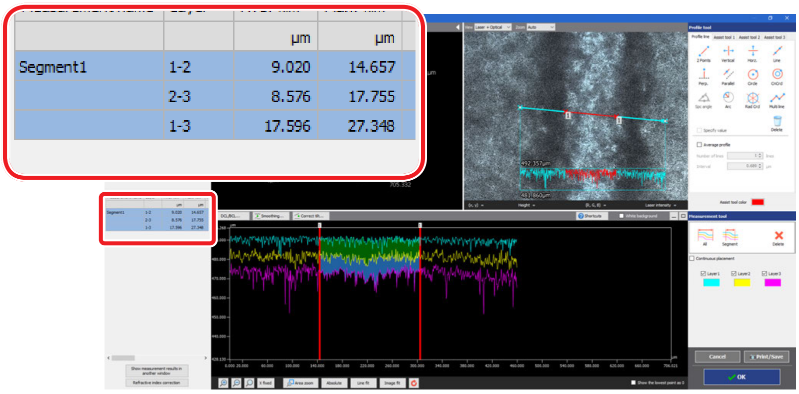


5. Click and select [Segment] of [Measurement tool].



6. Specify the start point and end point of the place to be measured.

Specify the place to be measured within the profile screen.
Move the cursor over the start point of the place where you want to detect the film thickness, then click it. Next, set a range by specifying an end point.



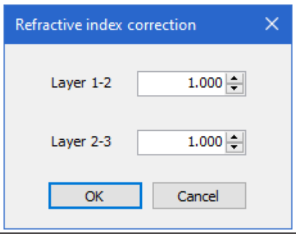
		µm	µm
Segment1	1-2	9.020	14.657
	2-3	8.576	17.755
	1-3	17.596	27.348

The measurement results will be displayed.

Point

To display the correct film thickness value, the index of refraction must be corrected.

Click the [Refractive index correction] button, then enter the refractive index of the film being measured.



Refractive index correction

Layer 1-2 1.000

Layer 2-3 1.000

Chapter 4

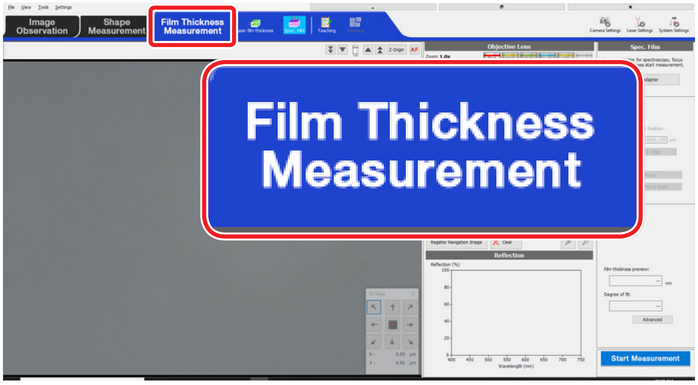
Spectral Film Thickness Measurement

4-1 Using Spectral Film Thickness

This section describes the operation procedure for the laser film thickness.

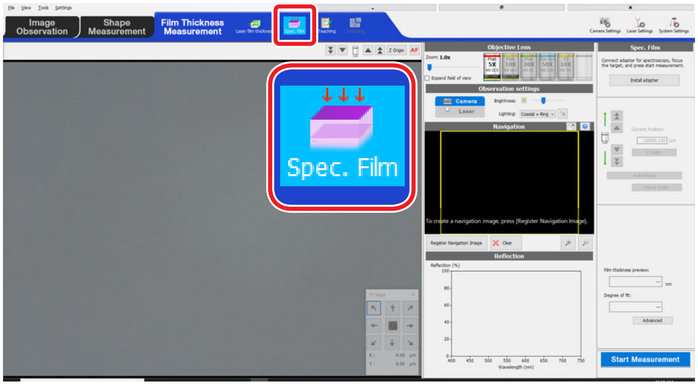
Measure the thickness (film thickness of more than 2 μm) and shape of the top three layers of a transparent target.

1. **On the toolbar, click [Film Thickness Measurement].**



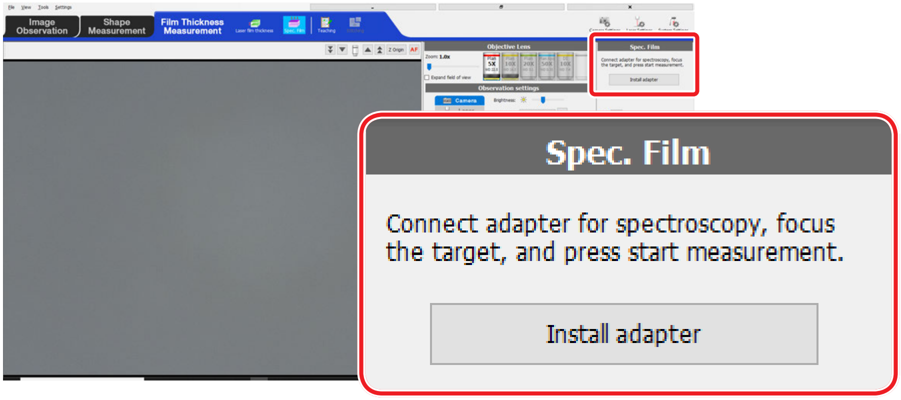
2. **Click the [Spec. Film] button.**

It will switch to the spectral film thickness of the film thickness measurement mode.



