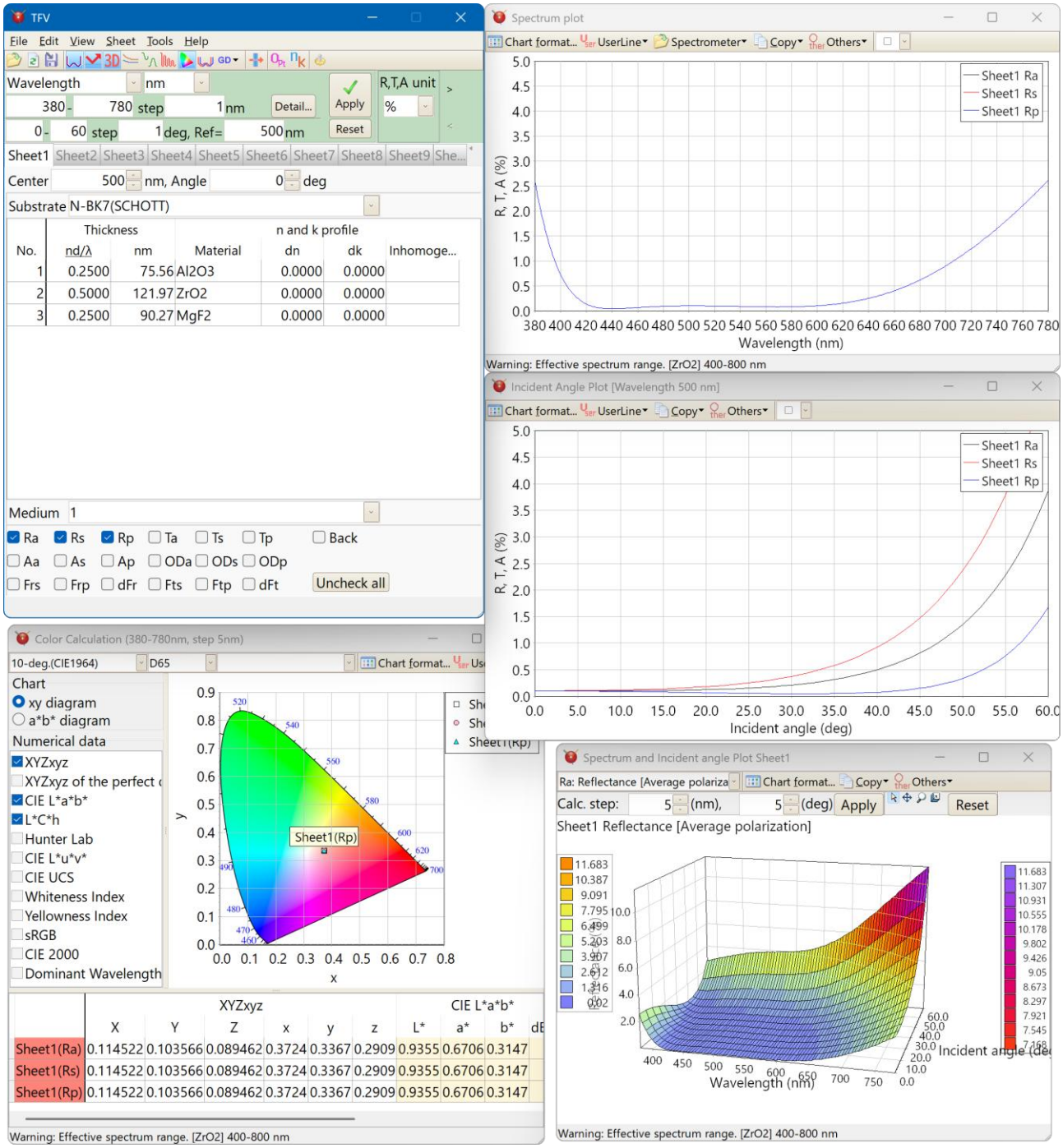
April 2025

User’s guide, 1st edition

Optical thin film design software TFV
Version 3.4

https://thinfilmview.com/



[Table of contents]

1. Summary

Features

Intuitive and easy operation.
Quick response by the real-time calculation system.
Thickness and refractive index can be changed quickly by using the slide bar or the up-and-down button with the mouse.
By the tab style sheet, the maximum of five film data can be calculated at the same time.
Supports many spectral types and units.

Functions

- Show the chart and the numerical value of reflectance, transmittance, absorption, optical density, phase, and group delay.

Spectrum type	Units
Wavelength	Å, nm, μm, mm
Frequency	PHz, THz, GHz
Wave number	cm^{-1}, μm^{-1}, 2π/cm
Angular frequency	rad/fs
Energy	eV, keV
g-Number	

Units of reflectance, transmittance and absorption
0-1, %, dB

Unit of phase change and incident angle
deg.

Group Delay type
GD: Group Delay
GDD: Group Delay Dispersion
CDC: Chromatic Dispersion Coefficient
TOD: Third Order Dispersion
FOD: Fourth Order Dispersion
5OD: Fifth Order Dispersion

Unit of Group Delay
fs, ps

- Show the chart and the numerical value of the dispersion data (n and k) of the substrate and the film material.
- The optical evaporation monitor simulation in consideration of the in-situ refractive index and of the tooling factor.
- Show the chart and the numerical value of the electric field intensity distribution.
- Color and color difference calculation.

  XYZxy, CIE L*a*b*, L*C*h, Hunter Lab, L*u*v*, UCS, Whiteness Index, Yellowness Index, sRGB, CIE2000, Dominant Wavelength
- Manufacturing errors analysis: Change analysis of the optical characteristic to the change in thickness, refractive index, and absorption coefficient of each layer. And Monte Carlo Simulation.
- Optimize design.

  Local search, Global search and Needle search.

- n and k analysis from mono layer measurement.
- Read the Spectrophotometer measurement data files and show it on the wavelength chart.

  Hitachi (UDSS, UDS, UDA, UV1 files), Olympus-USPM files, Shimadzu SPC files, Jasco JWS files, Ocean-Optics OOi-Base32 files, csv files. The relative measurement value is convertible in the absolute value.
- Show the user definition line on the chart.
- Periodic layer support.
- Japanese, English and Chinese-Traditional can be selected.

Specifications

The number of the maximum layers: 5000 layers (Grid row count less than 5000).

System requirements

· OS
Windows® 10 and 11.
Home or Pro Edition.
32bit or 64bit.

* It does not operate on Windows S mode.
* Does not work on Windows XP.
* Windows Vista, 7 and 8 are not supported (It may not work).

· CPU
Intel or AMD processor.
Intel Core i5 or AMD Ryzen5 or higher recommended.

· Memory
For 32bit OS, use up to 2GB of RAM.
For 64bit OS, use up to 4GB of RAM.
16GB or more are recommended.

· Screen resolution
Screen resolution of 1024 x 768 or higher.
Full HD (1920x1080) or higher is recommended.
Recommended screen with high resolution and large size.

· Storage capacity
Disk space capacity of 100 MB or more.

· USB port
One TYPE A port of USB 2.0 or 3.0 is required for hard key connection.
If your PC only has a Type-C port, please use a conversion adapter or USB hub.

2. Installation

Run the setup program from the CD-ROM or downloaded from the Client access page of the website (https://thinfilmview.com/en/userpage).

For more information, see the installation guide.
In order to set up, you must have Administrator privileges.

3. Using TFV

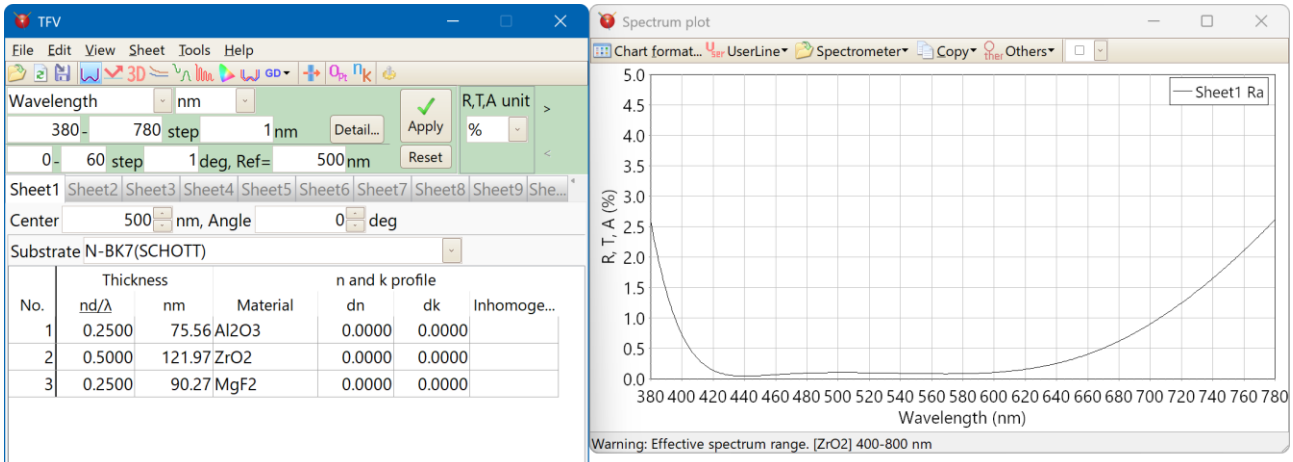
This chapter provides how to use TFV.

3.1. Start TFV

To start TFV, double-click [TFV] icon on the desktop.

When the TFV icon is not being created on the desktop, select [TFV] from Start menu ([Start] > [All Programs]* > [ThinFilmView] > [TFV].

Then, TFV main window and the spectrum chart appear.
The three layers AR coating design is shown on the main window as the example, and the calculation result is plotted on the spectrum chart.



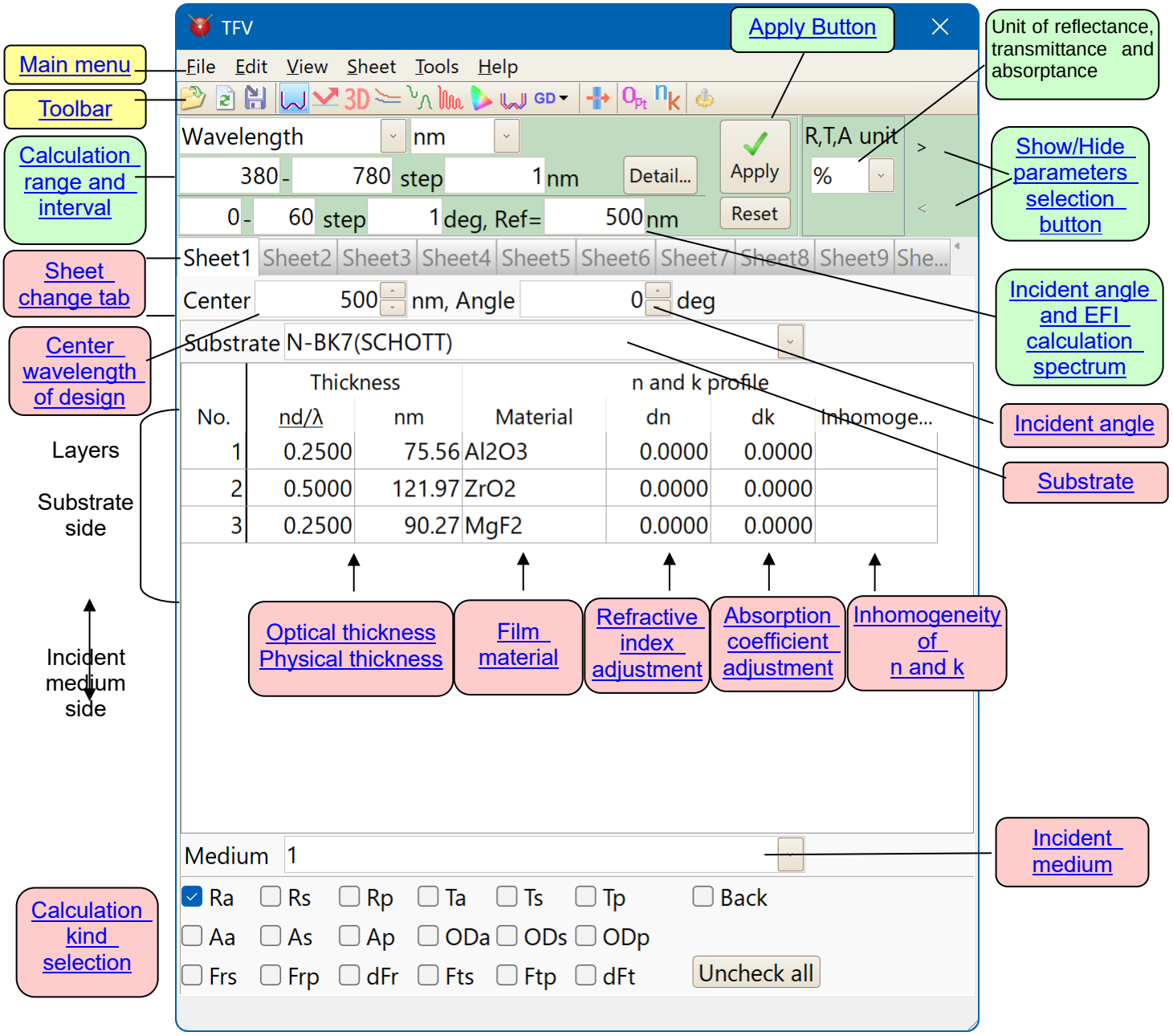
Spectrum plot window

Main window

* When error messages appear and TFV does not start, see the troubleshooting chapter. TFV must locate the hard key and load them before it can get started.

3.2. Main window

This is a brief explanation of the items displayed in the main window.

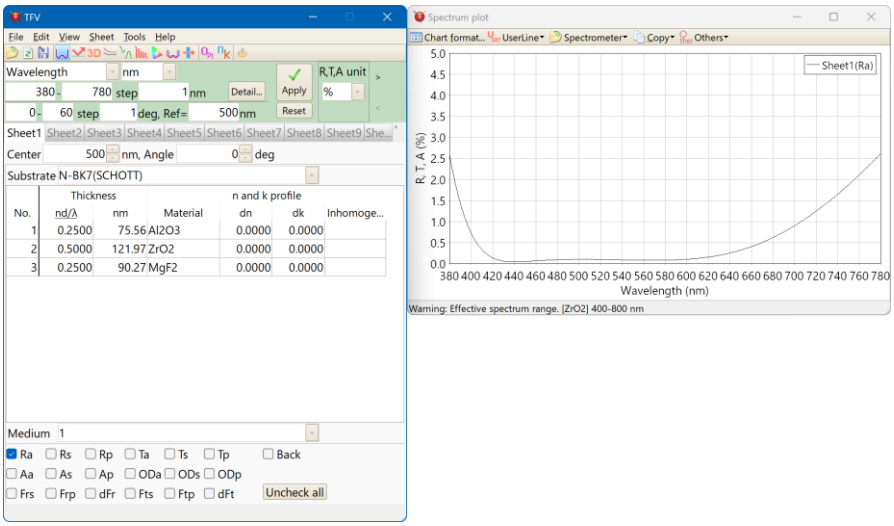


Design data can be registered in Sheet1 to Sheet20.

3.3. Explanation of calculation contents

3.3.1. Calculation of thin film at one interface

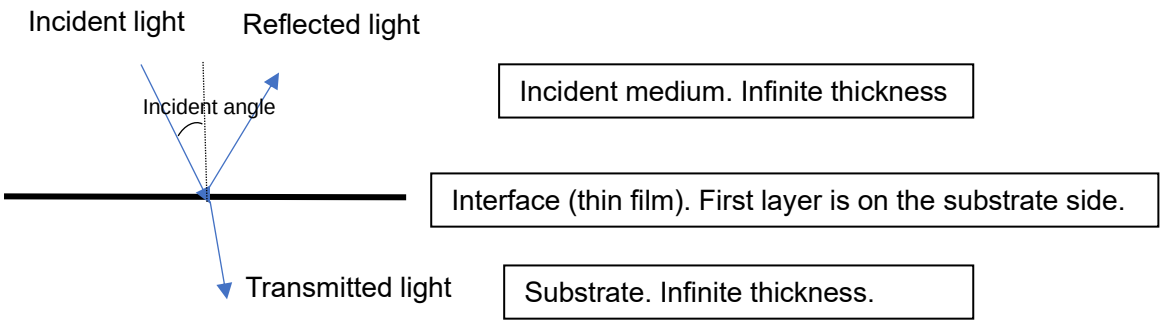
The contents calculated using the design data of each sheet in the main window are as follows.



The meaning of the design data displayed in Sheet1 of the main window shown above is as follows.

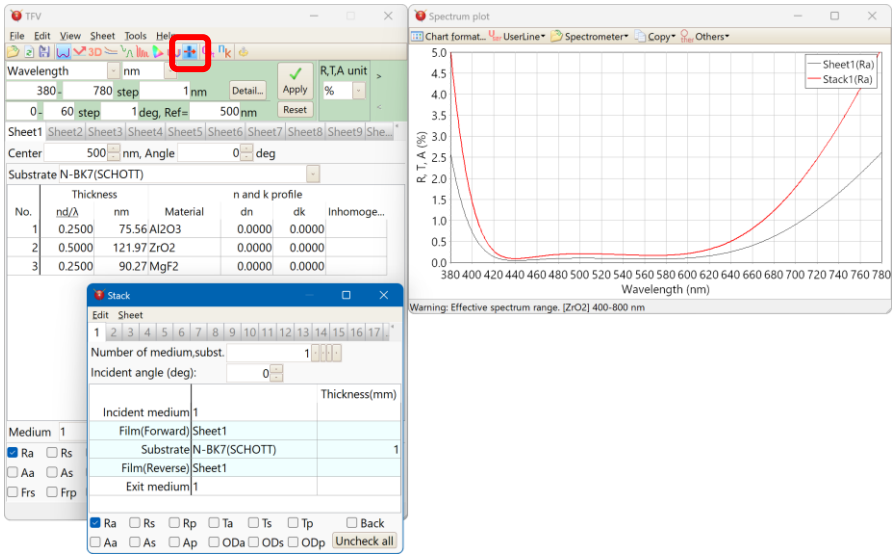
Substrate	SCHOTT BK-7	Thickness: Infinite
Thin film on substrate 1st layer	Al2O3	Film thickness nd=0.25λ, d=75.56 nm
Thin film on substrate 2nd layer	ZrO2	Film thickness nd=0.5λ, d=121.97 nm
Thin film on substrate 3rd layer	MgF2	Film thickness nd=0.25λ, d=90.27 nm
Medium (incident medium)	1 (air)	Thickness: Infinite
Center (center wavelength of design)	λ=500 nm	
Angle (Incident angle of light ray)	0 degree	

The reflectance shown below is displayed on the spectrum graph (Sheet1(Ra)).
Reflectance = reflected light ÷ incident light



3.3.2. Calculation of thin films with multiple reflections at multiple interfaces (stack)

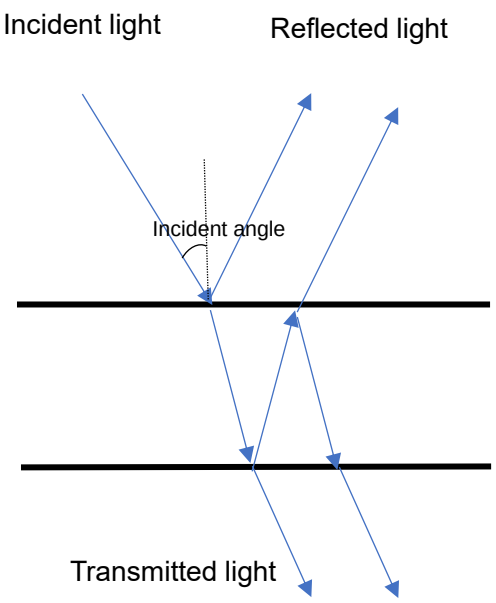
The stack feature allows you to calculate sums across multiple interfaces.



The meaning of the stack window shown above is as follows.

Incident medium	1 (air)	Thickness: Infinite
Film (Forward)	Thin film of Sheet1 of the main window. The first layer is on the substrate side.	
Substrate	SCHOTT BK-7	Thickness: 1mm
Film (Reverse)	Thin film of Sheet1 of the main window. The first layer is on the substrate side.	
Exit medium	1 (air)	Thickness: Infinite
Incident angle	0 degree	

The red line (Stack1(Ra)) on the spectrum plot shows the reflectance shown in the figure below.
Reflectance = reflected light ÷ incident light



Within thin films, light interferes.
Inside the medium or substrate, light does not interfere and undergoes multiple reflections (because it is thick, there is no interference).

Incident medium. Infinite thickness

Interface (thin film)

Substrate. Finite thickness.

Interface (thin film)

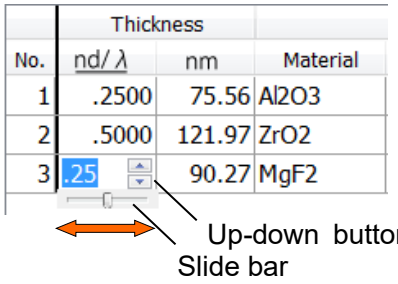
Exit medium. Infinite thickness

3.4. How to operate the film data

3.4.1. Changing the thickness

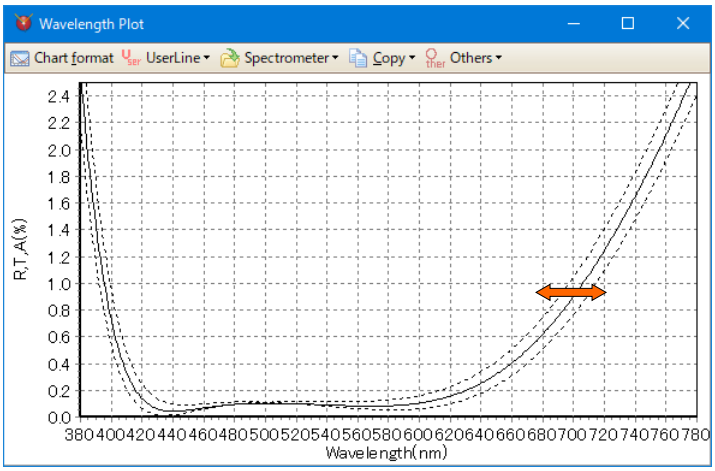
Click the numerical of “Thickness” column, then the slide bar and up-down button appear around the cell. Drag the slide bar, then the thickness value will change and the plot of the spectrum chart will also change automatically.

It is similar even with the up-down button.



Move the slide bar knob, and the thickness will change.

The chart will also change.



- How to use the keyboard.

You can use the keyboard to change the thickness. There are two ways as follows.

(1) How to move the slide bar by the keyboard.

Click the slide bar and then press the allow key. Then thickness will change.

The fault with this way is that the thickness can be changed only from the right end to the left end of the slide bar. The following way has not this limitation.

(2) How to change the thickness by the keyboard without using the slide bar.

Click the numerical cell **(do not click the slide bar)** and then press the arrow key **with Ctrl key**, then thickness changes. (But the slide bar does not move.) If press the upward or downward arrow key without Ctrl key, then current cell will move to another layer. You can change each layer thickness by the keyboard.

You can use Page-Up and Page-Down key instead of the arrow key. Then the amount of change thickness will double.

Press the Home key when returning to the original thickness.

Press the Enter key when relating the present thickness to the slide bar knob in the center.

3.4.2. Selecting the thickness display format

You can select the thickness display format.

Display columns	(1) Both optical and physical thickness. (2) Optical thickness only (3) Physical thickness only (4) Automatic switch optical and physical thickness(Previous version style) In automatic switch mode, if less than 10 value is entered then it will be calculated as the optical thickness, if ten or more value is entered then it will be calculated as the physical thickness.
Thickness unit	Unit of physical thickness: Angstrom, nm, μm or mm. Unit of optical thickness: nd/Lambda or QWOT. ※ If you select the (4) automatic switch mode then the unit of physical thickness is fixed to Angstrom and the unit of optical thickness is fixed to nd/Lambda.
Priority	Select then thickness priority when you select the both optical and physical thickness display. If the priority is Optical thickness, then the optical thickness remains constant when the center wavelength or the refractive index is changed and the displayed optical thickness are used for calculation. If the priority is Physical thickness, then the physical thickness remains constant and the displayed physical thickness are used for calculation.

(1) Both optical and physical thickness.

	Thickness	
No.	nd/λ	Å
1	.2500	755.6

	Thickness	
No.	QWOT	nm
1	1.0000	75.56

(2) Optical thickness only

	Thickness
No.	nd/λ
1	.2500

	Thickness
No.	QWOT
1	1.0000

(3) Physical thickness only

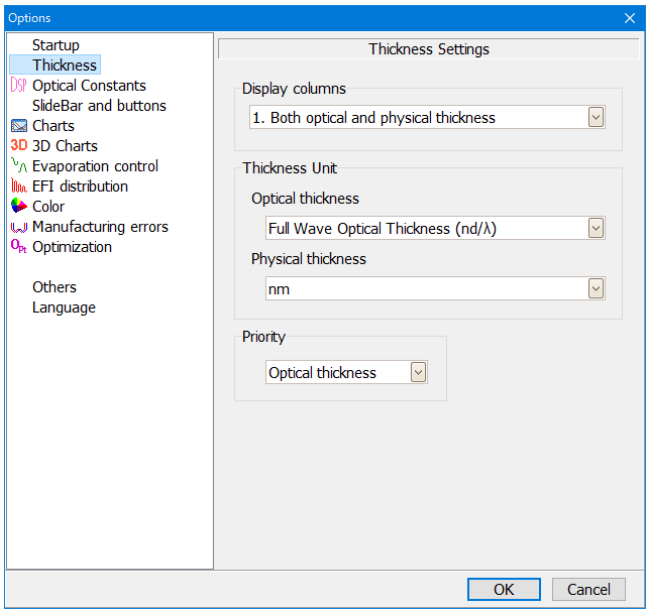
	Thickness
No.	nm
1	75.56

	Thickness
No.	Å
1	755.6

(4) Automatic switch optical and physical thickness(Previous version style)

	Thickness
No.	nd/λ or Å
1	.2500

For change these settings, select the [Options] from the [Tools] menu or toolbar and select [Thickness].



- Thickness priority

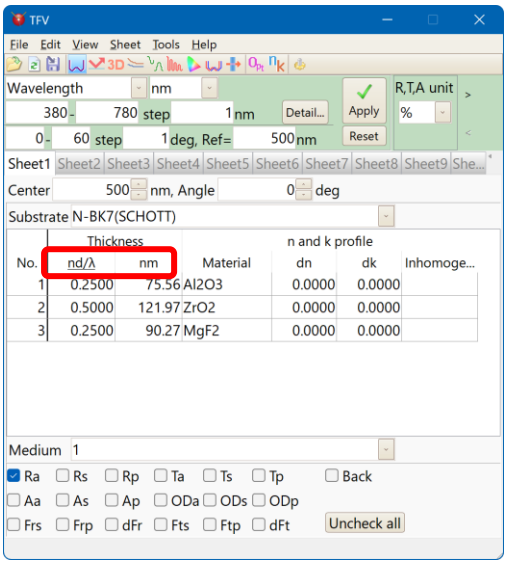
If [1. Both optical and physical thickness] is selected, it is necessary to select which of the optical thickness and the physical thickness is given priority in the [Priority] column.

[Operation in optical thickness priority]

When the center wavelength and refractive index are changed, the display value of the optical thickness is fixed and the physical thickness is changed. The optical thickness is used for calculation.

[Operation in physical thickness priority]

When the center wavelength and refractive index are changed, the display value of the physical thickness is fixed and the optical thickness is changed. The physical thickness is used for calculation.



An underline appears below the preferred thickness units.

- Note

When you change the priority, there is a slight error in calculation by the floating point.

Also, when the priority is different in save the film data and read the film data, there is a slight error in calculation.

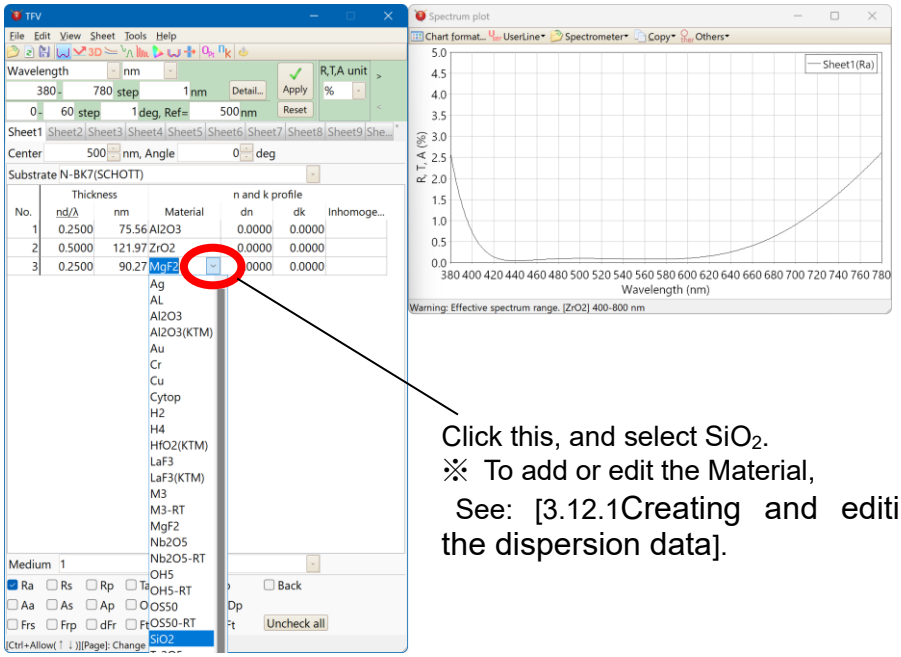
3.4.3. Changing the material

Click the cell of “Material” column, then the downward button will appear in the right side of the cell. Click this button, then the list of the film material will be displayed. You can select film material from this list. If there is no film material to use, the refractive index value can also be inputted directly.

- Example: How to change the film material of the 3rd layer into SiO_2 from MgF_2.

Click the MgF_2 cell of the 3rd layer and click the downward button, then the list of the material will appear. Select the SiO_2 from the list, then the film material of the 3rd layer will change to SiO_2 and the plot of the spectrum chart will also change.

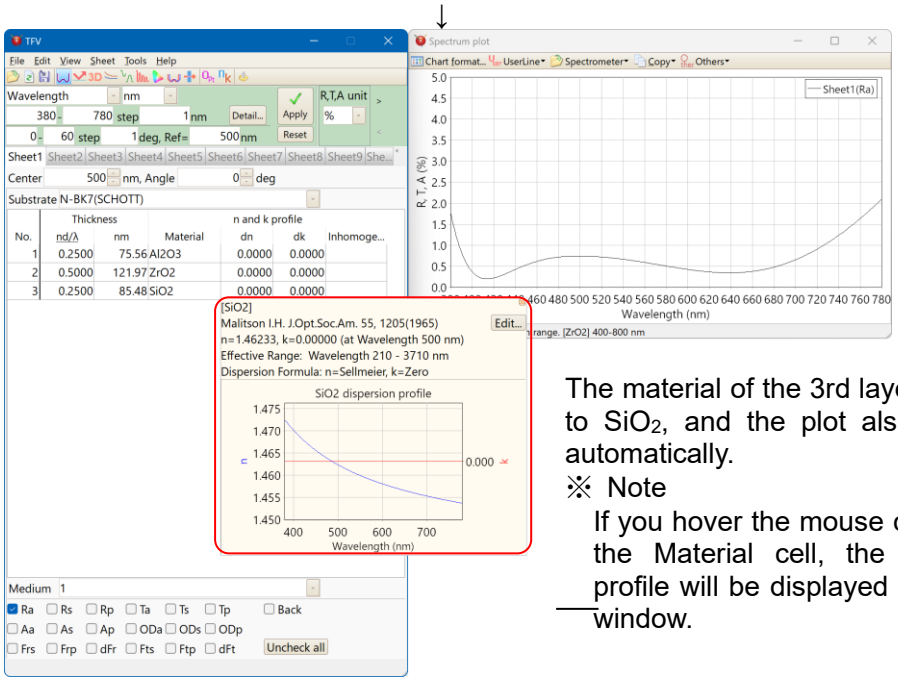
If select the MgF_2 again, then the plot of the spectrum chart will return.



Click this, and select SiO_2.

※ To add or edit the Material,

See: [3.12.1Creating and editing the dispersion data].



The material of the 3rd layer changes to SiO_2, and the plot also changes automatically.

※ Note

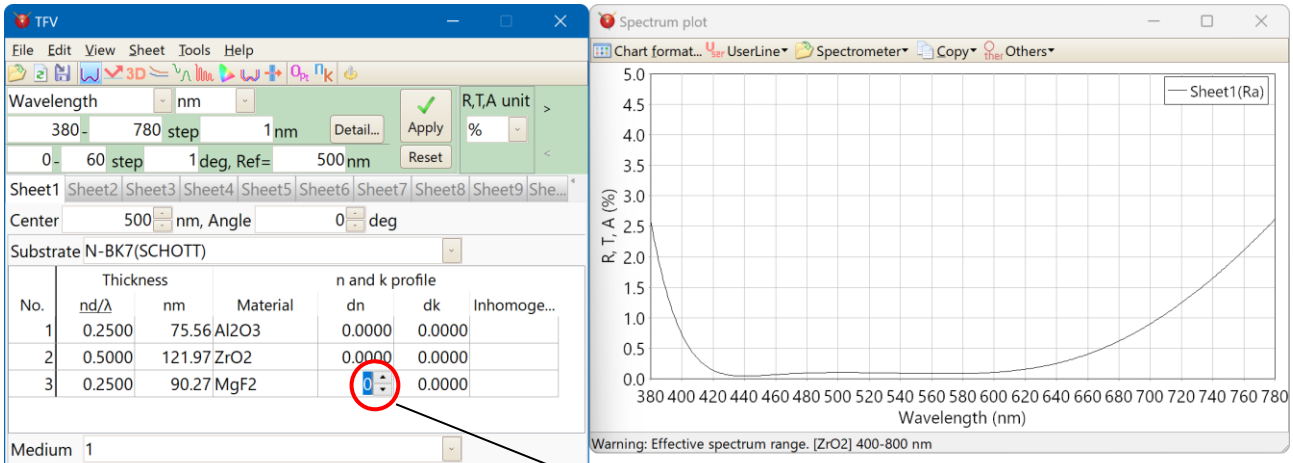
If you hover the mouse cursor over the Material cell, the dispersion profile will be displayed in a popup window.

3.4.4. Adjusting the refractive index (n)

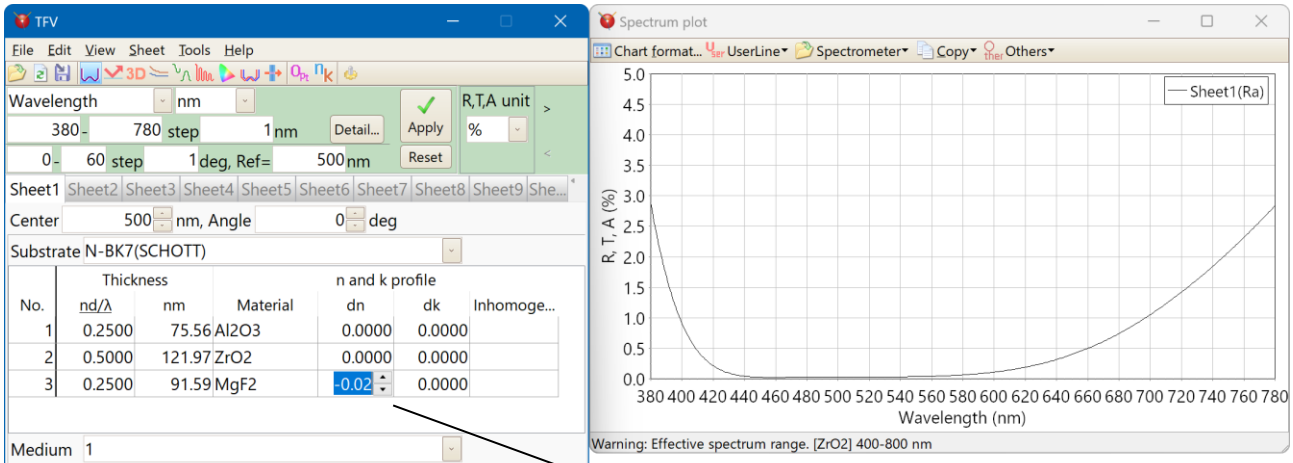
Click the cell of “dn” column, then the up-down button will appear. If you click the upward button, then the refractive index will become high. If you click the downward button, then the refractive index will become low.

This adjustment is increase and decrease of the refractive index specified by “Material”.

- Example : How to decrease 0.02 the refractive index of MgF_2 of the 3rd layer.
  Click the 3rd layer cell of “dn” column and click the downward button twice, and the value in the cell will change to -0.02. The refractive index of the 3rd layer decrease 0.02.



The refractive index will increase if you click the upward button.
The refractive index will decrease if you click the downward button.
Click the downward button twice, then the value of the cell will be changed as -0.02.



The refractive index of MgF2 decreases by 0.02 across all wavelengths.
The chart plot will change automatically.

In this case, the refractive index of MgF2 becomes 1.3648 at 500nm (1.3848 - 0.0200 = 1.3648).
The refractive index at other wavelengths is similarly reduced by -0.02.

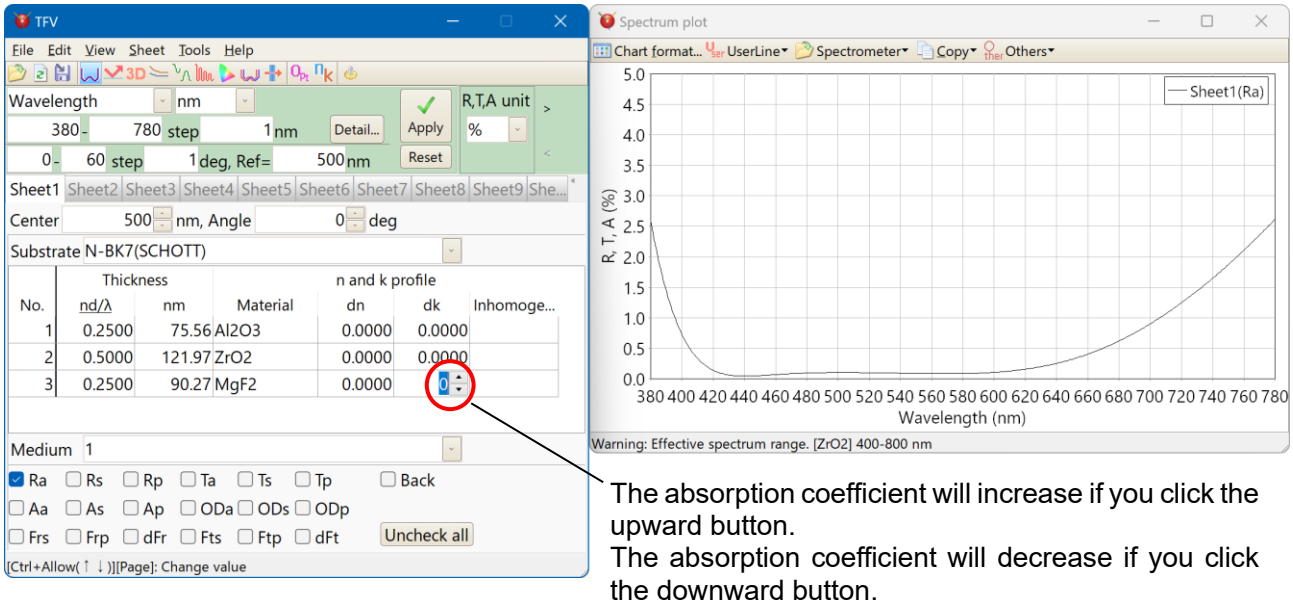
※ The quantity of change when button click that can be changed. See: [3.13.1Options]

3.4.5. Adjusting the absorption coefficient (k)

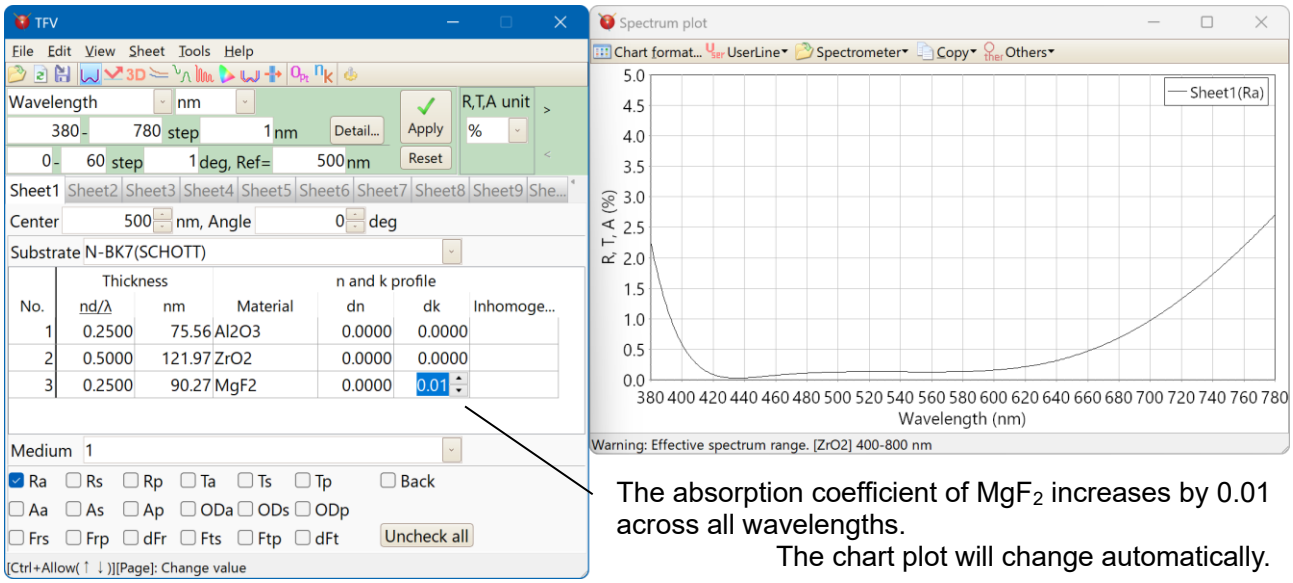
Click the cell of “dk” column, then the up-down button will appear. If you click the upward button, then the absorption coefficient will become high. If you click the downward button, then the absorption coefficient will become low.

This adjustment is increase and decrease of the absorption coefficient specified by “Material”.

- Example: How to increase 0.01 the absorption coefficient of MgF_2 of the 3rd layer.
  Click the 3rd layer cell of “dk” column and click the upward button twice, then the value of the cell will be changed as 0.01. The absorption coefficient of the 3rd layer increase 0.01.



The absorption coefficient will increase if you click the upward button.
The absorption coefficient will decrease if you click the downward button.
Click the upward button twice, and the value in the cell will change to 0.01.



The absorption coefficient of MgF_2 increases by 0.01 across all wavelengths.
The chart plot will change automatically.

In this case, the absorption coefficient of MgF2 becomes 0.01 at 500nm (0.0000 + 0.0100 = 0.0100).
The absorption coefficients at other wavelengths are similarly increased by +0.01.

※ The quantity of change when button click that can be changed. See: [3.13.1Options].

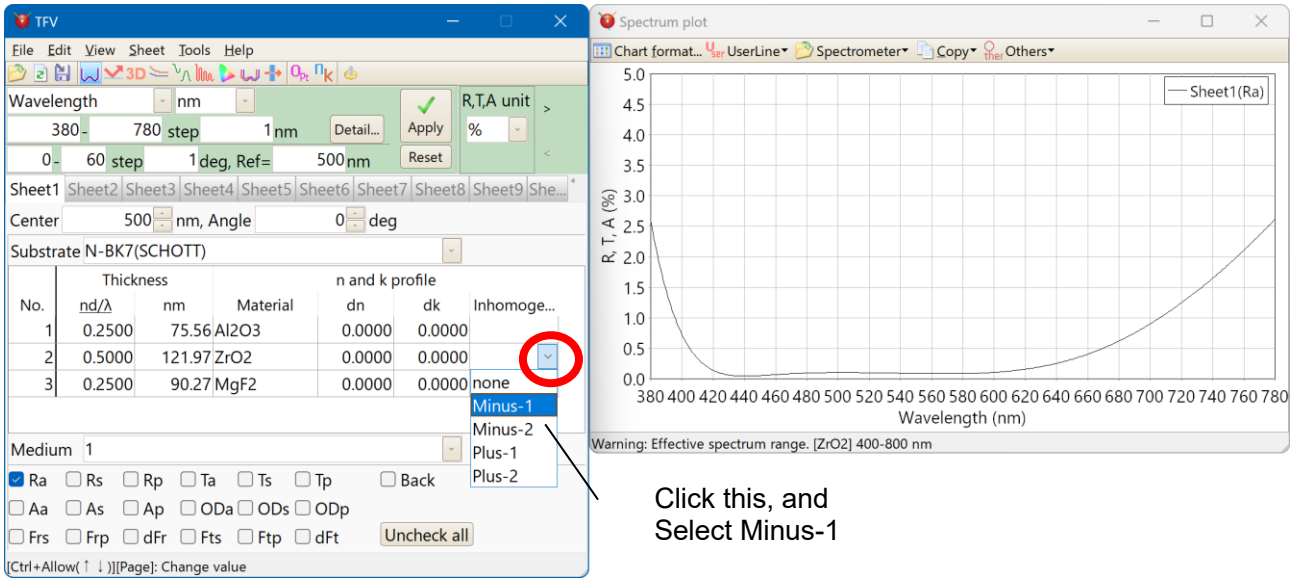
3.4.6. Selecting the inhomogeneity of n and k

Click the cell of “Inhomo...” column, then the downward button will appear in the right side of the cell. Click this button, then the list of the inhomogeneity will be displayed. You can select inhomogeneity from this list.

- Example: How to set the minus inhomogeneity in 2nd layer ZrO_2 .

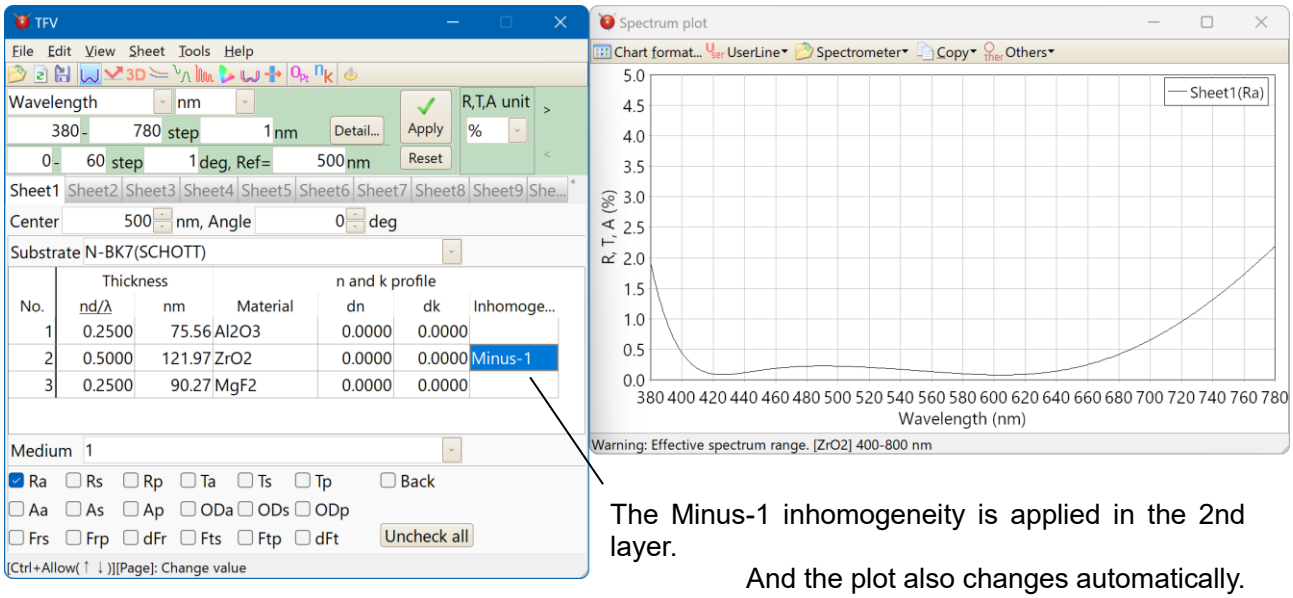
Click the ‘Inhomo...’ cell of the 2nd layer and click the downward button, then the list of the inhomogeneity will appear. Select the Minus-1 from the list, and then the minus inhomogeneity is applied in the 2nd layer.