3. **Mount the spectroscopy adapter.**

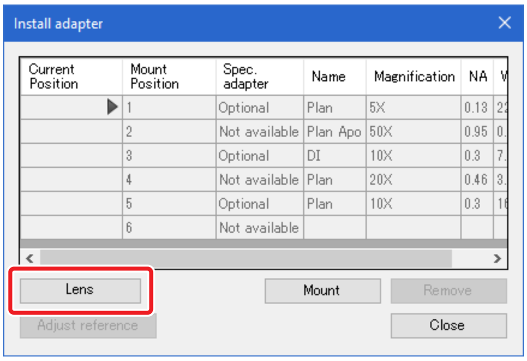
Click the [Install adapter] button from the spectral film thickness of the film thickness measurement mode.



Connect adapter for spectroscopy, focus the target, and press start measurement.

The confirm dialog box appears. Click the [OK] button.

4. **Click the [Lens] button.**

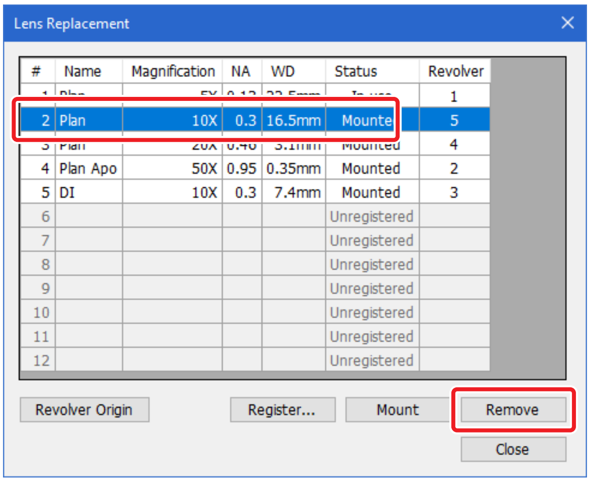

Install adapter

Current Position	Mount Position	Spec. adapter	Name	Magnification	NA	W
▶	1	Optional	Plan	5X	0.13	22
	2	Not available	Plan Apo	50X	0.95	0.
	3	Optional	DI	10X	0.3	7.
	4	Not available	Plan	20X	0.46	3.
	5	Optional	Plan	10X	0.3	16
	6	Not available				

The [Lens replacement] dialog box appears.

5. **Select the objective lens to be used, and click the [Remove] button.**

Follow the displayed instructions to remove the objective lens.


Lens Replacement

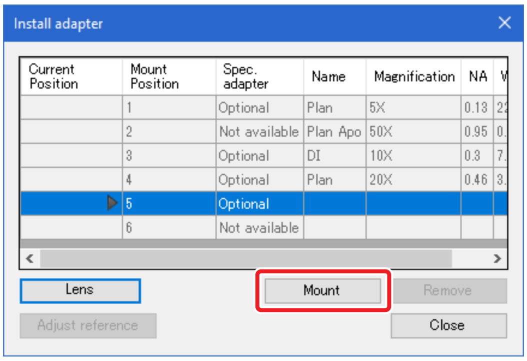
#	Name	Magnification	NA	WD	Status	Revolver
1	Plan	5X	0.13	23.5mm	In use	1
2	Plan	10X	0.3	16.5mm	Mounte	5
3	Plan	20X	0.46	3.1mm	Mounted	4
4	Plan Apo	50X	0.95	0.35mm	Mounted	2
5	DI	10X	0.3	7.4mm	Mounted	3
6					Unregistered	
7					Unregistered	
8					Unregistered	
9					Unregistered	
10					Unregistered	
11					Unregistered	
12					Unregistered	

Point

Make sure to confirm the [Spec. adapter] field. The spectroscopy adapter can be mounted only at the mount position displayed as "Mounted".

6. **Click the [Close] button, and close the [Lens Replacement] dialog box. Next, the spectroscopy adapter will be mounted on the position where the objective lens has been removed.**

Click the [Mount] button.

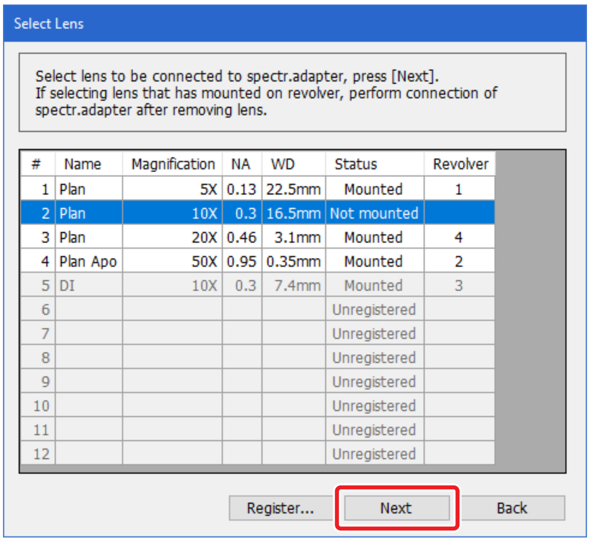

Install adapter

Current Position	Mount Position	Spec. adapter	Name	Magnification	NA	W
	1	Optional	Plan	5X	0.13	22
	2	Not available	Plan Apo	50X	0.95	0.
	3	Optional	DI	10X	0.3	7.
	4	Optional	Plan	20X	0.46	3.
▶	5	Optional				
	6	Not available				

The [Select Lens] dialog box appears.