If you select “none” then the inhomogeneity is canceled.



Click this, and
Select Minus-1

↓

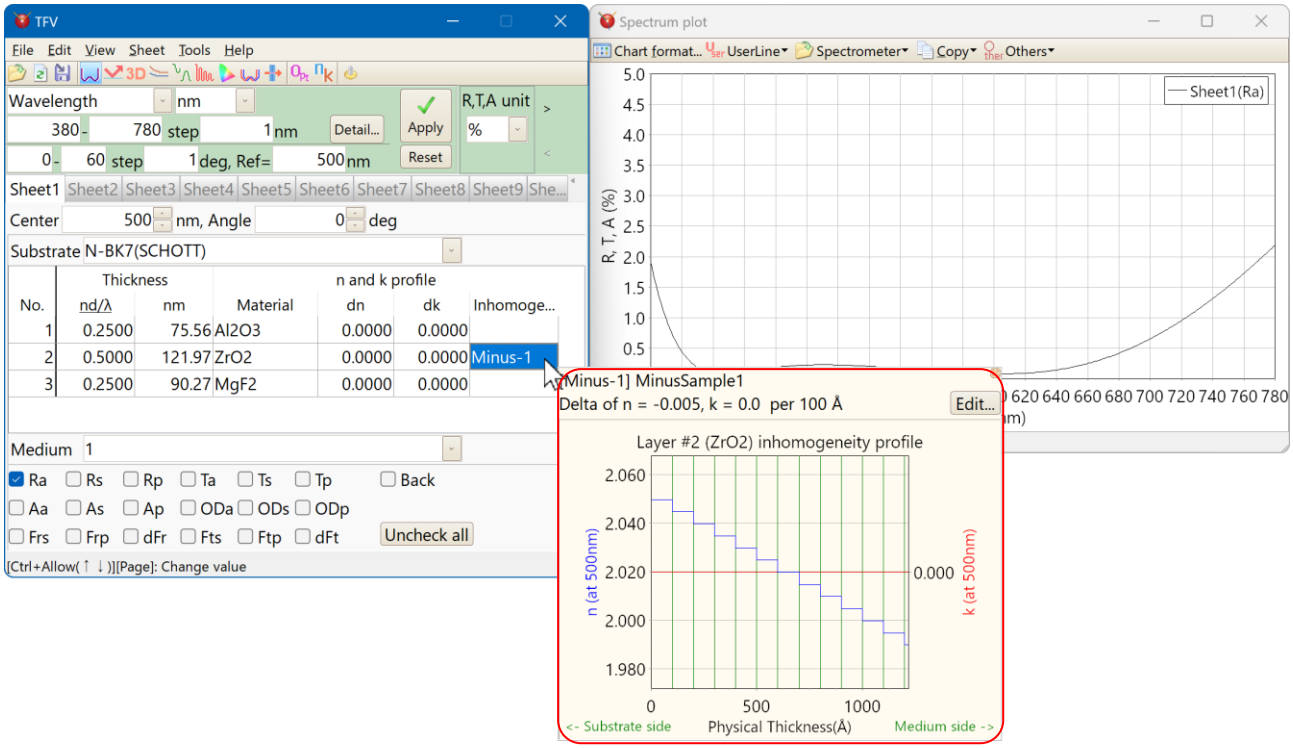


The Minus-1 inhomogeneity is applied in the 2nd layer.

And the plot also changes automatically.
In this case, the characteristic became wide band due to the minus inhomogeneity.

※ Note

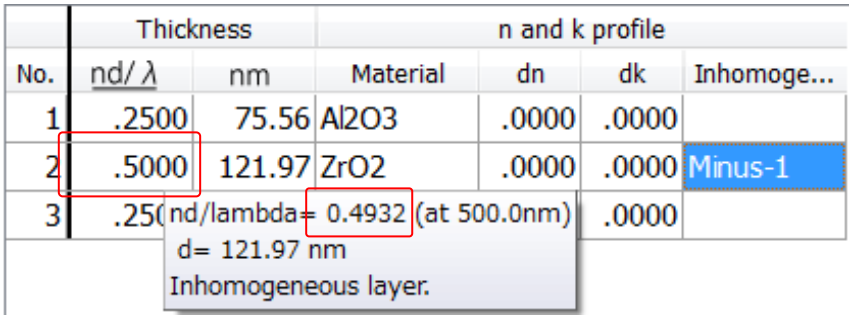
If the mouse pointer is hovered over the “Inhomo...” cell, then the Inhomogeneity profile are displayed on the popup window.



※ Note

If you set the optical thickness, the displayed optical thickness is different to actual optical thickness because the index (n) is change in inhomogeneous layer.

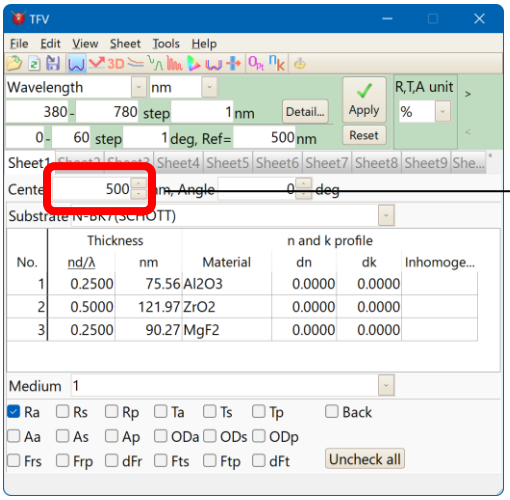
In this case (Minus-1), the displayed optical thickness is 0.5 and then actual optical thickness is nd/λ=0.4932.



※ To add or edit the inhomogeneity parameters, See: [3.12.3Creating and editing the inhomogeneity parameters].

3.4.7. Changing the center wavelength (reference wavelength) of the design

Click the up-down button in the red frame of the following figure, then the center wavelength will be changed.



Center wavelength of the design

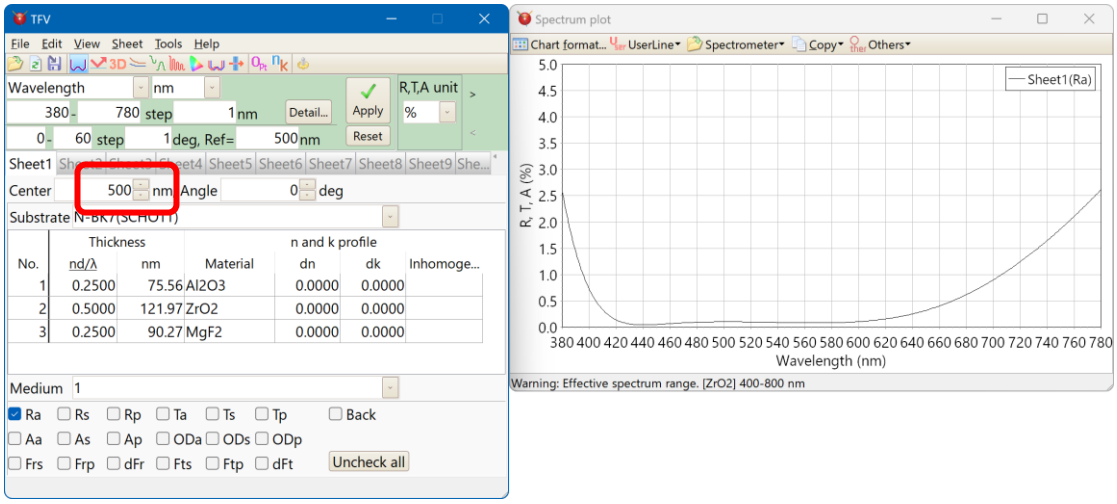
In this example, if the thickness value is 0.25 (1st layer and 3rd layer of the left figure) then the optical thickness is 125nm (nd = 0.25 × 500nm) where the center wavelength is 500nm.

If you want to change the center wavelength without changing the thickness, see: [3.4.8Changing the center wavelength but not change thickness]

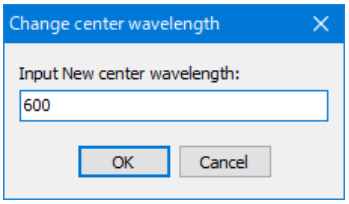
3.4.8. Changing the center wavelength but not change thickness

Select the menu [Edit] - [Change center wavelength (fix nd)...] or right click on the sheet tab and select [Change center wavelength (fix nd)...]. Input new center wavelength and push [OK]. Then the center wavelength is changed and the “thickness” value is also changed automatically as it keeps the same characteristic of the film.

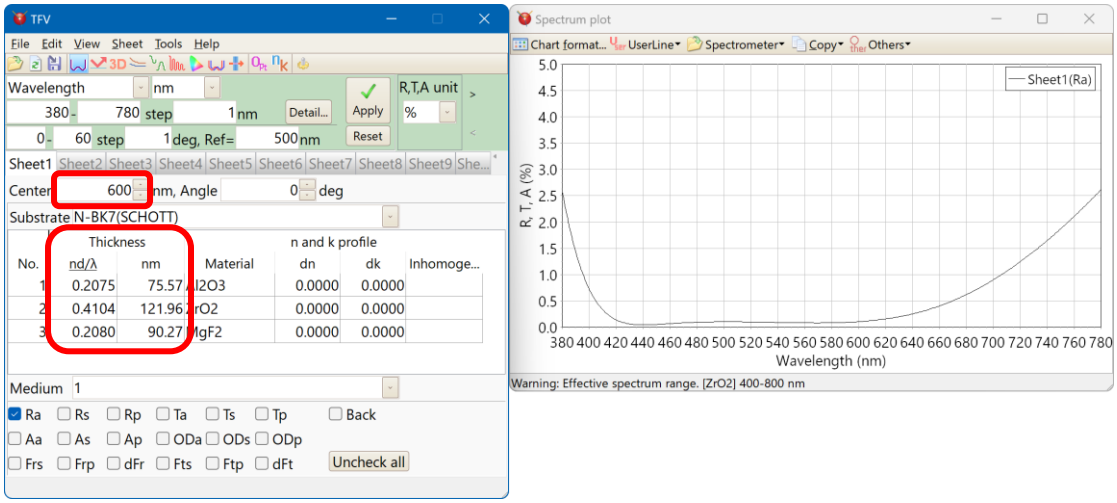
- Example: Change center wavelength from 500nm to 600nm as keep the same characteristic of the film



Select the menu [Edit] - [Change center wavelength (fix nd)...] or right click on the sheet tab and select [Change center wavelength (fix nd)...]. Input :600.



↓

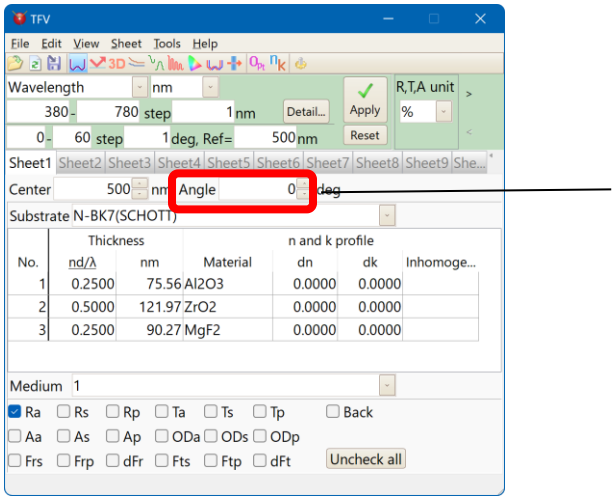


The center wavelength “Center” is changed from 500 nm to 600 nm, and the numerical value in the optical thickness field is adjusted. Reflection characteristics are nearly equal before and after center wavelength change. A slight shift occurs due to the error of the decimal point display digit number.

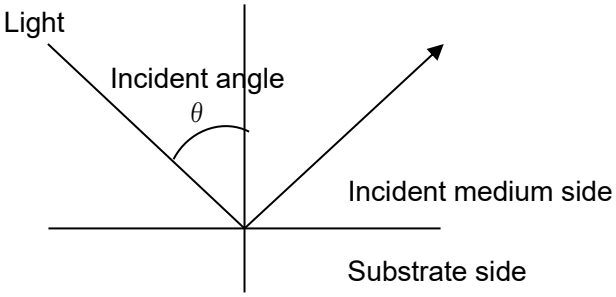
3.4.9. Changing the incident angle of the light

Click the up-down button in the red frame of the following figure, then the incident angle of the light will be changed.

The valid input range is 0 to 89.9999 degrees.

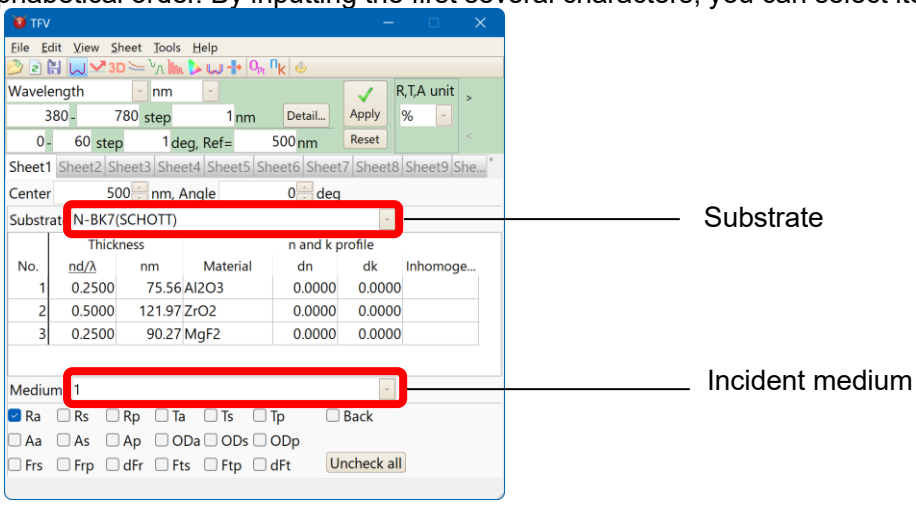


Incident angle of the light (degree)



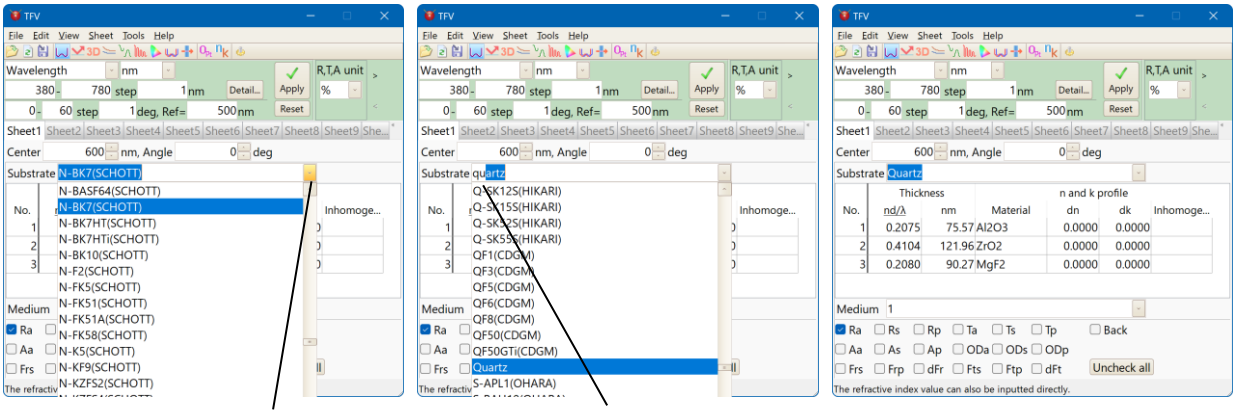
3.4.10. Changing the substrate and the incident medium

Click the downward button in the red frame of the following figure, then the list of the glass data will be displayed. You can select substrate glass from this list. The listed items have been sorted into alphabetical order. By inputting the first several characters, you can select items quickly.



- Example: Changing the substrate to “quartz”.

Click the downward button of the substrate column, and the list of glass data will appear. Input “qu” by the keyboard, then “Quartz” will be chosen. The spectrum chart plot will change automatically. You can close the list by pressing Enter or clicking the arrow button.



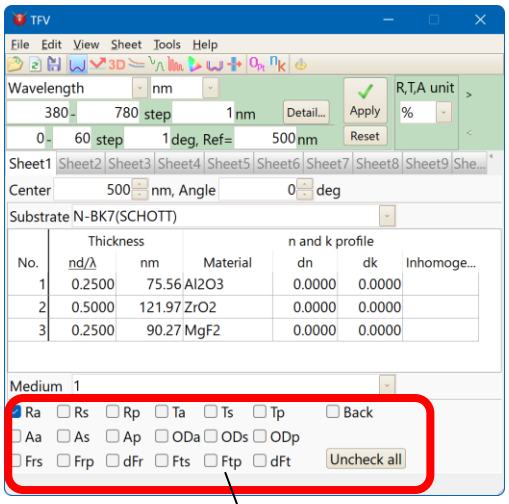
For opening the list, click the button → Input “qu” → For closing the list, press the enter

The incident medium can be changed by same way. 1 (= air) has been specified to the incident medium as default value. If there is no glass to use in this list, the refractive index value can also be inputted directly.

The incident medium is always calculated with an absorption coefficient (k) = 0.

3.4.11. Selecting the kind of the plot on the chart (reflectance, transmittance, absorptance, optical density, phase shift, polarization)

The kind of the plot is chosen by the check box located in the bottom of the main window.



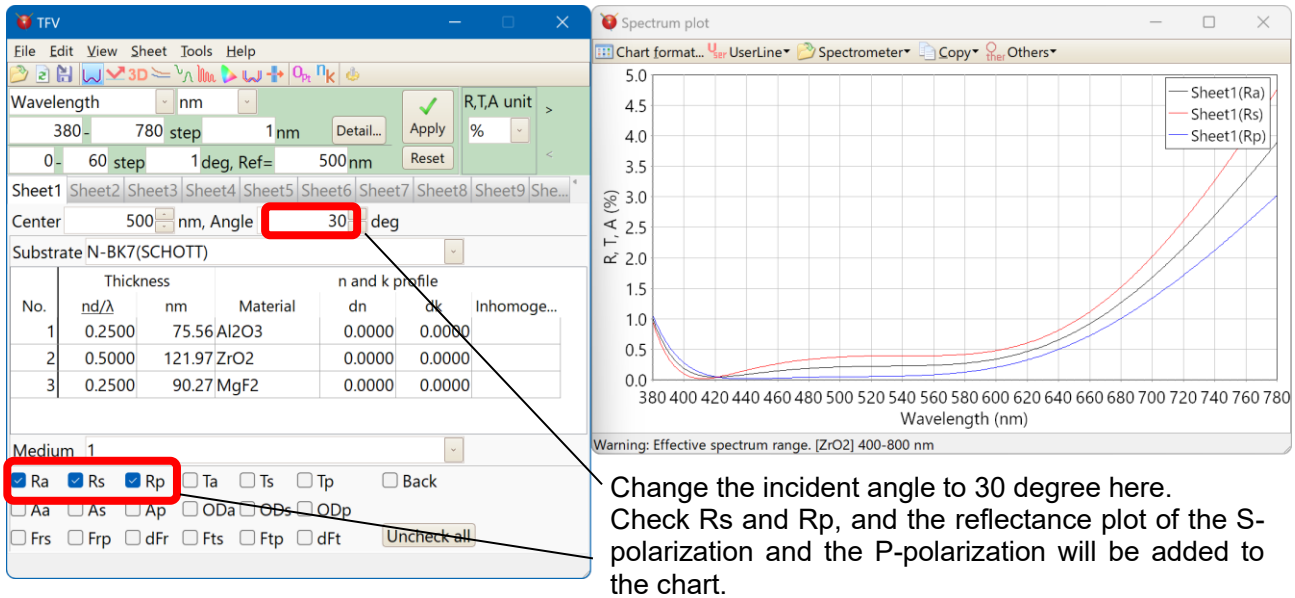
Kind of the plot

Ra	:	Reflectance (Average of s and p)
Rs	:	Reflectance s-polarization (TE)
Rp	:	Reflectance p-polarization (TM)
Ta	:	Transmittance (Average of s and p)
Ts	:	Transmittance s-polarization (TE)
Tp	:	Transmittance p-polarization (TM)
Aa	:	Absorptance (Average of s and p)
As	:	Absorptance s-polarization (TE)
Ap	:	Absorptance p-polarization (TM)
ODa	:	Optical density (Average of s and p)
ODs	:	Optical density s-polarization (TE)
ODp	:	Optical density p-polarization (TM)
Frs	:	Reflection phase shift s-polarization (TE)
Frp	:	Reflection phase shift p-polarization (TM)
dFr	:	Reflection phase difference (Frs-Frp or Frp-Frs)
Fts	:	Transmission phase shift s-polarization (TE)
Ftp	:	Transmission phase shift p-polarization (TM)
dFt	:	Transmission phase difference (Fts-Ftp or Ftp-Fts)
Back	:	Calc. for incident light from the reverse side
Unckeck all	:	Uncheck all.

As the default, Ra (Average reflectance of the S-polarization and the P-polarization) is chosen and plotted.

- Example : Plotting Rs (S-polarization of the reflectance) and Rp (P-polarization of the reflectance) on the chart.

  Check the Rs and Rp, then the three plots of Ra, Rs, Rp will be plotted on spectrum chart. If the incident angle is 0 degree, then the three plots overlap each other. Therefore the incident angle has been changed to 30 degree here.



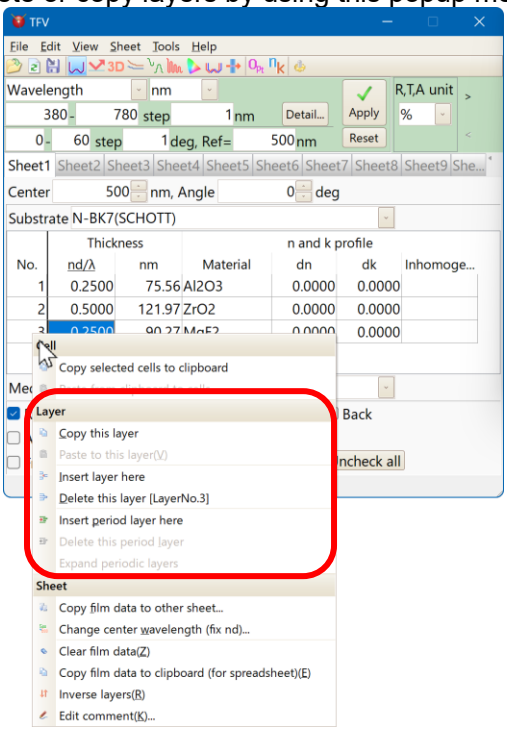
Change the incident angle to 30 degree here.
Check Rs and Rp, and the reflectance plot of the S-polarization and the P-polarization will be added to the chart.

You can plot Transmittance (Ta, Ts, Tp), Absorptance (Aa, As, Ap) and Reflective phase shift (Frs, Frp, dFr) by the same way.

* If the plot lines have over the range (ex. transmittance plot), then change Y-axis settings by double-click on the chart. Please refer to the chapter of operating the chart.

3.4.12. Adding, deleting or copying the layer

Right click the cell of the main window, and then the popup menu is displayed. You can add, delete or copy layers by using this popup menu.



・Example

【Adding layer】

Right-click the 3rd layer cell and select [Insert layer here], and the new layer will be added between the 2nd layer and the 3rd layer.

【Deleting layer】

Right-click the 3rd layer cell and select [Delete this layer], and the 3rd layer will be deleted.

【Copying a layer】

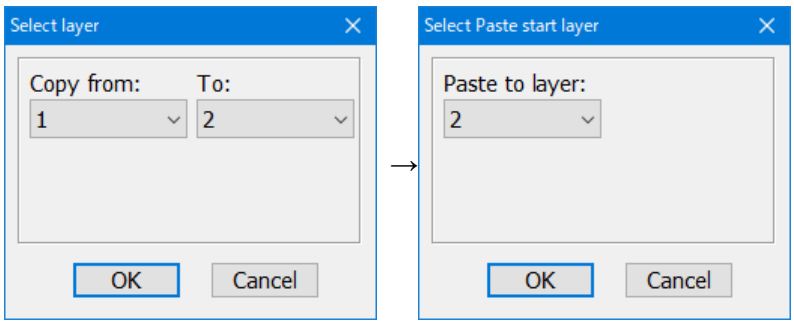
Select the [Copy this layer], then copy layer information to clipboard.

And then right click the layer to copy, select the [Paste to this layer].

【Copying more than one layers】

Select the [Edit] - [Copy Layer to clipboard...] from the menu. Then Select [Copy from:] and [To:], push [OK].

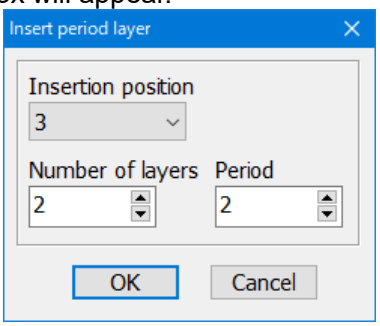
And then select [Edit]-[Paste Layer from clipboard...], select [paste to layer:].



In this case, the 1st-layer and the 2nd-layer is copied to the 2nd-layer and 3rd-layer respectively.

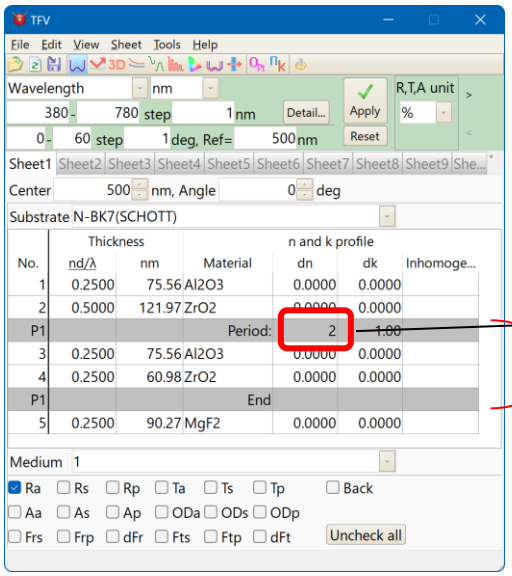
3.4.13. Setting the periodic layer

Select [Insert period layer here] from above-mentioned popup menu, then “Insert period layer” dialog box will appear.



Insertion position : Layer No.(In left case, periodic layer insert before the 3rd layer.)
Number of layers : The number of layers in the periodic layer.
Period : The cycle of the periodic layer.

Click the OK button, and the periodic layer will be inserted as shown in the following figure.



A periodic layer is between gray rows (from “Period:” to “End”).

The number on the right-hand side of “Period:” is the cycle of the periodic layer. Click this cell, then up-down button appears and the cycle can be changed easily.

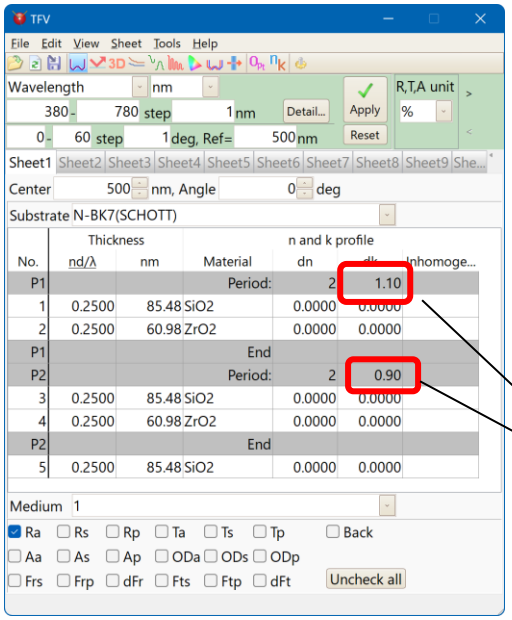
In left case, it is becoming the following.
Subst./Al_2O_3/ZrO_2/Al_2O_3/ZrO_2/Al_2O_3/ZrO_2/MgF_2/Air

Cycle

Periodic layer. Periodic layer(Cycle:2)

To delete the periodic layer, right-click the gray row and select [Delete this period layer].

- Setting the magnification of the periodic layer



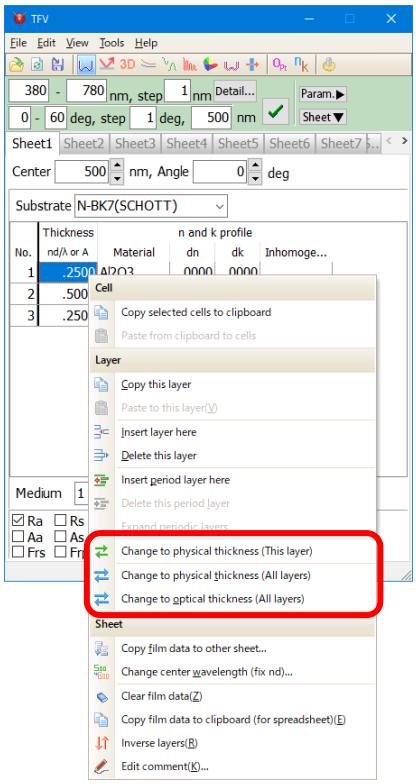
You can set the magnification of the thickness in the periodic layer.
In left case, the magnification is 1.1 at first periodic layer (P1), and the magnification is 0.9 at second periodic layer (P2).

The magnification is multiplied by the thickness in the periodic layer.
For example, when the magnification is 1.10, then the thickness is 0.25 × 1.10=0.275. When the magnification is 0.90, then the thickness is 0.25 × 0.90=0.225.

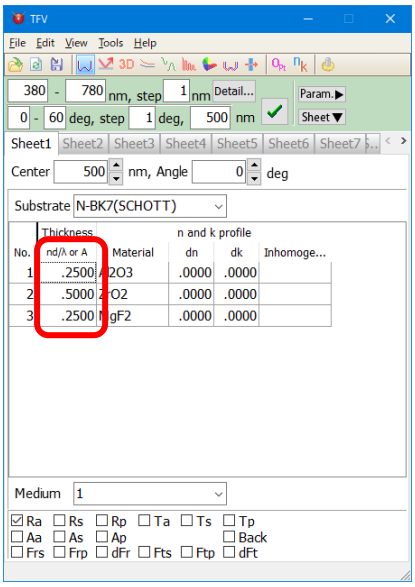
Magnification

3.4.14. Converting the optical thickness and physical thickness

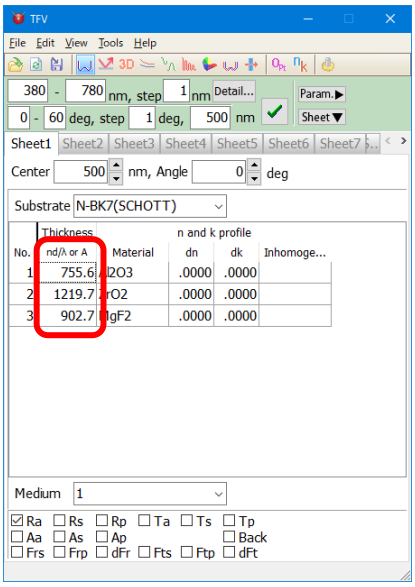
To convert the optical thickness and physical thickness vice versa, select [Edit] - [Change to physical thickness (All layers)]·[Change to optical thickness (All Layers)] from menu, or select [Change to physical thickness (this layer)]·[Change to optical thickness (this Layer)]·[Change to physical thickness (All layers)]·[Change to optical thickness (All Layers)] from right click popup menu on layer.



Optical thickness



Physical thickness



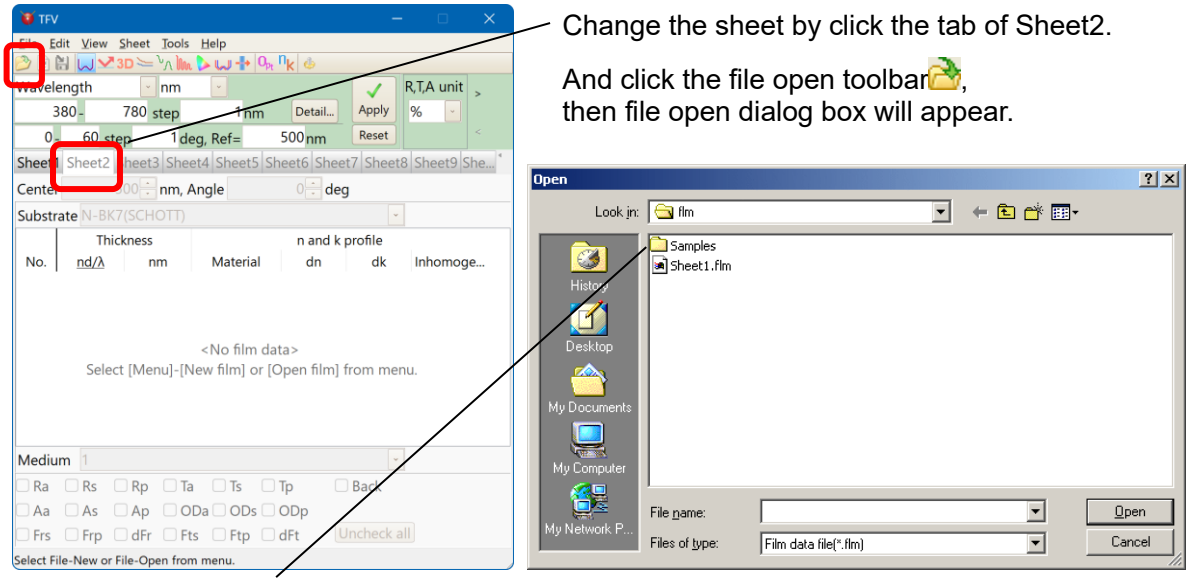
※ For computational error of the decimal point, the characteristics on the plot and the converted value has slight difference.

3.4.15. Changing the sheet and showing another film data

You can display the film data to five on the chart. It is convenient to compare the film data with the others.

- Example

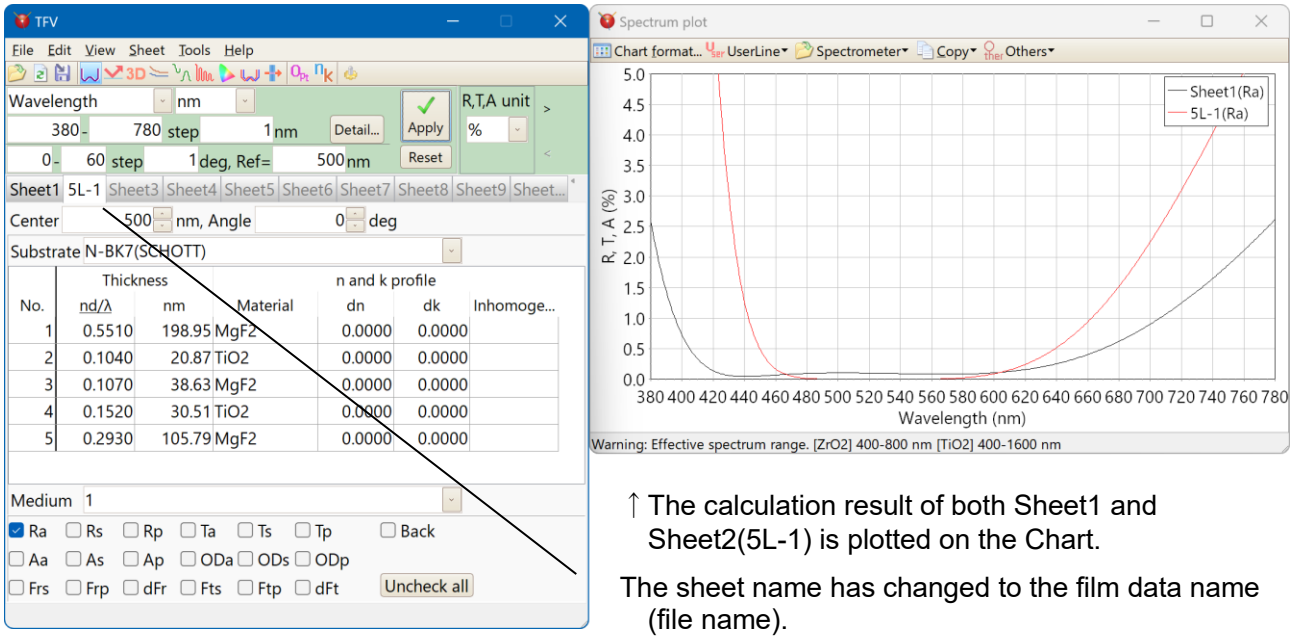
Reading the sample of the five-layer AR coating into Sheet2.



Change the sheet by click the tab of Sheet2.

And click the file open toolbar, then file open dialog box will appear.

Double-click the [Samples] folder and double-click the [AR] folder, then the sample list of the AR coatings will appear. Select the 5L-1 and click the Open button, then the film data of the 5L-1 will be displayed on Sheet2 and the calculation result will be displayed on the spectrum chart.



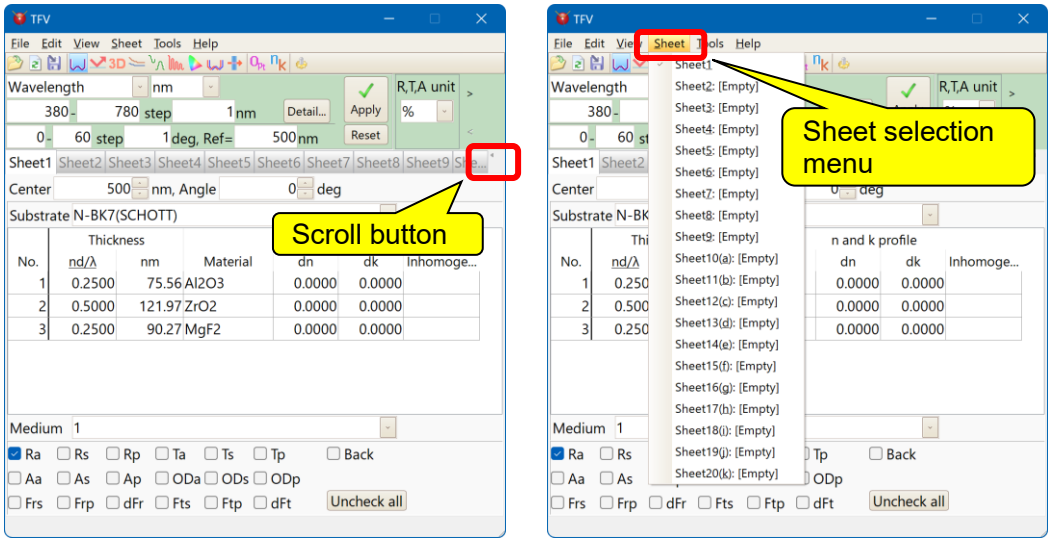
↑ The calculation result of both Sheet1 and Sheet2(5L-1) is plotted on the Chart.

The sheet name has changed to the film data name (file name).

※ You can change the plot color on the chart by double-clicking on the chart.

3.4.16. Selecting a sheet

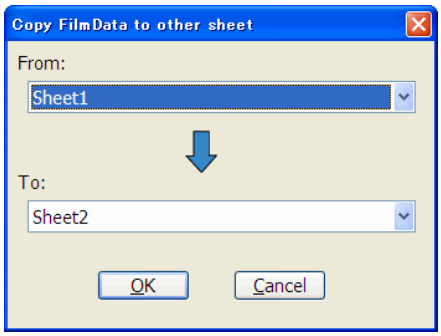
To select a hidden sheet, you can use the [scroll button] or [sheet selection button].



3.4.17. Copying the film data to the other sheet

To copy the film data to the other sheet, select [Edit]-[Copy film data to other sheet...] in menu or select [Copy film data to other sheet...] in right click popup menu on the sheet tab.

Following window appear, then select the sheet names and push [OK]..

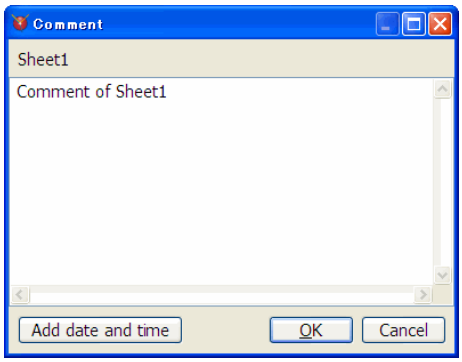


3.4.18. Editing the comments of the film data

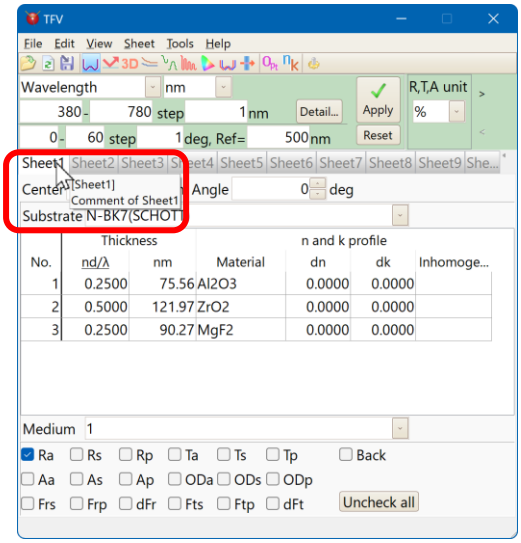
To edit the comments of the film data, select [Edit] - [Edit comment...] in the menu or select [Edit comment...] in right click popup menu on the sheet tab.

Following window appear, then input your comments and push [OK].

If you push [Add date and time]. then the current date and time is added in the comments.

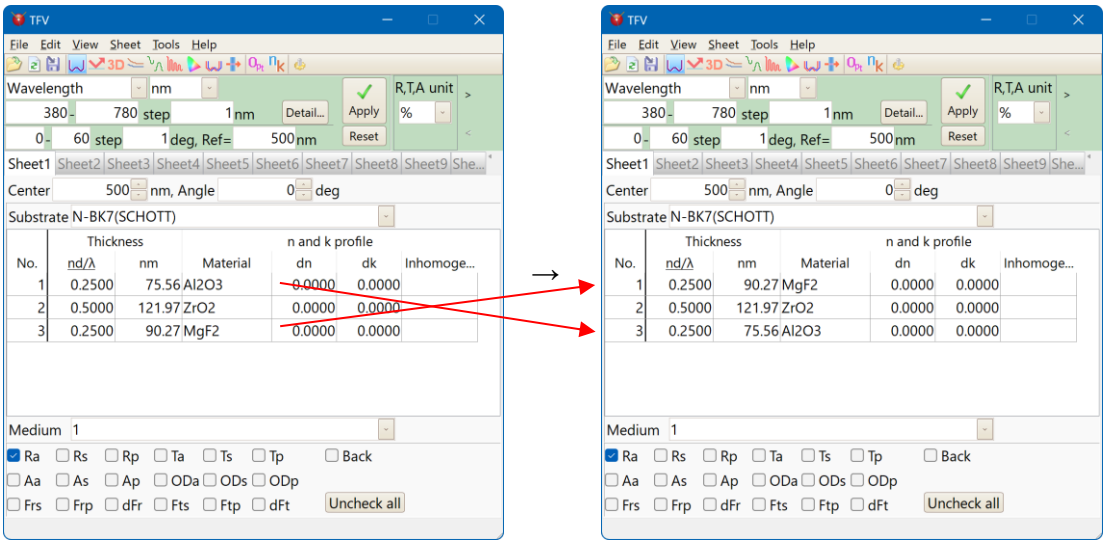


The comments will be appeared when you put the mouse cursor on the sheet tab.



3.4.19. Inversing the layers

To inverse the layers, select [Edit] - [Inverse layers] in the menu or select [Inverse layers] in right click popup menu on the sheet tab.



※ If there are inhomogeneous layers, It does not become complete inverse. For example, the minus inhomogeneous layer has been minus inhomogeneity after inverse.

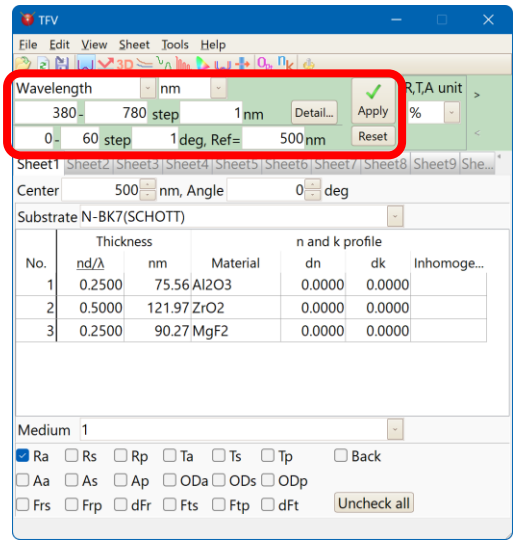
3.4.20. Changing the calculation ranges and the calculation intervals (x-axis of the spectrum chart and the incident angle chart)

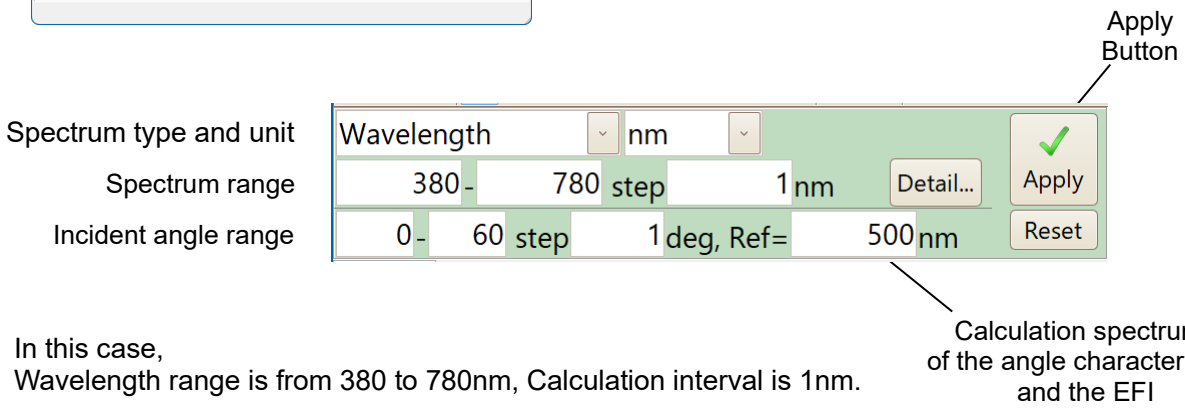
You can change the calculation ranges and the calculation intervals. The calculation ranges and the calculation intervals can be changed by the light green area between the toolbar and the sheet tab of the main window. The upper row of the light green area is for the spectrum range. The lower row of the light green area is for the incident angle range. The incident angle range is used for the incident angle chart. For information of the incident angle chart, see 3.6.2Incident angle plot chart

In the spectrum range setting field, you can set the spectrum type and unit, and the spectrum calculation range. The supported spectrum types and units are as follows.

Spectrum type	Units
Wavelength	Å, nm, μm, mm
Frequency	PHz, THz, GHz
Wave number	cm^{-1}, μm^{-1}, 2π/cm
Angular frequency	rad/fs
Energy	eV, keV
g-Number	

In the incident angle range setting field, you can set the calculation range of the incident angle characteristics. The unit of incident angle is deg.
(An incident angle of 90 degrees is calculated as 89.9999 degrees.)