7. Select the registration of the objective lens for the spectroscopy adapter to be mounted, and click the [Next] button.

Follow the displayed guidance to mount the spectroscopy adapter and objective lens.

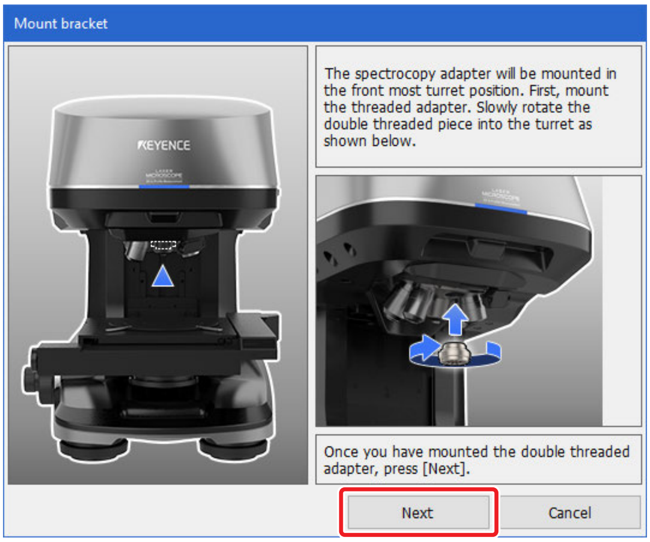


Select Lens

Select lens to be connected to spectr.adapter, press [Next].
If selecting lens that has mounted on revolver, perform connection of spectr.adapter after removing lens.

#	Name	Magnification	NA	WD	Status	Revolver
1	Plan	5X	0.13	22.5mm	Mounted	1
2	Plan	10X	0.3	16.5mm	Not mounted	
3	Plan	20X	0.46	3.1mm	Mounted	4
4	Plan Apo	50X	0.95	0.35mm	Mounted	2
5	DI	10X	0.3	7.4mm	Mounted	3
6					Unregistered	
7					Unregistered	
8					Unregistered	
9					Unregistered	
10					Unregistered	
11					Unregistered	
12					Unregistered	

8. Follow the on-screen instructions to mount the bracket, and click the [Next] button.



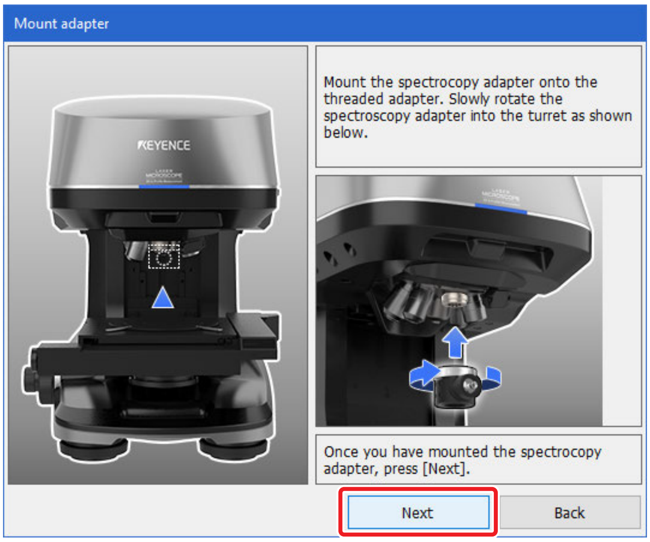
Mount bracket

The spectrocopy adapter will be mounted in the front most turret position. First, mount the threaded adapter. Slowly rotate the double threaded piece into the turret as shown below.

Once you have mounted the double threaded adapter, press [Next].

The [Mount adapter] dialog box appears.

9. **Follow the on-screen instructions to mount the adapter, and click the [Next] button.**



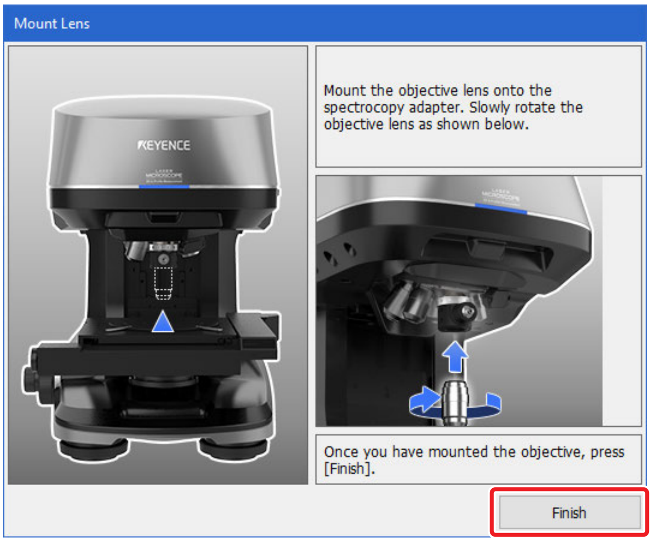
Mount adapter

Mount the spectrocopy adapter onto the threaded adapter. Slowly rotate the spectroscopy adapter into the turret as shown below.