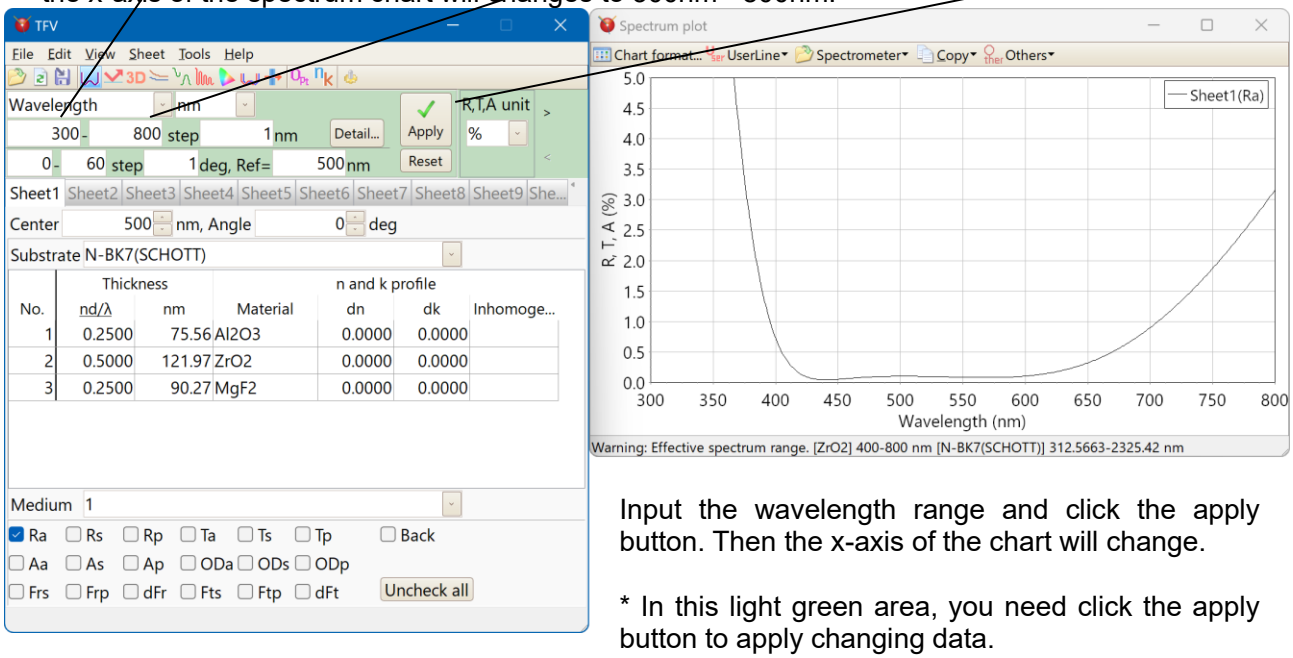


In this case,
Wavelength range is from 380 to 780nm, Calculation interval is 1nm.

※ **After changing the settings, press the "Apply" button. It will not be reflected in the calculation results until you press the "Apply" button.**
※ **Press the reset button to return to the initial value (the state when TFV was started).**

- Example ： Changing the wavelength range to 300nm - 800nm.

Input 300 into start spectrum area and 800 into end spectrum area. Click the apply button. Then the x-axis of the spectrum chart will changes to 300nm - 800nm.



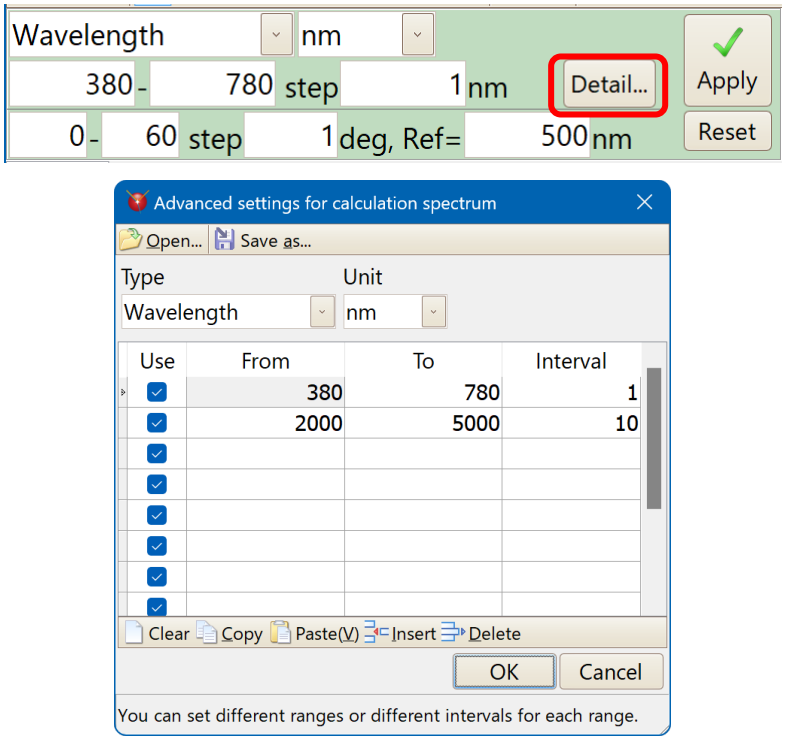
Input the wavelength range and click the apply button. Then the x-axis of the chart will change.

* In this light green area, you need click the apply button to apply changing data.

Although it will be more finely calculated if you change the spectrum interval and the incident angle interval to small, the calculation time become long. It will be a quick calculation if you change this interval to large, but the chart plot line become rough.

3.4.21. Set multiple spectrum ranges

When "Detail ..." in the spectrum range designation column is pushed, a window for setting the spectrum range for calculating spectral characteristics in detail is displayed. You can set the spectrum ranges intermittently or set different intervals for each range.



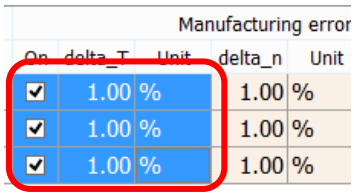
Command	Function
Open…	Open the spectrum range setting file.
Save as…	Save the spectrum range setting file.
Use	Checked: This row is used. Unchecked: This row is not used.
Clear	Clear the contents of this table.
Copy	Copy the contents of this table to clipboard.
Paste	Paste to this table from the clipboard.
Insert	Insert a blank line above the current line (the line with the triangular mark on the left).
Delete	Deletes the current line (the line on which the triangle mark is displayed at the left end).

- Refer to “3.13.1Options” to set the spectrum range at the start of this software.

3.4.22. Copy/Paste for cell in the design sheet

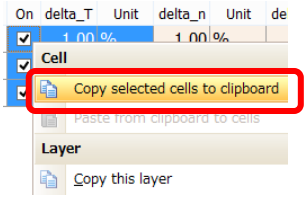
You can copy-pasting of design data by selecting the cells.

The cell that you want to copy and then selected with the mouse or [Shift + Arrow] key as shown in the figure below.

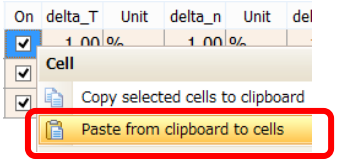


It is not possible to be selected with the mouse to the check box cell first. In this case, please select from lower right cell first by mouse or use [Shift + Arrow] key.

If select [Edit] – [Copy selected cells to clipboard] from the main menu or [Copy selected cells to clipboard] from the right-click menu or press Ctrl+c, then the contents of the selected range is copied to the clipboard.



If right-click a cell in the upper left corner that you want to paste, and press [Paste from clipboard to cells] or press Ctrl+v, then the clipboard contents will be copied.



You can also copy from Excel.

3.4.23. Number of decimal places that can be input

The number of digits after the decimal point that can be entered is 9.

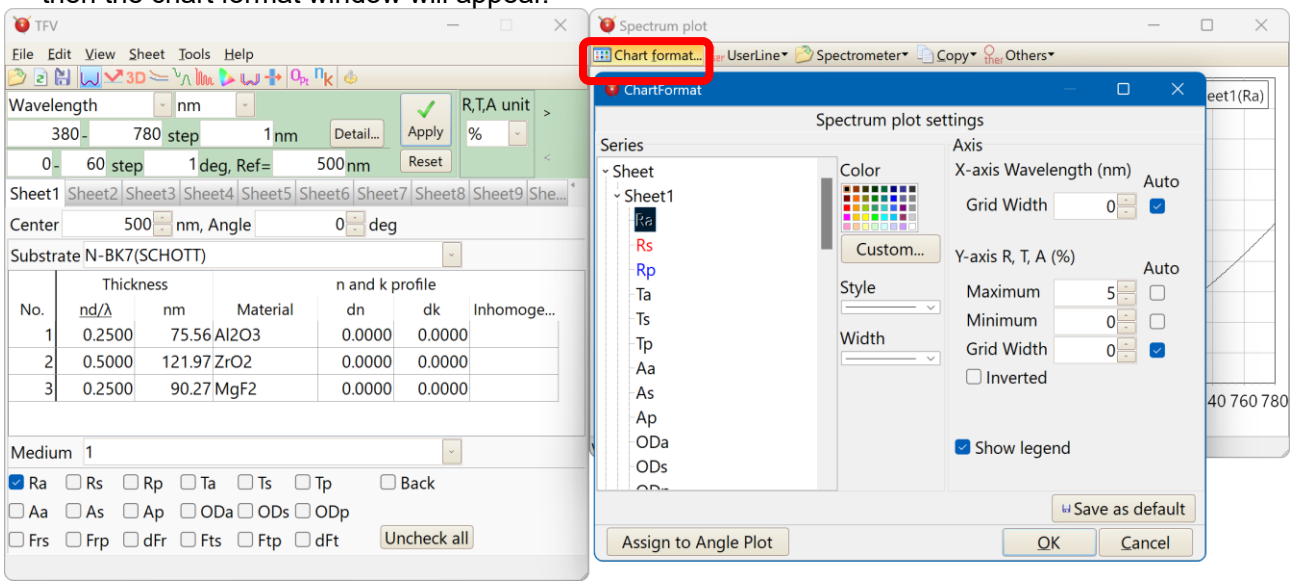
Even if you enter more than 9 digits, only 9 digits after the decimal point will be used in calculations.

3.5. Chart operation

3.5.1. Changing the y-axis and the series color (Chart format)

You can change the maximum value, the minimum value and the grid width of the y-axis and the series color of the plot lines to use the chart format. (The x-axis can change only grid width. You can change the maximum and the minimum value of the x-axis by the light green area of the main window.)

Select [Chart format] on the toolbar or right click popup menu or double click the chart window, then the chart format window will appear.



【Axes settings】

You can change the following items.

X-axis : Grid width (For changing maximum and minimum value, use main window. See.P.29)

Y-axis : Maximum, Minimum value and grid width

2nd-Y-axis : Maximum and Minimum value (This axis is use for phase shift plot.)

If you check [AUTO], then that setting will adjust automatically.

* Grid width may be automatically adjusted irrespective of the setting value, when small value or small chart size.

【Series color】

The series color can be changed for every series. Select the sheet number and series item, then select color. If there is no color to your liking, click [Custom] button for create color.

【Save settings】

If you click the [Save as default] button, then these settings of the chart format will be saved. The chart can be displayed by saved settings when starting TFV next time.

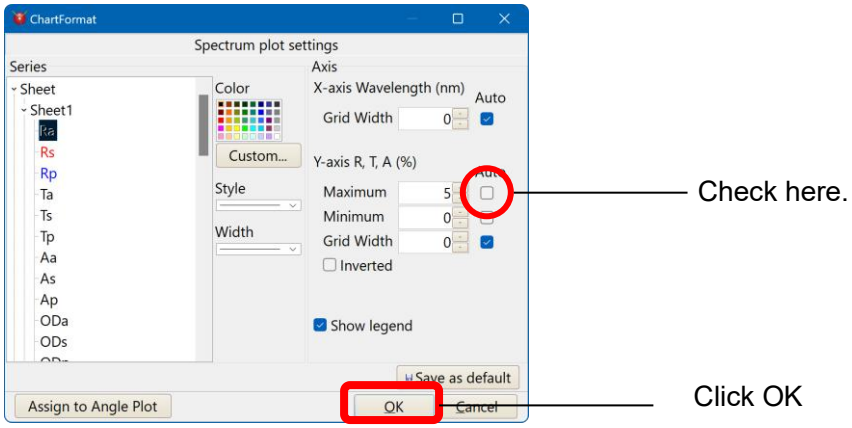
If you click the [OK] button without clicking the [Save as default] button, the change is effective until TFV finished. The changes return to the previous settings when starting TFV next time.

The example is shown in the following page.

- Example: Changing the maximum value of the Y-axis to automatically.

In the default settings, the Y-axis is set to 0 - 2.5%. The plot line may be out of range when displaying the transmittance plot etc. The easy way to fit the plot always in the axis range is changing the maximum value of the Y-axis to automatically.

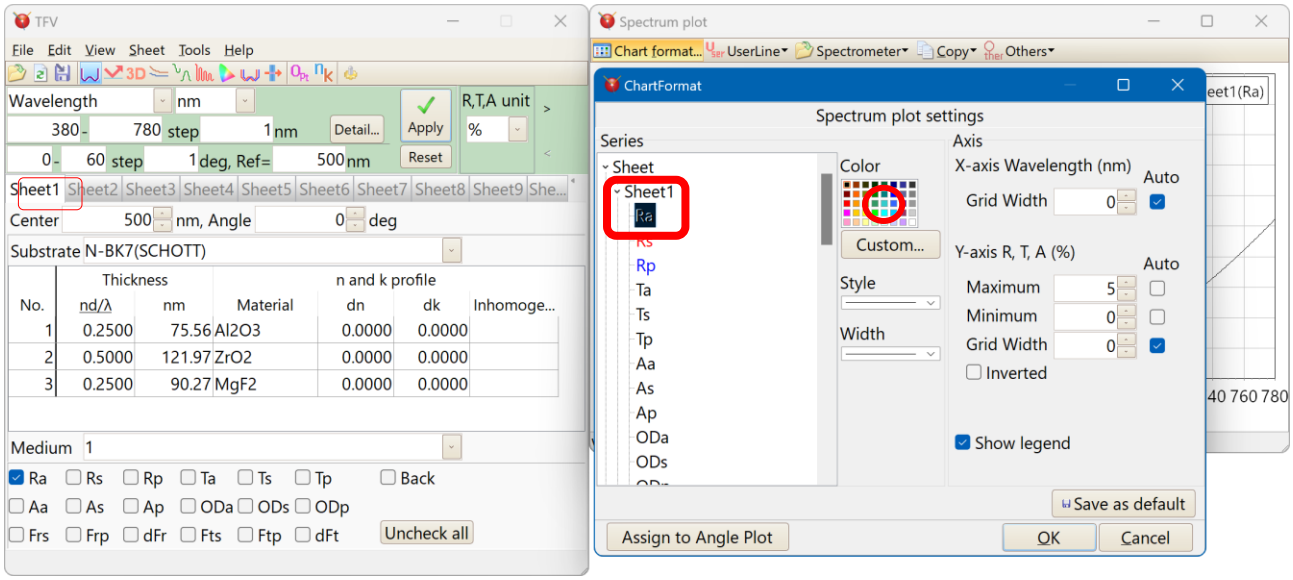
Check the [Auto] box of the Y-axis and click the [OK] button, then the maximum of the Y-axis will change automatically to fit the plot.



- Example: Changing the series color

Change the [Ra] series of the Sheet1 to yellowish green.

Select [Sheet1] and [Ra] from the list and then select the yellowish green from the color list. And click [OK] button. Then the color of the [Ra] plot line will change to yellowish green.



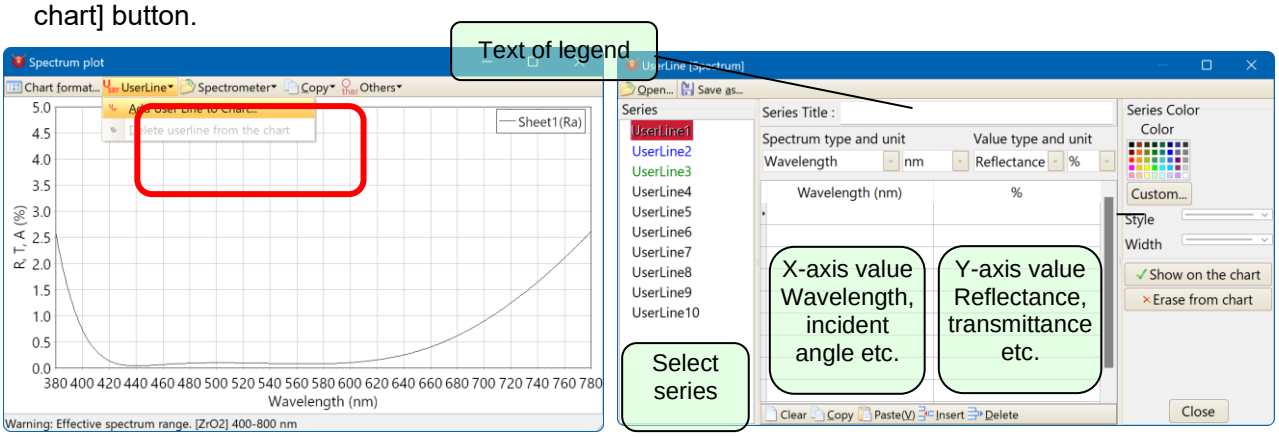
3.5.2. Adding the user defined line to the charts

You can add the user defined line to the charts.

Use for the target line of the design or the standard line etc. The numerical values of the plot line can be copied from spreadsheet software etc.

In order to add the user defined line to the chart, select [Add user line to chart…] on the toolbar or right-click popup menu.

Input data manually or paste from spreadsheet software. To add series to chart, push [Add to chart] button.



- Selecting the series
  First, select the series you want to add. You can add the user lines up to ten.

- Inputting the series title
  Series title is used as the legend in the chart. This is optional.

- Inputting the plot data
  Input the spectrum or the incident angle of the X-axis by ascending order to the list of left column.
  Input the value of the Y-axis (ex. reflectance, transmittance) to the list of right column.
  If you do not want connect between the point and the point with the line, insert the blank row in the list. Then it can avoid drawing the line between the data points, which up and down of the blank row.
  The plot data can also be copied and pasted from spreadsheet software via clipboard. After sorting by ascending order, copy to clipboard and click the [Paste] button on User line dialog box. (The paste data requires the tab separated value.)
  In order to add or delete the rows, you can use the [Insert] or the [delete] button.
  In order to create new user line from scratch, click the [Clear] button.

- Selecting the Type
  Select the type of series: Reflectance, Transmittance, Absorptance and Phase Shift.

- Selecting the series color
  Select the color, line style and line width.

- Adding the user defined line to the chart
  Click the [Add to chart] button, then the user defined line will be drawn on the chart.

- Deleting the user definition line from the chart.
  Select the series, and then click the [Erase from chart] button. Then the user defined line will be deleted from the chart.

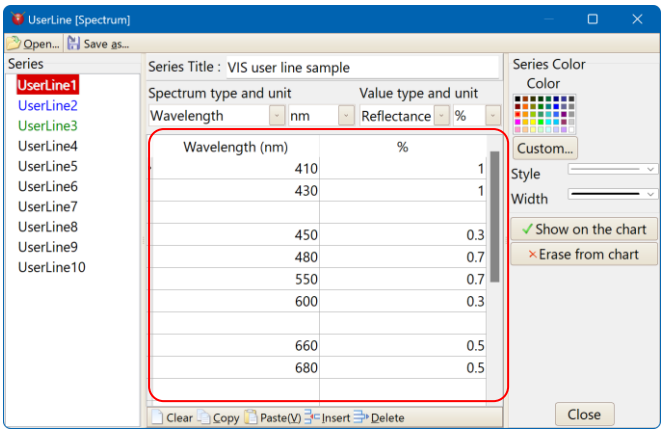
- Saving the user line data to the file, or reading it from file.
  You can save the user definition line data to the file and read it another opportunity.
  In order to save the data, click the [Save] button. You are asked for the user line name.
  In order to read the existing user line data from file, click the [Open] button and select file.

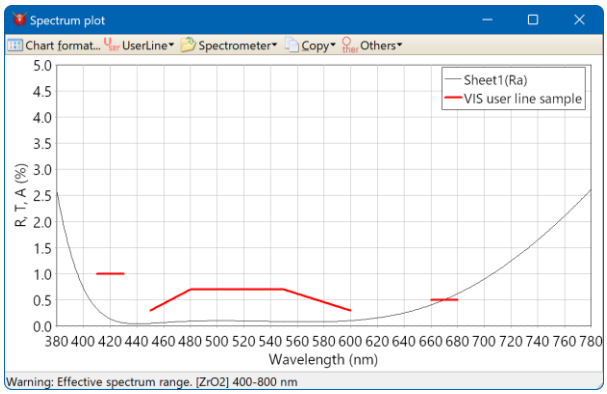
- Example

  Input the user defined line data as follows and click the [Add to chart] button, then the red line will be added to the chart.

In this case, the blank rows were inserted between 430nm and 450nm, and between 600nm and 660nm. Therefore, the user line become intermittently on the chart.

If insert a blank row then a line between data point does not draw.



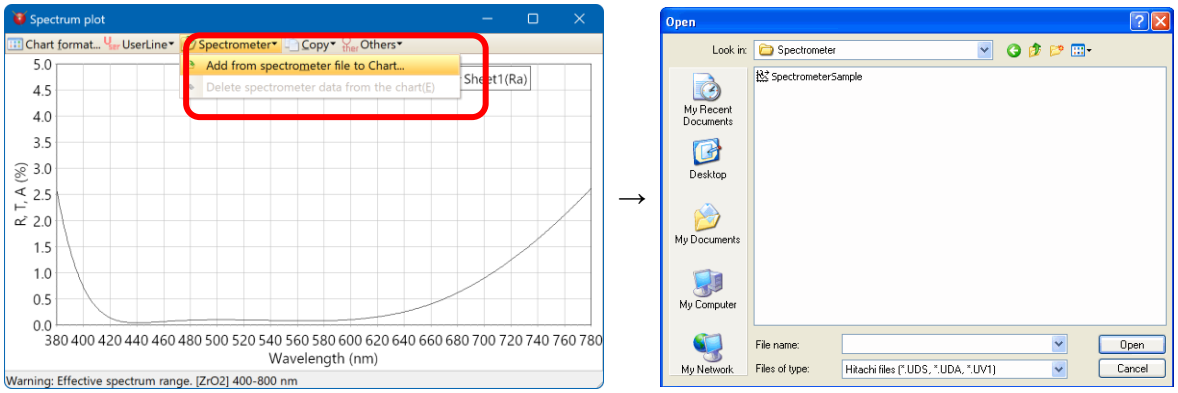


* This user line data had been saved as the sample of the VIS-AR coating already. Open the “Sample(VIS).usl” file from [Open] button, then the same data as the above example will be read.

3.5.3. Adding the spectrophotometer measured data to the charts

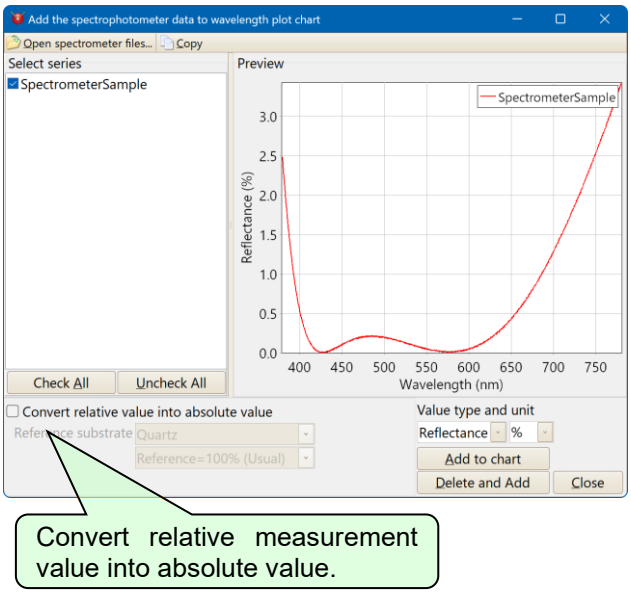
For add the spectrophotometer measured data to the spectrum plot chart, select [Spectrometer] - [Add from spectrometer file...] on the toolbar or right click popup menu.

Then file open dialog will appear. Select spectrometer measured files. You can select more than one file by Ctrl or Shift key.



Hitachi (UDSS, UDS, UDA, UV1 files), Olympus-USPM files, Shimadzu SPC files, Jasco JWS files, Ocean-Optics OOi-Base32 files, csv files, tab separated text files can be read.

Show preview chart will appear as follows.



- Select series

If there are more than one series, select you want to add series.

- Convert relative value into absolute value

If the measured data is relative value, you can convert the relative value into absolute value. Please check this item and select the reference substrate.

- Selecting the Kind
  Select the kind of series: Reflectance, Transmittance, Absorptance and Phase Shift.

- Add to chart

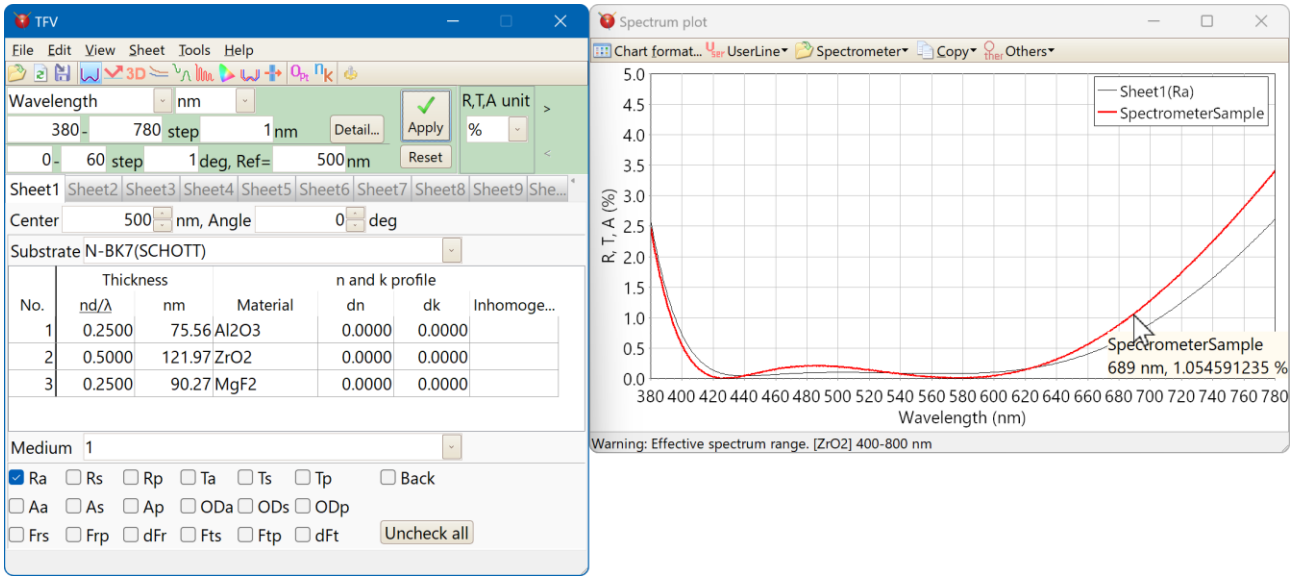
If you push [Add to chart], then the series that showing the preview add to spectrum plot chart.

Existing photometer series on the spectrum plot chart do not erase.

- Delete and Add

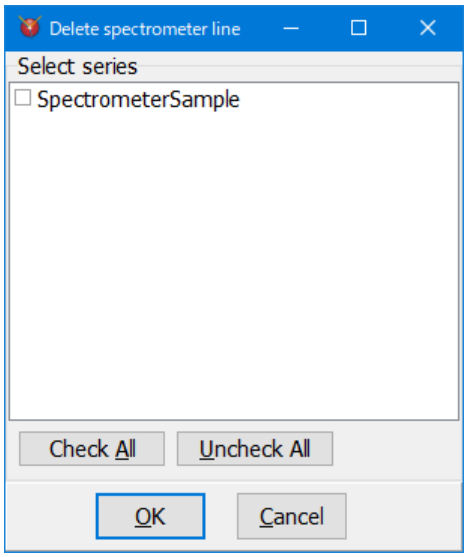
If you push [Delete and Add], then clear existing photometer series from the spectrum plot chart and add the showing preview series to the spectrum plot chart.

You can compare the measurement data with the design curve as follows.



- Delete spectrophotometer data from the chart

Select [Spectrometer] - [Delete spectrometer data from the chart] or right click popup menu.



· CSV file, tab-delimited text file format

The readable formats are as follows:

Wavelength[delimiter]MeasurementValue

Wavelength[delimiter]MeasurementValue

Wavelength[delimiter]MeasurementValue

.

.

.

It also supports multiple measurements:

Wavelength[delimiter]MeasurementValue1[delimiter]MeasurementValue2[delimiter]MeasurementValue3

Wavelength[delimiter]MeasurementValue1[delimiter]MeasurementValue2[delimiter]MeasurementValue3

Wavelength[delimiter]MeasurementValue1[delimiter]MeasurementValue2[delimiter]MeasurementValue3

.

.

.

Delimiter: Comma (,) or Tab character are supported.

Wavelength unit: nm

Measurement value unit: %

Number of wavelengths: No limit is set in the software.

Number of data points: No limit is set in the software.

You can specify series names in the header row:

Format (Single Series):
SomeText[delimiter]SeriesName

Format (Multiple Series):
SomeText[delimiter]SeriesName1[delimiter]SeriesName2[delimiter]SeriesName3

Even if there are multiple text lines at the top of the file, it will skip them until it reaches the rows with wavelength and measurement values.

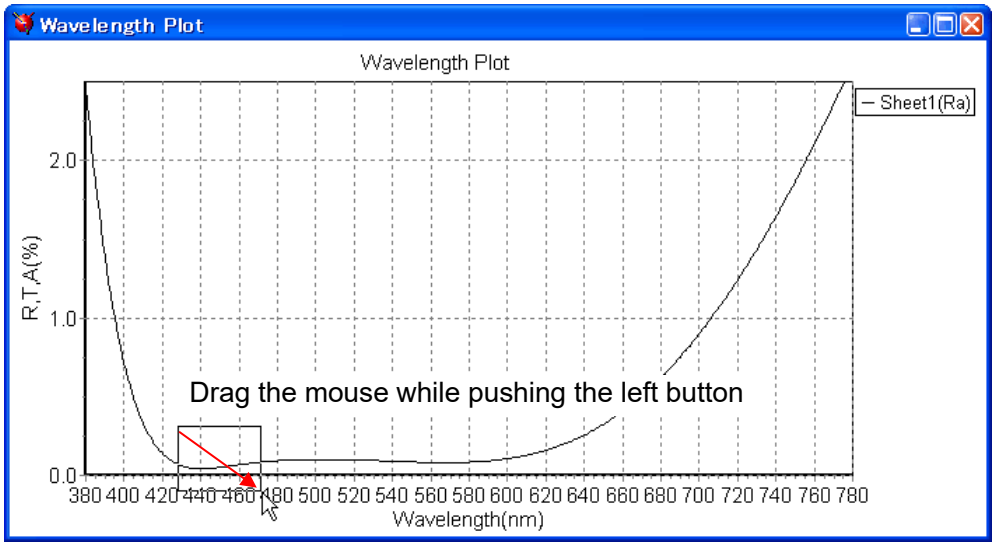
The row immediately above the wavelength and measurement value rows is treated as the header row.

It supports both ascending and descending wavelength order.

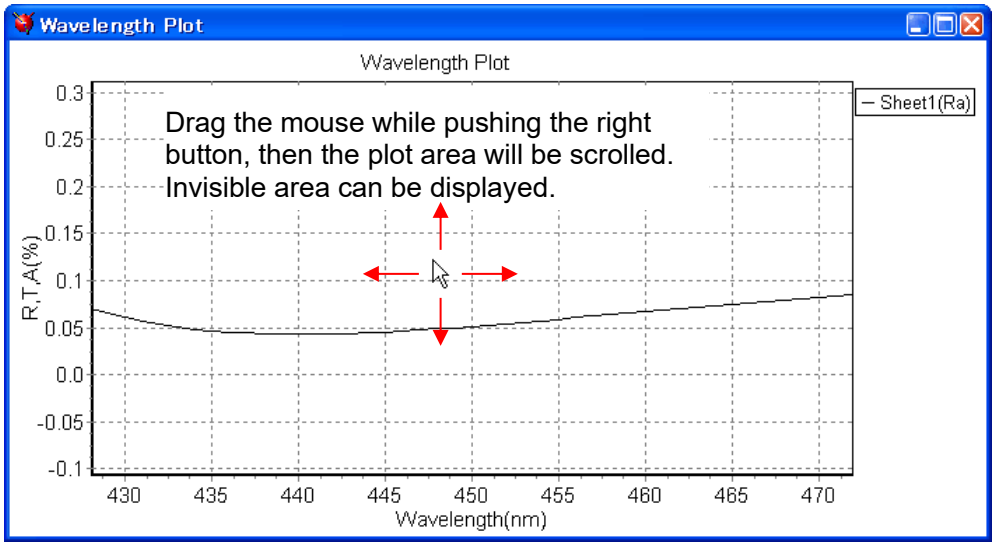
The character encoding is automatically detected.

3.5.4. How to use the zoom and panning on the chart

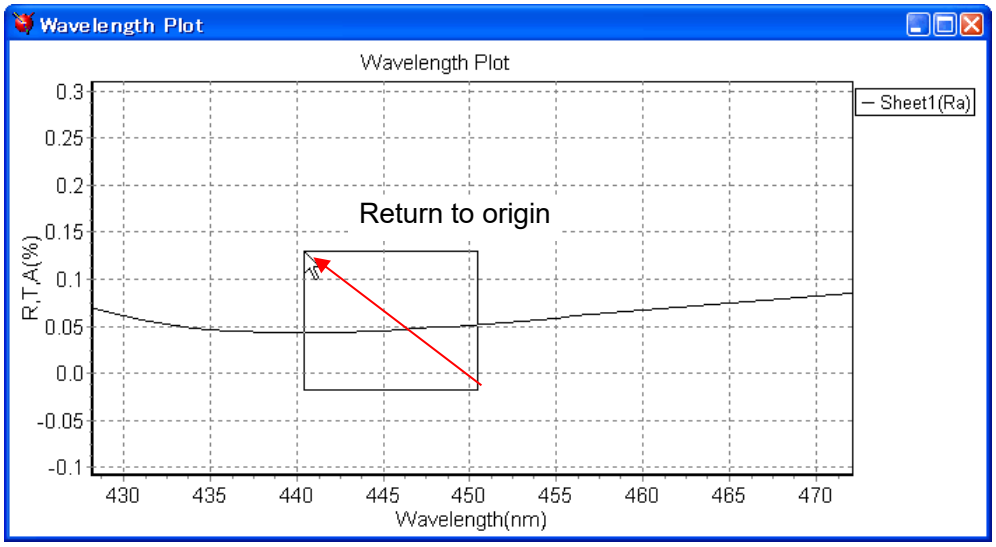
To zoom in on the chart, drag the mouse cursor to lower right direction with left button pushing. And then surround the area that you want zoom. Release the mouse button then the chart will be zoomed in.



↓The rectangle area by mouse cursor will be expanded.



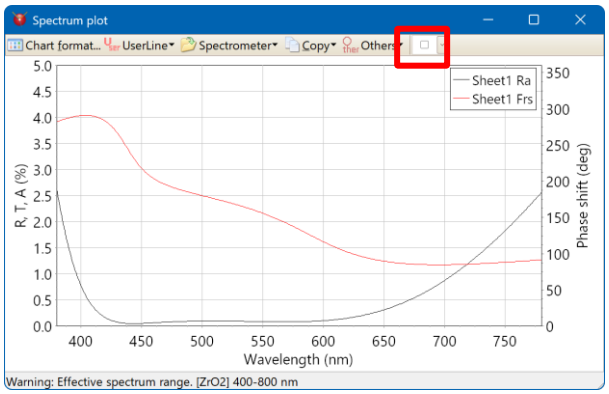
To return the original state, drag to the upper left direction while pushing the left button of the mouse.



3.5.5. Operating the spectrum chart and the incident angle chart

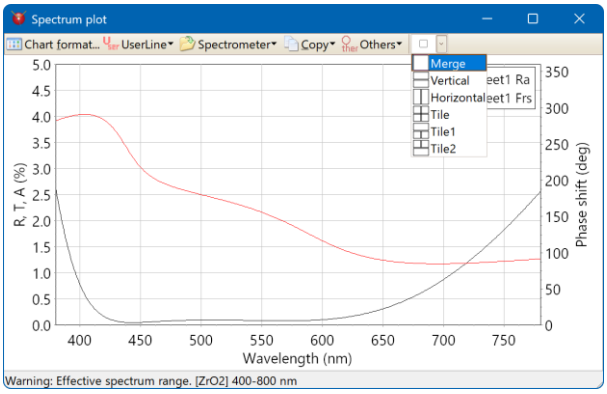
3.5.5.1. Arrange the chart view

To arrange the chart view, select [Arrange] box on tool bar.

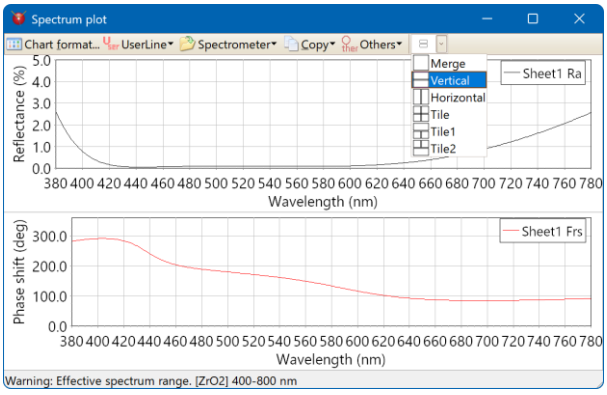


- Merge

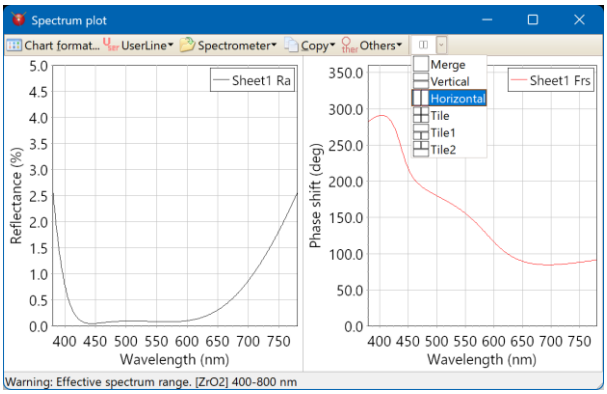
If there are three or more types of axes, selection is not possible.



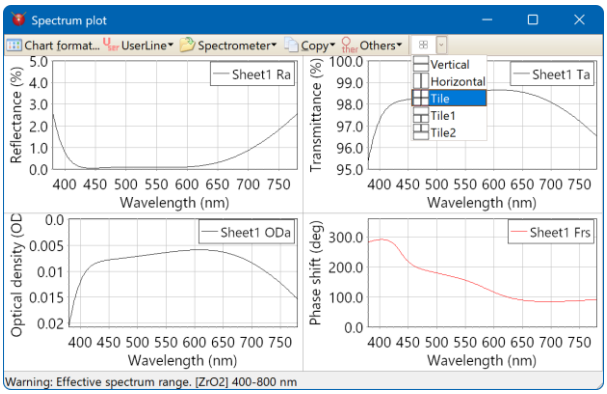
- Vertical



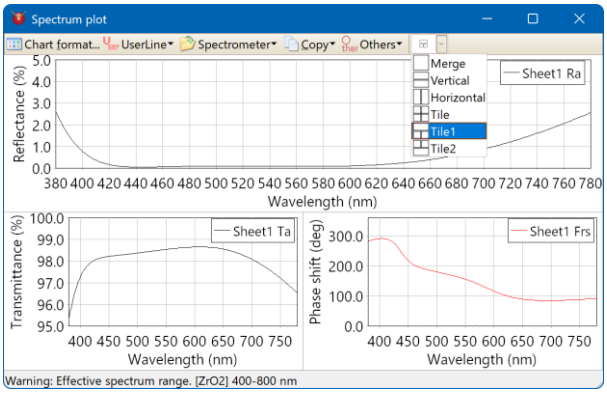
- Horizontal



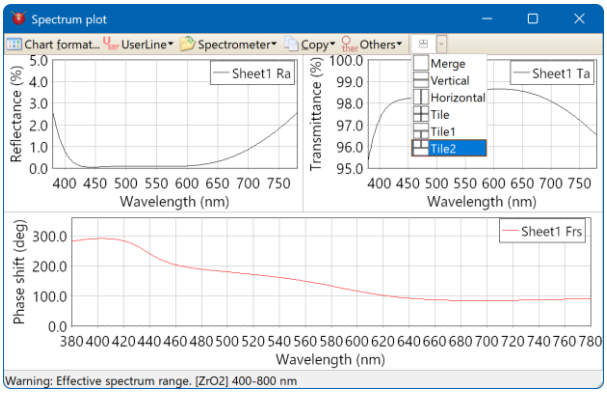
- Tile



- Tile1



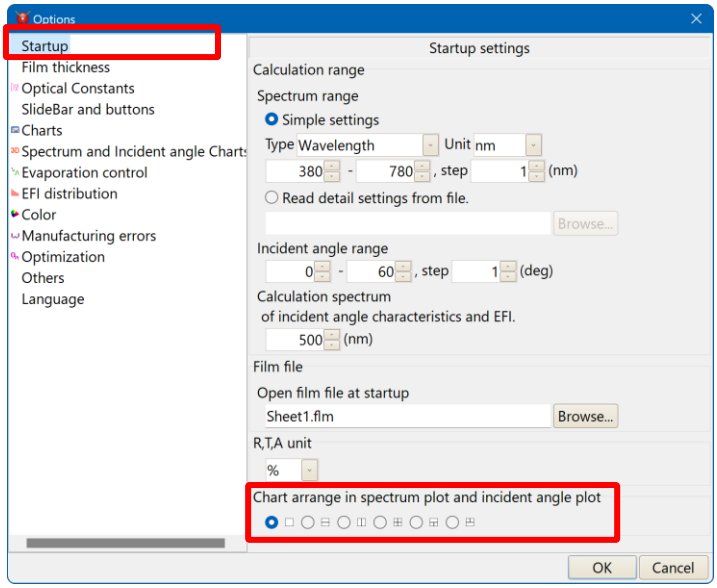
- Tile2



- Initial settings

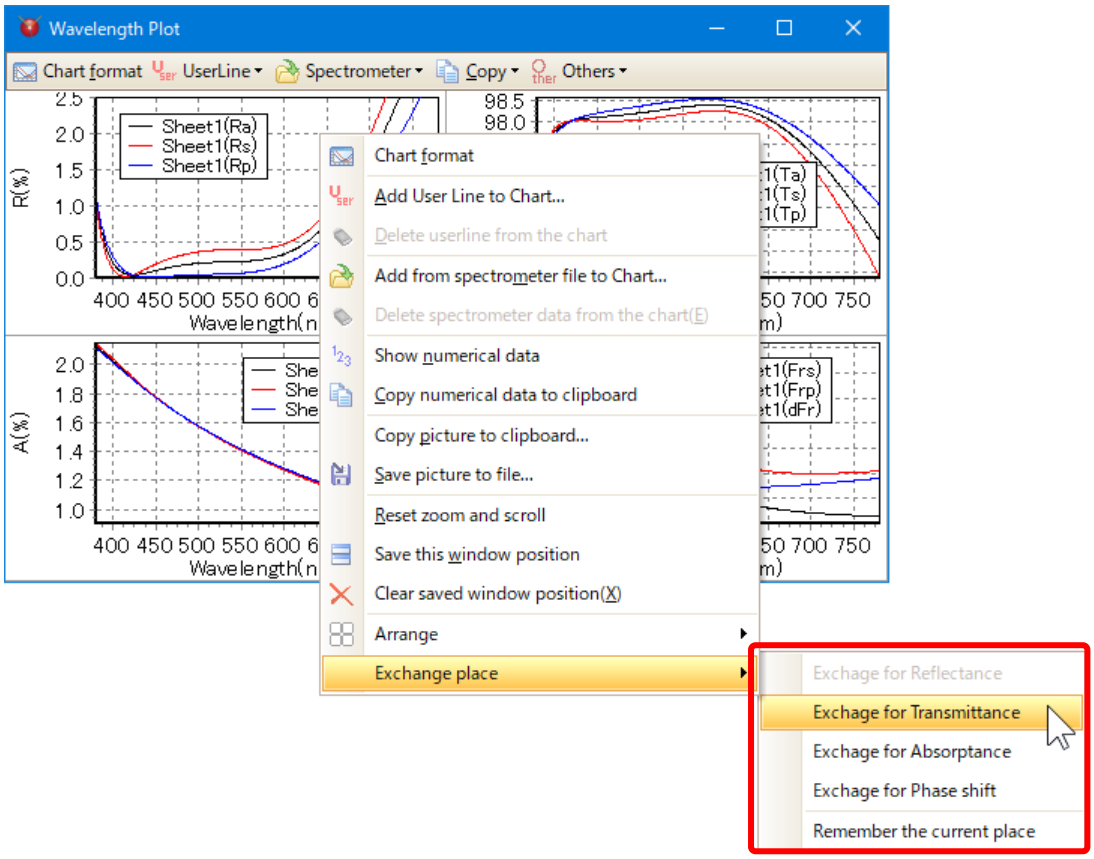
You can set the initial view.

For set the initial view, select [Options] from tool bar on the main window or select [Tools]-[Options] from main menu. Select [Startup]-[Chart arrange in spectrum plot and incident angle plot].



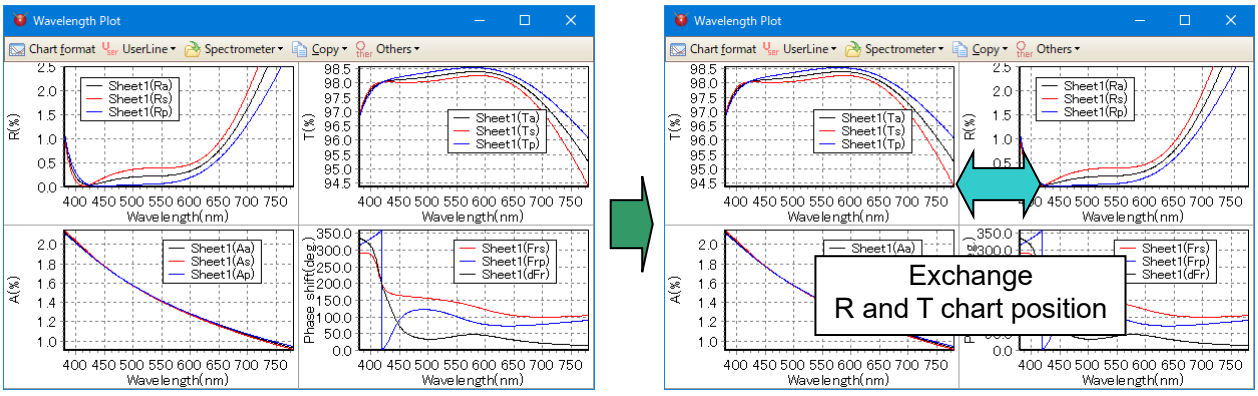
3.5.5.2. Exchange chart position

You can change the chart position if the arrange style except for merge view.
For exchange place, select [Exchange position] on the right click popup menu on the chart.



- Example: Exchange the Reflectance chart and the Transmittance chart.

Right click on the Reflectance chart and select [Exchange position]-[Exchange for Transmittance].



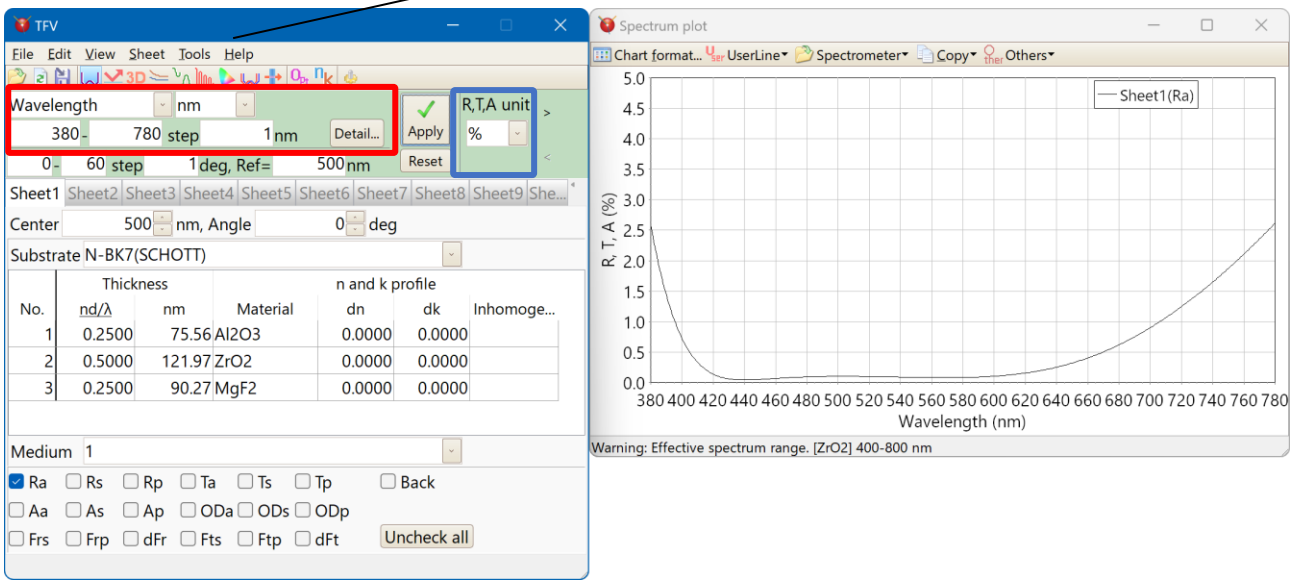
- Remember the current position

If you select [Remember the current position] then the current chart place is stored. The chart displayed stored position next time.