Once you have mounted the spectrocopy adapter, press [Next].

The [Mount Lens] dialog box appears.

10. **Follow the on-screen instructions to mount the lens, and click the [Finish] button.**



Mount Lens

Mount the objective lens onto the spectrocopy adapter. Slowly rotate the objective lens as shown below.

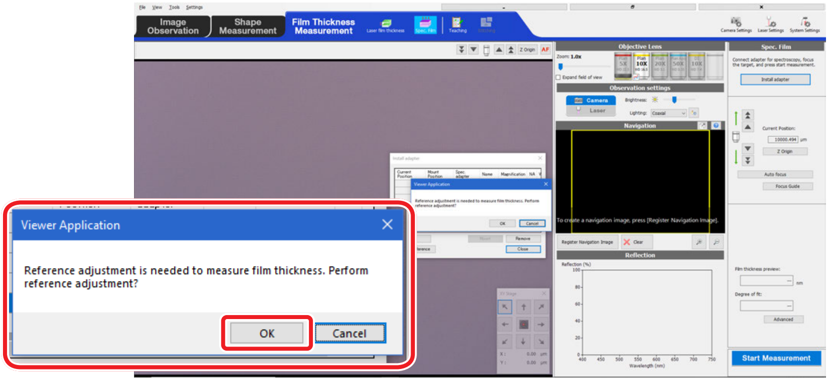
Once you have mounted the objective, press [Finish].

The confirm dialog box appears.

Point After this, connect the spectroscopy adapter to the spectrometer via the fiber optic cable, then perform reference adjustments.

11. Execute the reference adjustment.

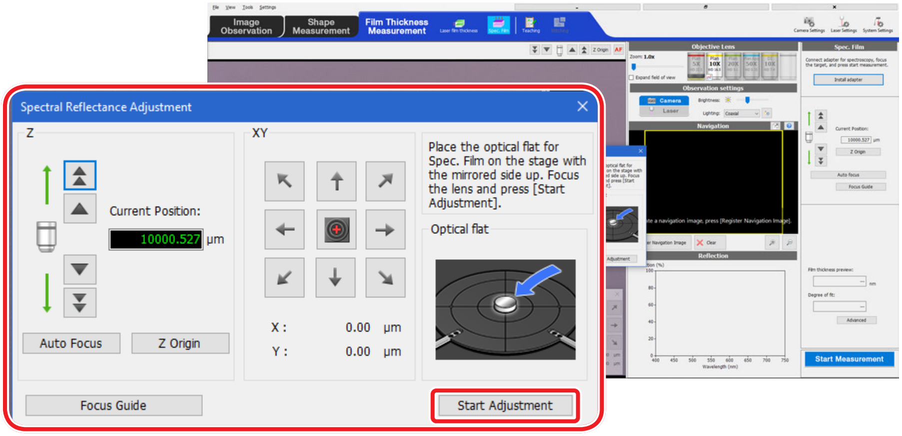
The confirmation dialog box appears, click the [OK] button.


Viewer Application

Reference adjustment is needed to measure film thickness. Perform reference adjustment?

12. Set the reference mirror (optical flat) for adjusting the reference for the spectral film thickness. After adjusting the focus, click the [Start Adjustment] button.

Execute the reference adjustment.


Spectral Reflectance Adjustment

Current Position: 10000.527 µm

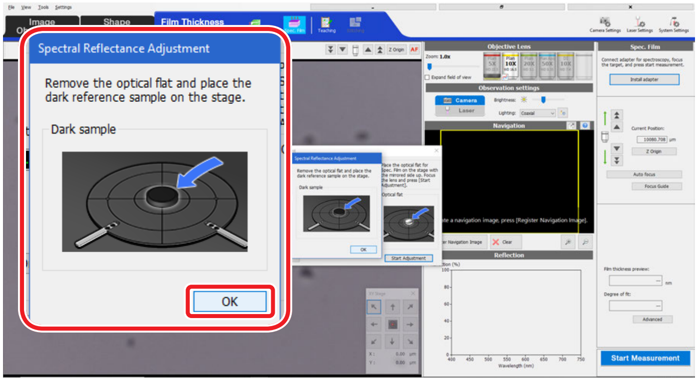
X : 0.00 µm

Y : 0.00 µm

Place the optical flat for Spec. Film on the stage with the mirrored side up. Focus the lens and press [Start Adjustment].

13. Set the dark sample for adjusting the reference for the spectral film thickness. After adjusting the focus, click the [OK] button.