3.6. How to use the various calculation functions

3.6.1. Spectrum plot chart

To show the spectrum plot chart, click the [spectrum plot] toolbar on the main window.



You can set the spectrum type, units, and calculation range in the red frame in the image above.
The supported spectrum types and units are as follows.

Spectrum type	Units
Wavelength	Å, nm, μm, mm
Frequency	PHz, THz, GHz
Wave number	cm^{-1}, μm^{-1}, 2π/cm
Angular frequency	rad/fs
Energy	eV, keV
g-Number	

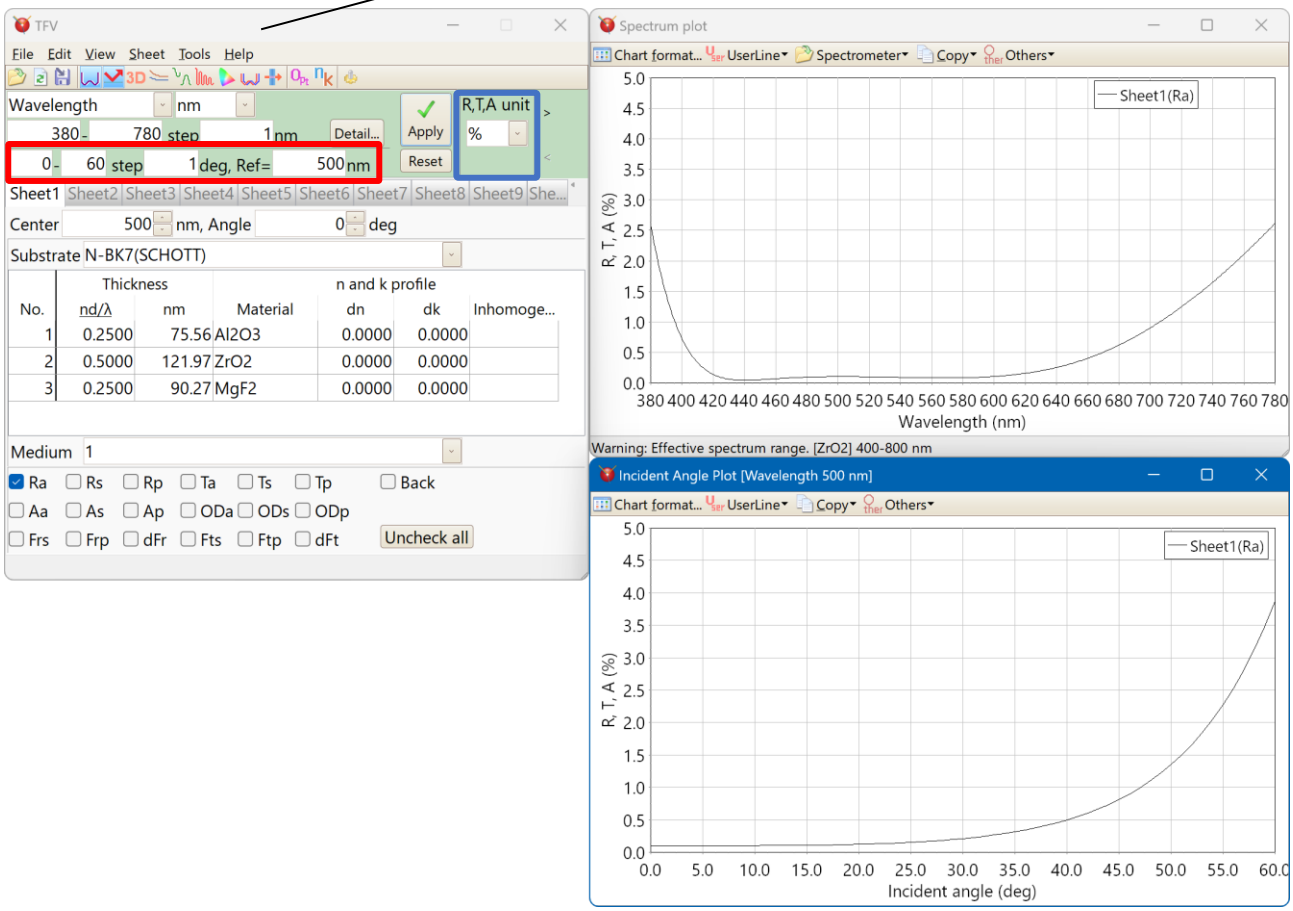
After changing the spectrum type, units, and calculation range, click the "Apply" button to perform the calculation and reflect it on the graph, etc.

You can set the units for reflectance, transmittance, and absorption in the blue frame "R, T, A units" in the above figure.
Units can be selected from 0-1, %, and dB.

Hint:
Set the film thickness unit from the menu: [Tools] - [Options] - [Film thickness] - [Thickness unit].
The center wavelength unit is linked to the physical film thickness unit.

3.6.2. Incident angle plot chart

To show the incident angle plot chart, click the [incident angle plot] toolbar on the main window.
Incident angle chart is displayed on the bottom of the spectrum chart.

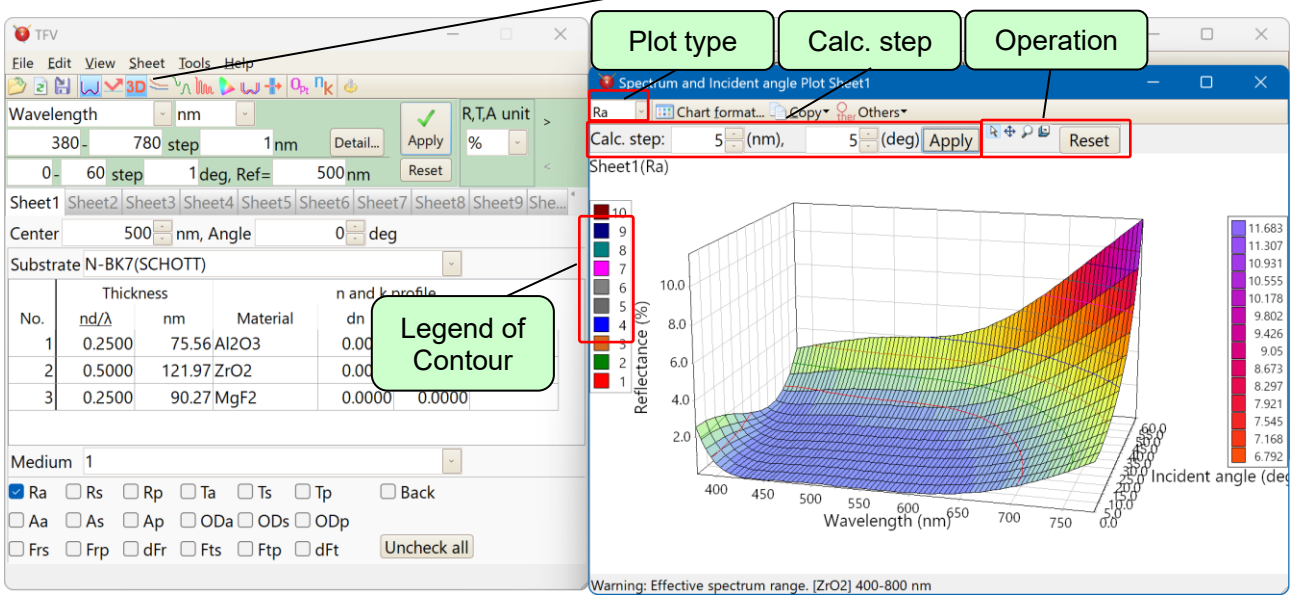


In the red frame in the above figure, you can set the calculation range and calculation spectrum (reference wavelength).
After changing the calculation range and reference spectrum, click the "Apply" button to perform the calculation and reflect it on the graph, etc.

You can set the units for reflectance, transmittance, and absorption in the blue frame "R, T, A units" in the above figure.
Units can be selected from 0-1, %, and dB.

3.6.3. Spectrum and incident angle 3D chart

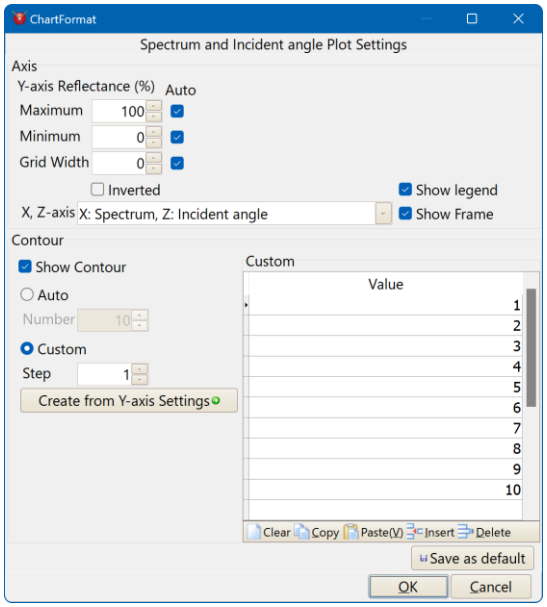
To show the spectrum and the incident angle 3D plot chart, click the [3D Spectrum and incident angle plot] toolbar on the main window.



- Explanation of the wavelength and incident angle plot settings.

Plot type	: Select from Ra, Rs, Rp, Ta, ... ,
Calc. step	: Set the wavelength step (nm) and incident angle step (degree) for calculation. When the [Apply] button is pushed, it is reflected in the chart.
Operation	:  : Rotate,  : Move,  : Zoom,  : Change depth width [Reset]: The chart returns normal position.

- Chart format



・Axis

Set the maximum, minimum and grid width value.

X, Z-axis: You can replace the wavelength axis and the incident angle axis.

Show frame: Show the frame on the chart surface.

・Contour

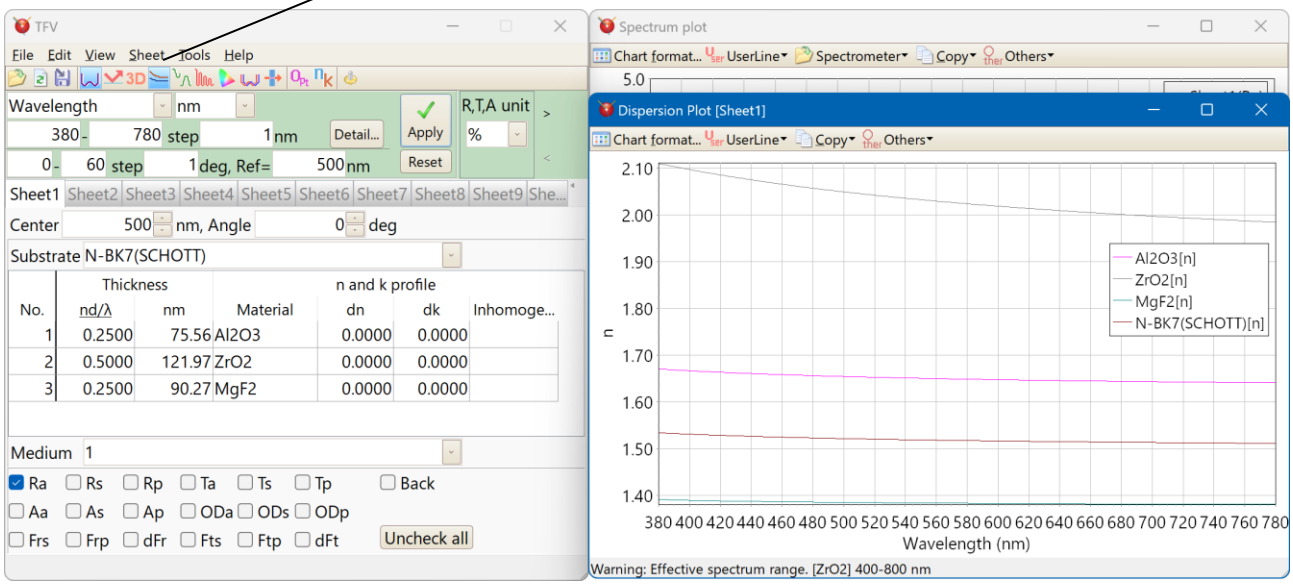
Select auto, then the contour lines adjusts automatically. Set the number of contour lines.

Select custom, then you can set the contour lines manually. Input the contour values in the table.
When push the [Create from R, T, A Settings], [Create from Phase Settings], then set the contour values automatically input from the Y-axis settings.

3.6.4. Dispersion plot chart

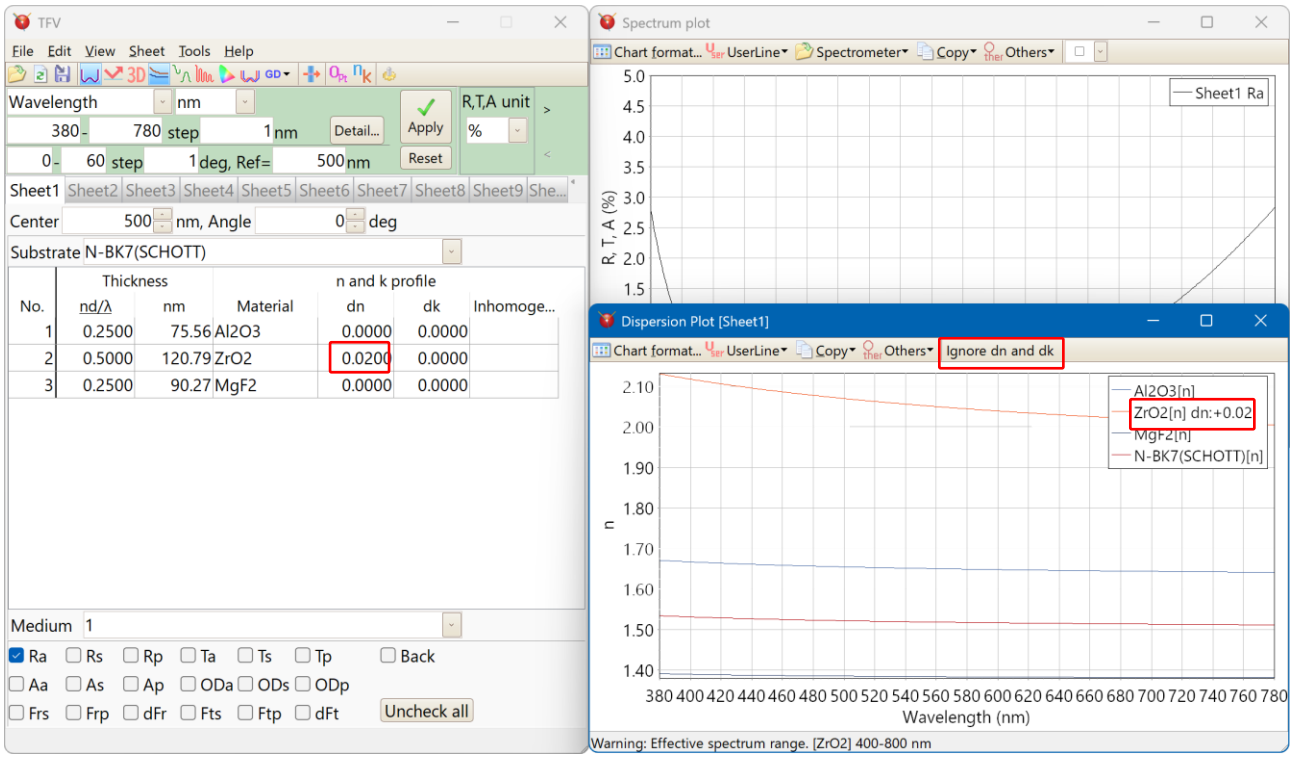
To show the dispersion plot chart, click the [Dispersion plot] toolbar on the main window.

The dispersion (refractive index and absorption coefficient) of the substrate and the film material on current sheet are plotted on the chart. Refractive index is Y-axis. Absorption coefficient is 2nd Y-axis. The absorption coefficient is not plotted when its value is zero for the calculation spectrum range.



If dn or dk is used in the design data, the values of n and k including dn and dk will be plotted.

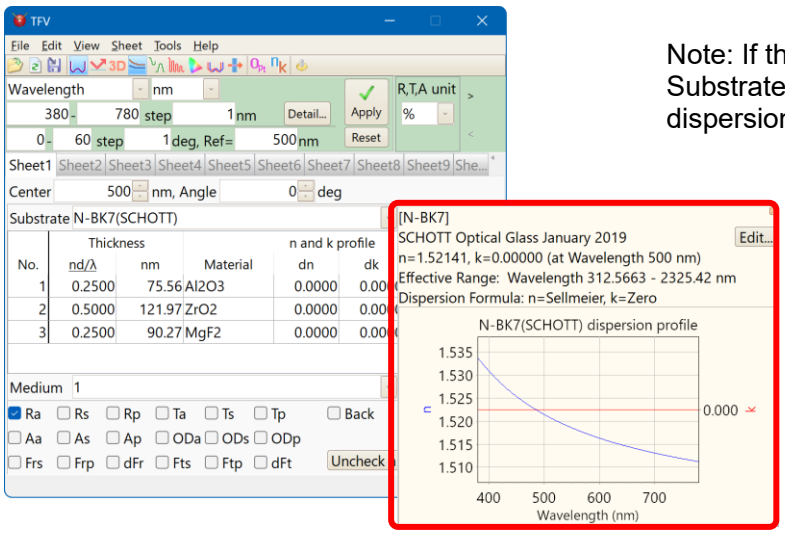
If you do not want to include dn and dk, press "Ignore dn and dk" on the toolbar.



To change the Y-axis and the series color, select [Chart format]).

To change the X-axis (spectrum range), change the calculation spectrum range on the main window.

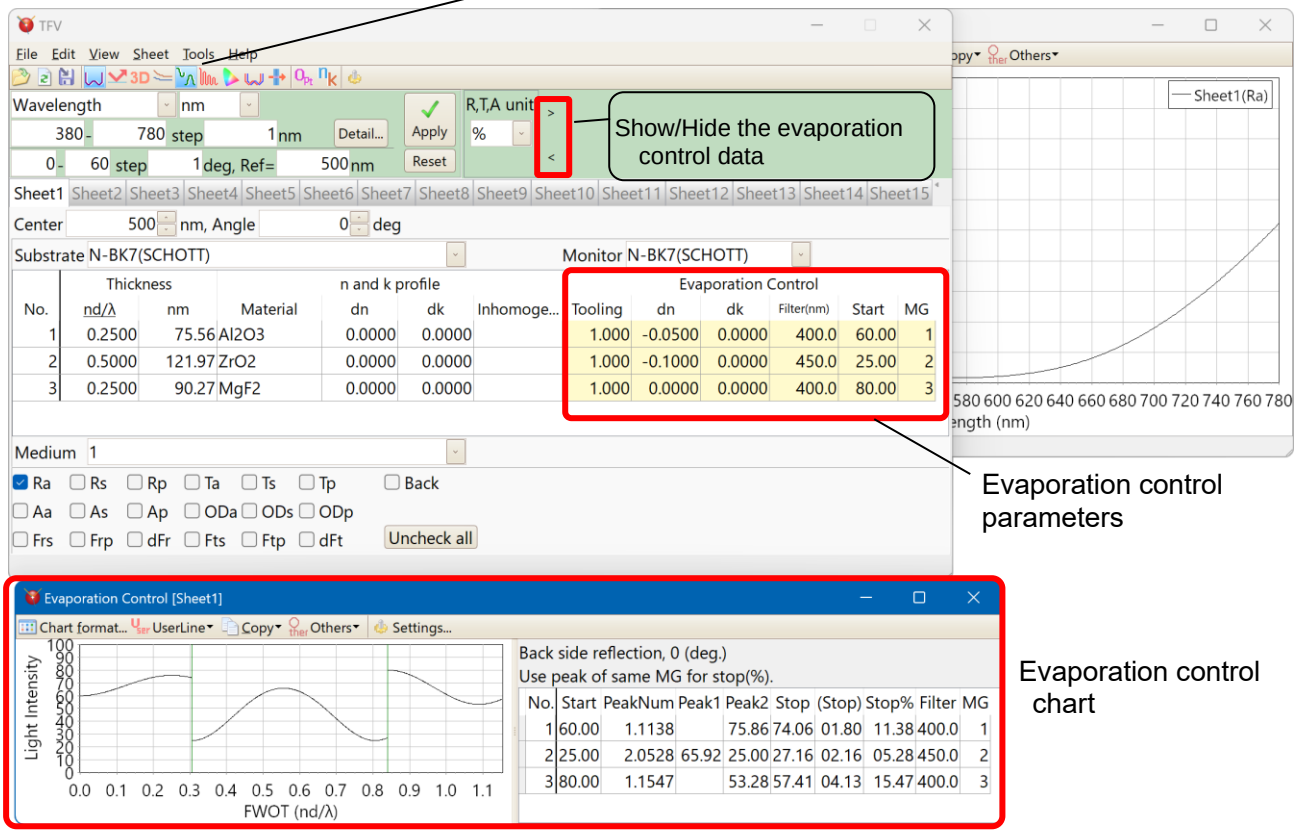
If you change the sheet of the main window, then the dispersion of the changed sheet will be plotted.



Note: If the mouse cursor put on the Substrate, Material or Medium, then dispersion profile chart will appear.

3.6.5. Optical evaporation monitor

To show the light intensity change of the optical monitor, click the [Evaporation control] toolbar on the main window. The chart is displayed on the bottom of the main window, and the main window spreads on right-hand side. The optical evaporation control parameters appears.



The 1st layer, 2nd layer and 3rd layer from the left side of the chart. The green vertical lines represent the boundary of the layer.

The right side of the window, there are numerical information of the Start, Peak and Stop.

By settings, you can change the optical measurement systems.

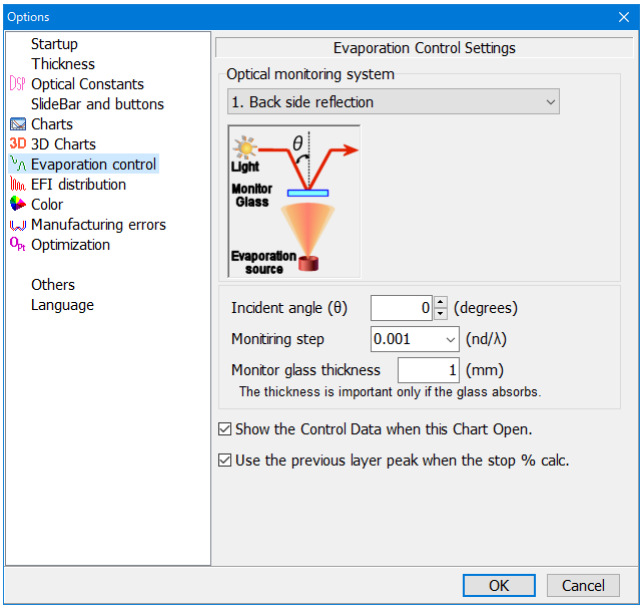
Usually, the thickness on the monitor glass differs from it on the substrate glass. And the refractive index of the design (in atmosphere) differs from it during evaporation (in-situ). In TFV, it is possible to simulate in consideration of these points.

- Explanation of each item of the evaporation control data

Monitor	: Kind of monitor glass
Tooling	: The ratio of thickness on the substrate and the monitor glass (Tooling = Thickness of the substrate / Thickness of the monitor glass)
dn	: Adjustment of the refractive index when evaporation control (during evaporation) This value is added to the refractive index of the “Material.
dk	: Adjustment of the absorption coefficient when evaporation control (during evaporation) This value is added to the absorption coefficient of the “Material.
Filter	: The wavelength of the interference filter used for light measurement. (Unit : nm)
Start	: Light intensity at the optical monitor start. When 0 is specified, it is continuation from the last light intensity of the front layer.
MG	: Position of the monitor glass If you want to use same monitor glass for other layer, set the same number.

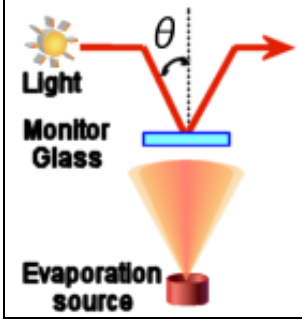
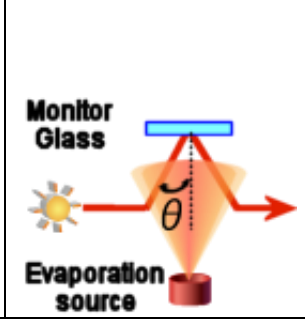
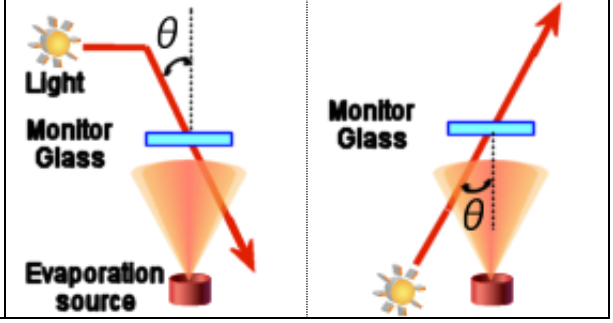
- Settings of evaporation control

Select [Settings...] on the toolbar, then following window will appear.



- Optical monitoring system

You can select from four kind of the monitoring systems.

1. Back side reflection	2. Front side reflection	3. transmission
		

1, 2: The result is different if the layer has absorption.

- Incident angle

Input θ of above figure.

- Monitoring step

Input the unit to calculating the light intensity. Recommended value is 0.01 or 0.001.

- Monitor glass thickness

Input monitor glass thickness. If glass has not absorption, then it is not necessary to input this value.

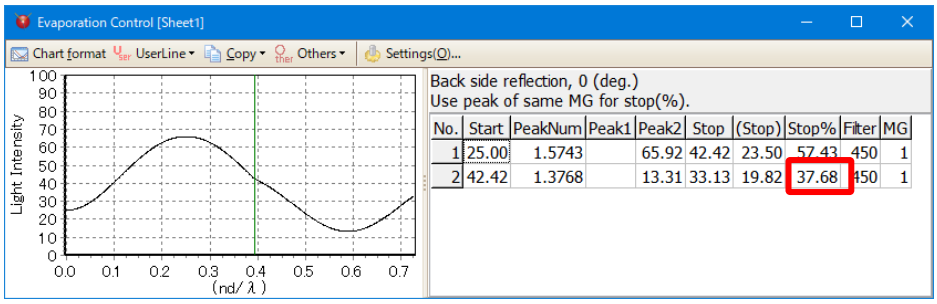
- Show the Control Data when this Chart Open.

If this item is checked, then the evaporation control data will be appeared on the right-hand side of the main window automatically when showing the evaporation control chart.

- Use the previous layer peak when the stop% calc.

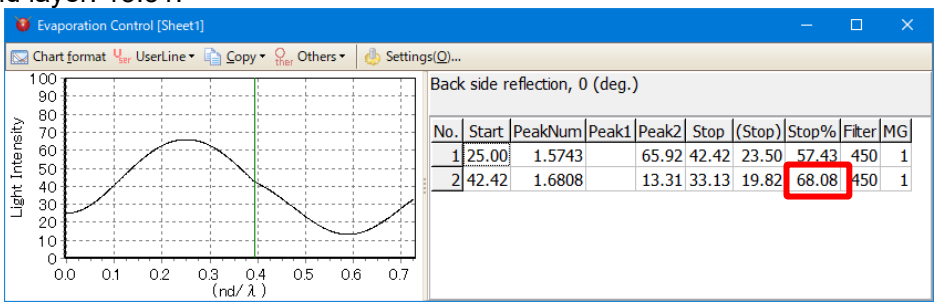
If this item is checked, then use the peak of the previous layer using same monitor glass when stop % calculation.

Example1： Checked this item.
The Stop% of the 2nd layer is 37.68% from the peak of the 1st layer: 65.92 and the 2nd layer: 13.31.



No.	Start	PeakNum	Peak1	Peak2	Stop	(Stop)	Stop%	Filter	MG
1	25.00	1.5743		65.92	42.42	23.50	57.43	450	1
2	42.42	1.3768		13.31	33.13	19.82	37.68	450	1

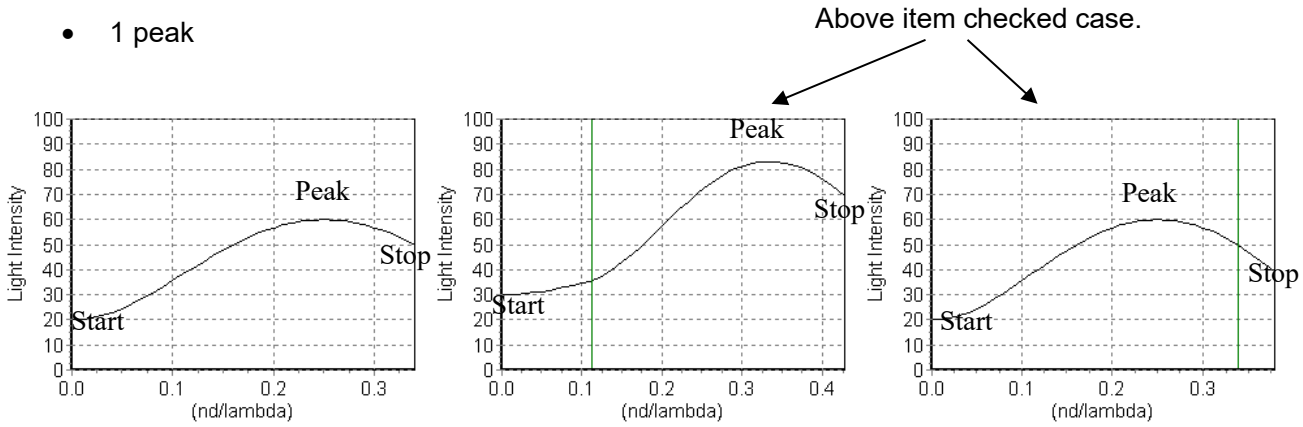
Example2： Unchecked this item.
The Stop% of the 2nd layer is 68.08% from the start of the 1st layer: 42.42 and the peak of the 2nd layer: 13.31.



No.	Start	PeakNum	Peak1	Peak2	Stop	(Stop)	Stop%	Filter	MG
1	25.00	1.5743		65.92	42.42	23.50	57.43	450	1
2	42.42	1.6808		13.31	33.13	19.82	68.08	450	1

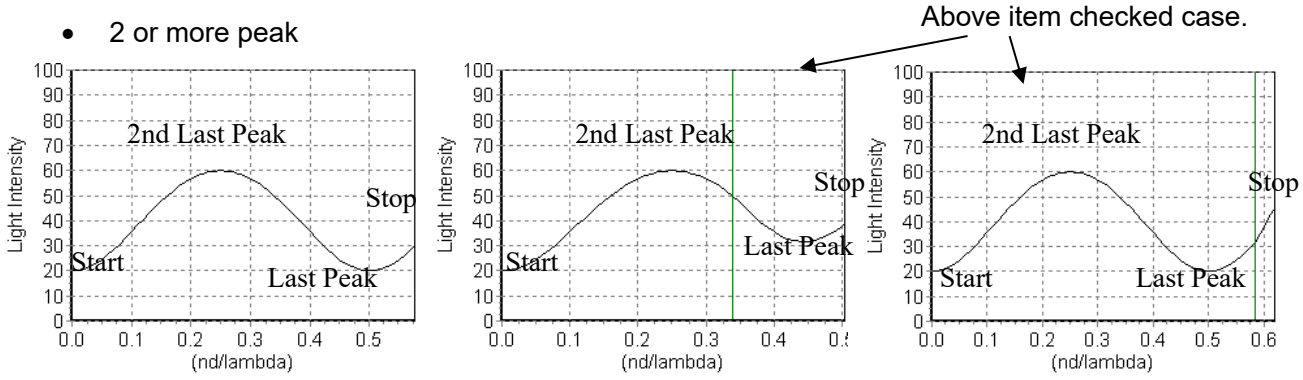
[Calculation method of the Stop%]

- 1 peak



Stop(%) = 100 * (Peak-Stop)/(Peak-Start)

- 2 or more peak

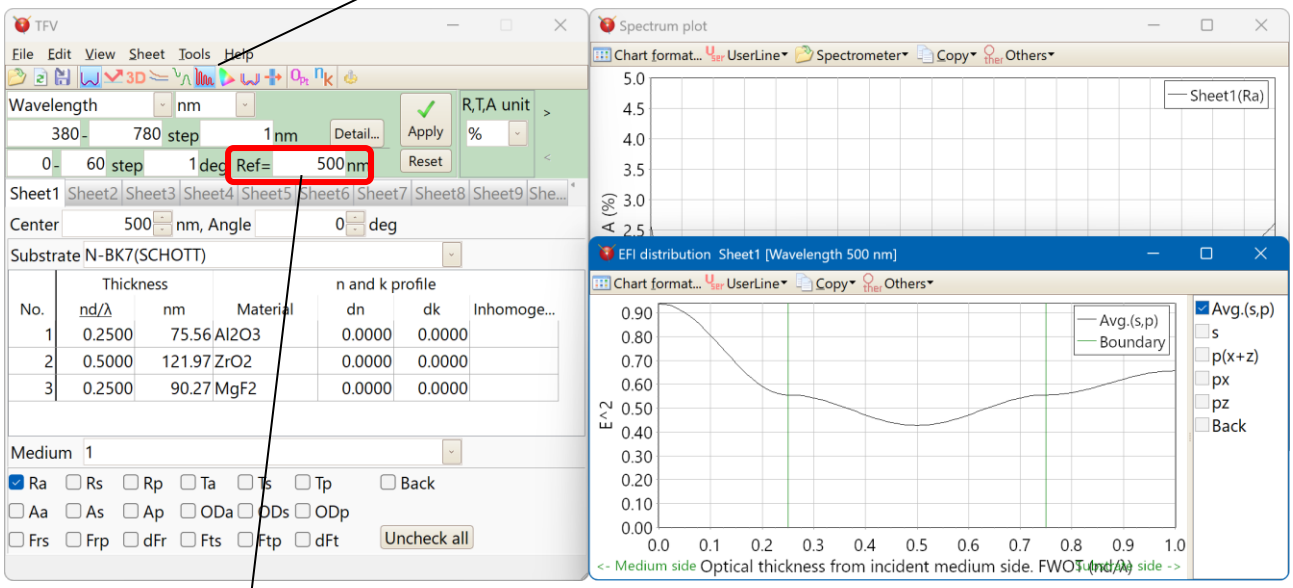


Stop (%) = 100 * (LastPeak-Stop) / (2ndLastPeak-LastPeak)

3.6.6. Electric field intensity (EFI) distribution

To show the EFI distribution, click the [Electric field intensity] toolbar on the main window. The EFI distribution of the current sheet will be plotted on the chart.

The EFI is initialized as 1 for the intensity of the incident light.

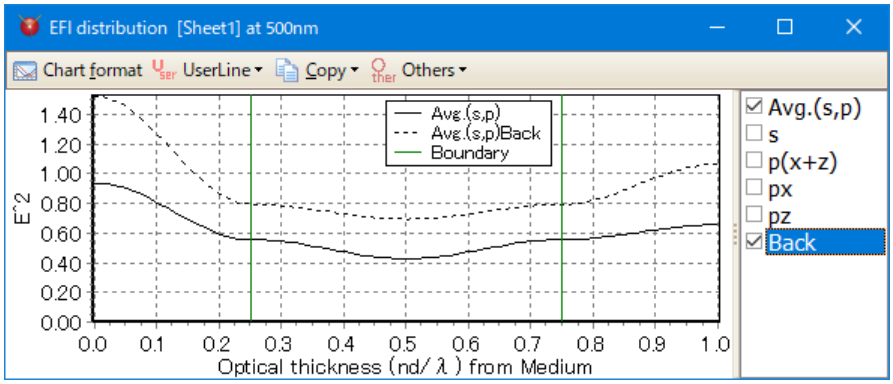


Select kind of the polarization from the right side of the chart.

Ave.(s,p)	:	Average of s-polarization and p-polarization
s	:	s-polarization (y-component)
p(x+z)	:	Total of p-polarization (x-component +z-component)
px	:	x-component of p-polarization (parallel for film surface)
pz	:	z-component of p-polarization (vertical for film surface)
Back	:	EFI from the reverse side

EFI distribution chart

※ By selecting the [Back], then EFI of both from the front surface and the back surface are displayed at same time.



If you change the sheet of the main window, then the EFI of the changed sheet will be plotted.

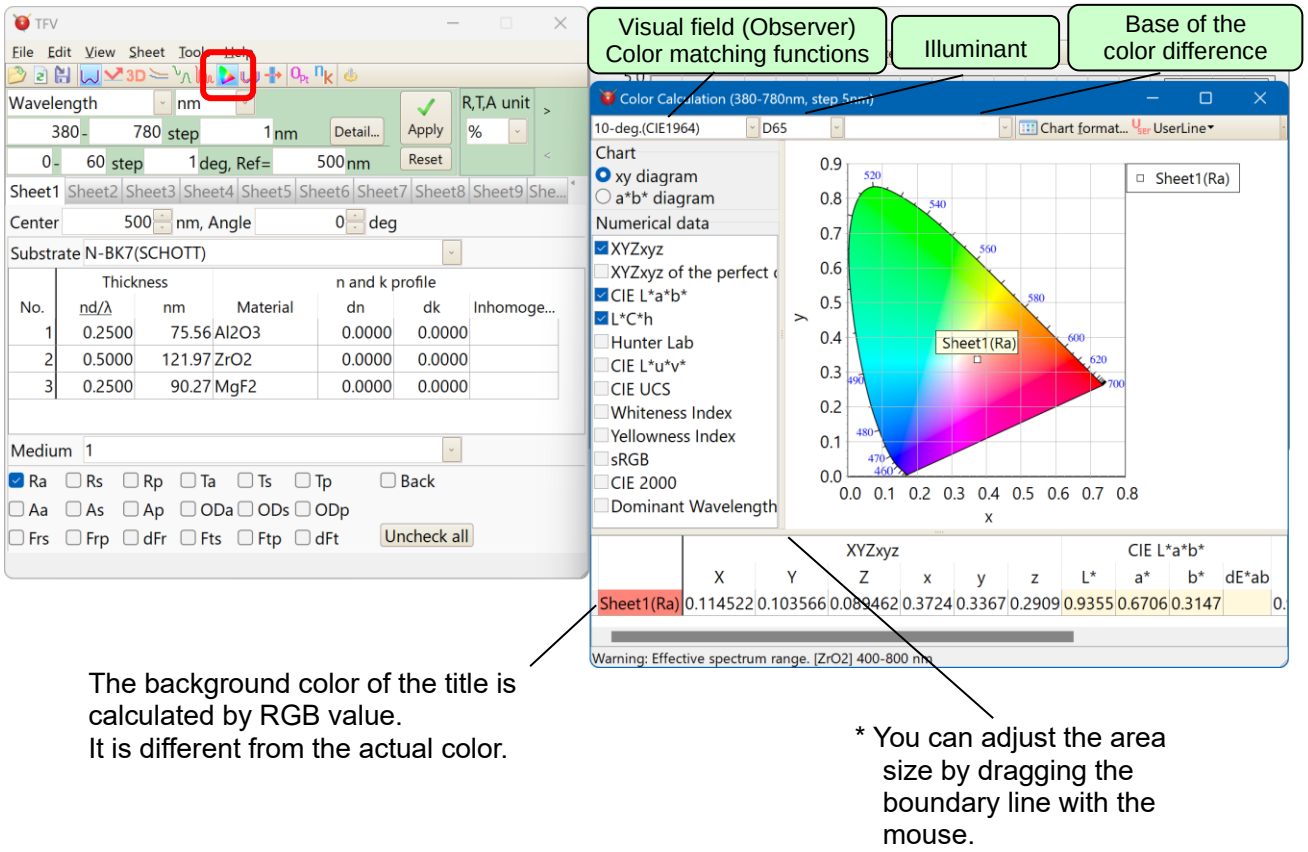
3.6.7. Color chart

To show the color value of the reflective light and the transmittal light, click the [Color calculation] toolbar on the main window.

The xy chromaticity diagram or the a*b* chromaticity diagram and various chromaticity values are calculated.

If you select Ra, Rs, Rp, Ta, Ts or Tp on the lower part of the main window, then corresponding numerical value and chromaticity diagram will be displayed on the color calculation window.

When two or more results are displayed, it is possible to calculate the color difference. Please select the base of the color difference.



- Explanation of the selectable items in the window

Visual field (Observer)	: Select 2-degree (CIE 1931) or 10-degree (CIE 1964).
Illuminant	: Select Illuminant. (Type of light source)
Base of the color difference	: Select the base of the color difference calculation. The color difference calculation is enabled when there are two or more calculation results.
Chart	: Select the type of the chromaticity diagram. You can select the xy of the CIE XYZ color space or a*b* of the CIE L*a*b* color space.
Numerical data	: Select the type of the numerical data. You can select the XYZxy, CIE L*a*b*, L*C*h, Hunter Lab, L*u*v*, UCS, Whiteness Index, Yellowness Index, sRGB, and Dominant Wavelength.

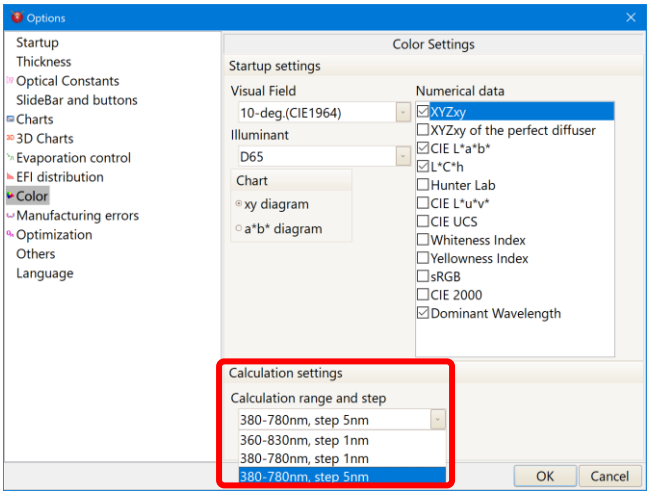
- Explanation of the kind of the color calculation

Color system		Chromaticity etc.	Color difference
XYZ(Yxy) (CIE1931,CIE1964)	:	Tristimulus values X, Y, Z, Chromaticity coordinates x, y	
XYZxy of the perfect diffuser	:	Tristimulus values Xn, Yn, Zn, Chromaticity coordinates xn, yn	
L*a*b*(CIE1976)	:	Lightness L*, Chromaticity a*b*	dE*ab
L*C*h*	:	Lightness L*, Metric Chroma C*, Metric Hue-Angle h(deg)	Hue difference dH*, dL*, dC*, Color difference dE94
Hunter Lab	:	L, a, b	dEh
L*u*v*(CIE1976)	:	L*, u*, v*	dE*uv
UCS(CIE1976)	:	u', v'	
Whiteness Index	:	WI E313 (Only illuminant C,2-deg.,Reflectance) WI CIE (Only illuminant D65, Reflectance)	
Yellowness Index	:	YI E313 (Only illuminant C,2-deg, Reflectance) YI D1925 (Only illuminant C,2-deg)	
sRGB	:	R, G, B	
CIE2000	:	-	dE2000
Dominant Wavelength	:	λd: Dominant Wavelength λc: Complementary Wavelength pe: Excitation Purity pc: Colorimetric Purity	

- Calculation range and step

You can select 3 types: "360-830 nm, 1 nm spacing", "380-780 nm, 1 nm spacing", "380-780 nm, 5 nm spacing (default)" from the main menu [Tools] – [Option] – [Color].

If the data such as color matching function, light source, reflectance and transmittance does not include the entire selected wavelength range, or if the wavelength interval is different, the data is calculated by linear interpolation.



- Registration of user created color matching functions

Color matching functions data files are in the Color\CMF folder of the TFV installation folder (usually C:\TFV).

xyz2.csv is the CIE1931 color matching function, and xyz10.csv is the CIE 1964 color matching function.

Create your own color matching function data file referring to these files, and save it in the Color\CMF folder. After restarting TFV, you can select in the combo box of the field of view.

- Kind of the illuminant

A, B, C, D50, D55, D65, D75, E, F1, F2, F3, F4, F5, F6, F7, F8, F9, F10, F11, F12, ID50 and ID65 are registered.

User-created illuminant data can be registered.

- Registration of user created light source

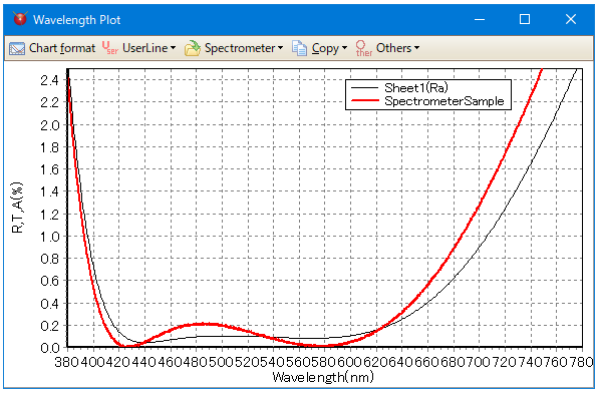
Illuminant data files are in the Color\LS folder of the TFV installation folder (usually C:\TFV).

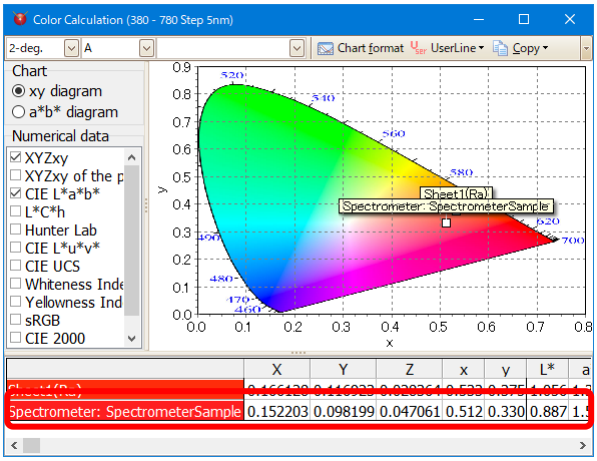
Create your own illuminant data file referring to the registered illuminant data file, such as A.csv and D65.csv, and save it in the Color\LS folder.

After restarting TFV, you can select in the illuminant combo box.

- Color calculation of then spectrometer and the user line

If spectrophotometer data and user line data is displayed at a spectrum graph, the color calculation results are displayed in the color calculation window.





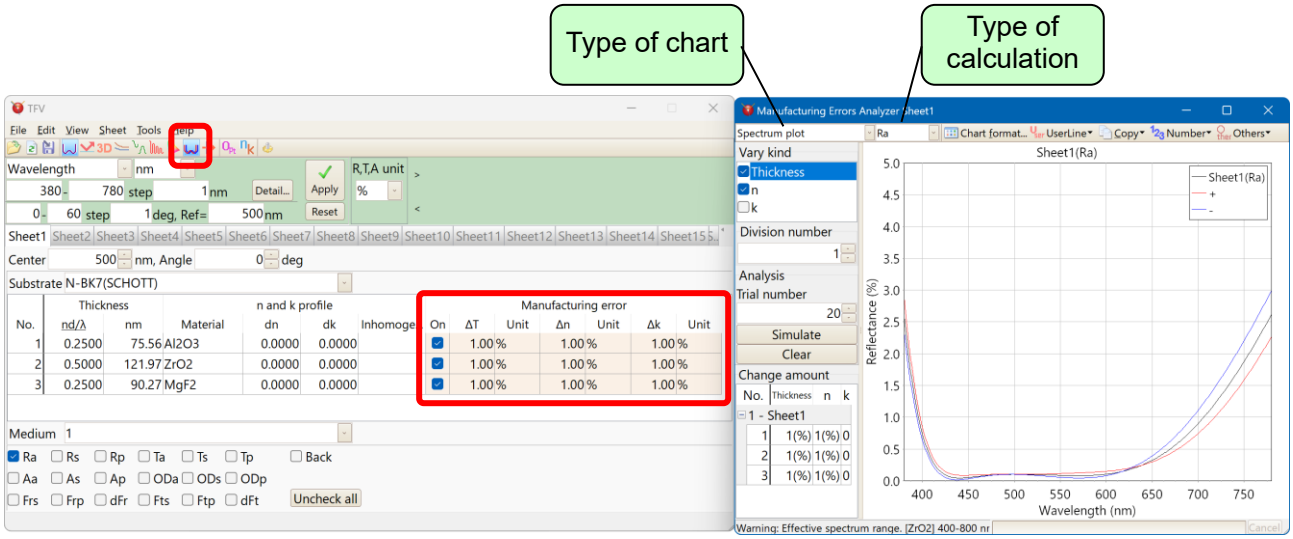
Colors are calculated for user-created color matching functions, user-created light source data, spectrophotometer data, and user line data by performing linear interpolation at the wavelength set in "Calculation range and step" on the previous page.