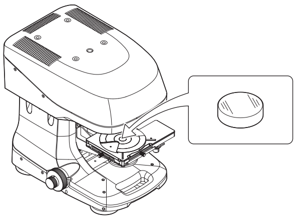
The adjustment using the dark sample is performed, and the confirmation dialog box to finish the adjustment appears.


Spectral Reflectance Adjustment

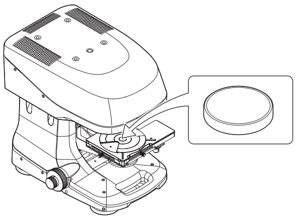
Remove the optical flat and place the dark reference sample on the stage.

- **A note about reference adjustment**
  The spectral film thickness measurement measures the film thickness from changes in each light wavelength reflected from the measurement object. Therefore, a reference adjustment with a reference mirror (optical flat) and a dark sample is required before the measurement.

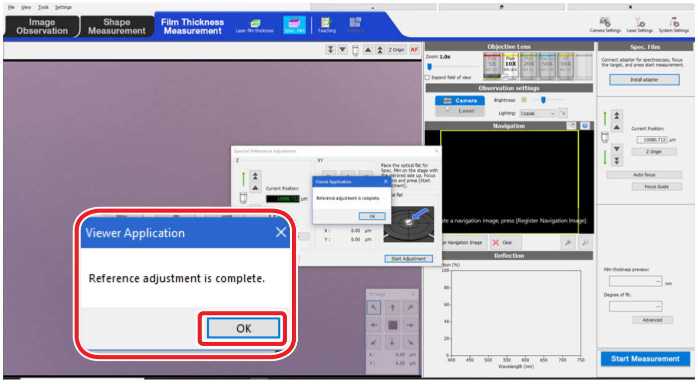
- **A note about the reference mirror (optical flat)**
  Use the reference mirror (optical flat) that is supplied with the spectral film thickness unit VK-T300.



- **A note about the dark sample**
  Use the dark sample that is supplied with the spectral film thickness unit VK-T300.



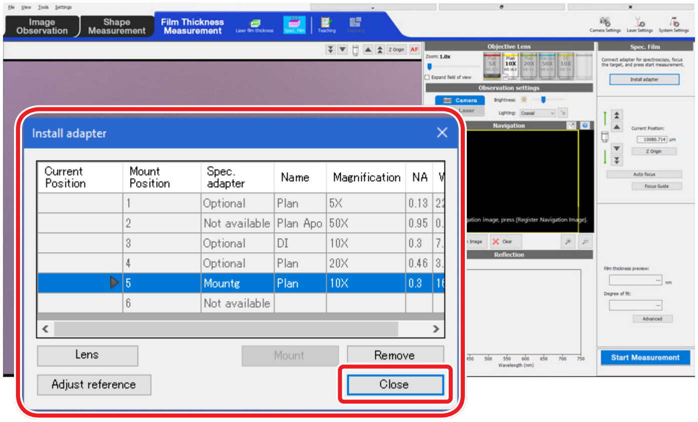
14. **Click the [OK] button.**



Viewer Application

Reference adjustment is complete.

15. **Click the [Close] button in the [Install adapter] window.**

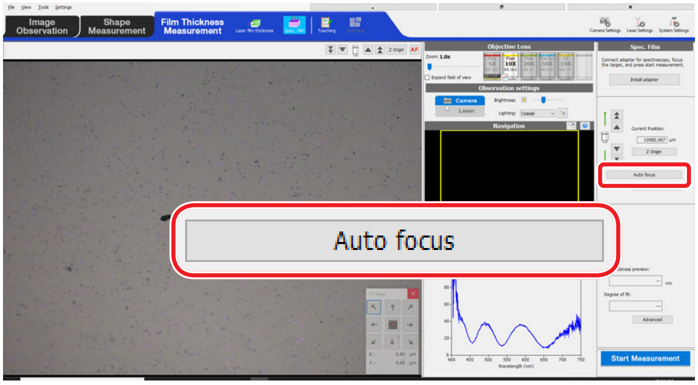


Install adapter

Current Position	Mount Position	Spec. adapter	Name	Magnification	NA
	1	Optional	Plan	5X	0.13
	2	Not available	Plan Apo	50X	0.95
	3	Optional	DI	10X	0.3
	4	Optional	Plan	20X	0.46
▶	5	Mountg	Plan	10X	0.3
	6	Not available			

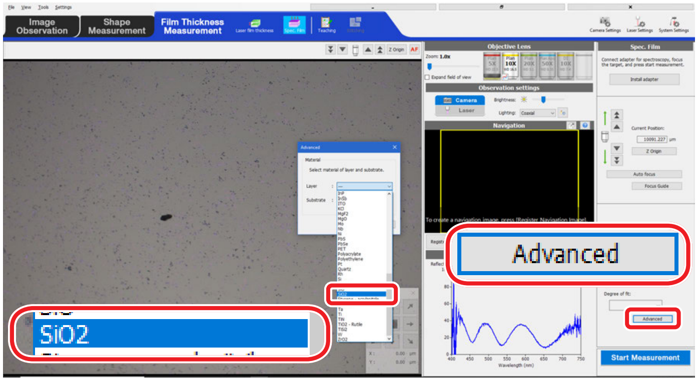
The adjustment is complete.

16. **Set the sample for the measurement, and adjust the focus.**

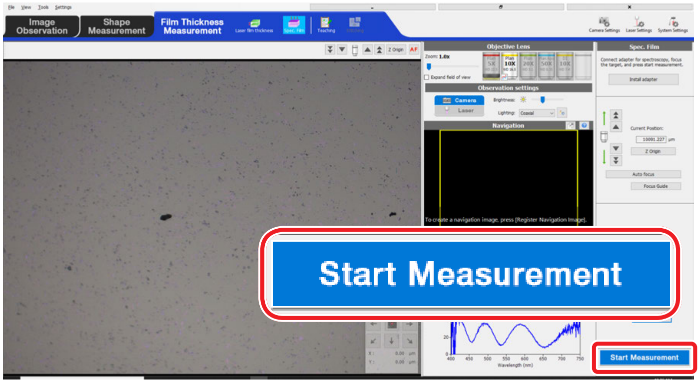


17. Set the film component in the advanced settings window as needed.

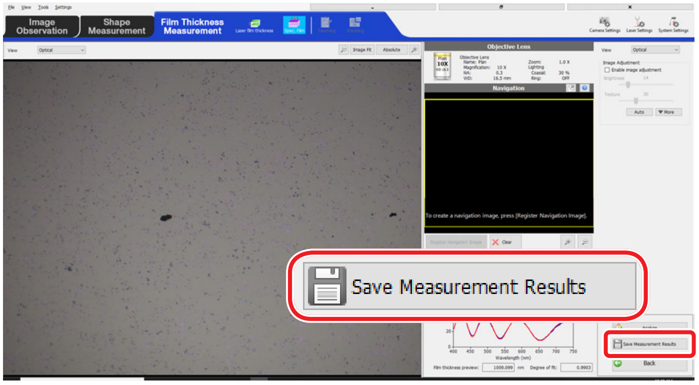
If the film component is one layer, selecting a film material will display [Film thickness preview] and [Degree of fit].



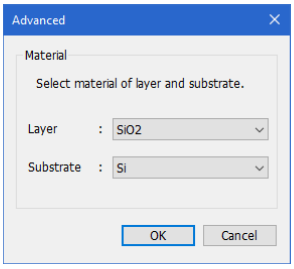
18. Click the [Start Measurement] button.



19. Save the measurement result.



- **Advanced settings**
  In the advanced settings dialog box, setting the base and film thickness material displays the [Film thickness preview] and [Degree of fit] in real time. Note that the measurement is performed without the film component setting if it is the sample with 2 or more layers.



Advanced

Material

Select material of layer and substrate.

Layer : SiO2
Substrate : Si

Point

Before starting measurement, adjust the focus and brightness to the best conditions.

4-2 Analyzing Spectral Film Thickness

Next, we will see how to analyze the obtained spectral film thickness data.

1. **Click the [Add data] button, and select the saved measurement data.**

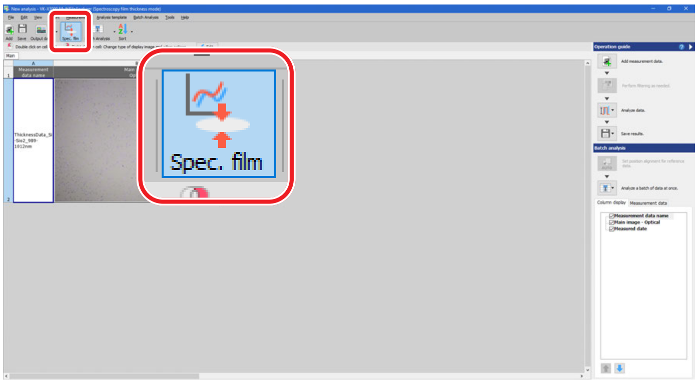
The obtained spectral film thickness data will appear.

Add data

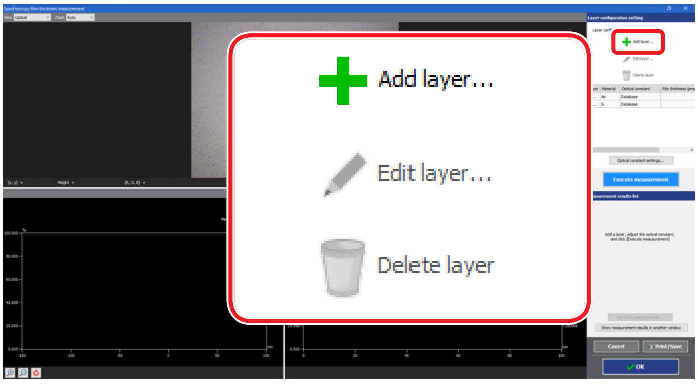
Click the above button to add measurement data and start analysis.

2. **Select the spectral film thickness measurement.**

On the toolbar, click the [Spec. film] button. Alternatively, you can select [Spectroscopy film thickness measurement] from the [Measurement] menu.