3.6.8. Manufacturing errors analysis

To show the manufacturing errors analysis chart, click [Manufacturing errors analyzer] toolbar on the main window.

You can use manufacturing errors analyzer when investigating the influence to the optical characteristic of the error of the thickness, the refractive index and the absorption coefficient in each layer, or when investigating the critical layer of the deviation between the design and the actual film.

The manufacturing errors by the Mote Carlo simulation can be identified.



- Manufacturing error parameters in the main window

On	: Select the layer to change the thickness, n and k.
ΔT	: Input the thickness range.
Unit	: Select the thickness unit.
Δn	: Input the refractive index range.
Unit	: Select the refractive index unit.
Δk	: Input the absorption coefficient range.
Unit	Input the absorption coefficient unit.

- Explanation of the items in the chart window

Type of chart	: Select the wavelength chart, incident angle chart or color chart.
Type of calculation	: Select Reflectance, Transmittance, Absorptance, OD, phase, Group delay and polarization.
Vary kind	: Select the type of change (Thickness, refractive index and/or absorption coefficient)
Division number	: Set the number of divisions for mismatch. For example, If the set number is 5 and ΔT=10% then thickness calculation = -10%, -8%, -6%, -4%, -2%, 0%, +2%, +4%, +6%, +8%, +10%. If the number is 1 and ΔT=10% then the thickness calculation = -10%, 0%, +10%. If delta values are different for each layer: When 10% at 1st layer, 20% at 2nd layer, division number is 1, then calculate for [1st layer -10%, 2nd layer -20%], [1st layer 0%, 2nd layer 0%], [1st layer +10%, 2nd layer +20%].

Analysis	: Trial num: Input the trial number of Monte Carlo simulation. [Simulate] button: Start simulation. [Clear] button: Clear the simulated results. If the standard deviation (σ) is chosen in units of ΔT, Δn, Δk, the value will vary with the normal (Gaussian) distribution. If you select something else other than σ, the value will vary with a uniform distribution.
Change amount	: Showing the varying values of each layer of the thickness, refractive index (n) and absorption coefficient (k).

To change the Y-axis and the series color, double-click on the chart (or right-click and select [Chart format]).

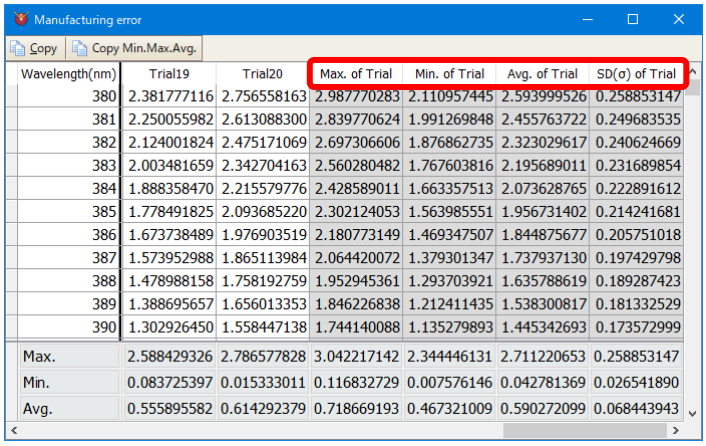
To change the X-axis, change the calculation spectrum range on the main window.

- Manufacturing errors for stack

When the stack window is displayed, the stack manufacturing error is calculated. When the stack window is closed, the manufacturing error on one side (of the main window) is calculated.

- To show the numerical results

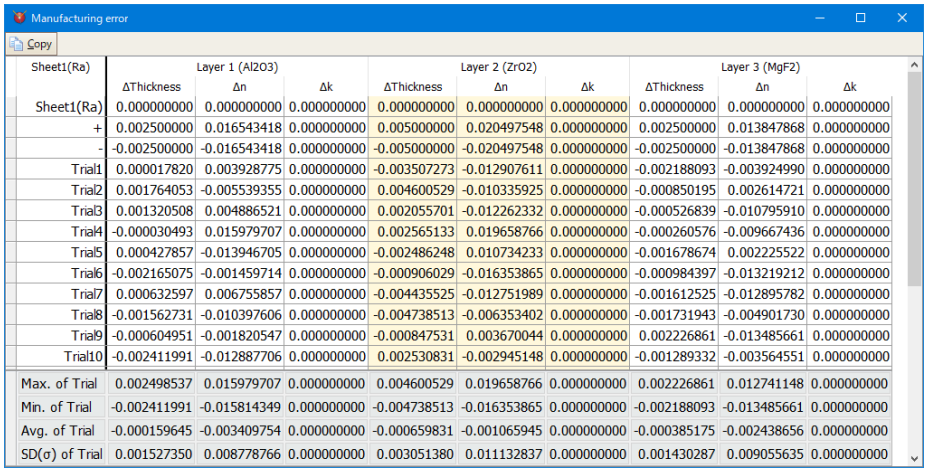
To show the numerical values, right-click on the chart and select the [Show numerical data] or [Show the delta of thickness, n and k for each calculation] on the popup menu.



Wavelength(nm)	Trial19	Trial20	Max. of Trial	Min. of Trial	Avg. of Trial	SD(σ) of Trial
380	2.381777116	2.756558163	2.987770283	2.110957445	2.593999526	0.258853147
381	2.250055982	2.613088300	2.839770624	1.991269848	2.455763722	0.249683535
382	2.124001824	2.475171069	2.697306606	1.876862735	2.323029617	0.240624669
383	2.003481659	2.342704163	2.560280482	1.767603816	2.195689011	0.231689854
384	1.888358470	2.215579776	2.428589011	1.663357513	2.073628765	0.222891612
385	1.778491825	2.093685220	2.302124053	1.563985551	1.956731402	0.214241681
386	1.673738489	1.976903519	2.180773149	1.469347507	1.844875677	0.205751018
387	1.573952988	1.865113984	2.064420072	1.379301347	1.737937130	0.197429798
388	1.478988158	1.758192759	1.952945361	1.293703921	1.635788619	0.189287423
389	1.388695657	1.656013353	1.846226838	1.212411435	1.538300817	0.181332529
390	1.302926450	1.558447138	1.744140088	1.135279893	1.445342693	0.173572999
Max.	2.588429326	2.786577828	3.042217142	2.344446131	2.711220653	0.258853147
Min.	0.083725397	0.015333011	0.116832729	0.007576146	0.042781369	0.026541890
Avg.	0.555895582	0.614292379	0.718669193	0.467321009	0.590272099	0.068443943

Numerical data on the chart series.

The maximum, minimum, average and standard deviation values are also displayed.



Sheet1(Ra)	Layer 1 (Al2O3)			Layer 2 (ZrO2)			Layer 3 (MgF2)		
	ΔThickness	Δn	Δk	ΔThickness	Δn	Δk	ΔThickness	Δn	Δk
Sheet1(Ra)	0.000000000	0.000000000	0.000000000	0.000000000	0.000000000	0.000000000	0.000000000	0.000000000	0.000000000
+	0.002500000	0.016543418	0.000000000	0.005000000	0.020497548	0.000000000	0.002500000	0.013847868	0.000000000
-	-0.002500000	-0.016543418	0.000000000	-0.005000000	-0.020497548	0.000000000	-0.002500000	-0.013847868	0.000000000
Trial1	0.000017820	0.003928775	0.000000000	-0.003507273	-0.012907611	0.000000000	-0.002188093	-0.003924990	0.000000000
Trial2	0.001764053	-0.005539355	0.000000000	0.004600529	-0.010335925	0.000000000	-0.000850195	0.002614721	0.000000000
Trial3	0.001320508	0.004886521	0.000000000	0.002055701	-0.012262332	0.000000000	-0.000526839	-0.010795910	0.000000000
Trial4	-0.000030493	0.015979707	0.000000000	0.002565133	0.019658766	0.000000000	-0.000260576	-0.009667436	0.000000000
Trial5	0.000427857	-0.013946705	0.000000000	-0.002486248	0.010734233	0.000000000	-0.001678674	0.002225522	0.000000000
Trial6	-0.002165075	-0.001459714	0.000000000	-0.000906029	-0.016353865	0.000000000	-0.000984397	-0.013219212	0.000000000
Trial7	0.000632597	0.006755857	0.000000000	-0.004435525	-0.012751989	0.000000000	-0.001612525	-0.012895782	0.000000000
Trial8	-0.001562731	-0.010397606	0.000000000	-0.004738513	-0.006353402	0.000000000	-0.001731943	-0.004901730	0.000000000
Trial9	-0.000604951	-0.001820547	0.000000000	-0.000847531	0.003670044	0.000000000	0.002226861	-0.013485661	0.000000000
Trial10	-0.002411991	-0.012887706	0.000000000	0.002530831	-0.002945148	0.000000000	-0.001289332	-0.003564551	0.000000000
Max. of Trial	0.002498537	0.015979707	0.000000000	0.004600529	0.019658766	0.000000000	0.002226861	0.012741148	0.000000000
Min. of Trial	-0.002411991	-0.015814349	0.000000000	-0.004738513	-0.016353865	0.000000000	-0.002188093	-0.013485661	0.000000000
Avg. of Trial	-0.000159645	-0.003409754	0.000000000	-0.000659831	-0.001065945	0.000000000	-0.000385175	-0.002438656	0.000000000
SD(σ) of Trial	0.001527350	0.008778766	0.000000000	0.003051380	0.011132837	0.000000000	0.001430287	0.009055635	0.000000000

Delta value of thickness, n and k for each calculation.

- To copy the numerical results

To copy the numerical values, right-click on the chart and select the [Copy numerical data to clipboard] on the popup menu or click the [Copy] toolbar button on the [Manufacturing Errors Data window].

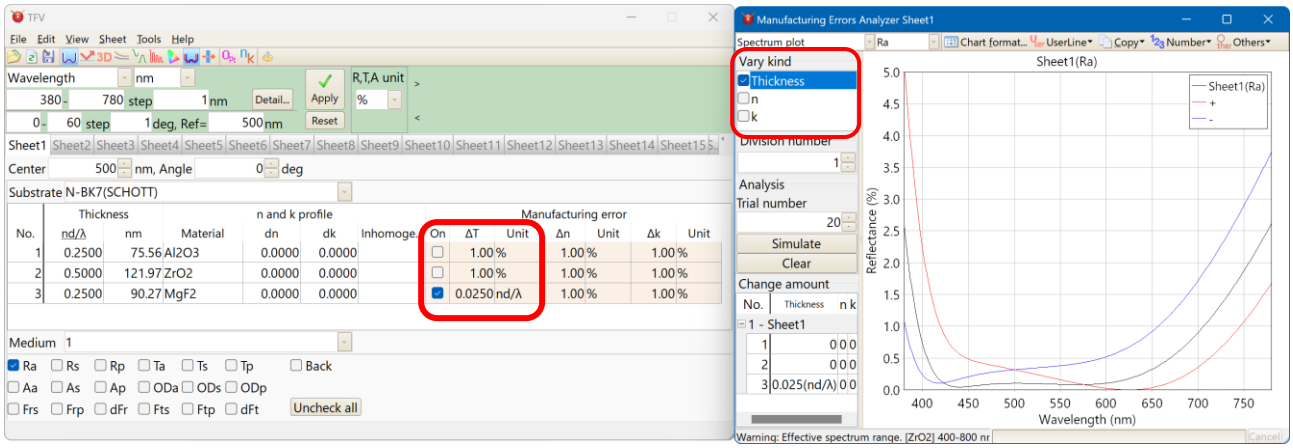
To copy the numerical values of only maximum, minimum and average values, right-click on the chart and select the [Copy only Max. Min. and Ave. data to clipboard] on the popup menu or click the [Copy Max. Min. Ave.] toolbar button on the [Manufacturing Errors Data window].

If you click the [Copy vary value to clipboard] on the popup menu of chart then the vary value on the chart window are copied to clipboard.

- Example of the mismatch analysis

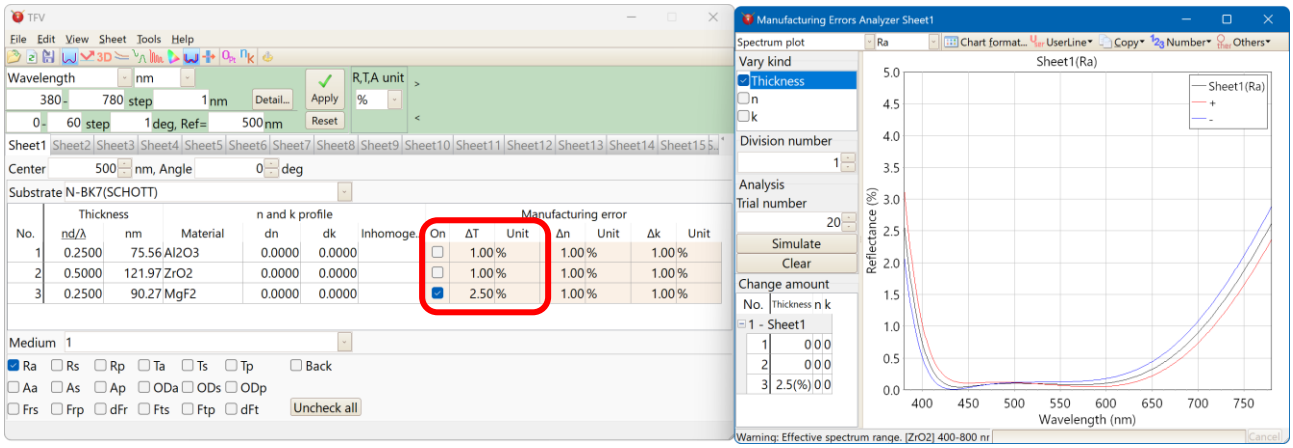
【Example 1】Showing the reflective characteristic of the spectrum when the thickness(0.25) of the 3rd layer(MgF2) changes **±0.025**.

Put a check in the [On] column only 3rd layer, input 0.025 in [ΔT] column and select “nd/λ” in [Unit] column on 3rd layer (MgF2). And put a check on “Uniform“ in [Distribution], check on “Thickness” in [Vary kind] in the chart window.



【Example 2】Showing the reflective characteristic of the spectrum when the thickness(0.25) of the 3rd layer(MgF2) changes **±2.5%**.

Put a check in the [On] column only 3rd layer, input 2.5 in [ΔT] column and select “%” in [Unit] column on 3rd layer (MgF2). And put a check on “Thickness” in [Vary kind] in the chart window.

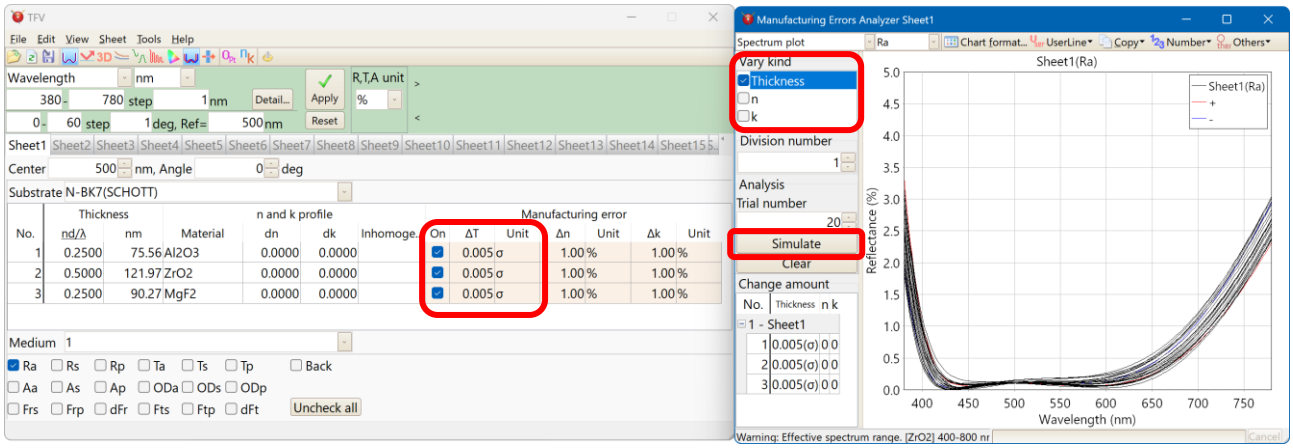


- Example of the manufacturing errors analysis

【Example 1】All layers thickness change Monte Carlo simulation of 20 times at Standard Deviation **0.005σ** of Normal (Gaussian) distribution.

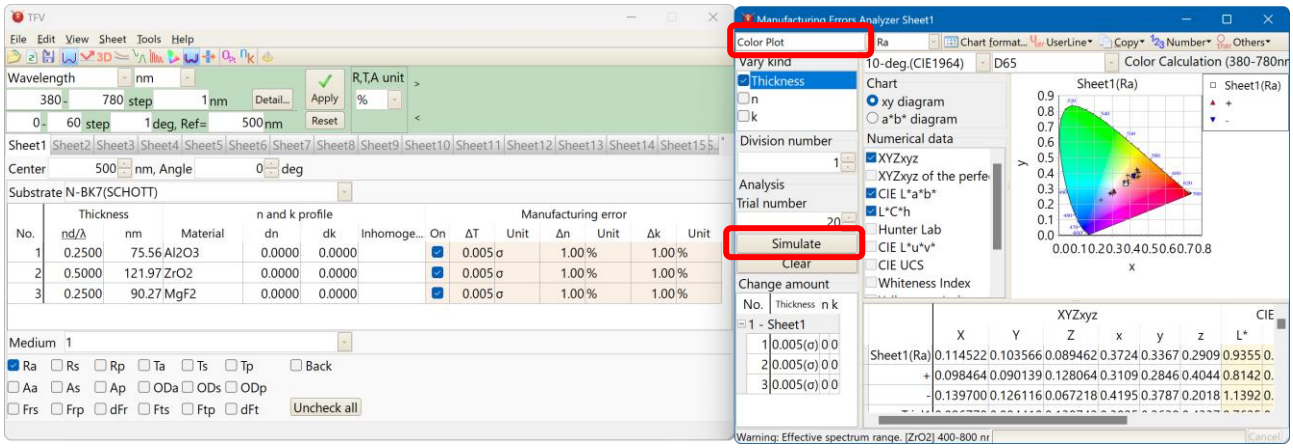
Put a check in the [On] column, input 2.5 in [σT] column on all layers. And put a check on “Thickness” in [Vary kind] in the chart window.

Input 20 in the [Trial num.], then push [Simulate].



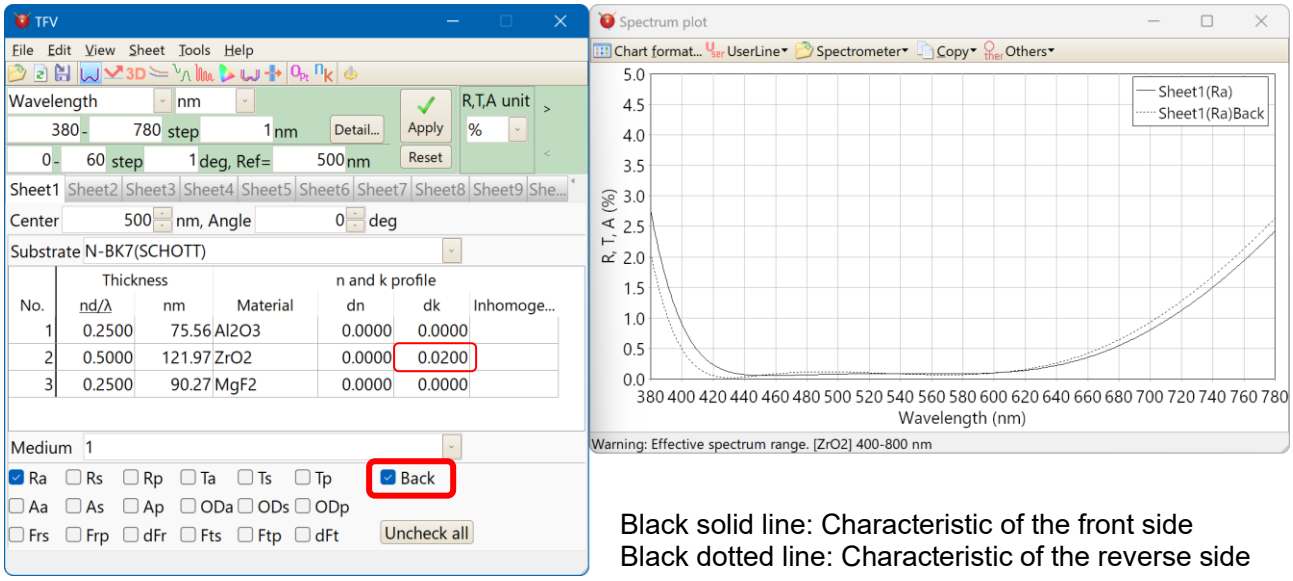
【Example 2】Color simulation in above case.

Select [Color Calculation], and then push [Simulate].



3.6.9. Reverse side characteristic

Select the [Back] on the main window, and then the calculation result from the reverse side will be plotted on the chart.



Black solid line: Characteristic of the front side
Black dotted line: Characteristic of the reverse side

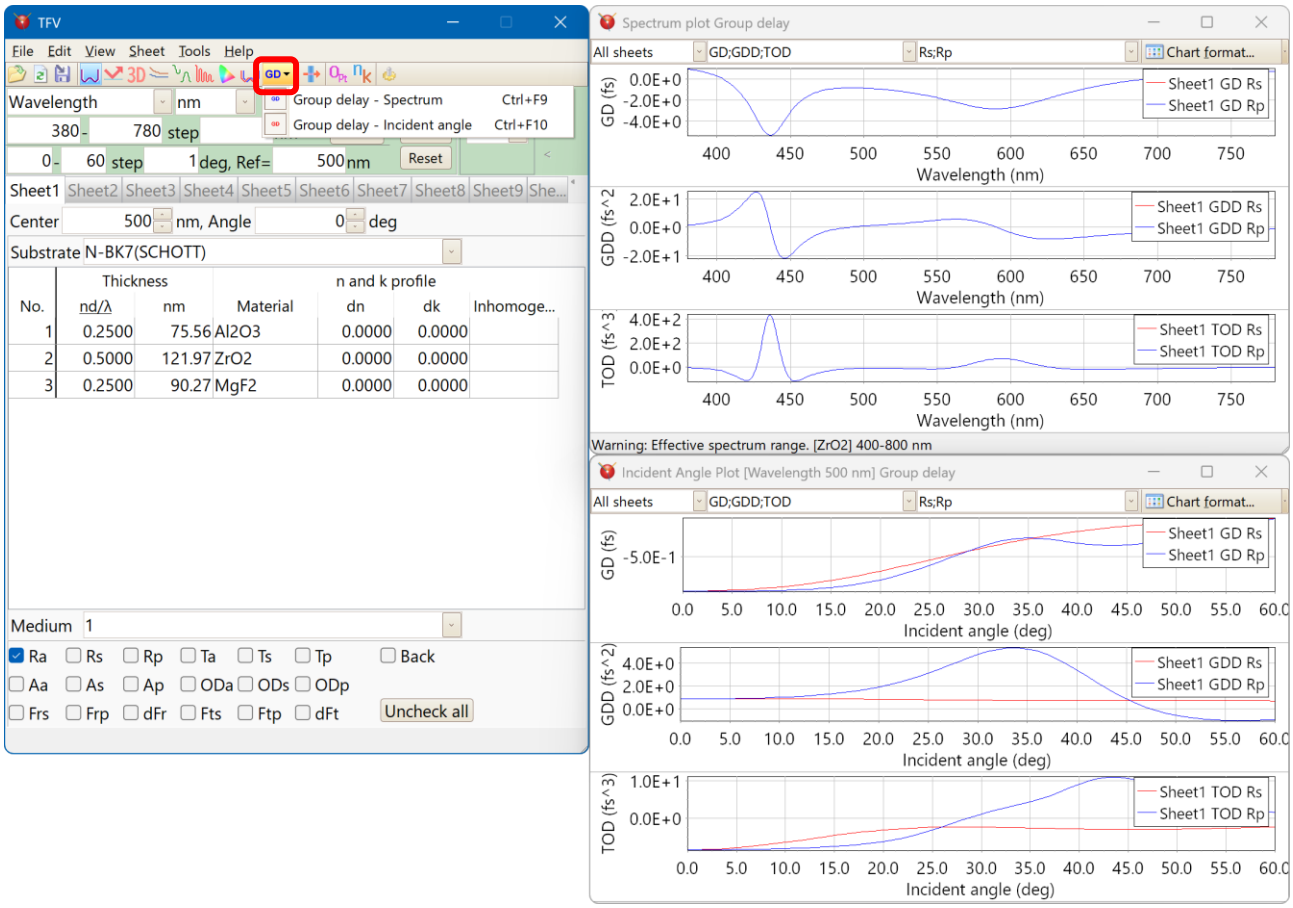
The reverse side characteristic can be display on the spectrum plot chart, incident angle plot chart, EFI plot chart and color calculation.

※ The reverse side characteristic is calculated as the same light path from the front. Therefore, the incident angle of reverse side is different from the front side.

3.6.10. Group Delay

To display the group delay and group delay dispersion graphs, press the GD toolbar in the main window.

You can display the spectrum graph and the incident angle graph.



The supported types and units of group delay are as follows.

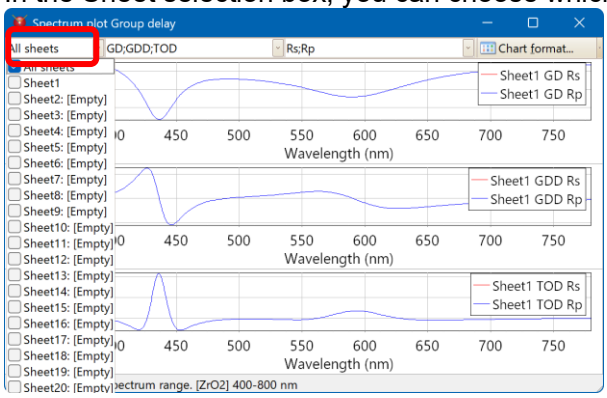
Group Delay type
GD: Group Delay
GDD: Group Delay Dispersion
CDC: Chromatic Dispersion Coefficient
TOD: Third Order Dispersion
FOD: Fourth Order Dispersion
5OD: Fifth Order Dispersion

Unit of Group Delay
fs, ps

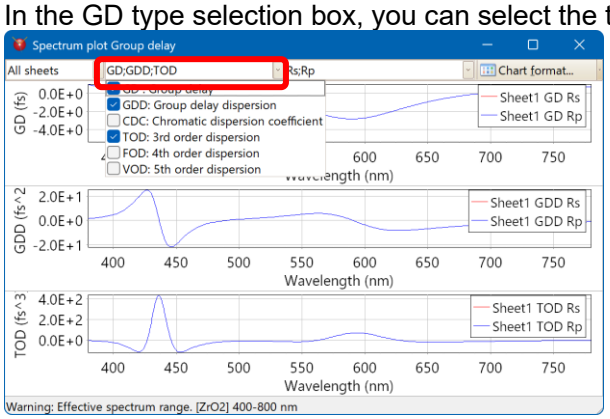
The spectral range and incident angle range can be set in the calculation range settings section of the main window.
The unit of group delay can be set in [Tools] - [Options] - [Phase and Group Delay] - "Group delay units" in the main window.

In the calculation of group delay, differentiation also includes the optical constants (the dispersion formulas of n and k).
Numerical differentiation (finite difference) with large errors is not used.

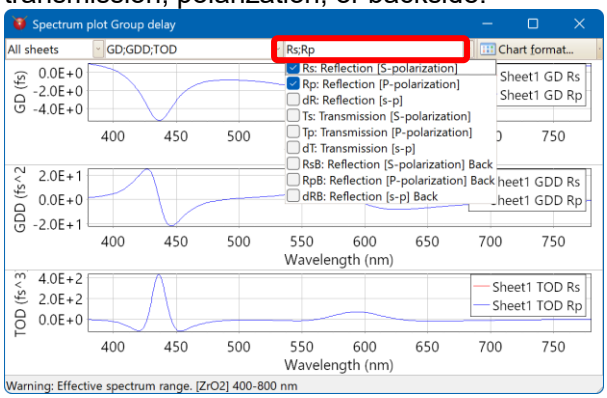
In the Sheet selection box, you can choose which sheet's graph in the main window to display.



In the GD type selection box, you can select the type of GD.



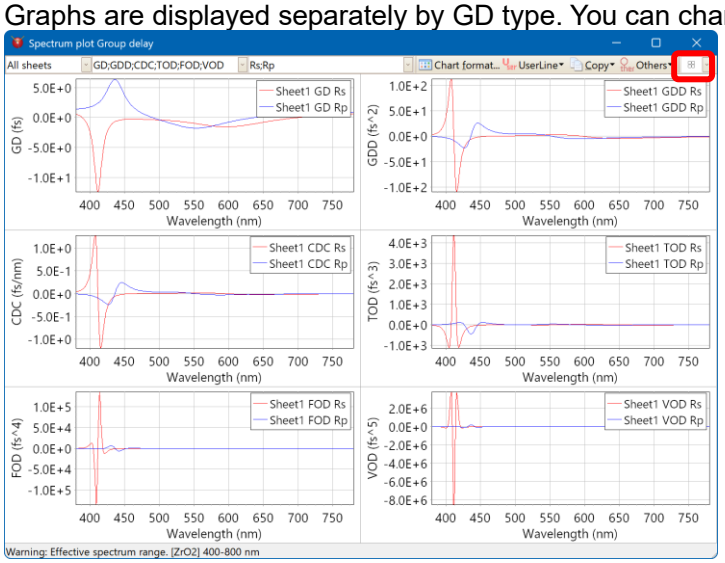
In the Calculation Type selection box, you can select the calculation type, such as reflection, transmission, polarization, or backside.



The group delay graph does not link with the calculation type selection section at the bottom of the main window.

Select the calculation type using the selection box at the top of the graph window.

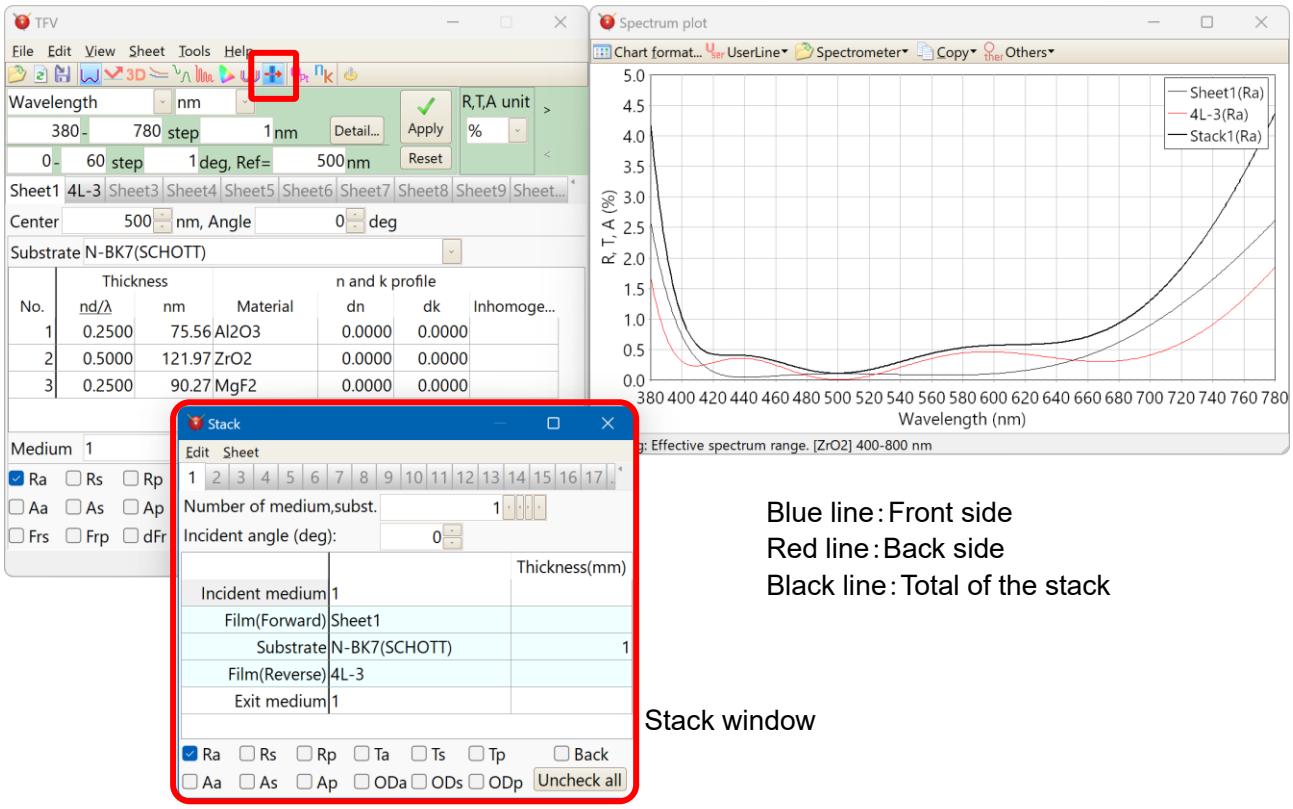
Graphs are displayed separately by GD type. You can change the arrangement using the toolbar.



3.6.11. Total of multiple substrates (Stack)

To show the stack window for total of multiple parallel plano-substrates, click the [Stack window].

The calculation result of stack can display on the spectrum plot, incident angle plot and color calculation.



Blue line : Front side
Red line : Back side
Black line : Total of the stack

Stack window

Place "film" and "substrate or medium" alternately between the incident medium and the exit medium. There are 20 sheets. Multiple configurations can be displayed simultaneously in graphs and numbers.

[Setting items of stack]

Items	Contents
Number of medium, subst.	Set the number of substrate and medium. Pressing a small button increases [>] or decreases [<] "Film" and "Substrate / Medium" one by one (total of 2 rows). Pressing a large button increases [>] or decreases [<] "Film" and "Substrate / Medium" two each (total of 4 rows). You can set up to 5000 substrates / medium total. Due to the speed of calculation, recommended to use on the order of <10 substrates / medium.
Incident angle	Set the angle of incidence of rays incident on the initial substrate surface from the incident medium.
Incident medium	Set the incident medium.

	The incident medium is always calculated with an absorption coefficient (k) = 0.
Film(Forward) Film(Reverse) By clicking with the mouse, you can select whether it is Forward or Reverse direction.	Set the film design and film direction. You can select the film design displayed on the sheet in the main window. [None] means without film. *Film direction [Film (Forward)] : Place the film in the direction of the upper row in the incident medium and the lower row in the substrate. [Film (Reverse)] : Place the film in the direction of the lower row, the incident medium, the upper row the substrate.
Substrate Medium By clicking with the mouse, you can select whether it is a substrate or a medium.	Set the substrate and medium. With the medium to medium as one block, spectral characteristics for each block can be displayed numerically. Spectral characteristics of each block are not displayed on the graph. Only the spectral characteristics of the entire configuration are displayed in the graph. * For the block, refer to the next section. Individual colors are displayed alternately for each block. There is no optical difference between "substrate" and "medium". In order to separate the block, distinguish between substrate and medium.
Exit medium	Set the exit medium.
Thickness(mm)	Set the thickness of the substrate and medium. The thickness is meaningful when the internal transmittance of the substrate / medium is less than 100. When the internal transmittance is 100, spectral characteristics do not change even if the thickness is changed. When the thickness is set to 0, calculate as internal transmittance 100. Even if the thickness is set to 0, the substrate / medium will not be lost.
Ra, Rs, Rp, Ta, Ts, Tp, Aa, As, Ap, Oda, ODs, ODp, Back	Select the type of calculate. Ra : Reflectance (Average) Rs : Reflectance S-polarization (TE) Rp : Reflectance P-polarization (TM) Ta : Transmittance (Average) Ts : Transmittance S-polarization (TE) Tp : Transmittance P-polarization (TM) Aa : Absorptance (Average) As : Absorptance S-polarization (TE) Ap : Absorptance P-polarization (TM) ODa : Optical density (Average) ODs : Optical density S-polarization (TE)

	ODp : Optical density P-polarization (TM) Back : Incident light from the reverse side

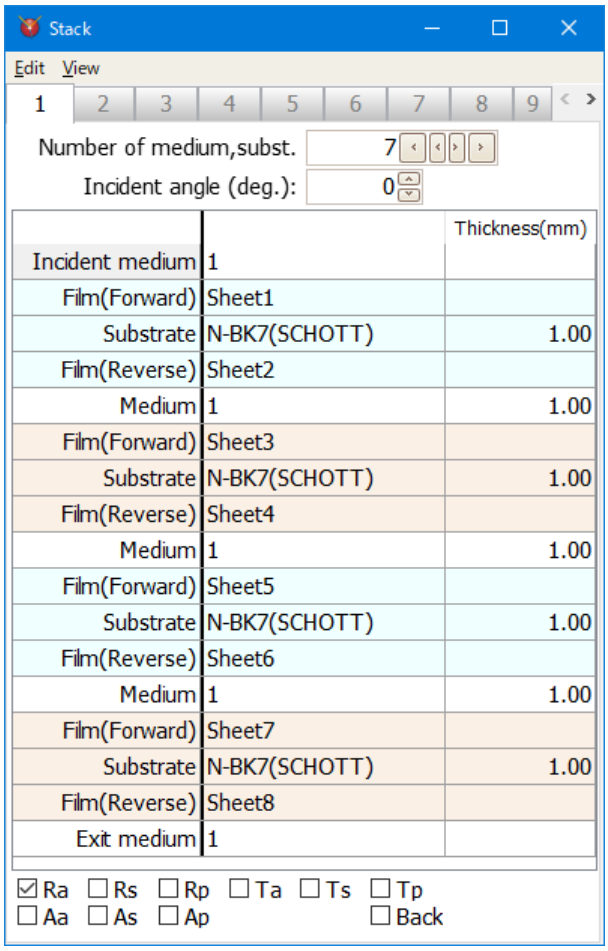
* In the calculation of the film on each side of the stack, the incident angle, the incident medium, and the substrate of the film configuration of the main window are ignored, and the incident angle, incident medium, and substrate of the stack window are used.

* Tips for Using Stacks

The Stack function performs calculations based on these principles:
Films: Coherent (light interferes)
Substrate/Medium: Incoherent (light does not interfere; multiple reflections are considered)

For materials with strong absorption, such as metals, light transmission is blocked when they become sufficiently thick.
Such materials are typically not used as the incident Medium, intermediate Substrate, or intermediate Medium within the Stack.
Please use them as Films or as the final Exit medium (Substrate).

For materials with weak absorption, such as colored glass, please set the absorption coefficient (k) = 0 and use the internal transmittance setting instead.

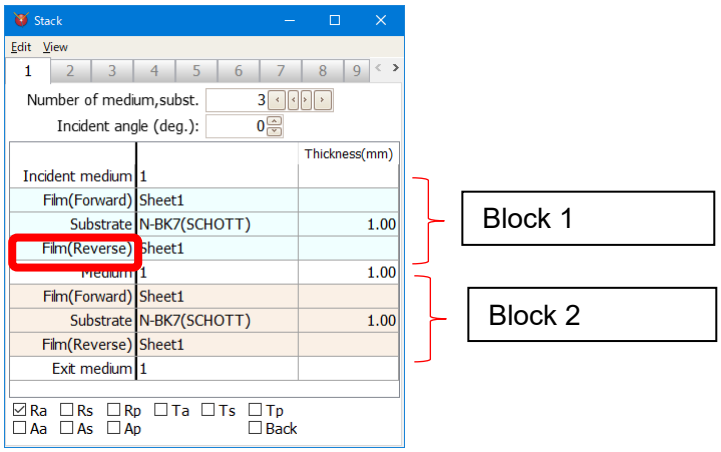


Total spectral characteristics can be calculated when films are attached to stack of multiple substrates.

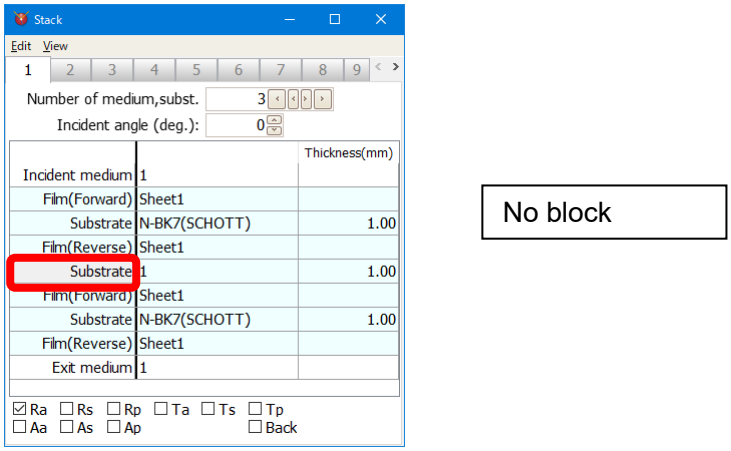
- Block

With the medium to medium as one block, spectral characteristics for each block can be displayed numerically.

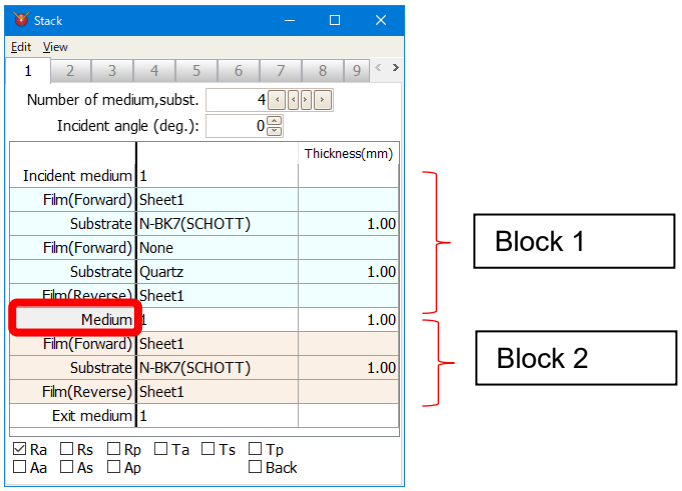
・Example 1



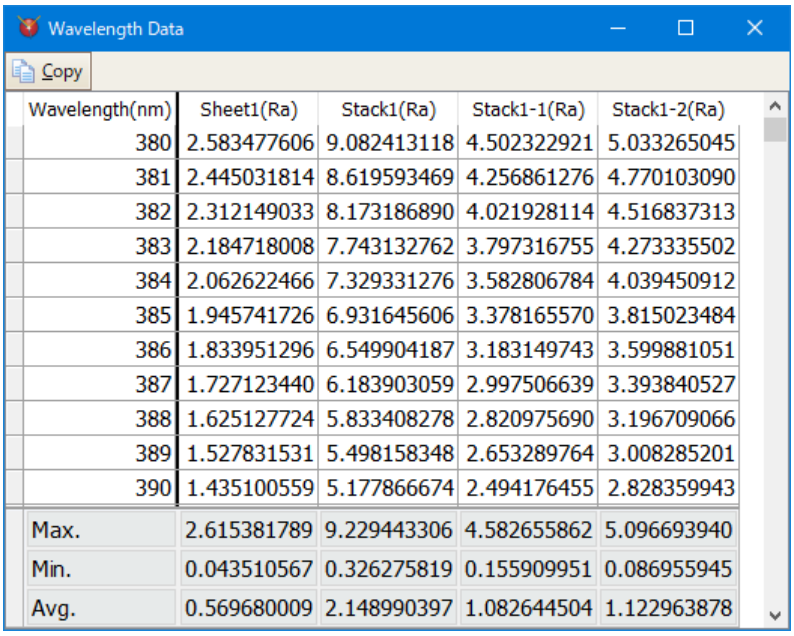
・Example2



・Example3



Right-click the spectrum plot window or incident angle plot window and select [Show numerical data]. Calculation result of the total structure of the stack and each block are displayed.



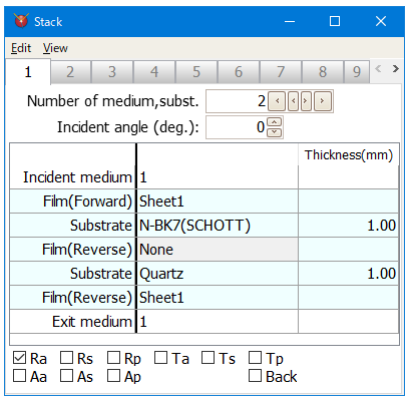
Wavelength(nm)	Sheet1(Ra)	Stack1(Ra)	Stack1-1(Ra)	Stack1-2(Ra)
380	2.583477606	9.082413118	4.502322921	5.033265045
381	2.445031814	8.619593469	4.256861276	4.770103090
382	2.312149033	8.173186890	4.021928114	4.516837313
383	2.184718008	7.743132762	3.797316755	4.273335502
384	2.062622466	7.329331276	3.582806784	4.039450912
385	1.945741726	6.931645606	3.378165570	3.815023484
386	1.833951296	6.549904187	3.183149743	3.599881051
387	1.727123440	6.183903059	2.997506639	3.393840527
388	1.625127724	5.833408278	2.820975690	3.196709066
389	1.527831531	5.498158348	2.653289764	3.008285201
390	1.435100559	5.177866674	2.494176455	2.828359943
Max.	2.615381789	9.229443306	4.582655862	5.096693940
Min.	0.043510567	0.326275819	0.155909951	0.086955945
Avg.	0.569680009	2.148990397	1.082644504	1.122963878

Sheet1	Calculation result of Sheet1 at the main window.
Stack 1	Calculation result of Stack1 at the stack window.
Stack 1-1	Calculation result of block1 in Stack1 at the stack window.
Stack 1-2	Calculation result of block2 in Stack1 at the stack window.

- Settings for laminated glass etc.

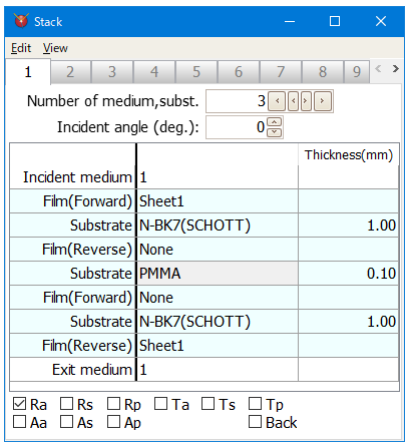
・Example 1

Contact glass and glass without sandwiching the films.
Set the film be [None] as follows.
In this example, since the film sandwiched between N-BK7(SCHOTT) and Quartz is [None], the two glasses are in contact.



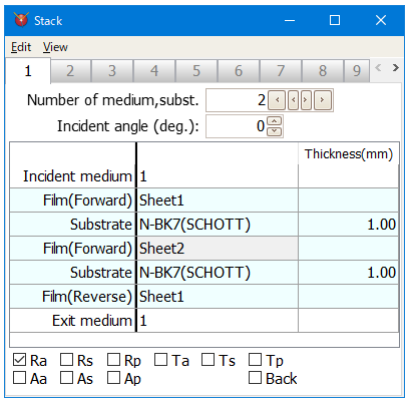
・Example 2

When a film, adhesive, etc. are caught between 2 glasses. If the thickness of the film or adhesive is thick and it exceeds the coherence length, consider the film or adhesive as the substrate and do as follows. In this example, PMMA of 0.1 mm thickness is sandwiched between two BK7.



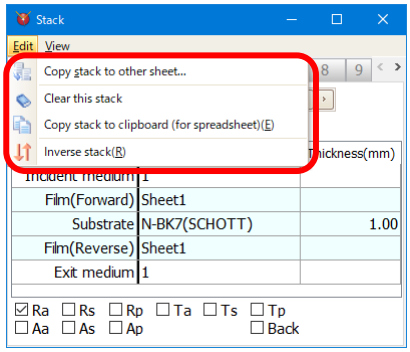
・Example 3

When a film, adhesive, etc. are caught between 2 glasses. If the thickness of the film or adhesive is thin and it is an interference region, consider the film or adhesive as a film as follows. Set a single layer of film or adhesive on Sheet 2 of the main window.