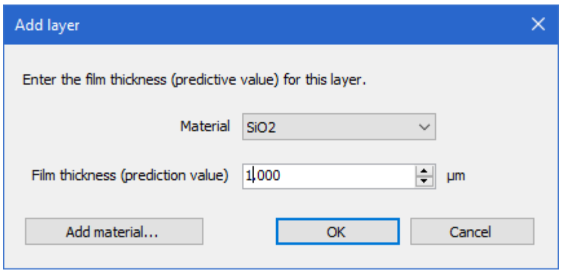
3. **Click the [Add layer] button in [Layer configuration setting] on the top right of the screen, and enter the layer configuration (material and thickness) of the measured sample.**



The [Add layer] window appears.

Select [Material] of the [Add layer] window from the pull-down menu.

In addition, enter the prediction value (design value) of the film.



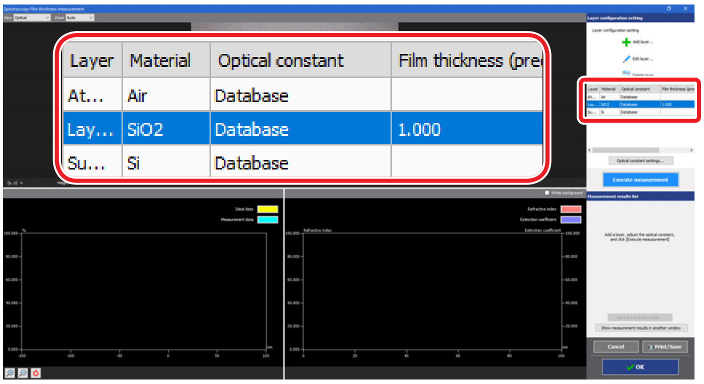
Enter the film thickness (predictive value) for this layer.

Material: SiO2

Film thickness (prediction value): 1.000 µm

Click the [OK] button.

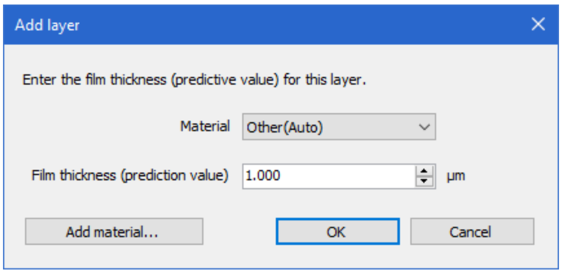
The layer of the material selected for the film component is added.



Layer	Material	Optical constant	Film thickness (pre
At...	Air	Database	
Lay...	SiO2	Database	1.000
Su...	Si	Database	

■ Automatic material judgment function

When selecting “Other(Auto)” for material of the [Add layer] window, the material with the highest fit degree from the entire database will be selected automatically.

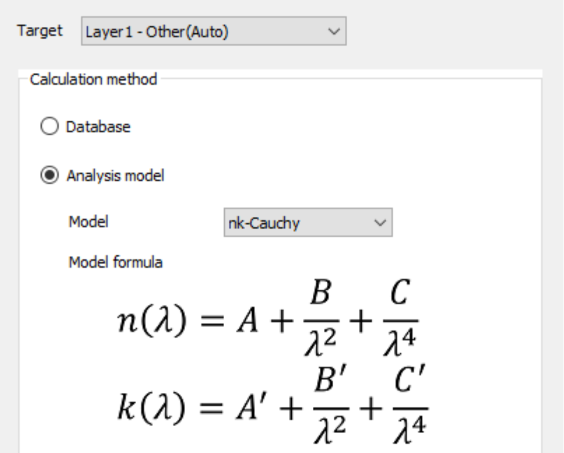


Enter the film thickness (predictive value) for this layer.

Material: Other(Auto)

Film thickness (prediction value): 1.000 µm

When selecting “nk-Cauchy” in the analysis model of the [Advanced settings for the optical constant] window, measurement results with higher fit degree can be acquired.



Target: Layer1 - Other(Auto)

Calculation method

○ Database

● Analysis model

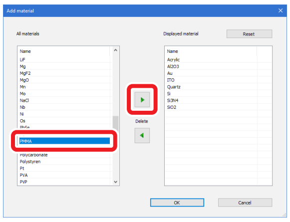
Model: nk-Cauchy

Model formula

$$n(\lambda) = A + \frac{B}{\lambda^2} + \frac{C}{\lambda^4}$$

$$k(\lambda) = A' + \frac{B'}{\lambda^2} + \frac{C'}{\lambda^4}$$

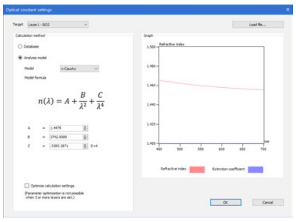
- **A note about the material**
  If the appropriate material does not exist in the material selection of the [Add layer] window, click the [Add material] button to display more materials from the database.