3.6.11.1. Edit stack

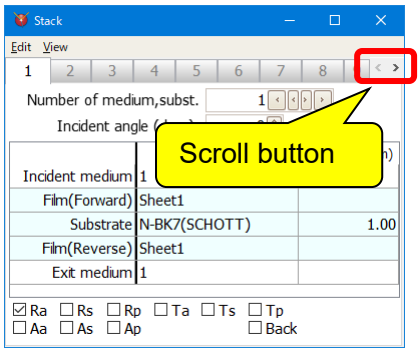
From the stack window menu, select [Edit] or right-click the tab, you can copy and paste the stack configuration, etc.

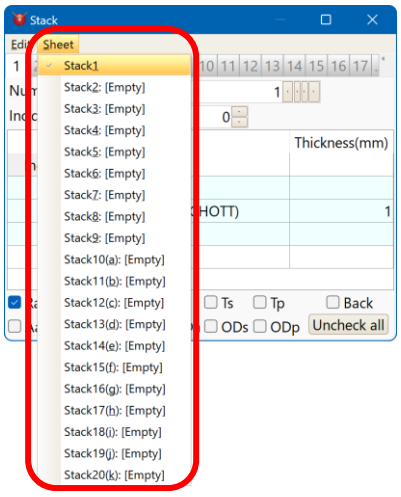


Copy stack to other sheet	Copy stack to other sheet.
Clear this stack	Clear the stack on this sheet.
Copy stack to clipboard (for spreadsheet)	Copy this stack to clipboard. You can paste to spreadsheet software etc.
Inverse stack	Flip upside down in this stack.

3.6.11.2. Selecting a sheet on stack window

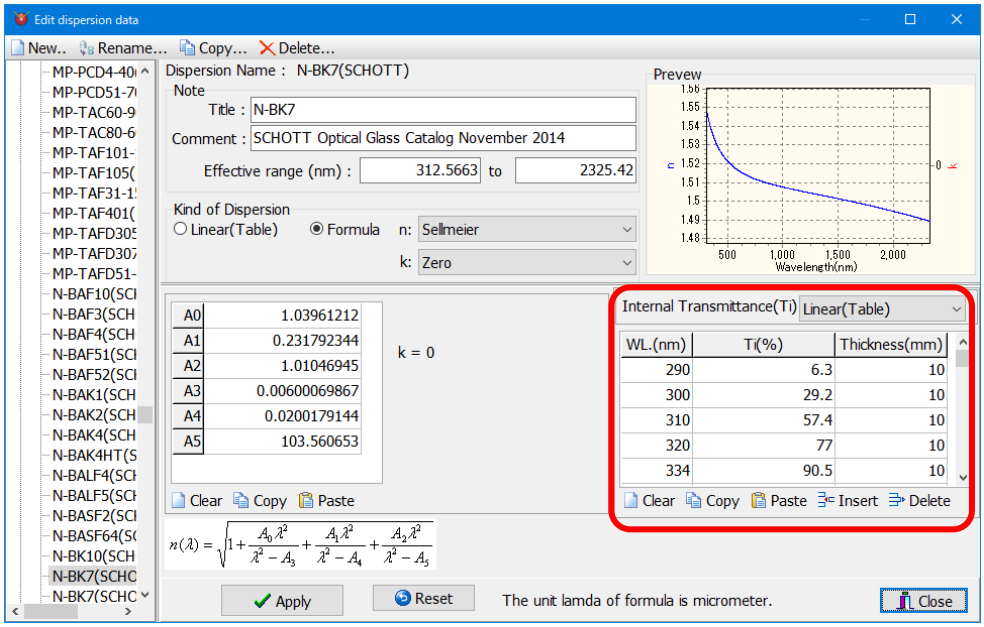
To select a hidden sheet, use the [scroll button]. Or from the menu, click [Sheet].





3.6.12. Internal transmittance for substrate and medium

On the Edit dispersion window, register the internal transmittance.
Register the internal transmittance for each wavelength (nm) and thickness (mm).
Multiple thickness can be registered.
At the time of calculation, the internal transmittance is obtained by linearly interpolating the registration data of the thickness closest to the substrate / medium thickness specified in the stack window.
In the case of just the middle thickness of registration data, use the data of the thinner thickness.
For calculation of reflection / transmission at the boundary surface, k is used.
For calculation of attenuation in the substrate and medium, internal transmittance is used.
Register k and internal transmittance respectively as necessary.



Kind of internal transmittance

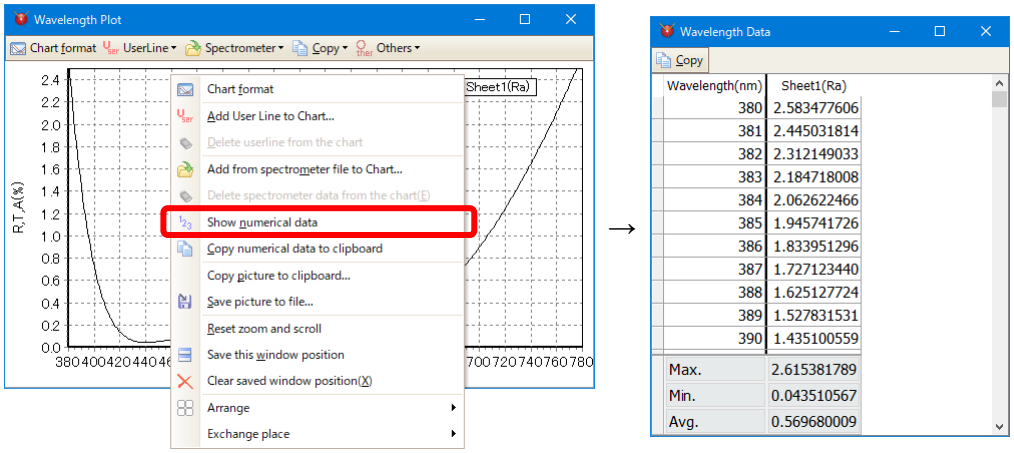
Items	Contents
Lossless (Ti=100%)	Without internal loss.
Linear(Table)	Register the internal transmittance for each wavelength (nm) and thickness (mm). Calculate the internal transmittance by linear interpolation between wavelengths.
Calc. Ti from k	Ti is calculated from k by Lambert-Beer law.

* If you set the thickness to 0mm in the stack window, calculate it as internal transmittance 100.

3.6.13. Showing the numerical value of the calculation results

All calculation results can be displayed as the numerical value.

To show the numerical values, right-click on the chart and select the [Show numerical data] on the popup menu.

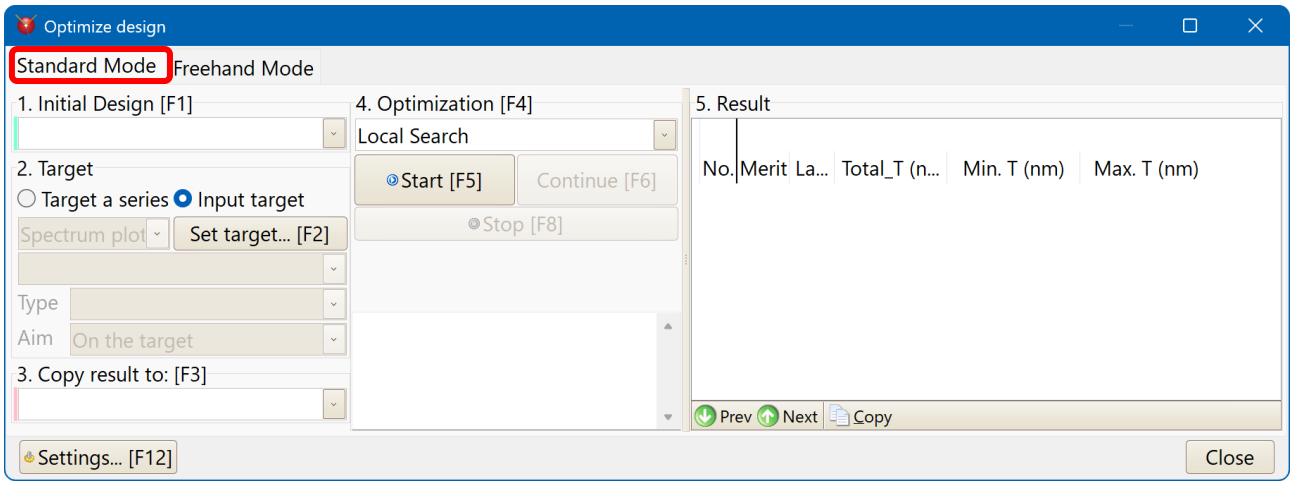


The user line and spectrophotometer line are also displayed as numerical values, but they are interpolated values based on the calculation range and calculation interval in the main window.

3.7. Optimize design (1) Standard mode

To show the optimize design functions, click the [Optimize design] on the main window.

Optimize functions of TFV has standard mode and free-hand mode.
This chapter explains the standard mode. Next chapter explains free-hand mode.
Standard mode is general way of optimize design.
Standard mode has three search methods. Local search, global search and needle search.



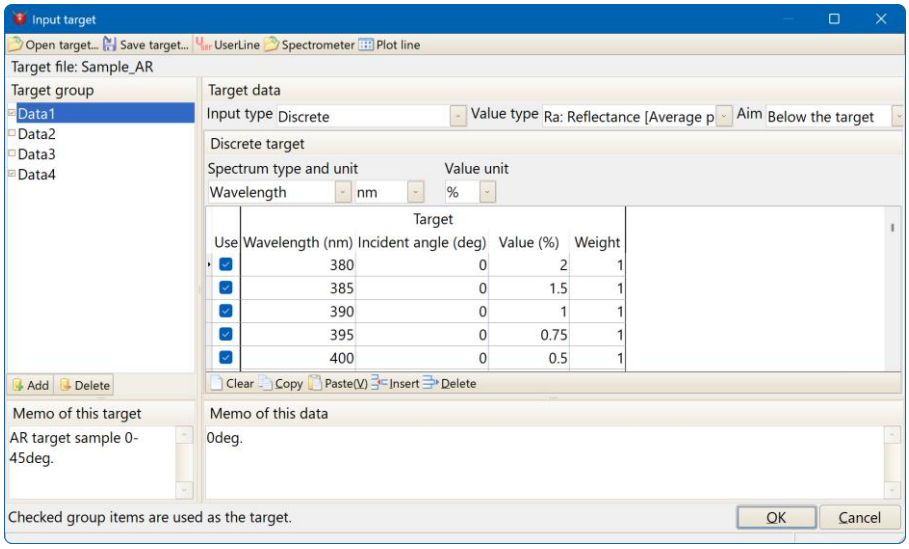
1. Initial design	Select the initial design. You can select the design from the sheets on the main window.
2. Target	
Target a series	Select the showing series on the wavelength plot or the incident angle plot as the target. Type: Select the Ra, Rs, Rp, Ta... as the type of the target values. Aim: Select from [On the target], [Above the target] and [Below the target]
Input target	Pressing the “Set target...” button will display the screen for entering targets. You can set complex targets, such as combined wavelength and incident angle targets, targets including multiple polarizations, and weighted targets.
3. Copy result to:	Select the sheet to show the optimization result.
4. Optimization	Select the optimization method from local search, global search and needle search. “Local search”: Only layer thickness is optimized with the number of layers fixed. “Global search”: Only layer thickness is optimized with the number of layers fixed. Multiple solutions are calculated by repeating optimization while changing film thickness increasingly. “Needle search”: Optimize by increasing the number of layers.
Start button	Start optimization.
Stop button	Stop optimization by force.
Continue button	Continue the optimization. This function enables only needle search.

Settings button	For set the Optimization parameters. See: [3.13.1Options]
5. Result	Displays the merit function and number of layers of the obtained solution. The smaller the merit value, the closer the solution is to the target. Multiple rows are displayed if multiple solutions are obtained. When you select a row, its film composition is displayed on the sheet in the main window. No.: Number of the results obtained. The results are sorted in order of decreasing merit function value (closer to the target). Merit: Value of Merit function. Merit = $\sqrt{\frac{1}{N}\sum_{i=1}^{N}(T_i - T_i')^2}$ N: Number of targets T_j: Calculated value T_j': Target value Total_T: Total physical film thickness of all layers Min. T: Physical thickness of the thinnest layer Max. T: Physical thickness of the thickest layer

- Explanation of the input target

If you push [Set target] on the optimization design window, Input target window will appear.

In input target, you can set the spectrum, incident angle and weight independently. And you can use plural kind of Ra, Rs, Rp, Ta... and type of aim.



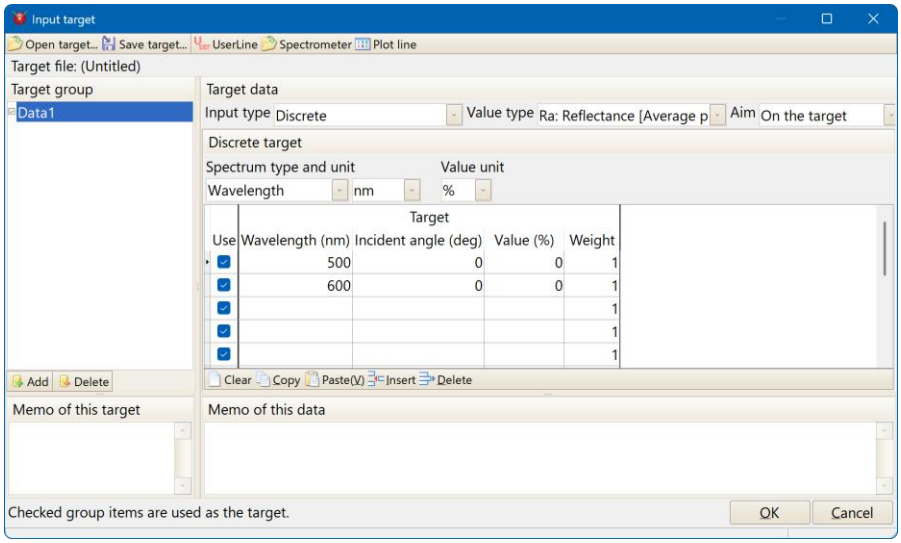
Target group	Target group is the set of target data. You can separate the target data as the Data1, Data2... Checked items are used in optimization. You can input the memo in [Memo of this target] column.
Add	Add the new target data in the target group column.
Delete	Delete the selected target from the target group column.
Target data	The target data that selected in the target group column is displayed. You can set the value from the manually input, userline file, spectrometer file, the plot series on the chart and paste from the clipboard. You can input the memo in [Memo of this data].
Open target	Open the saved target file.
Save target	Save the target.
UserLine	Read the userline file and put the showing table.
Spectrometer	Read the spectrometer file and put the showing table.
Plot line	Read the plot series on the chart and put the showing table.

- Input type

  [Discrete]

  Enter one point for each line as a target.

  The figure below is an example of targeting 0% reflectance for normal incidence at a wavelength of 500 nm and 0% reflectance for normal incidence at a wavelength of 600 nm.



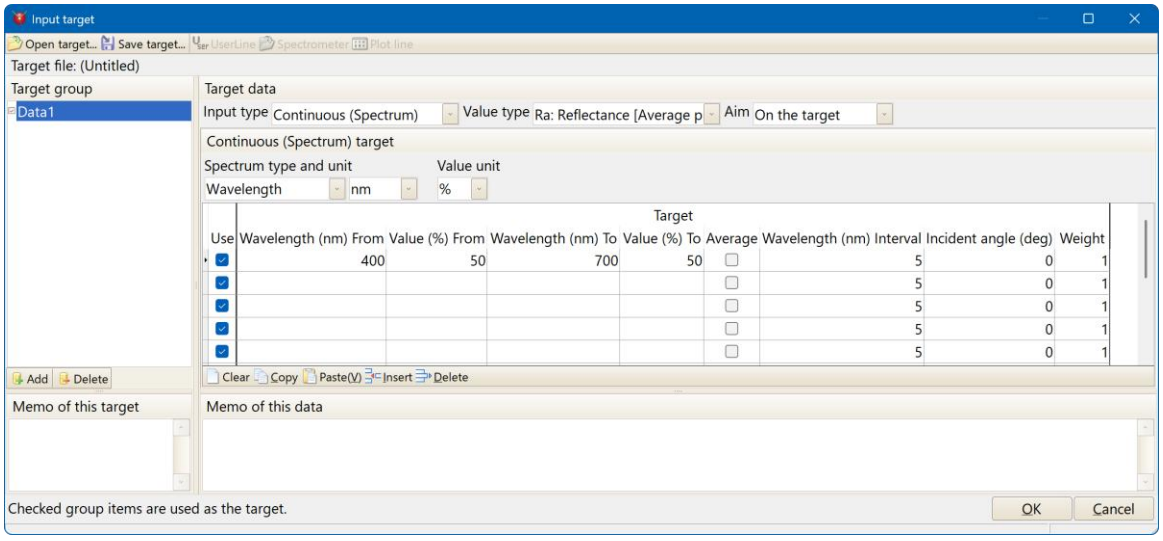
  [Continuous (Spectrum), Continuous (Incident Angle)]

  Enter continuous values such as XX% for the wavelength from XX nm to XX nm and XX% for the reflectance from the incident angle XX degrees to XX degrees.

  The figure below is an example of targeting a reflectance of 50% for normal incidents with wavelengths from 400 nm to 700 nm. 5nm is entered in the wavelength interval field. The actual target to be set is a reflectance of 50% for a total of 61 wavelengths of 400, 405, 410, ..., 700 nm.

  If you want to target a diagonal line, for example, in the figure below, if you enter 50 for the Value (begin) and 0 for the Value (end), the diagonal straight line from 400nm, 50% to 700nm, 0% will be the target.

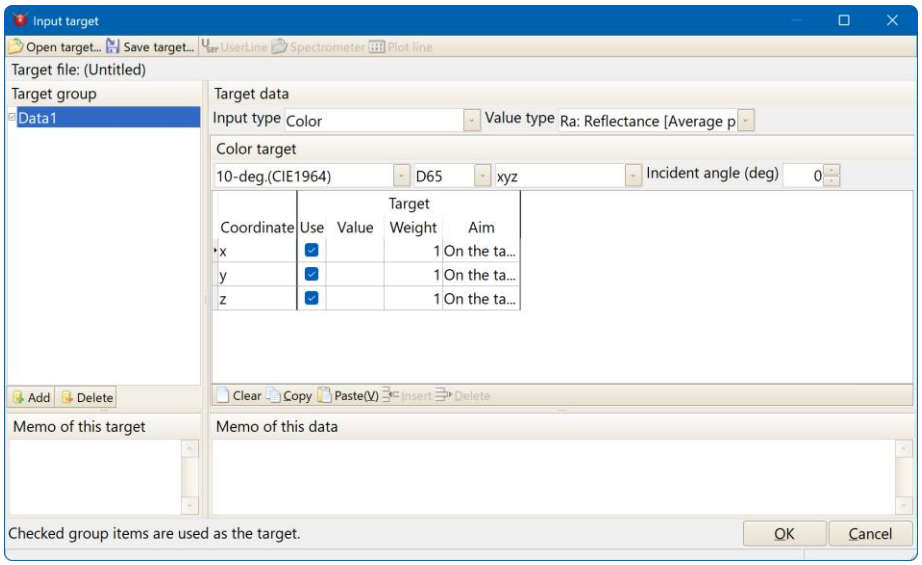
  If you check the [Average] field, the average value will be the target. If you check [Average] in the example below, optimization is performed so that the average reflectance of a total of 61 wavelengths of 400, 405, 410, ..., 700 nm is 50%.



[Color]

Select the visual field (observer), light source (illuminant), and color system, and set the target for each color coordinate.

If you want to set multiple targets, add a target group.



The targets appear on the spectrum plot, the incident angle plot ,the spectrum and incident angle 3D plot and Group delay plot charts. If you specify a color for the target type (color target), the target is not displayed on the graph.

3.7.1. Local search

Local search use Levenberg-Marquardt Method for optimization thickness.

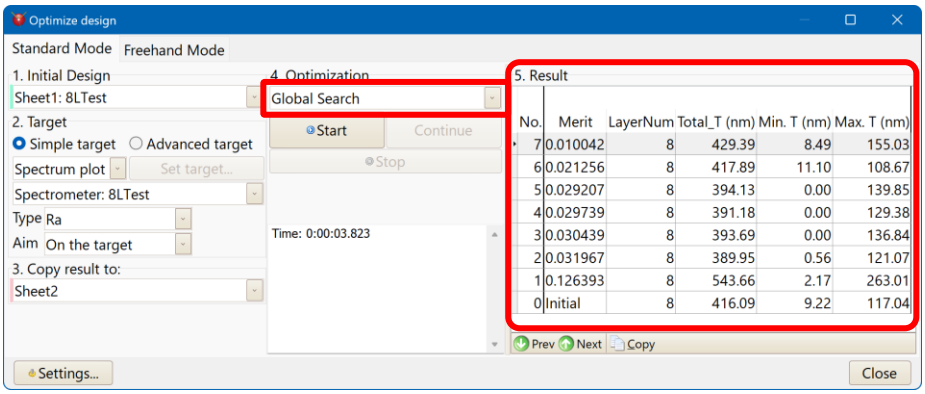
Push the [Start] button to start optimization. Optimization is finished then optimization result appears on the sheet.

3.7.2. Global search

Global search is used Simulated Annealing Method and Levenberg-Marquardt Method.

Push the [Start] button to start optimization. Optimization is finished then some kind of results appears as follows. Select a result from the lists then the design of selected result will be shown on the sheet of the main window.

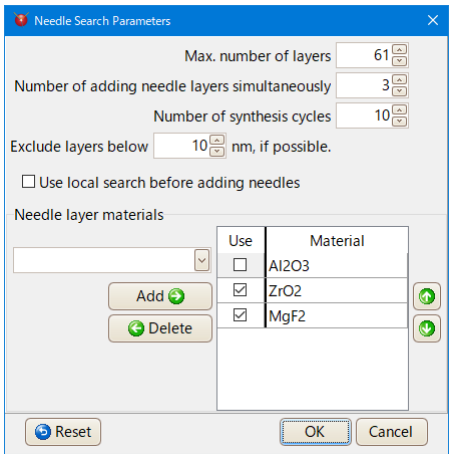
You can set the optimization parameters by push the [Settings] button. See: [3.13.1Options].



3.7.3. Needle search

Needle search works by adding the needle-like layers into the design. After the needle-like layers have been added, the local search is used to optimization.

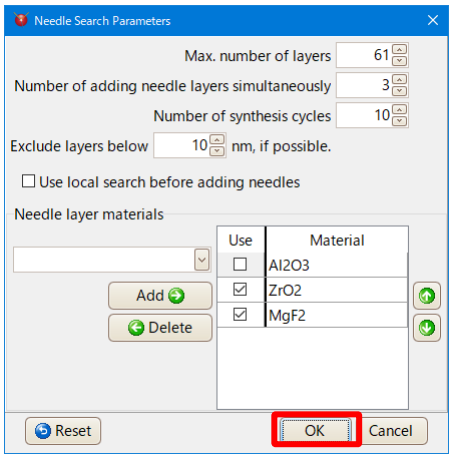
When you push [Start] button then following window appears.



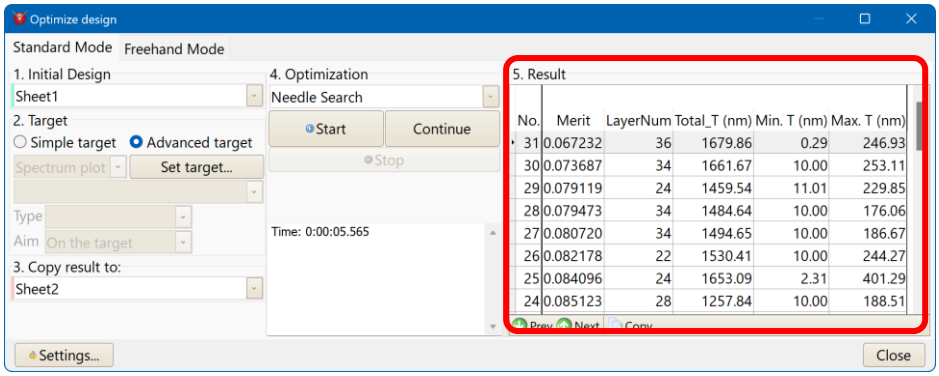
- Explanation of the needle search parameters

Max. number of layers	Set the maximum number of layers.
Number of adding needle layers simultaneously	Set the number of adding needle layers simultaneously. If needle search has not good effect, then less than this number of layers is used.
Number of synthesis cycles	Set the repeat number of the needle search. If needle search has no good effect on the method, then optimization will be finished before reaching this number.
Exclude layers below ～nm, if possible.	Do not make layers with physical film thickness less than ～nm. However, the results including the layer of ～nm or less are also displayed.
Use local search before adding needles	If checked, local search will be done before adding needles.
Needle layer materials	Set the needle layer materials. The upper material has high priority. Unchecked materials are not use in needle search.

Press the OK button to start optimization.



Multiple results are displayed in the result column as follows. They are arranged in descending order of merit value (in descending order of target). When you select a row, its film design is displayed on the sheet in the main window.



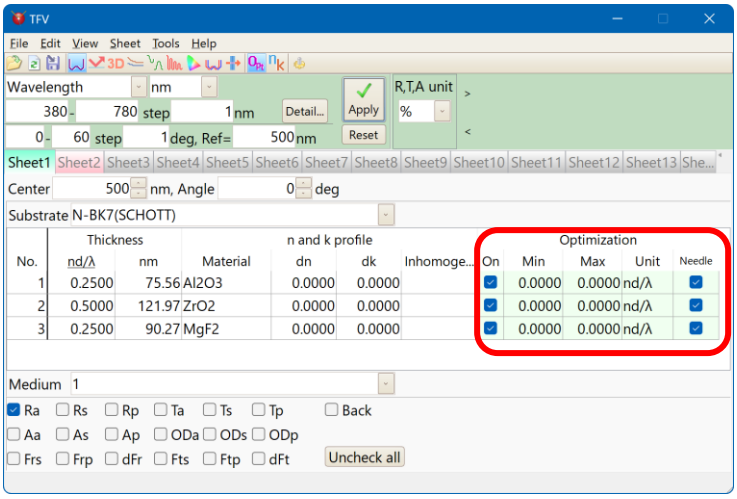
- Continue of needle search

After first needle search, [Continue] button will be enabled.
When push [Continue], then continue the needle search.
By increasing the "Number of synthesis cycles" on the needle search parameter screen, you can reduce the number of times you press the continue button.

For needle optimization, refer to: Sh. A. Furman and A.V.Tikhonravov, "Basics of optics of multilayer systems", Editions Frontiers, 1992

3.7.4. Optimization parameters of each layers

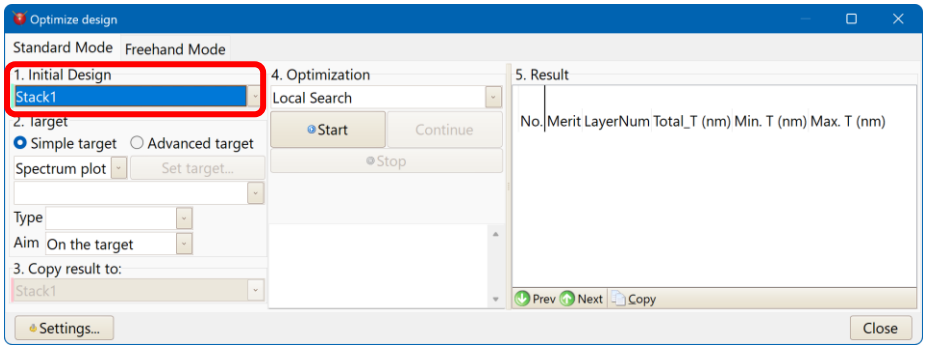
If the optimization design window will appear, then the main window spreads on right-hand side and the optimization parameters columns will appear.



Opt	Whether you want to optimize this layer. Checked: Optimize this layer. Unchecked: No optimize this layer.
Min	Minimum thickness of this layer.
Max	Maximum thickness of this layer. If this value is zero, then max. thickness value of optimization settings (3.13.1Options) will be used as maximum thickness.
Unit	The thickness unit of Min and Max.
Needle	Whether you want to insert needle layers in this layer. Checked: Insert needle layers. Unchecked: Not insert needle layer.

3.7.5. Stack optimization

When you display the stack window, you can select the stack for the initial design. Optimize all film configurations used in the stack.

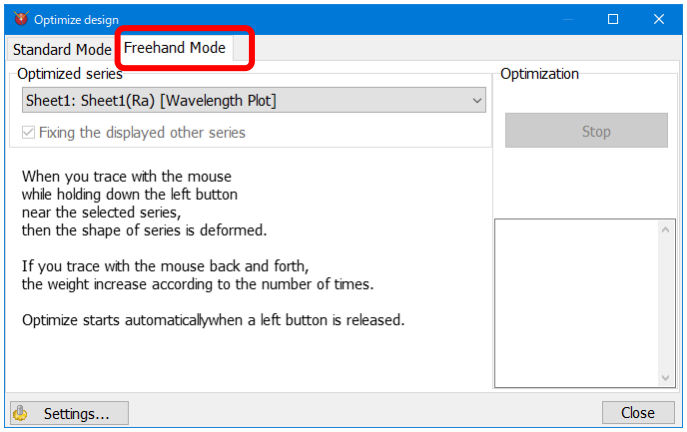


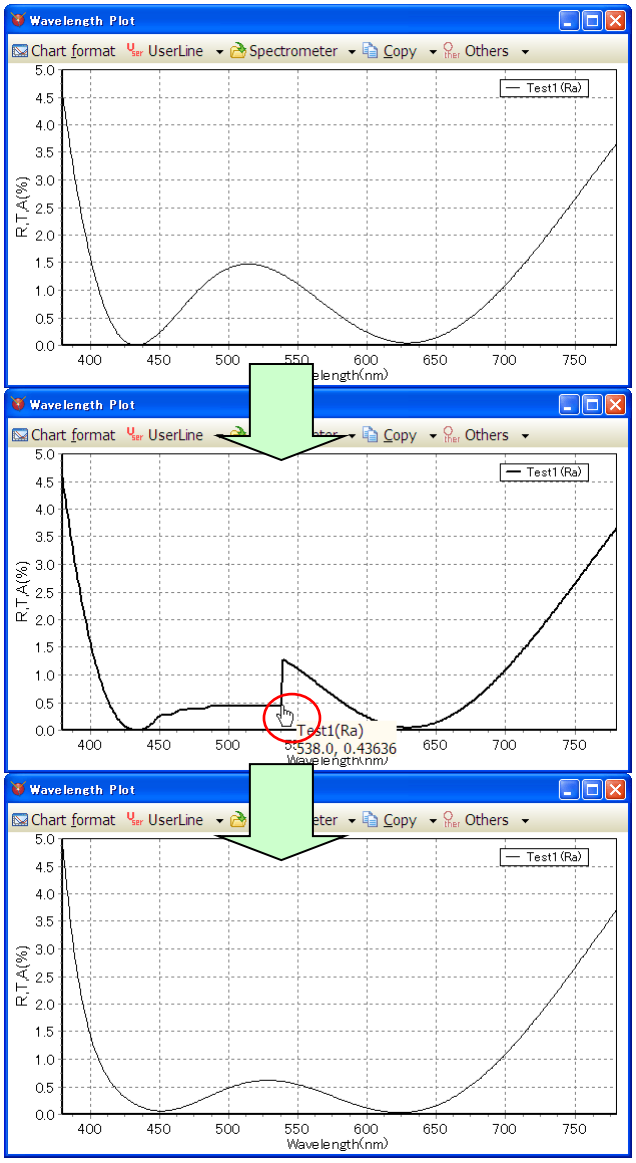
3.8. Optimize design (2) Free-hand mode

When you trace with the mouse while holding down the left button near the selected series, then the shape of series is deformed. Optimize will be started automatically when you release the left button.

You can select series from the spectrum plot and the incident angle plot.

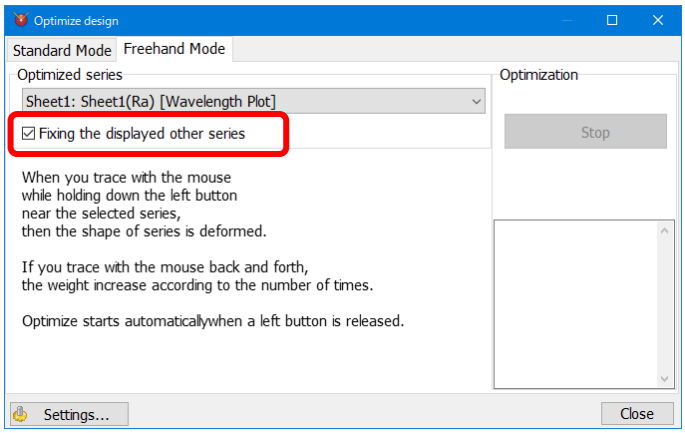
3.8.1. Basic operation





In the free-hand mode, mouse cursor is changed to hand point shape.

3.8.2. Behavior when multiple series are displayed



When multiple series are displayed for initial design, if you check “Fixing the displayed other series” then all displayed series for initial design are used as the target.

For example, if it has been displayed Ra, Ra(back) and Ta in Sheet1 on the chart and you select the [Sheet1(Ra)] at “Optimized series” and you check the "Fixing the displayed other series", then the optimization is performed to target the three series of deformed Ra, Ra(back) and Ta. If you uncheck the "Fixing the displayed other series", then the optimization is performed to target only series of deformed Ra.

3.8.3. Weight with the mouse

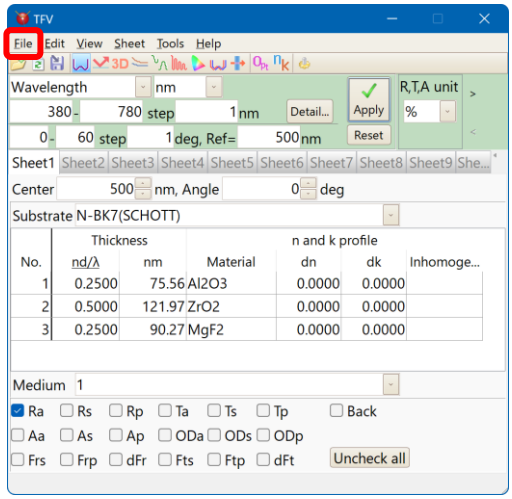
If you trace with the mouse back and forth, the weight of point data of target increase according to the number of times.

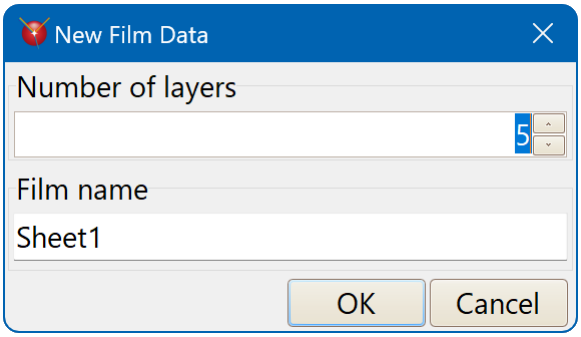
For example, when deforming the shape of the range of 500nm ~ 550nm of Ra, if you trace two round trips in mouse a range of 500nm ~ 550nm then the weights of point data of target in 500nm ~ 550nm are 4. The weights of other range are 1.

3.9. New Creating, reading and saving the film data

3.9.1. New creating the film data

(1) Select the sheet you want create new.
(2) Select the [File] - [New...] command from main menu.
(3) Input the film name and the layer number, and click [OK] button.



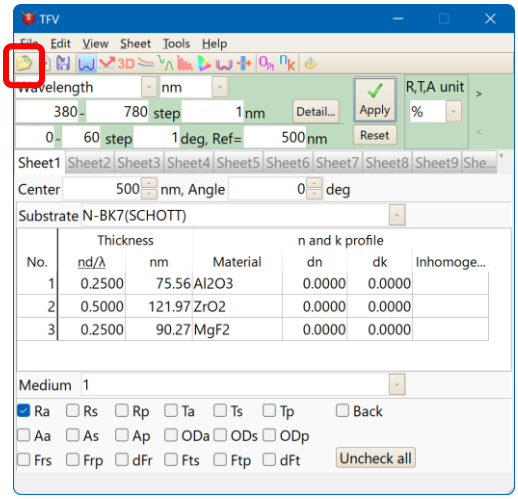


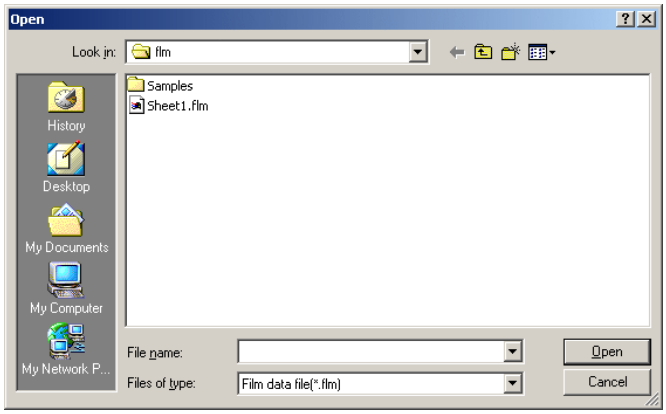
When there is an existing film data in the sheet, the existing film data is canceled. And the film data of default thickness and default material is created.

When there is not a film data in the sheet, the film data of default thickness and default material is created. And the sheet become editable.

3.9.2. Reading the film data from file

(1) Select the sheet you want read the film data.
(2) Click the [Open] toolbar or select the [File] - [Open...] command from main menu.
(3) Select a file you want read, and click [Open] button.



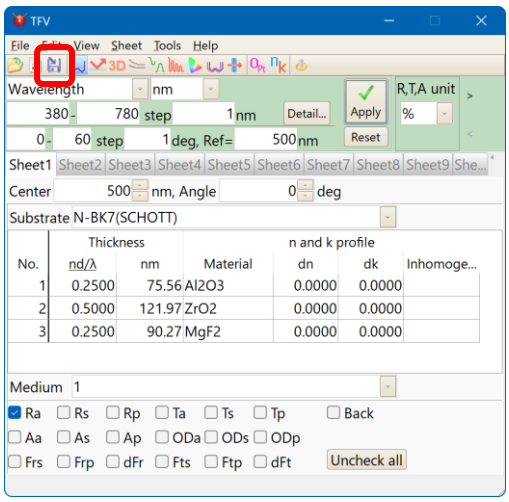


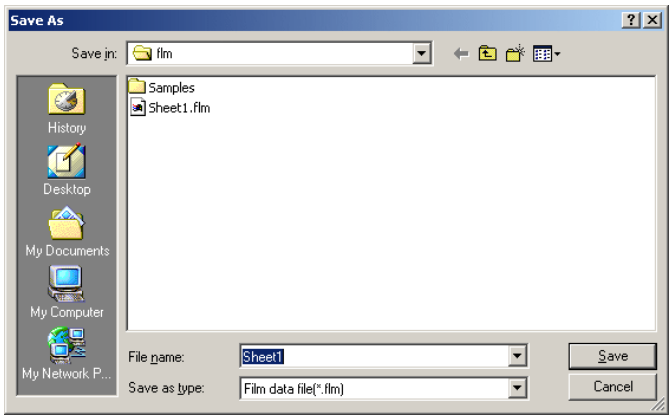
3.9.3. Saving the film data to file

(1) Select the sheet you want save the film data.

(2) Click the [Save] toolbar or select the [File] - [Save as...] command from main menu.

(3) Input a file name you want save, and click [Save] button.



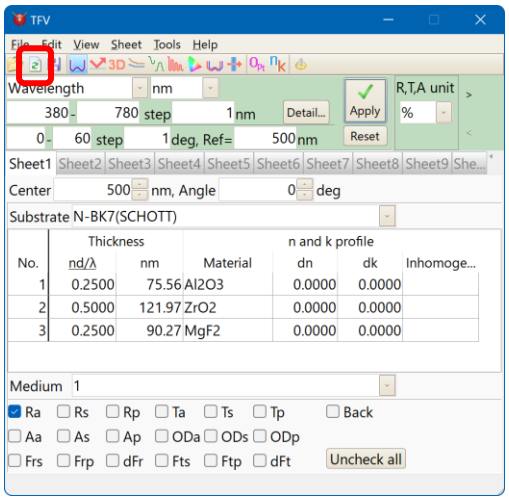


3.9.4. Reloading the film data to saved data

You can return the film data to saved data after changing thickness and material etc.

Click the [Reload] toolbar or select the [File] - [Reload] command from main menu, then the film data in the sheet return to the stored data.

* Attention : The edited data are canceled and cannot be restored.



3.9.5. Film fata file compatibility with old version

If you save the film data file of the new version in the old version, then the items that do not exist in the old version will be deleted.

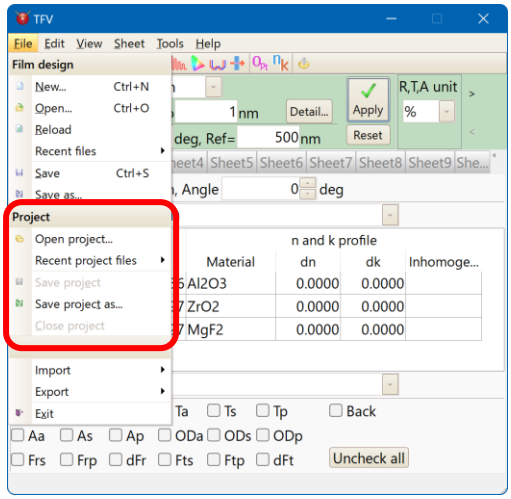
Items that are saved will be as follows for each version.

		TFV3.0 or later	TFV2.2
Thickness	Optical thickness	○	If you read the files of TFV3.0 in TFV2.2, the thickness that is set to priority in TFV3.0 (where the underline is displayed in the title) will be loaded.
	Physical thickness	○	
n and k profile	Material	○	○
	dn	○	○
	dk	○	○
	Inhomogeneity	○	○
Evaporation control	Tooling	○	○
	dn	○	○
	dk	○	○
	Filter(nm)	○	○
	Start	○	○
	MG	○	○
Optimization	On	○	○
	Min	○	○
	Max	○	○
	Unit	○	×The unit is always nm.
	Needle	○	○
Manufacturing error	On	○	×
	delta_T	○	×
	Unit of delta_T	○	×
	delta_n	○	×
	Unit of delta_n	○	×
	delta_k	○	×
	Unit of delta_k	○	×
Period layer	Period	○	○
	Magnification	○	○
Others	Center wavelength of design	○	○
	Incident angle	○	○
	Substrate	○	○
	Incident medium	○	○
	Monitor glass	○	○
	Comment	○	○

○: Saved item, ×: Unsaved item

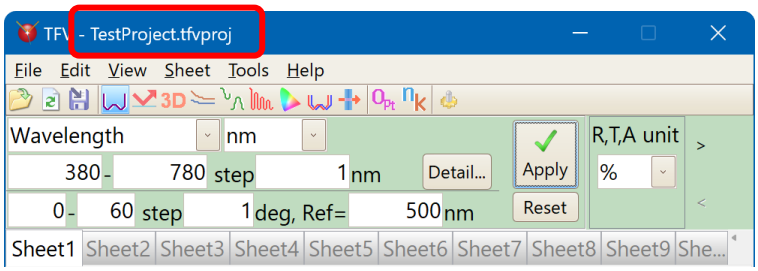
3.10. Loading and saving the project

You can save the film data of each sheets, window positions, chart formats and user line etc. as the “Project”.



3.10.1. Saving the project

To save the project, click the [Save Project As...] from main menu.



Saved project file name will be displayed on title bar.

To overwrite the project, click the [Save Project] from main menu.

- Stored contents

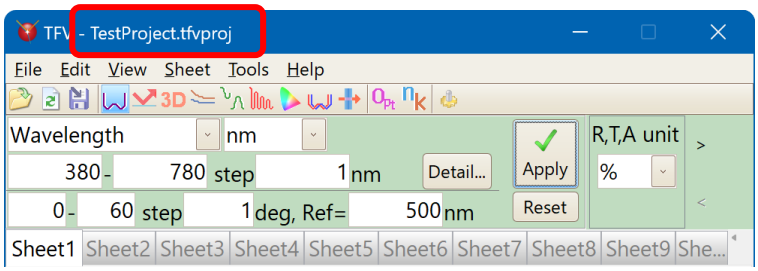
The following contents are saved.

Items	Stored contents
Film data	Film data file name of each sheets on main window.
Calculation settings	Start wavelength, end wavelength, wavelength interval, start incident angle, end incident angle, incident angle interval and calculation wavelength of the incident angle characteristic.
Type of the plot	Selection state of type of the plot (Ra,Rs,Rp,Ta...dFt,Back) on each sheets.
Number of sheet	Number of visible sheet on main window.
Main window	Display position, size and selected sheet.
User line	File name of visible user line, line color, line style and line width. Except unsaved user line.
Photometer line	File name of visible user line, line color, line style and line width. If converted absolute value, reference substrate name also will be saved.
Chart format	Chart format of each chart.

EFI distribution	Selection state of type of the plot (Ave.(s,p), s...).
Color calculation	Selection state of visual field, illuminant, base of the color difference, diagram kind and numerical data.
Manufacturing errors chart	Selection state of type of chart (wavelength, incident angle or color), kind of plot (Ra, Rs...), vary kind.
Stack window	Number of visible sheets on stack window. Incident angle, incident medium, film, medium, substrate, exit medium, thickness, kind of plot(Ra, Rs...) and window position.

3.10.2. Loading the project

To load the project, click the [Open Project] from main menu.



Loaded project file name will be displayed on title bar.

- Restored contents

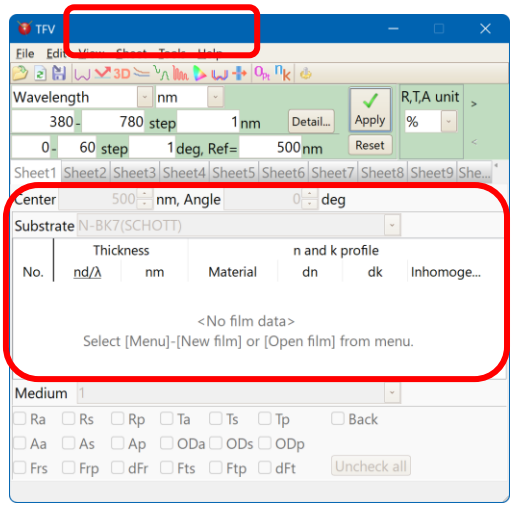
The following contents are loaded and restored.

Items	Restored contents
Film data	Load film data to each sheet from stored film data file name.
Calculation settings	Set start wavelength, end wavelength, wavelength interval, start incident angle, end incident angle, incident angle interval and calculation wavelength of the incident angle characteristic to main window.
Type of plot	Set state of type of plot (Ra,Rs,Rp,Ta...dFt,Back) to each sheets.
Number of sheet	Set number of visible sheet on main window.
Main window	Restore display position, size and selected sheet.
User line	Load user line from stored user line file name. Restore the line color, line style and line width.
Photometer line	Load photometer line from stored photometer file name. Restore the line color, line style and line width. If converted absolute value, restore it.
Chart format	Restore chart format of each chart.
EFI distribution	Restore selection state of type of the plot (Ave.(s,p), s...).
Color calculation	Restore selection state of visual field, illuminant, base of the color difference, diagram type and numerical data.
Manufacturing errors chart	Restore selection state of kind of chart (wavelength, incident angle or color), type of plot (Ra, Rs...), vary type.
Stack window	Restore number of visible sheets on stack window.

	Restore incident angle, incident medium, film, medium, substrate, exit medium, thickness, type of plot (Ra, Rs...) and window position.

3.10.3. Closing the project

To close the project, click the [Close project] from main menu.



Project file name
will be cleared from title bar.
And film data will be cleared.

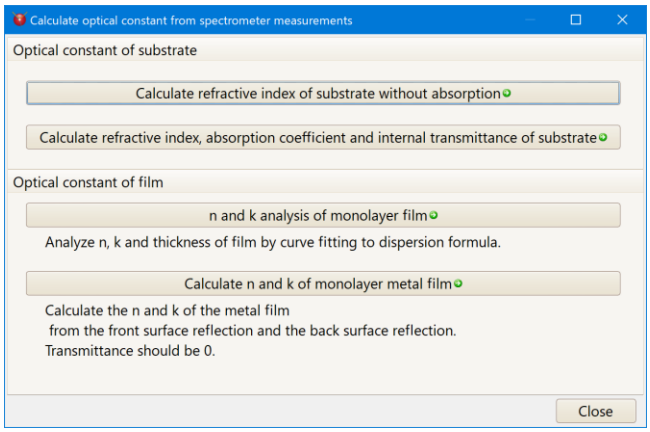
3.10.4. Loading recent project

To load the recent project, select from the [Recent project files] from main menu.

3.11. n and k calculation for substrate and film

This function calculates n and k of a substrate or monolayer film from the measured values of spectral reflectance and spectral transmittance.

From the menu of the main window, select [Tools] - [nkn and k analysis of substrate or monolayer film...], and the following screen will be displayed.

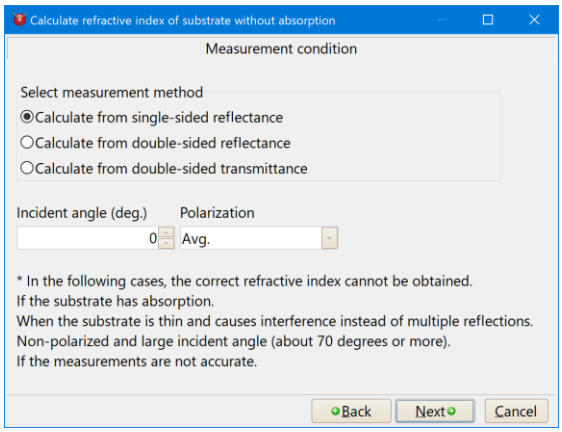


3.11.1. Calculate refractive index of substrate without absorption

Calculate the refractive index of a substrate without films.
It is used when there is no absorption on the substrate.
A single-sided matte substrate or double-sided polished substrate is required.

[Tools] - [nkn and k analysis of substrate or monolayer film...] – [Calculate refractive index of substrate without absorption]

(1) Setting of measurement conditions

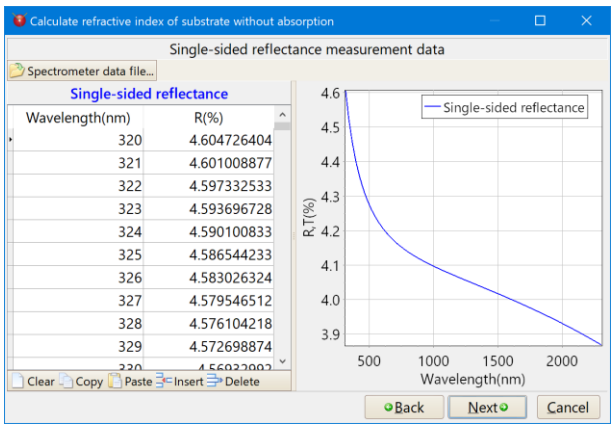


Select the measurement method from three types: single-sided spectral reflectance, double-sided spectral reflectance, and transmittance.

Enter the incident angle and select the polarization (s-polarized, p-polarized, average).

Click [Next].

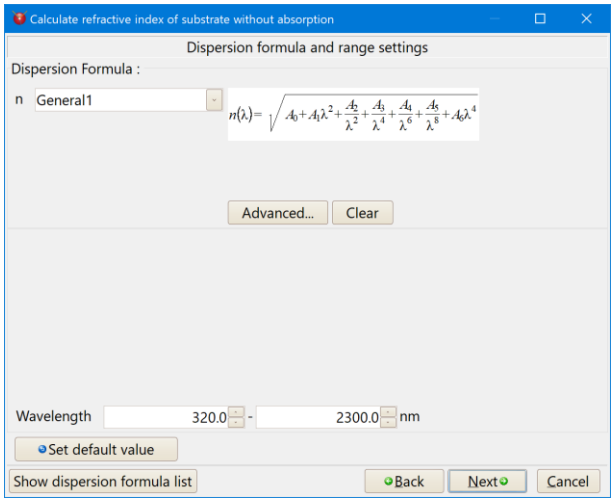
(2) Input of measured value



Read the spectrometer measurement data file from [Spectrometer data file...] or input measurement value directly. You can also paste from other software, such as Excel(R).

Click [Next].

(3) Select dispersion formula and wavelength range



Select the dispersion formula and the wavelength range to be calculated.

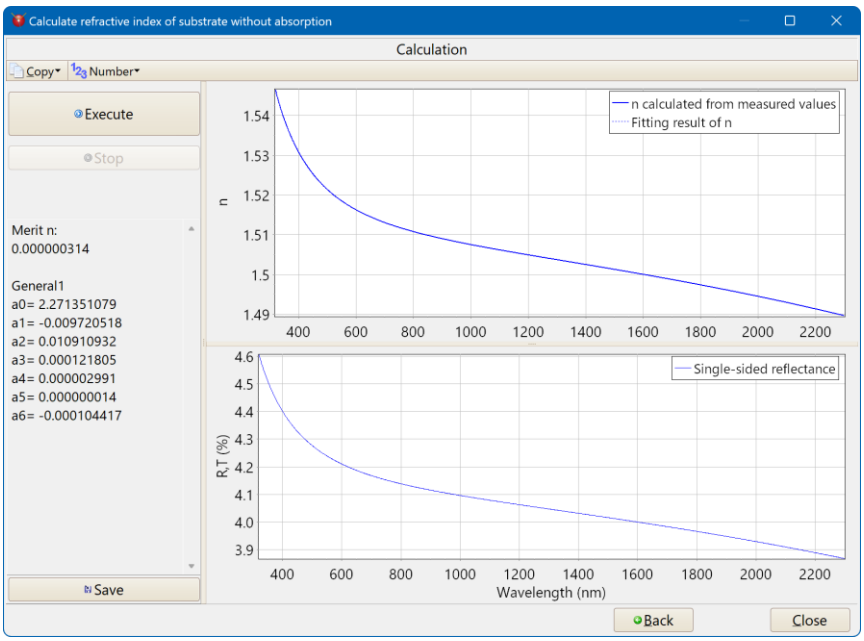
[Advanced]

You can set the initial values of the dispersion formula parameters by pressing [Advanced].

If the wavelength range is too wide and the fitting to the dispersion formula does not work, narrow the wavelength range or select “Linear (Table)” in the “Dispersion Formula” column.

Click [Next].

(4) Calculation



Click the [Execute] button to calculate n.

The solid line in the graph above is n calculated from the measured values. The dotted line is the fitting result of n calculated from the measured value to the dispersion formula.

The graph below is the measured value entered in step 2.

“Merit” is the difference between n (solid line) calculated from the measured value and the fitting result (dotted line). The smaller the number, the better the fitting.

Below that, the parameters of the dispersion formula are displayed.

If the fitting doesn't work, try the calculation in step 3 by choosing a different dispersion formula or “Linear (Table)”.

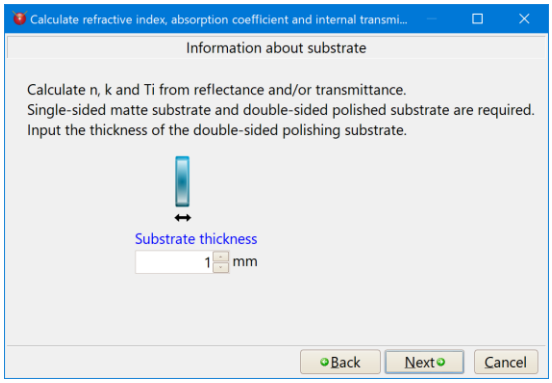
If you press [Save], you can save it as substrate data.

3.11.2. Calculate refractive index, absorption coefficient and internal transmittance of substrate

Calculate the refractive index of a substrate without films.
It is used when substrate has absorption.
Both single-sided matte substrate and double-sided polished substrate are required.

[Tools] - [nkn and k analysis of substrate or monolayer film...] – [Calculate refractive index, absorption coefficient and internal transmittance of substrate]

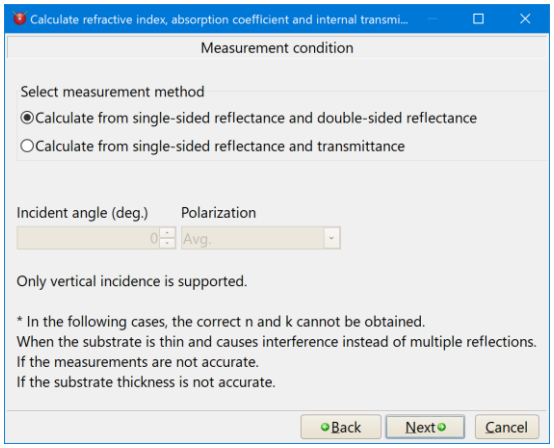
(1) Input substrate information



Input the thickness of the double-sided polishing substrate.

Click [Next].

(2) Setting of measurement conditions

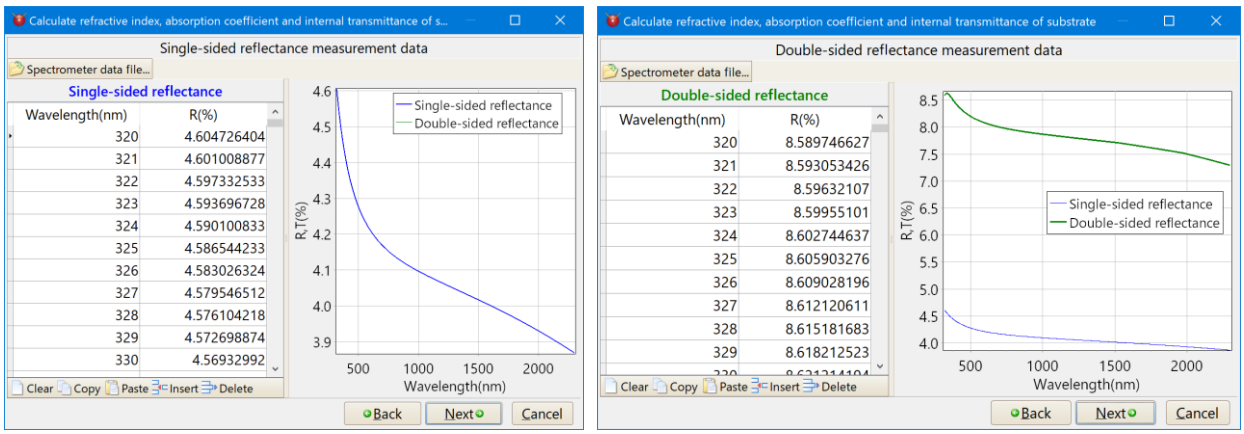


Select which measurement method to use, "Calculate from single-sided reflectance and double-sided reflectance" or "Calculate from single-sided reflectance and transmittance".

Only normal incident is supported. It does not support the measurement of oblique incident (because the solution cannot be determined). Depending on the required accuracy of n and k, it is often possible to substitute the measured values of 5° and 12° incidents as normal incident.

Click [Next].

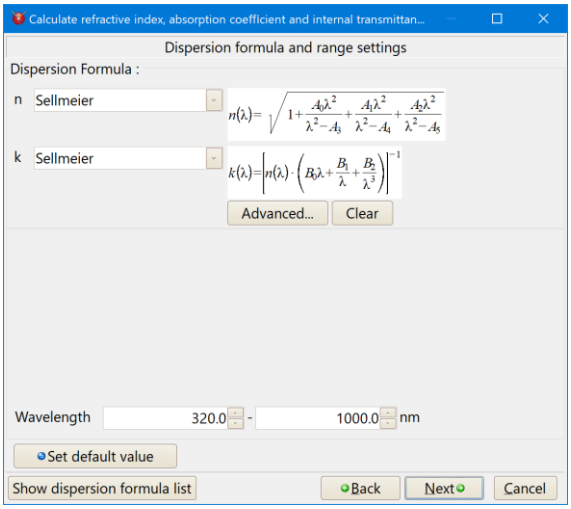
(3) Input of measured value



Read the spectrometer measurement data file from [Spectrometer data file...] or input measurement value directly. You can also paste from other software, such as Excel(R).

Click [Next].

(4) Select dispersion formula and wavelength range



Select the dispersion formula and the wavelength range to be calculated.

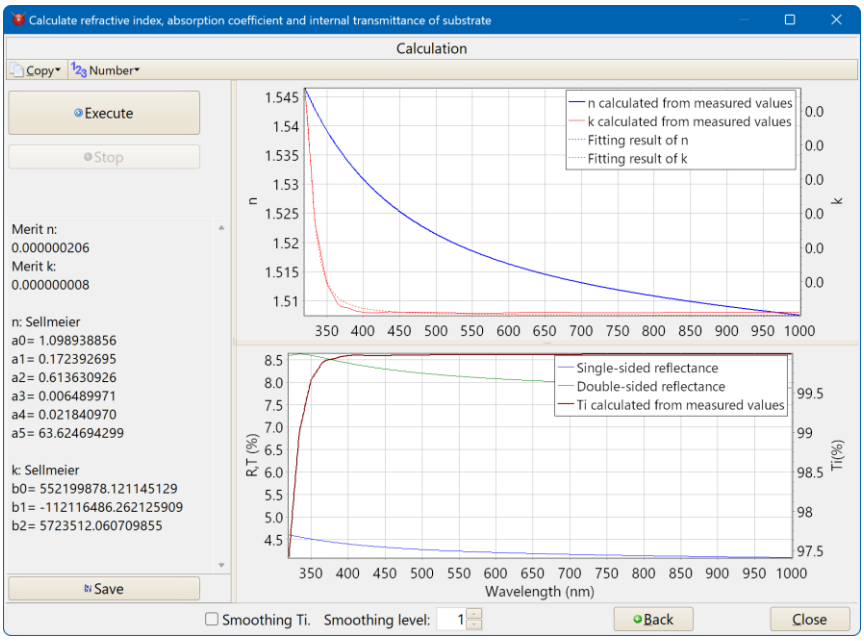
[Advanced]

You can set the initial values of the dispersion formula parameters by pressing [Advanced].

If the wavelength range is too wide and the fitting to the dispersion formula does not work, narrow the wavelength range or select “Linear (Table)” in the “Dispersion Formula” column.

Click [Next].

(5) Calculation



Click the [Execute] button to calculate n, k and Ti.

The solid line in the graph above is n and k calculated from the measured values. The dotted line is the fitting result of n and k calculated from the measured value to the dispersion formula.

The graph below is the measured value entered in step 3 and the calculation result of the internal transmittance (Ti).

The internal transmittance is not dispersion formula fitting. Since it is a value calculated directly from the measured value, there is noise in the measured value. At the bottom of the screen, there is a column for setting whether to “Smoothing Ti” and “Smoothing level”, so please smooth as necessary.

“Merit” is the difference between n and k (solid line) calculated from the measured value and the fitting result (dotted line). The smaller the number, the better the fitting.

Below that, the parameters of the dispersion formula are displayed.

If the fitting doesn't work, try the calculation in step 4 by choosing a different dispersion formula or “Linear (Table)”.

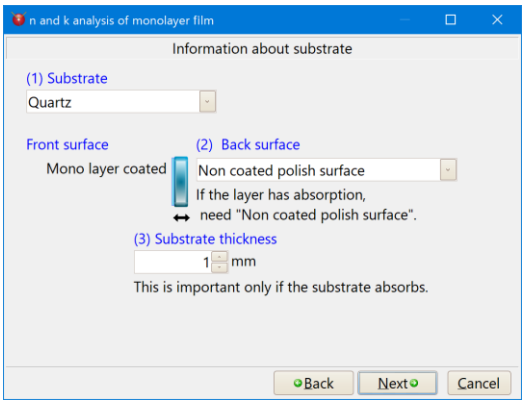
If you press [Save], you can save it as substrate data.

3.11.3. n and k analysis of monolayer film

From the spectral reflectance and spectral transmittance, n, k and film thickness (d) of the film are analyzed by curve fitting to the dispersion formula.

[Tools] - [nk n and k analysis of substrate or monolayer film...] – [n and k analysis of monolayer film]

(1) Input substrate information



Substrate

Select the substrate. Quartz (synthetic quartz) is recommended.

Back surface

Select the back-side surface type of the substrate.

Select either "Non coated polish surface" or "No reflection surface (black paint or frosted)".

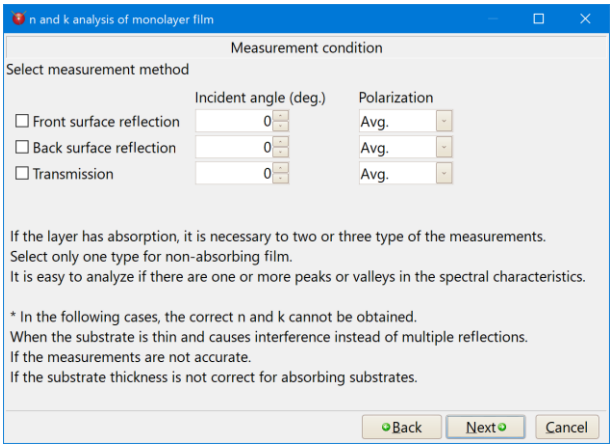
Substrate thickness

Enter the thickness of the substrate. Required only if the substrate has absorption.

If there is no absorption on the substrate, it will be ignored.

Click [Next].

(2) Setting of measurement conditions

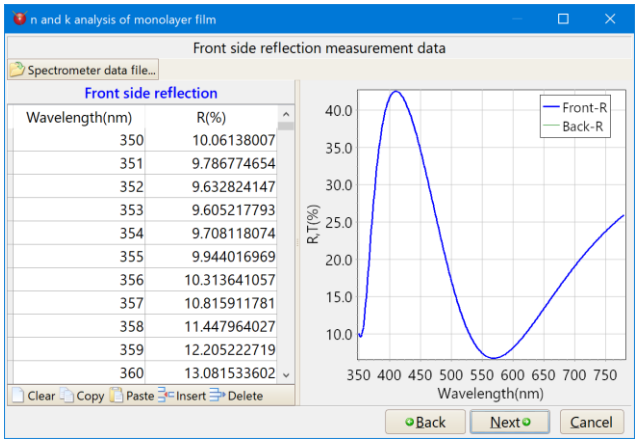


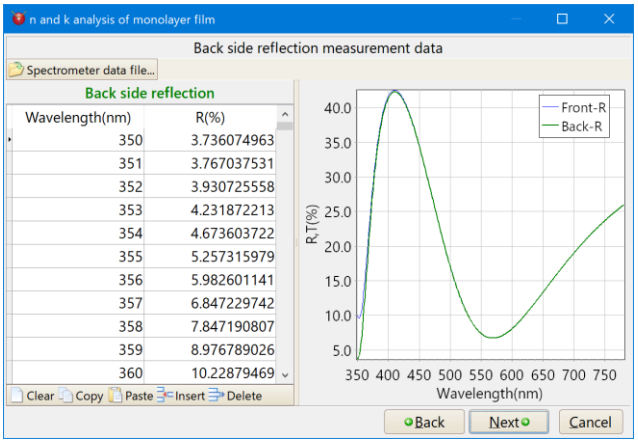
Select and enter the measurement type, incident angle, and polarization type.

To analyze the absorption coefficient k, it is necessary to use a double-side polished substrate and measure at least two types of "Front surface reflection", "back surface reflection", and "Transmission".

Click [Next].

(3) Input of measured value

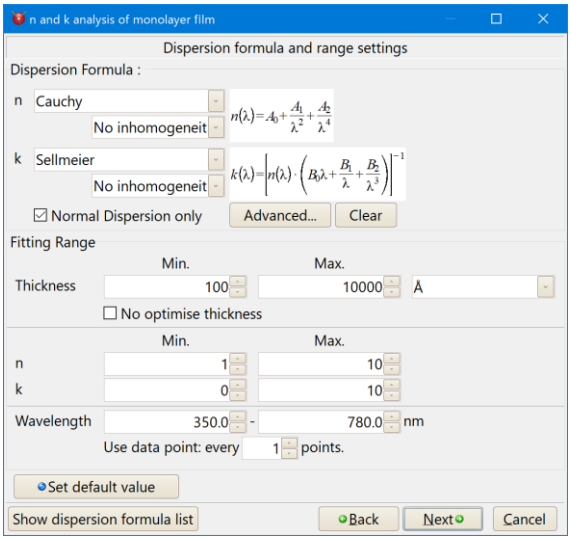




Read the spectrometer measurement data file from [Spectrometer data file...] or input measurement value directly. You can also paste from other software, such as Excel(R).

Click [Next].

(4) Select dispersion formula and analyzing range



Select the dispersion formula and input the fitting range and the data point interval.

You also choose here whether to analyze the inhomogeneity of n and k.

If you check [Normal dispersion only], only normal dispersion (dispersion in which the refractive index increases as the wavelength becomes shorter) is analyzed. If unchecked, analysis including anomalous dispersion is performed.

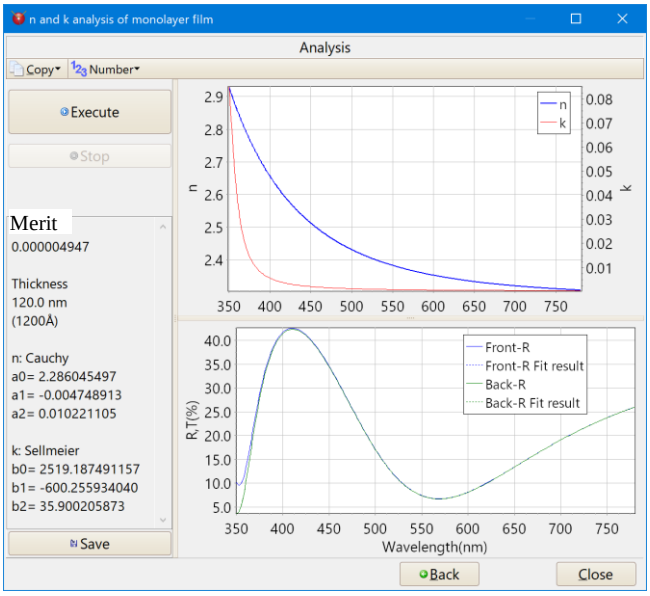
[Advanced]

You can set the initial values of the dispersion formula parameters by pressing [Advanced].

If the wavelength range is too wide and the fitting to the dispersion formula does not work, set the narrow the wavelength range.

Click [Next].

(5) Analysis



Click the [Execute] button to analysis n, k and d.

The graph above is the analysis result of n and k.

The graph below shows the measured value (solid line) input in step 3 and the reflectance / transmittance (dotted line) calculated from the analysis results of n and k.

“Merit” is the difference between the measured value (solid line) and the reflectance / transmittance (dotted line) calculated from the analysis results of n and k. The smaller the number, the better the fitting.

“Thickness” is the analysis result of the film thickness.

Below that, the parameters of the dispersion formula are displayed.

Even if the merit is small, the film thickness may be different, so check carefully whether it is a plausible film thickness.

If the fitting doesn't work, try choosing a different dispersion formula or narrowing the wavelength range in step 4.

If you press [Save], you can save it as film material data.

* The n and k analysis of mono-layer film estimates n, k and film thickness (d) of the film by curve fitting to a dispersion formula. Check the spectral characteristics, n, k values, and film thickness to see if the solution that appears is correct. Also, refer to "Notes on n and k analysis” in the next section.

3.11.3.1. Notes on n and k analysis

The analysis of film n and k depends on measurement precision, substrate selection, wavelength range, etc. It is difficult to analyze when there are inhomogeneities or when the dispersion curve can not be represented by dispersion formula.

- Substrate

It is important that the substrate refractive index data be accurate.

If the substrate refractive index data is inaccurate, it cannot be analyzed correctly.

Even when the surface of the board has dirt, it cannot be analyzed correctly.

Recommended substrate is fused silica (quartz). Because of no absorption and has a known refractive index and is chemically stable. When SiO2 film on quartz substrate, it cannot be analyzed because the refractive index is almost the same. In that case, please use a substrate with a different refractive index from the thin film.

- Film Thickness

If the film thickness is too thin or too thick, it may not be analyzed correctly.

In many cases, it is easier to reach the correct solution if there are one or more peaks or valleys in spectral characteristics.

- Measurement

It is important that the measured values are accurate.

In the extreme case, in the case of a theoretically impossible measurement value that adds transmission and reflection plus 100 or λ / 2 thickness and falls below the substrate reflection, there is no solution and it cannot be analyzed.

For example, if the measurement of transmittance is inaccurate, it may be better to analyze with only two kinds of surface reflection and back reflection.

For films without absorption, only one surface reflection or transmittance measurement is sufficient.

- Wavelength range

If the wavelength range is too wide, it may not be possible to analyze well because the dispersion curve cannot be expressed with one dispersion formula. In such a case please try to analyze the wavelength range separately. In some cases, please change dispersion formula for each wavelength range.

Finally, calculate n and k of each wavelength from the dispersion equation and register the data of all wavelength regions in the linear (table) form.

- Dispersion formula

Using a simple dispersion formula with fewer parameters will often make it easier to analyze.

If it seems absorption is zero, please select the dispersion formula of k is “zero”.

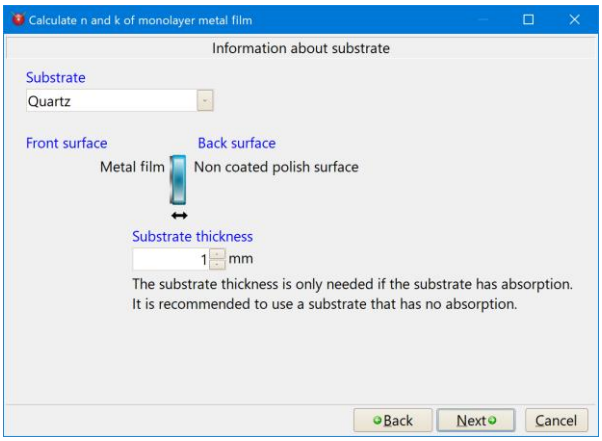
3.11.4. Calculate n and k of monolayer metal film

Calculate n and k of the metal film from the front surface reflectance and the back-surface reflectance.

The substrate must be thick enough and have a zero transmittance.

[Tools] - [nkn and k analysis of substrate or monolayer film...] – [Calculate n and k of monolayer metal film]

(1) Input substrate information



Substrate

Select the substrate. Quartz (synthetic quartz) is recommended.

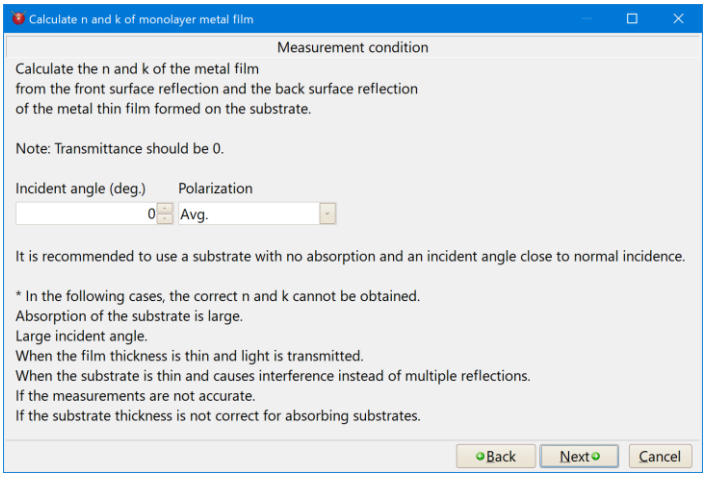
Substrate thickness

Enter the thickness of the substrate. Required only if the substrate has absorption.

If there is no absorption on the substrate, it will be ignored.

Click [Next].

(2) Setting of measurement conditions

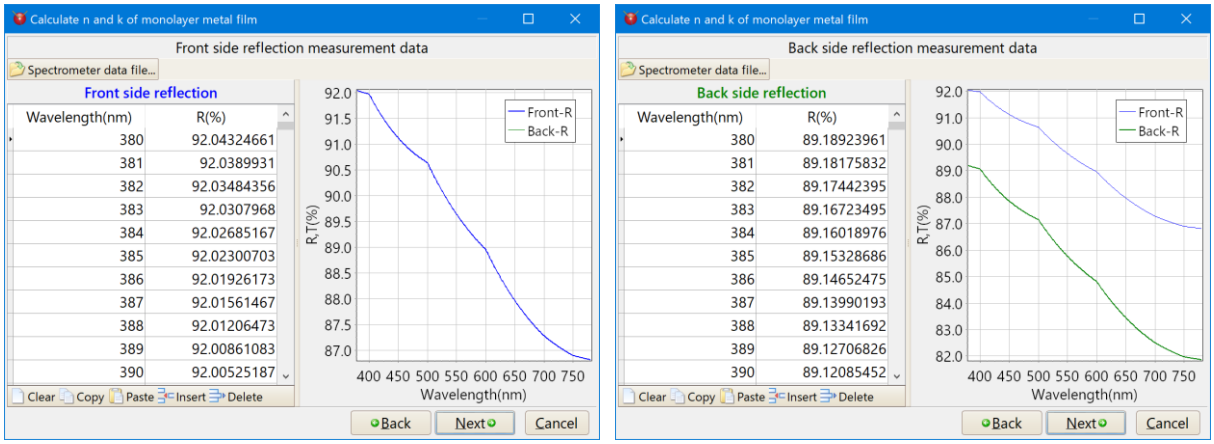


Enter the incident angle and select the polarization (s-polarized, p-polarized, average).

It is recommended to measure at or near normal incidence.

Click [Next].

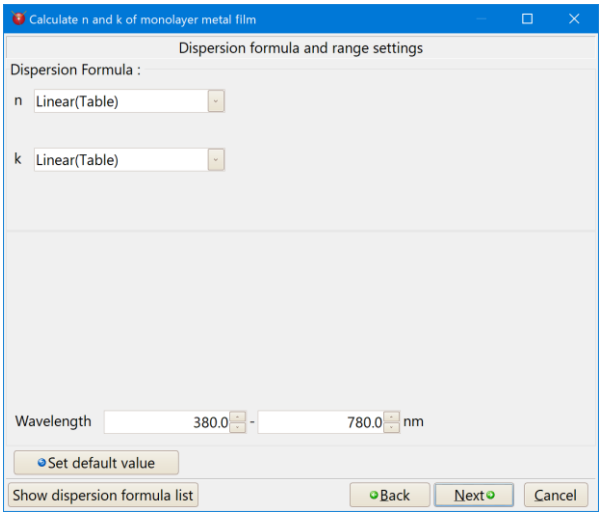
(3) Input of measured value



Read the spectrometer measurement data file from [Spectrometer data file...] or input measurement value directly. You can also paste from other software, such as Excel(R).

Click [Next].

(4) Select dispersion formula and wavelength range



Select the dispersion formula and the wavelength range to be calculated.

In the n and k calculation of the metal film, “Linear (Table)” is selected as the initial value in the dispersion formula column, but you can also select the dispersion formula.

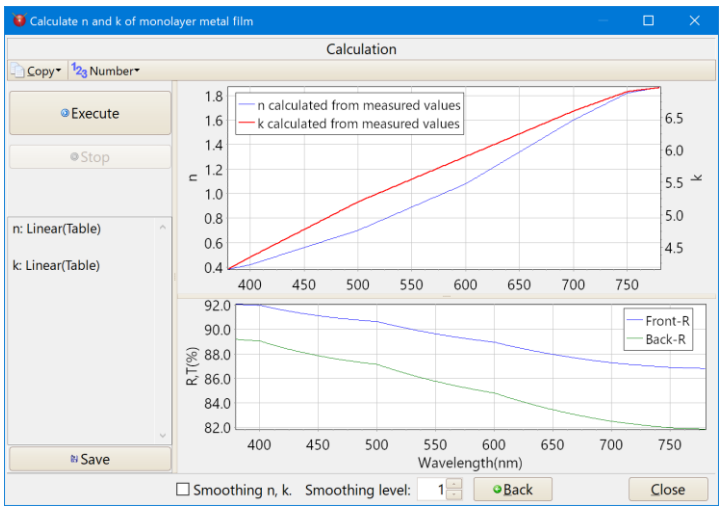
[Advanced]

You can set the initial values of the dispersion formula parameters by pressing [Advanced].

If the wavelength range is too wide and the fitting to the dispersion formula does not work, narrow the wavelength range or select “Linear (Table)” in the “Dispersion Formula” column.

Click [Next].

(5) Calculation



Click the [Execute] button to calculate n and k.

The solid line in the graph above is n and k calculated from the measured values. The dotted line is the fitting result of n and k calculated from the measured value to the dispersion formula. In the case of “Linear (Table)”, there is no fitting result (dotted line).

The graph below is the measured value entered in step 3.

When you select “Linear (Table)”, then it is a value calculated directly from the measured value, there is noise in the measured value. At the bottom of the screen, there is a column for setting whether to “Smoothing n, k” and “Smoothing level”, so please smooth as necessary.

“Merit” is the difference between n and k (solid line) calculated from the measured value and the fitting result (dotted line). The smaller the number, the better the fitting.

Below that, the parameters of the dispersion formula are displayed.

For Linear (Table), “Merit” and the parameters of the dispersion formula are not displayed.

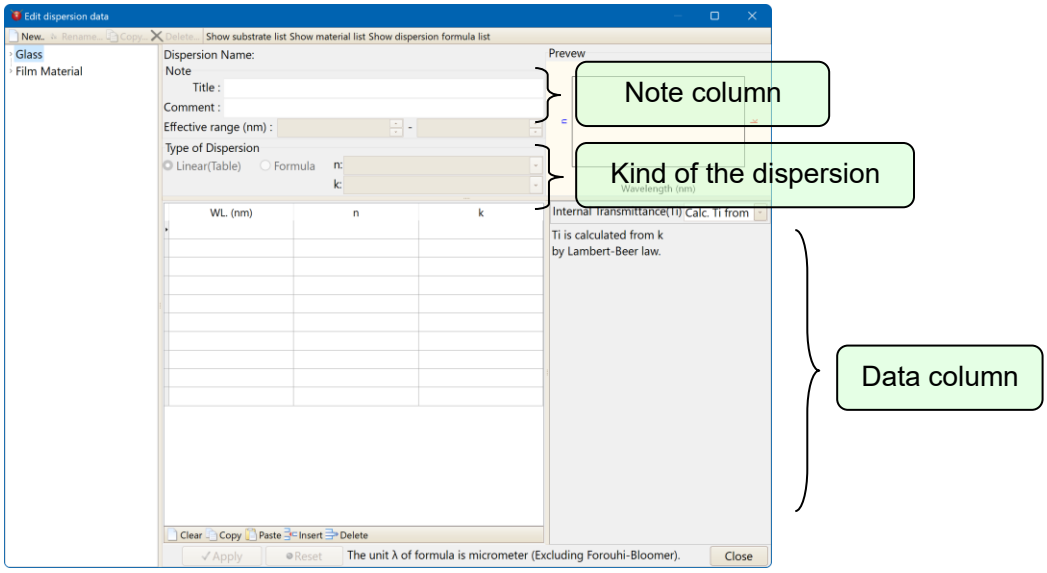
If the fitting doesn't work, try the calculation in step 4 by choosing a different dispersion formula or “Linear (Table)”.

If you press [Save], you can save it as substrate data.

3.12. Other functions

3.12.1. Creating and editing the dispersion data

To create or edit the dispersion data, select the [Tools] - [Edit dispersion data...] from the main menu, or push [Edit...] on the dispersion profile popup window.

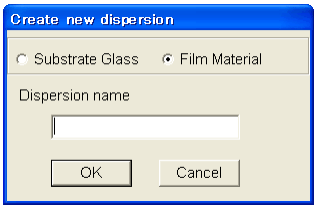


- Editing the existing dispersion

To edit the existing dispersion, select the dispersion name from the list of left side in the window.

- Creating the new dispersion.

To create a new dispersion, click the [New] button on the top of the window. Then select the type (Substrate or Film material) and input the dispersion name.



- Explanation of the items

【Note column】

Input the title, comment and effective wavelength range of the dispersion.

* Please be sure to enter the effective range. There may be differences in calculation results depending on effective range. Please refer to “3.13.1.3 Optical constants settings”.

【Kind of the dispersion】

Select a type of the dispersion. You can select the linear interpolation or the type of dispersion formula.

See the following page concerning the type of dispersion formula.

【Data column】

Input the wavelengths, n (refractive indexes) and k (absorption coefficients), when you select the linear interpolation.

Input the coefficient of the dispersion formula, when you select a dispersion formula.

In case of substrate, internal transmittance can also be entered. About internal transmittance, refer to “3.6.12 Internal transmittance for substrate and medium”.

When linear interpolation, you can paste the data to column via clipboard from spreadsheet software etc. To paste the data, click the [Paste] button after copying the data with spreadsheet software etc.

To add or delete the line, click the [Insert Row] or [Delete Row] button.

3.12.2. Type of dispersion formulas

You can use the data point table (linear interpolation) and following dispersion formula for the dispersion of n and k.

You can use these dispersions for both the glass (substrate and incidence medium) and film material.

[Dispersion formulas of refractive index n]

Name	Formula
Sellmeier	$n(\lambda)=\sqrt{1+\frac{A_0\lambda^2}{\lambda^2-A_3}+\frac{A_1\lambda^2}{\lambda^2-A_4}+\frac{A_2\lambda^2}{\lambda^2-A_5}}$
Sellmeier2	$n(\lambda)=\sqrt{1+A_0+\frac{A_1\lambda^2}{\lambda^2-{A_3}^2}+\frac{A_2}{\lambda^2-{A_4}^2}}$
Sellmeier3	$n(\lambda)=\sqrt{1+\frac{A_0\lambda^2}{\lambda^2-A_4}+\frac{A_1\lambda^2}{\lambda^2-A_5}+\frac{A_2\lambda^2}{\lambda^2-A_6}+\frac{A_3\lambda^2}{\lambda^2-A_7}}$
Sellmeier4	$n(\lambda)=\sqrt{A_0+\frac{A_1\lambda^2}{\lambda^2-A_3}+\frac{A_2\lambda^2}{\lambda^2-A_4}}$
Sellmeier5	$n(\lambda)=\sqrt{1+\frac{A_0\lambda^2}{\lambda^2-A_5}+\frac{A_1\lambda^2}{\lambda^2-A_6}+\frac{A_2\lambda^2}{\lambda^2-A_7}+\frac{A_3\lambda^2}{\lambda^2-A_8}+\frac{A_4\lambda^2}{\lambda^2-A_9}}$
SellmeierT1	$n(\lambda)=\sqrt{A_0+\frac{A_1\lambda^2}{\lambda^2-A_2}}$
SellmeierT2	$n(\lambda)=\sqrt{A_0+\frac{A_1\lambda^2}{\lambda^2-A_2}+A_3\lambda^2}$
SellmeierX1	$n(\lambda)=\sqrt{1+\frac{A_0\lambda^2}{\lambda^2-{A_3}^2}+\frac{A_1\lambda^2}{\lambda^2-{A_4}^2}+\frac{A_2\lambda^2}{\lambda^2-{A_5}^2}}$
General1	$n(\lambda)=\sqrt{A_0+A_1\lambda^2+\frac{A_2}{\lambda^2}+\frac{A_3}{\lambda^4}+\frac{A_4}{\lambda^6}+\frac{A_5}{\lambda^8}+A_6\lambda^4}$
General2 (Old Schott)	$n(\lambda)=\sqrt{A_0+A_1\lambda^2+\frac{A_2}{\lambda^2}+\frac{A_3}{\lambda^4}+\frac{A_4}{\lambda^6}+\frac{A_5}{\lambda^8}}$
Cauchy	$n(\lambda)=A_0+\frac{A_1}{\lambda^2}+\frac{A_2}{\lambda^4}$
Hartmann1	$n(\lambda)=A_0+\frac{A_1}{\lambda-A_2}$
Hartmann2	$n(\lambda)=A_0+\frac{A_1}{(\lambda-A_2)^2}$

Herzberger	$n(\lambda) = A_0 + A_1\lambda^2 + \frac{A_2}{(\lambda^2 - 0.168^2)} + \frac{A_3}{(\lambda^2 - 0.168^2)^2}$
Herzberger2	$n(\lambda) = A_0 + \frac{A_1}{(\lambda^2 - 0.028)} + \frac{A_2}{(\lambda^2 - 0.028)^2} + A_3\lambda^2 + A_4\lambda^4 + A_5\lambda^6$
QUAD	$n(\lambda) = A_0 + \frac{A_1}{\lambda^2}$
QUADSK	$n(\lambda) = A_0 + A_1\lambda + A_2\lambda^2$
Conrady	$n(\lambda) = A_0 + \frac{A_1}{\lambda} + \frac{A_2}{\lambda^{3.5}}$
Handbook1 (Handbook of Optics)	$n(\lambda) = \sqrt{A_0 + \frac{A_1}{(\lambda^2 - A_2)} - A_3\lambda^2}$
Handbook2 (Handbook of Optics)	$n(\lambda) = \sqrt{A_0 + \frac{A_1\lambda^2}{(\lambda^2 - A_2)} - A_3\lambda^2}$
Extended (ZEMAX)	$n(\lambda) = \sqrt{A_0 + A_1\lambda^2 + \frac{A_2}{\lambda^2} + \frac{A_3}{\lambda^4} + \frac{A_4}{\lambda^6} + \frac{A_5}{\lambda^8} + \frac{A_6}{\lambda^{10}} + \frac{A_7}{\lambda^{12}}}$
Extended2 (ZEMAX)	$n(\lambda) = \sqrt{A_0 + A_1\lambda^2 + \frac{A_2}{\lambda^2} + \frac{A_3}{\lambda^4} + \frac{A_4}{\lambda^6} + \frac{A_5}{\lambda^8} + A_6\lambda^4 + A_7\lambda^6}$
Extended3 (ZEMAX)	$n(\lambda) = \sqrt{A_0 + A_1\lambda^2 + A_2\lambda^4 + \frac{A_3}{\lambda^2} + \frac{A_4}{\lambda^4} + \frac{A_5}{\lambda^6} + \frac{A_6}{\lambda^8} + \frac{A_7}{\lambda^{10}} + \frac{A_8}{\lambda^{12}}}$
Buchdahl	$n(\lambda) = A_0 + A_1\omega(\lambda) + A_2\omega(\lambda)^2,\ \ \omega(\lambda) = \frac{\lambda - A_3}{1 + 2.5(\lambda - A_3)}$
DRUDE	$n^2(\lambda) - k^2(\lambda) = A_0 - \frac{A_1 {A_2}^2 \lambda^2}{\lambda^2 + {A_2}^2}$
LorentzianK	$n(\lambda) = \sqrt{A_0 + k(\lambda)^2 + A_1\lambda^2 \frac{(\lambda^2 - {A_2}^2)}{(\lambda^2 - {A_2}^2)^2 + {A_3}^2\lambda^2}}$
Forouhi-Bloomer	$n(E) = n(\infty) + \frac{B_0 E + C_0}{E^2 - BE + C}$ $B_0 = \frac{A}{Q}\left(\frac{-B^2}{2} + E_g B - {E_g}^2 + C\right),\ C_0 = \frac{A}{Q}\left(\left({E_g}^2 + C\right)\frac{B}{2} - 2E_g C\right),$ $Q = \frac{1}{2}(4C - B^2)^{\frac{1}{2}},\ E = \frac{hc}{\lambda}$ h: Planck's constant, c: Light speed, The unit of E: eV.

A0, A1, A2, A3, A4, A5, A6, A7, A8 and A9: material constants.

The unit of λ: μm (Excluding Forouhi-Bloomer).

[Dispersion formulas of absorption coefficient k]

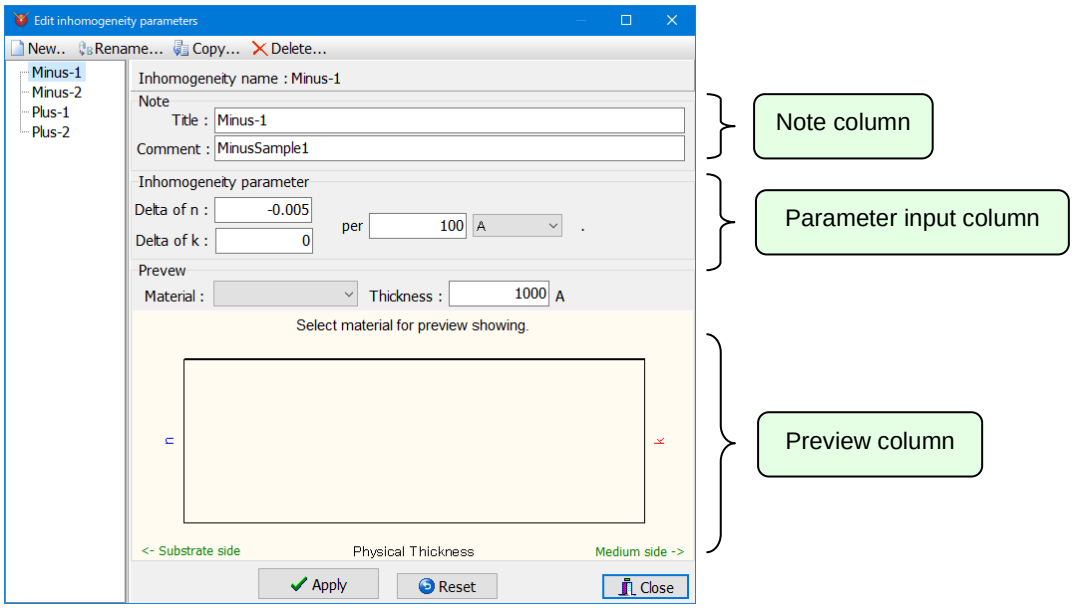
Name	Formula
Sellmeier	$k(\lambda)=\left[n(\lambda)\cdot\left(B_0\lambda+\frac{B_1}{\lambda}+\frac{B_2}{\lambda^3}\right)\right]^{-1}$
Cauchy	$k(\lambda)=B_0+\frac{B_1}{\lambda^2}+\frac{B_2}{\lambda^4}$
Exponential	$k(\lambda)=B_0\exp(B_1\lambda^{-1})$
QUADSK	$k(\lambda)=B_0+B_1\lambda+B_2\lambda^2$
DRUDE	$2n(\lambda)k(\lambda)=\frac{A_1A_2\lambda^3}{\lambda^2+{A_2}^2}$
LorentzianK	$k(\lambda)=\sqrt{\frac{0.5}{n(\lambda)}\times\frac{A_1A_3\lambda^3}{(\lambda^2-{A_2}^2)^2+{A_3}^2\lambda^2}}$
Forouhi-Bloomer	$k(E)=\frac{A(E-E_g)^2}{E^2-BE+C}$ $E=\frac{hc}{\lambda}$ h: Planck's constant, c: Light speed, The unit of E: eV.

B0, B1 and B2: material constants.

The unit of λ: μm (Excluding Forouhi-Bloomer).

3.12.3. Creating and editing the inhomogeneity parameters

To create or edit the inhomogeneity parameters, select [Tools] - [Edit inhomogeneity parameters...] from the main menu, or push [Edit...] on the inhomogeneity profile popup window.

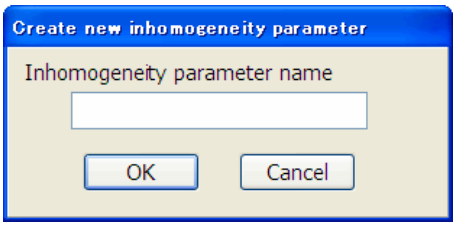


- Editing the existing inhomogeneity parameters

To edit the existing inhomogeneity parameters, select the inhomogeneity name from the list on the left side in the window.

- Creating a new inhomogeneity parameter

To create a new inhomogeneity profile, click the [New] on the top of the window. Then input inhomogeneity parameter name.



- Explanation of the items

【Note column】

Input the title and comment of the inhomogeneity.

These are displayed in inhomogeneity profile popup window when you put the mouse cursor on the substrate or film material column of the main window. These are for notes purpose only. These do not have an effect to the value of the inhomogeneity parameters.

【Parameter input column】

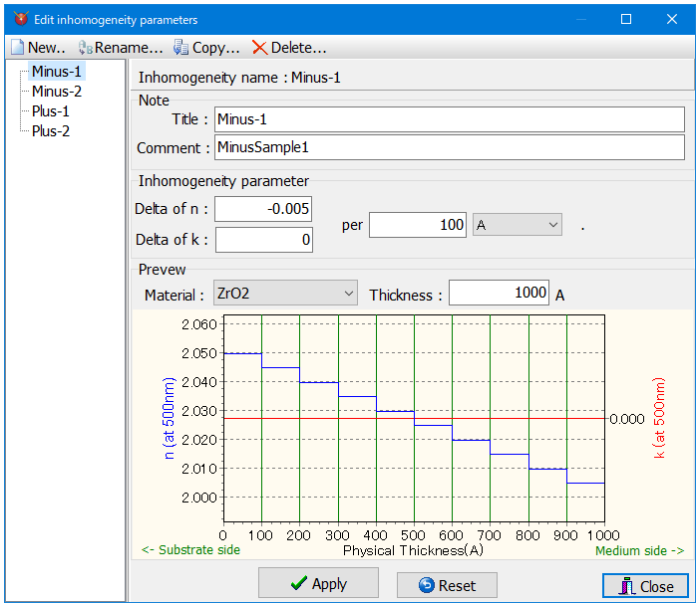
Input the increase or decrease of n and/or k. And input the thickness step for increase or decrease of n and k.