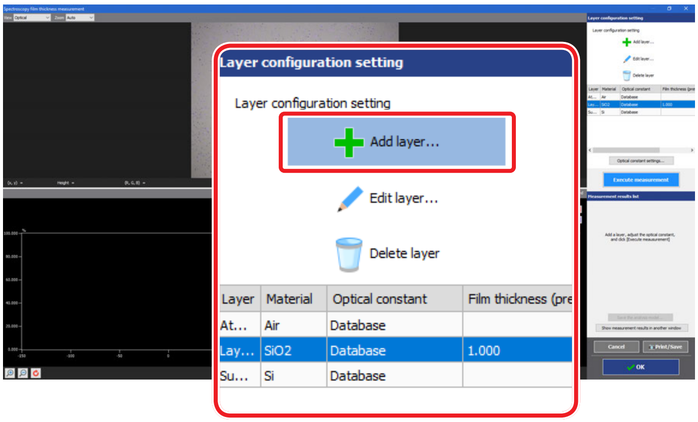
Select the material that you want to add, and click the [Add] button. It is added from the database to the “Show material” list. Click the [OK] button and confirm it.

- **Setting of the base and atmospheric air**
  Double-click the base as needed to change the settings of material etc.

- **Advanced settings for the optical constant**
  When an appropriate material does not exist in the material selection of the [Add layer] window or the [Add material] database, or when the material is an unknown sample, set the best calculation method from the analysis model for calculating optical constants.

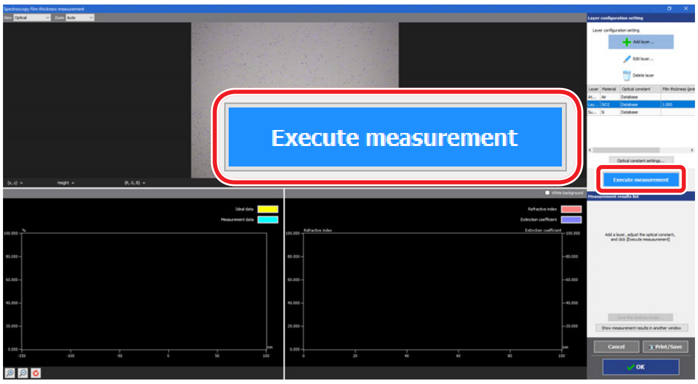


4. **If multiple layers exist on the sample, add additional layers and confirm the additional materials.**



Layer	Material	Optical constant	Film thickness (pre
At…	Air	Database	
Lay…	SiO2	Database	1.000
Su…	Si	Database	

5. **Click the [Execute measurement] button.**



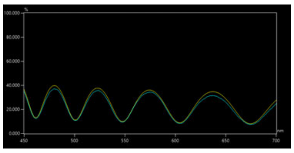
The measurement results of each film thickness appear in the measurement results list.

Layer	Material	Film thickness		Fit degree	Opt
Atm…	Air				Data
Lay…	SiO2	1.008	µm		Data
Sub…	Si				Data
All		1.008	µm	0.9628	

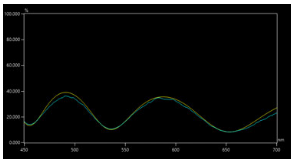
The film thickness values of each layer are displayed on the bottom right of the screen.

In addition, a graph showing the intensity of reflected light for each wavelength is displayed on the bottom left of the screen, and a graph showing the refractive index for each wavelength is displayed on the bottom left of the screen.

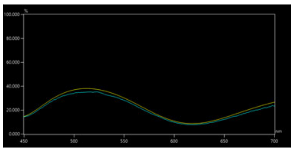
- **About the measurement result**
  When using spectral film thickness measurement, thicker films decrease the period of the waveform, displaying more waves in the chart. This change in waveform allows for thickness measurement.



SiO_2 2000 nm



SiO_2 1000 nm



SiO_2 500 nm

MEMO

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KEYENCE CORPORATION
1-3-14, Higashi-Nakajima, Higashi-Yodogawa-ku, Osaka, 533-8555, Japan PHONE: +81-6-6379-2211
www.keyence.com/glb

AUSTRIA
Phone: +43 (0)2236 378266 0
BELGIUM
Phone: +32 (0)15 281 222
BRAZIL
Phone: +55-11-3045-4011
CANADA
Phone: +1-905-366-7655
CHINA
Phone: +86-21-3357-1001
CZECH REPUBLIC
Phone: +420 220 184 700

FRANCE
Phone: +33 1 56 37 78 00
GERMANY
Phone: +49-6102-3689-0
HONG KONG
Phone: +852-3104-1010
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Phone: +36 1 802 7360
INDIA
Phone: +91-44-4963-0900
INDONESIA
Phone: +62-21-2966-0120

ITALY
Phone: +39-02-6688220
KOREA
Phone: +82-31-789-4300
MALAYSIA
Phone: +60-3-7883-2211
MEXICO
Phone: +52-55-8850-0100
NETHERLANDS
Phone: +31 (0)40 206 6100
PHILIPPINES
Phone: +63-(0)2-8981-5000

POLAND
Phone: +48 71 368 61 60
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Phone: +40 (0)269 232 808
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Phone: +65-6392-1011
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Phone: +421 (0)2 5939 6461
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Phone: +41 (0)43 455 77 30

TAIWAN
Phone: +886-2-2721-8080
THAILAND
Phone: +66-2-369-2777
UK & IRELAND
Phone: +44 (0)1908-696-900
USA
Phone: +1-201-930-0100
VIETNAM
Phone: +84-24-3772-5555

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