※ The smaller you input the thickness step, the longer the calculation time.

【Preview column】

If you select the film material from the “Material”, then the preview chart of the inhomogeneity profile will appear. The “Thickness” value is the maximum value on the chart bottom axis.

- Example of the inhomogeneity parameters



Delta of n is -0.005 and thickness step is 100 Angstrom in these settings.

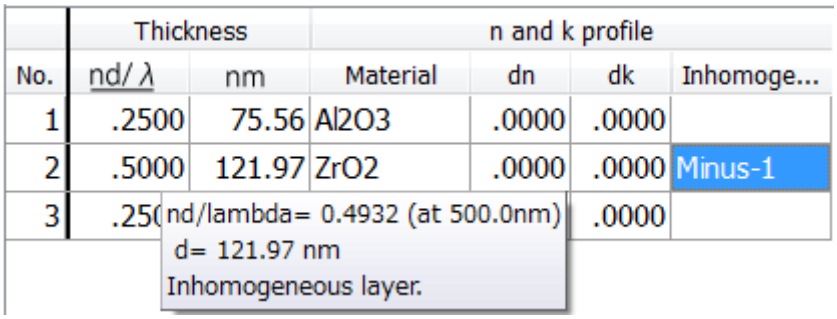
In this case, n decrease in -0.005 value every 100 Angstrom. k is invariable because Delta of k is 0.

The inhomogeneity profile is shown on the preview chart in case of the Material is ZrO_2 and thickness is 1000 Angstrom.

The wavelength of n and k is the center wavelength on the main window.

※ In inhomogeneity layer, if you set the thickness as optical thickness, the actual optical thickness is different from the input optical thickness. Because the n is changing every thickness step.

Following example, the inputted optical thickness of the 2nd layer is 0.5, the actual optical thickness is nd/λ = 0.4932.

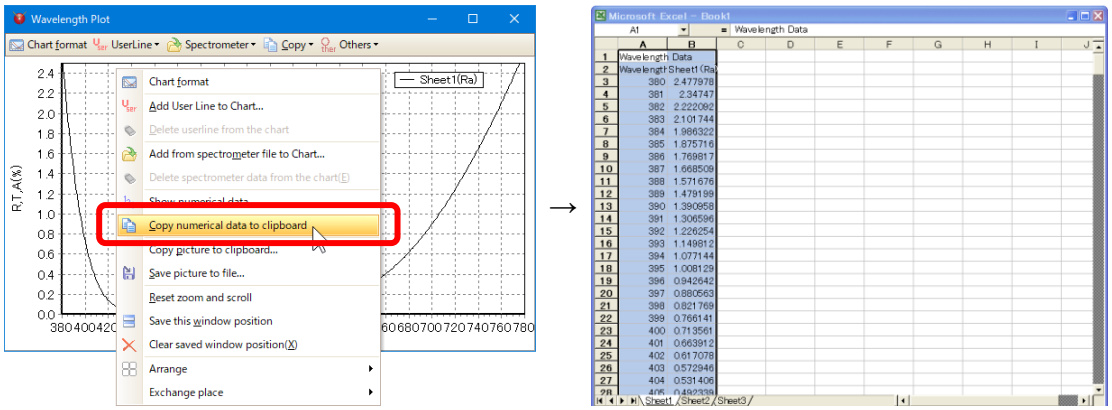


3.12.4. Cooperating with other software (Copy and paste of the numerical values and the charts)

You can paste the numerical values and the charts to other software via clipboard.

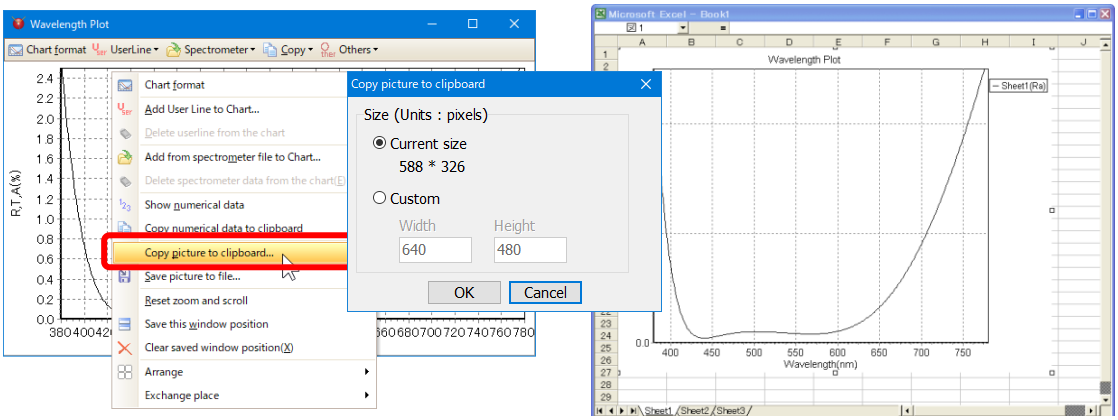
- Pasting the numerical values to other software.

Right-click on the chart, and select [Copy numerical data to clipboard] from popup menu. And then execute the paste command with spreadsheet software (example: Microsoft(R) Excel) etc.



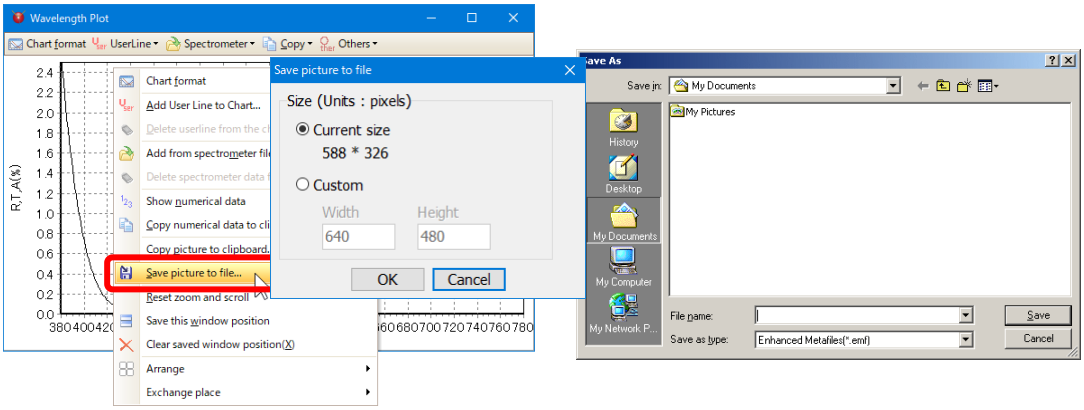
- Pasting the charts to other software.

Right-click on the chart, and select [Copy picture to clipboard] from popup menu. Then the dialog box for specifying the picture format and the size is appear. Select the picture format and the size and click the [OK] button. And then execute the paste command with other software.



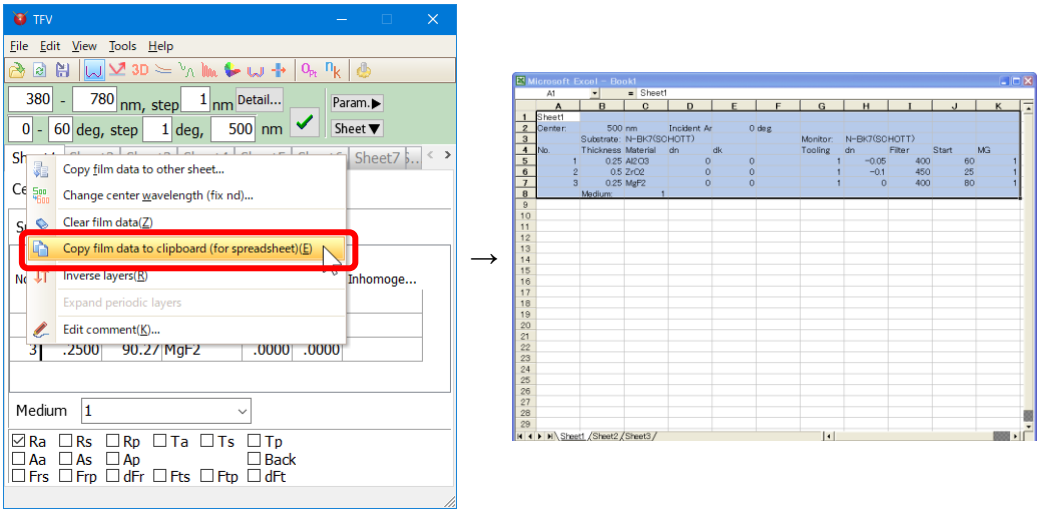
- Saving the charts to file

You can save the charts to file. Right-click on the chart and select [Save picture to file] from popup menu. Then the dialog box for specifying the picture format and the size is appear. Select the picture format and the size and click the [OK] button. And then save the chart under a new name.



- Pasting the film data to other software

Right-click the sheet tab on the main window, and select [Copy film data] from popup menu. And then execute the paste command with spreadsheet software (example: Microsoft(R) Excel) etc.

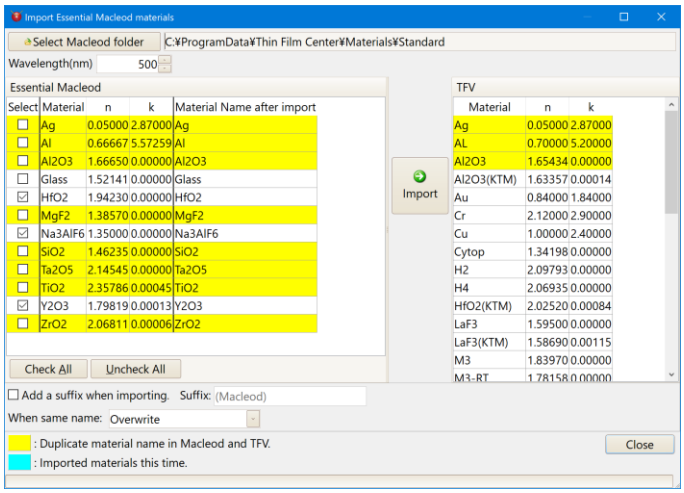


3.12.5. Import of Essential Macleod data

You can import Essential Macleod's Material and Substrate. In addition, design data (dds file) can be read.

- Material import

From the main window menu, select [File] - [Import] - [Import Essentials Macleod materials].



By default, the list of Materials registered in Macleod's Standard folder is displayed on the left side of the screen. If you want to import other data, please click [Select Macleod folder] button and specify the folder.

When you enter a wavelength in the wavelength field, n and k for the wavelength is displayed in the n and k field. Please use this as reference information.

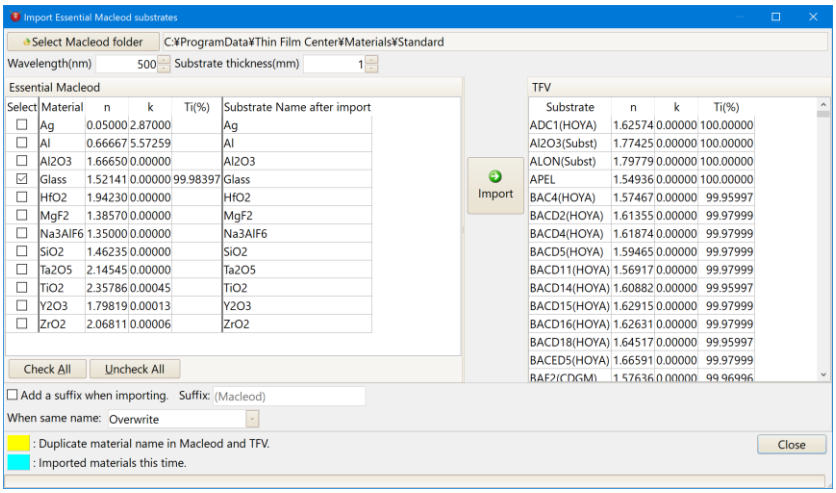
At the bottom of the screen, check "Add a suffix when importing" to add the characters specified in "Suffix" to the end of the Material name and import.

If "Overwrite" is selected in the "When same name" column at the bottom of the screen, if the material name is the same for Essential Macleod and TFV, importing will overwrite TFV Material. Select " Add a number at the end" to add numbers at the end of Essential Macleod's Material Name and import it so that it does not overwrite the TFV Material.

When you press the Import button, the material with a check mark in the Essential Macleod selection field will be imported into TFV.

- Substrate import

From the main window menu, select [File] - [Import] - [Import Essentials Macleod substrates].



Essential Macleod does not distinguish between material data and substrate data, so both are displayed in a mixed list. Manually select and import from check boxes in the selection field.

Internal transmittances with the same name are also imported.

By default, the list of Materials registered in Macleod's Standard folder is displayed on the left side of the screen. If you want to import other data, please click [Select Macleod folder] button and specify the folder.

When you enter a wavelength in the wavelength field, n, k and Ti for the wavelength is displayed in the n, k and Ti field. When you enter the thickness in the Substrate thickness column, the Ti column will show the internal transmission at the thickness. Please use as reference information.

At the bottom of the screen, check "Add a suffix when importing" to add the characters specified in "Suffix" to the end of the Material name and import.

If "Overwrite" is selected in the "When same name" column at the bottom of the screen, if the material name is the same for Essential Macleod and TFV, importing will overwrite TFV substrate. Select " Add a number at the end" to add numbers at the end of Essential Macleod's Material Name and import it so that it does not overwrite the TFV substrate.

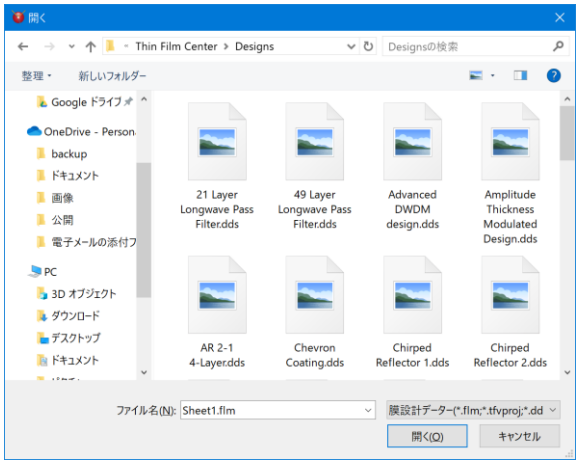
When you press the Import button, the material with a check mark in the Essential Macleod selection field will be imported into TFV. Internal transmittances with the same name are also imported.

- Read design data(dds files)

You can import Essential Macleod design data (dds file) from [File]-[Open] from the main window menu.

The center wavelength, incident angle, substrate, incident medium, number of layers, film thickness / material of each layer, and Note are read.

If the material of the same name does not exist in TFV, the materials are automatically imported.



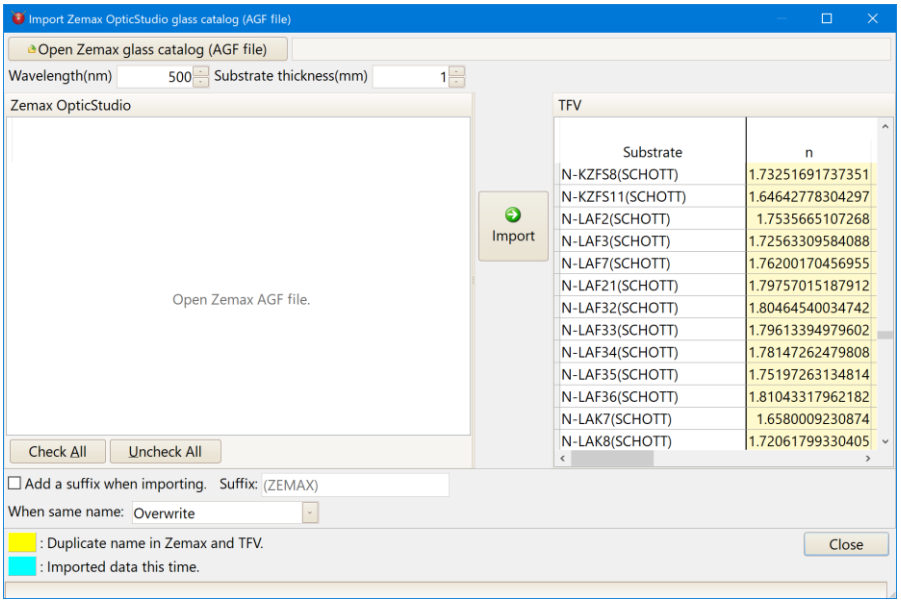
3.12.6. Import ZEMAX glass data File

You can import the glass data (AGF file) of the optical design software ZEMAX.

From the main window menu, select [File] - [Import] - [Import Zemax OpticStudio glass catalog (AGF file)…].

Click the [Open Zemax glass catalog (AGF file)] and select the AGF file.

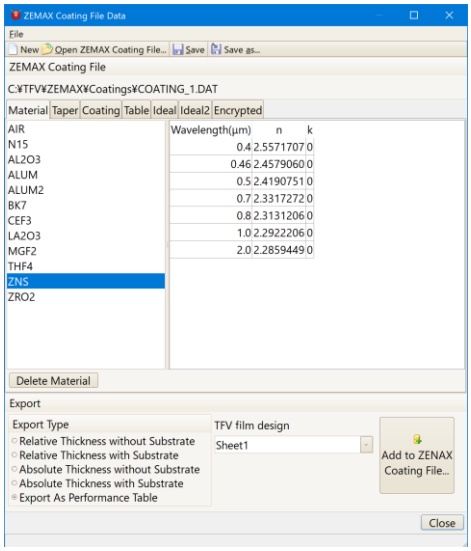
If glass data with the same name already exists in the TFV, it will be overwritten. Be careful not to accidentally overwrite the glass data.



3.12.7. Export to ZEMAX Coating File

You can export film design or spectral performance to ZEMAX software for optical system design.

From the main window menu, select [File] - [Export] - [Export to ZEMAX COATING File…].



New	Create a new ZEMAX Coating File.
Open ZEMAX Coating File	Load ZEMAX Coating File. Used to add design data and spectrum data to the existing ZEMAX Coating File.
Save	Overwrites and saves ZEMAX Coating File.
Save as	Name and save the ZEMAX Coating File.

Note: The default file name for ZEMAX Coating File is "COATING.DAT". According to the ZEMAX manual, this file is overwritten during ZEMAX installation, so it is not recommended to change it. It is recommended to save under another name.

- Select export type

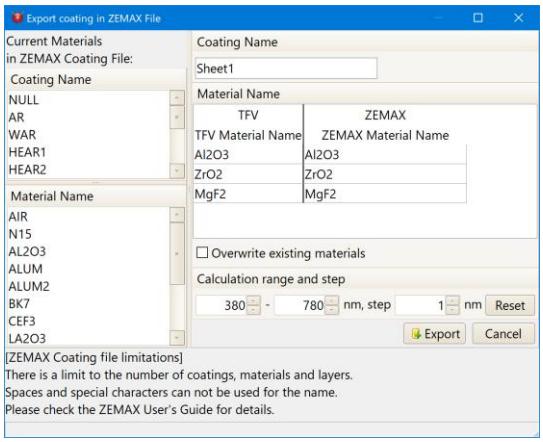
In the export field at the bottom of the screen, select the content to be exported.

Relative Thickness without Substrate	Export design data (thickness of each layer, nk data of each materials) to [Material], [Coating] section. Relative thickness: Exports the film thickness as optical thickness (FWOT). Absolute thickness: Exports the film thickness as physical thickness (μm). When selecting the Relative Thickness, be careful that the center wavelength of TFV and the control wavelength of ZEMAX are the same. ZEMAX should include an opaque substrate as a layer. If the substrate is opaque, select "with substrate". Add and export the substrate as a zero thickness layer.
Relative Thickness with Substrate	
Absolute Thickness without Substrate	
Absolute Thickness with Substrate	
Export As Performance Table	Export spectral data (calculation result) as table data. Export reflectance, transmittance, and phase for the specified incident angle and wavelength to the [Table] section.

Select the TFV film design (sheet name) to be exported in the [TFV film design] field.

- Export of film design

When the [Add to ZEMAX Coating File ...] button is pressed, the following screen is displayed.



Enter the Coating Name and the ZEMAX Material Name so that they do not overlap with the names used in the ZEMAX Coating File.

If you want to overwrite the already existing Material name, check [Overwrite existing materials].

If dn and dk are used in the design data of TFV, they can be registered as separate Materials.

The calculation wavelength range and interval column are for specifying the data point of the nk dispersion data of Material. Please be aware that if there are too many data, ZEMAX will not accept it. In ZEMAX 2009 edition, the number of distributed data points per Material is up to 120.

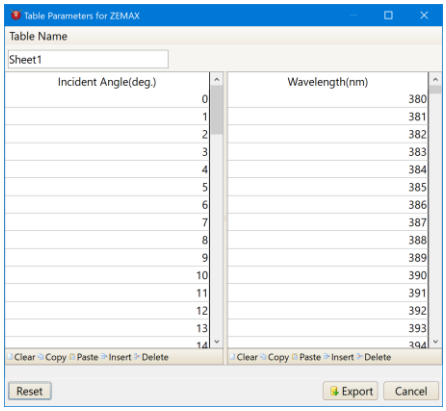
For the limitations of ZEMAX, please refer to the ZEMAX User ’s Guide.

Click the [Export] button to export to ZEMAX Coating File.

Note: At this point, it has just been registered in memory and has not yet been saved to a file. Please save the file at the end.

- Export as performance table

In the export type, with [Export as performance table] selected, click the [Add to ZEMAX Coating File ...] button to display the following screen.



Enter table name, incident angle and wavelength.

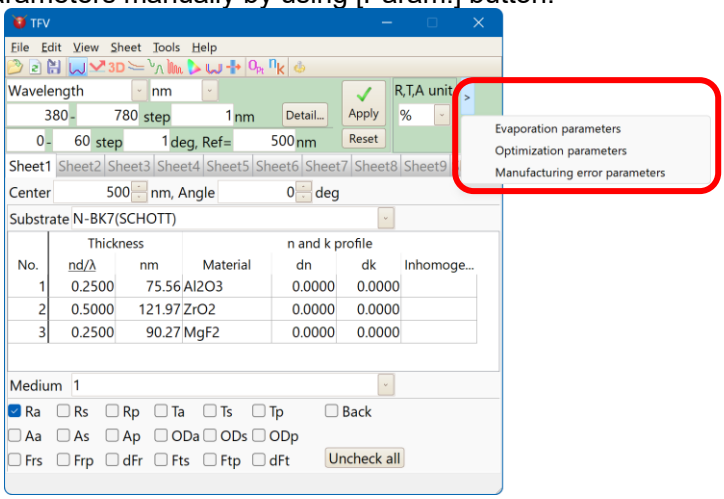
When the [Reset] button is pressed, the contents of the wavelength range and incident angle range set in the main window are automatically input. Or you can paste the incident angle and wavelength from Excel etc. in the toolbar at the bottom of the screen.

Click the [Export] button to export to ZEMAX Coating File.

Note: At this point, it has just been registered in memory and has not yet been saved to a file. Please save the file at the end.

3.12.8. Showing parameters in main window

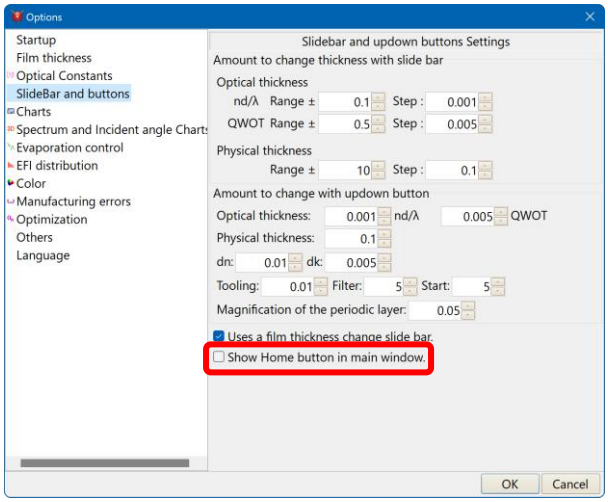
You can show evaporation parameters, optimization parameters and manufacturing error parameters manually by using [Param.] button.



3.12.9. Display Home button to return the film thickness to the initial value

In the main window, you can display the Home button to restore the film thickness of the selected layer.

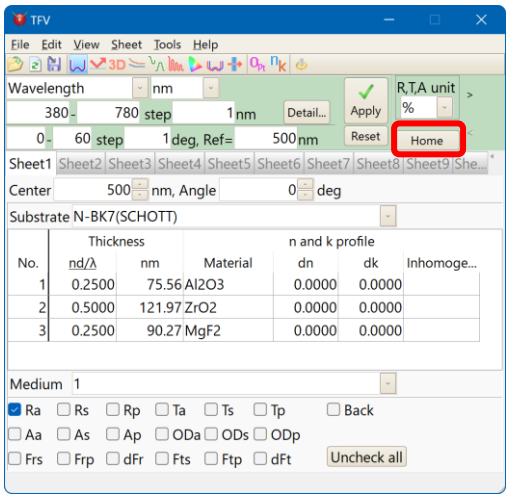
The same operation as pressing the Home key is performed.



If "Show home button in main window" is checked in [Tool] - [Options] - [SlideBar and Buttons] from the main window menu, the Home button will be displayed.

When the Home button is pressed, the film thickness of the selected layer returns to the initial value.

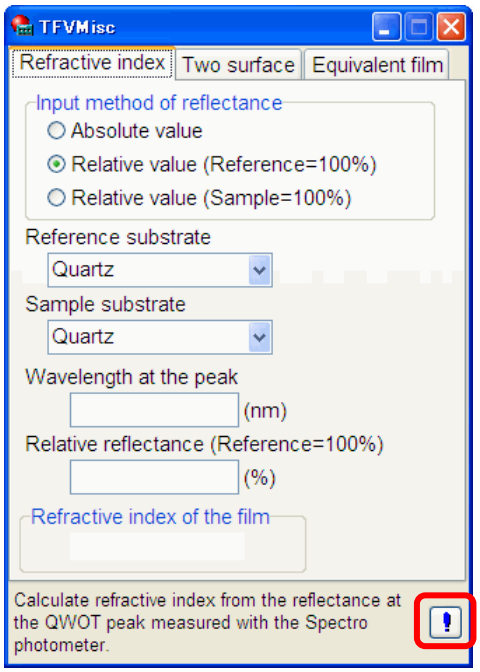
The operation is the same as pressing the Home key. For details on the Home key, refer to “3.4.1Changing the thickness”, “How to use the Keyboard”.



3.12.10. Misc. calculator

The misc. calculator is the simple calculation tool of thin film. To start the misc. calculator, select the [Tools] - [Misc calculator] in menu.

There are three functions in misc. calculator. Calculate the refractive index from λ/4 film, total reflectance from two surfaces and three layers equivalent film.

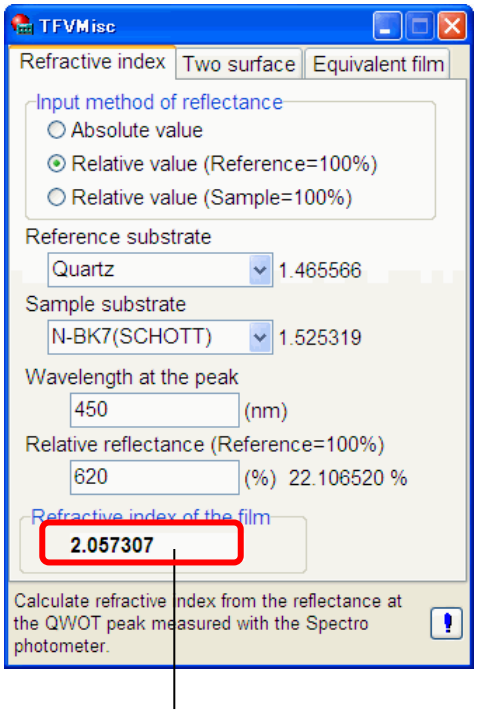


You can change the language.

You must restart the misc. calculator to change language.

【Refractive index】

Calculate refractive index from the reflectance at the QWOT peak measured with the spectrophotometer.

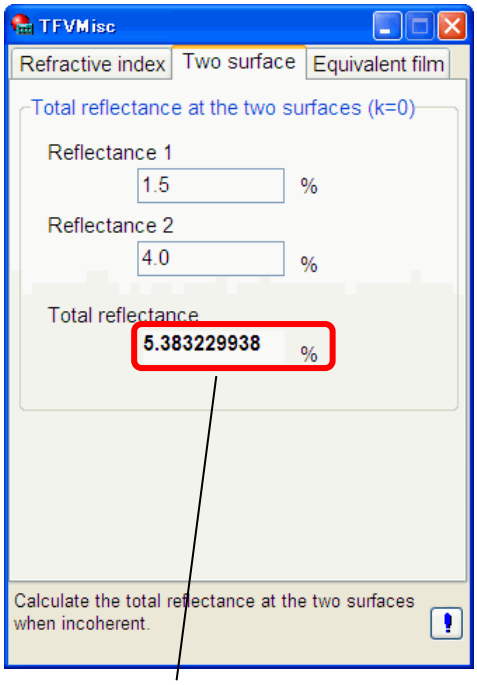


- Input method of reflectance
  Absolute value: Input reflectance as the absolute value.
  Relative value(Reference=100): Input reflectance as the relative value.
  Relative value (Sample=100): When set reference and sample vice versa. Input reflectance as the relative (measured) value.
- Reference substrate
  Select reference substrate. The refractive index value can also be inputted directly.
- Sample substrate
  Select sample substrate. The refractive index value can also be inputted directly.
- Wavelength at the peak
  Input the wavelength at the peak.
- Reflectance
  Input measured peak value.

After input all items, show the calculation result.

【Two surface】

Calculate the total reflectance at the two surfaces when incoherent. Only support if k=0.



- Reflectance1

  Input reflectance of the front surface.

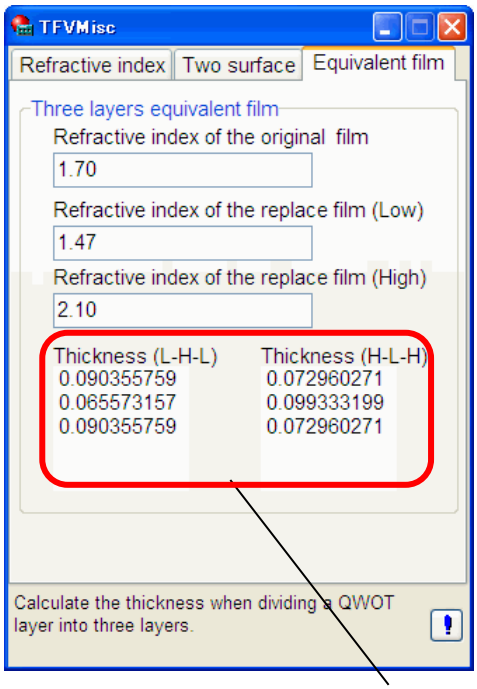
- Reflectance2

  Input reflectance of the back surface.

After input all items, show the calculation result.

【Equivalent film】

Calculate the thickness when dividing a QWOT layer into three layers.



- Refractive index of the original film

  Input reflective index of the original QWOT film.

- Refractive index of the replace film(Low)

  Input refractive index of the replace low index film

- Refractive index of the replace film(High)

  Input refractive index of the replace high index film

After input all items, show the calculation results. There are two kinds of the result.

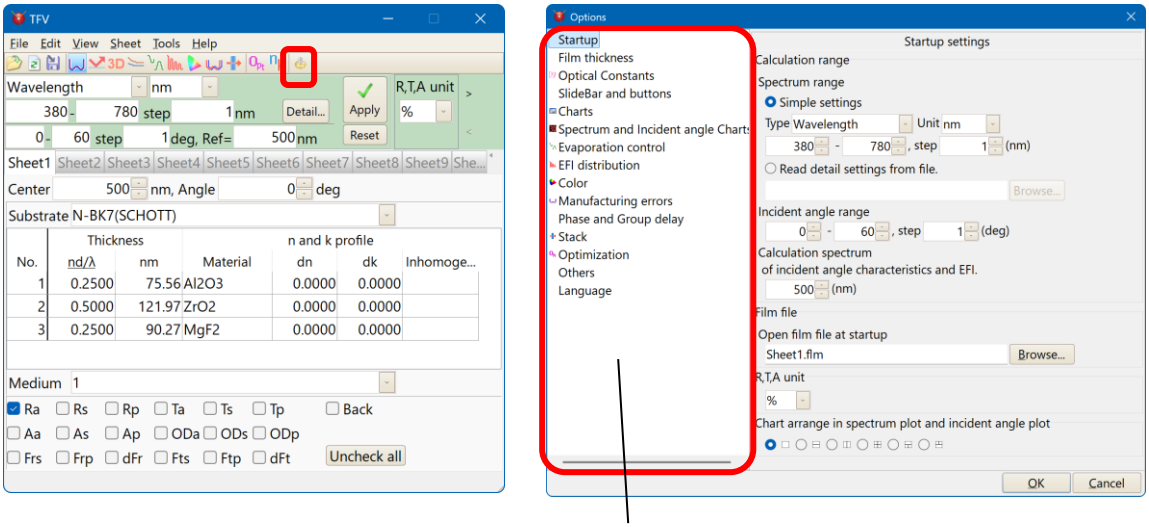
Left side result is Low - High - Low type. Right side result is High - Low - High type.

You can select more better result from two kinds of the result.

3.13. Configuring TFV

3.13.1. Options

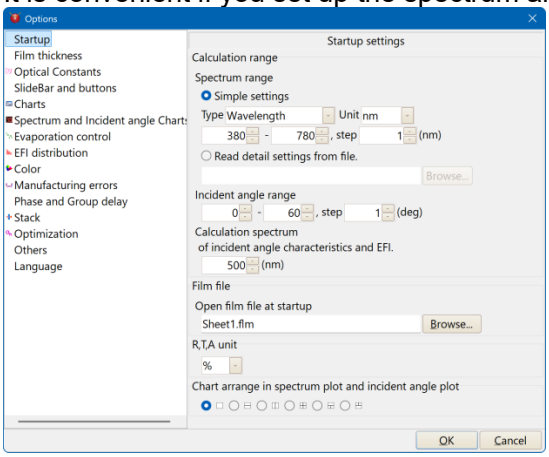
To customizing the initial settings or the operation settings, click the [Options] toolbar on the main window or select [Tools] - [Options] from main menu.



Select items for customizing

3.13.1.1. Startup settings

Set up the state when TFV start.
It is convenient if you set up the spectrum and the incident angle range etc. that you use well.



[Spectrum range]
Set up the spectrum range and interval at startup.

[Incident angle range]
Set up the incident angle range and interval at startup.

[Open film data file at startup]
Set up the film data file read into Sheet1 at startup.

[Sheets in main window]
Set up the number of visible sheets in main window at startup.

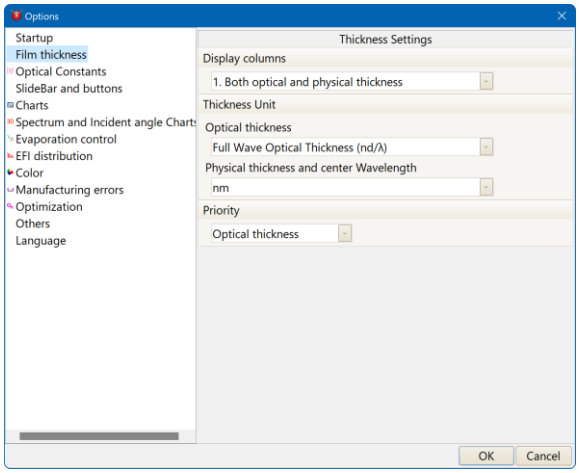
[Sheets in stack window]
Set up the number of visible sheets in stack window at startup.

[Chart arrange in spectrum and incident angle plot]
Set up the chart arrange in spectrum and incident angle plot at startup.

[Show About Box at start up]
Select whether the version information dialog box is displayed at startup.

3.13.1.2. Thickness settings

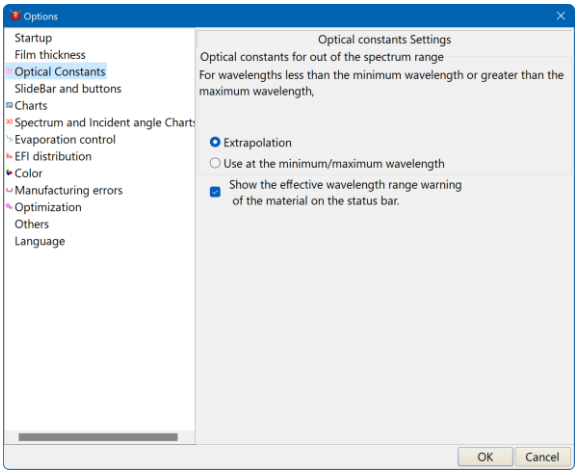
Set up the thickness display format in main window.

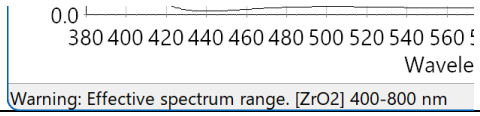


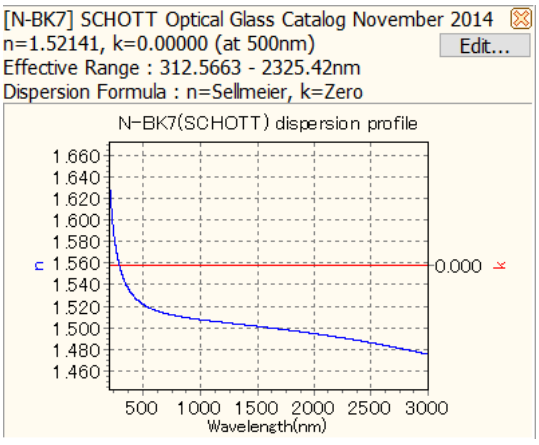
Display columns	(1) Both optical and physical thickness. Thickness: No. / nd/λ / Å — 1 / .2500 / 755.6 Thickness: No. / QWOT / nm — 1 / 1.0000 / 75.56 (2) Optical thickness only Thickness: No. / nd/λ — 1 / .2500 Thickness: No. / QWOT — 1 / 1.0000 (3) Physical thickness only Thickness: No. / nm — 1 / 75.56 Thickness: No. / Å — 1 / 755.6 (4) Automatic switch optical and physical thickness(Previous version style) Thickness: No. / nd/λ or Å — 1 / .2500 In automatic switch mode, if less than 10 value is entered then it will be calculated as the optical thickness, if ten or more value is entered then it will be calculated as the physical thickness.
Thickness unit	Unit of physical thickness: Angstrom, nm, μm, mm. Unit of optical thickness: nd/Lambda or QWOT. ※ If you select the (4) automatic switch mode then the unit of physical thickness is fixed to Angstrom and the unit of optical thickness is fixed to nd/Lambda.
Priority	Select then thickness priority when you select the both optical and physical thickness display. If the priority is Optical thickness, then the optical thickness remains constant when the center wavelength or the refractive index is chanded and the displayed optical thickness are used for calculation. If the priority is Physical thickness, then the physical thickness remains constant and the displayed physical thickness are used for calculation.

3.13.1.3. Optical constants settings

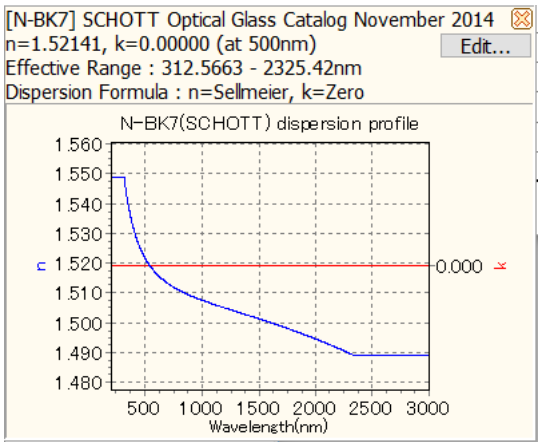
Sets the calculation method of the optical constant when the calculation spectrum of the spectral characteristic deviates from the effective wavelength range of the optical constant of the substrate or film material.



Extrapolation	If n and k are set by linear interpolation (table format), straight lines are directly extended outside the wavelength range and n and k are calculated by extrapolation. If it is set as a dispersion formula, even if it is out of the effective wavelength range, n and k are calculated using the dispersion formula.
Use at the minimum/maximum wavelength	The values of n and k at both ends on the short wavelength side and long wavelength side respectively are used as the values of n and k outside the wavelength range.
Show the effective wavelength range warning of the material on the status bar.	When checked, a warning will be displayed in the status bar at the bottom of the window if the calculation range of the spectrum graph or incident angle graph exceeds the valid range of the substrate/incident medium or material dispersion data. 



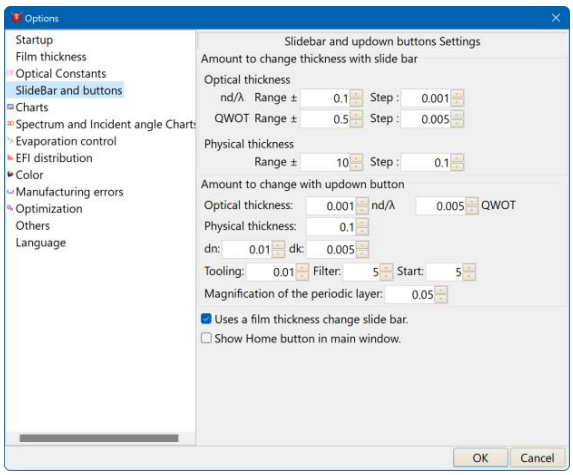
When "Extrapolate" is selected.



When "Use at the minimum / maximum wavelength" is selected.

3.13.1.4. Slidebar and updown buttons settings

Set up the amount of change of film data when moving the slide bar or pushing the updown buttons.



←In this case,
When thickness is 0.25 (Optical thickness: nd/ λ), the thickness can be change from 0.15 to 0.35 step 0.001 by moving the slide bar from the left edge to the right edge.

When thickness is 100 (Physical thickness:nm), the thickness can be change from 90 to 110 step 0.1 by moving the slide bar from the left edge to the right edge.

[Slidebar (Thickness Control]

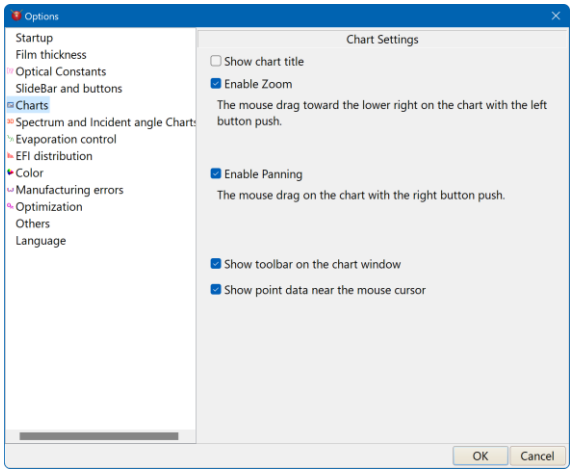
Set the thickness range and step of optical thickness and physical thickness respectively.
Range ： Set up the width of change when moving the slide bar from the left edge to the right edge.
Step ： Set up the quantity of change when moving the slide bar per one step.
These “Step” settings are also effective for using arrow keys.

[Updpwn step on film data]

Optical thickness	Set up the quantity of change when pushing the updown button in the case of optical thickness.
Physical thickness	Set up the quantity of change when pushing the updown button in the case of physical thickness.
dn	Set up the quantity of change when pushing the updown button on the “dn” column.
dk	Set up the quantity of change when pushing the updown button on the “dk” column.
Tooling	Set up the quantity of change when pushing the updown button on the “tooling” column.
Filter	Set up the quantity of change when pushing the updown button on the “filter” column.
Start	Set up the quantity of change when pushing the updown button on the “start” column.
Magnification of the periodic layer	Set up the quantity of change when pushing the updown button on the Magnification of the periodic layer column.

3.13.1.5. Chart settings

Set up the appearance and the operation of charts.



[Show chart title]

Select whether the title of the chart top is displayed. A Title will be displayed when checked.

[Enable zoom]

Select whether the zoom function is enabled. It will be enabled when checked.

[Enable Panning]

Select whether the panning function is enabled. It will be enabled when checked.

See: [3.5.4How to use the zoom and panning on the chart]

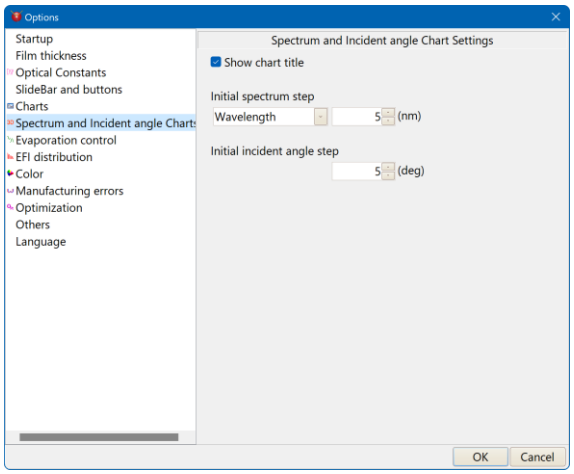
[Show toolbar on the chart window]

Select whether the toolbar on the chart window is visible. It will be visible when checked.

[Show point data near the mouse cursor]

Select whether the point data on the series at nearest mouse cursor is enabled. It will be enabled when checked.

3.13.1.6. Wavelength and incident angle 3D chart settings



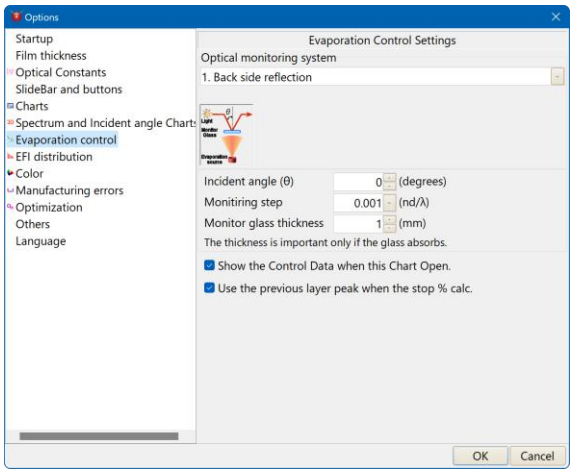
[Initial wavelength step]

Set the initial value of the wavelength calculation step. (nm)

[Initial incident angle step]

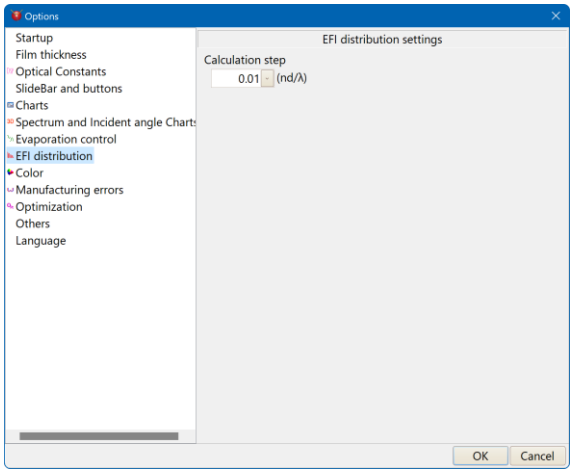
Set the initial value of the incident angle calculation step. (deg.)

3.13.1.7. Evaporation control settings



See: [3.6.5 Optical evaporation monitor]

3.13.1.8. EFI distribution settings

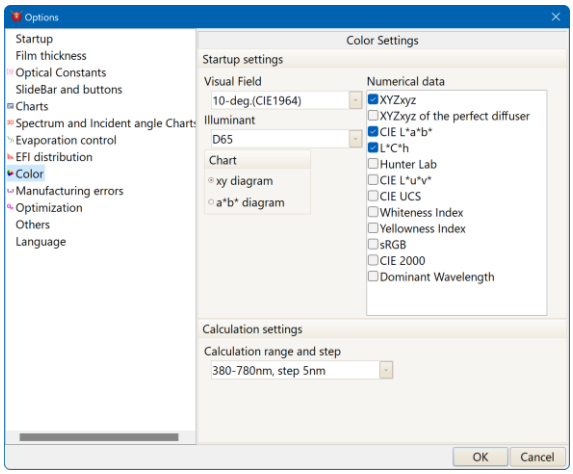


[Calculation step]

Calculation step of EFI. Recommended value is 0.01 or 0.001.

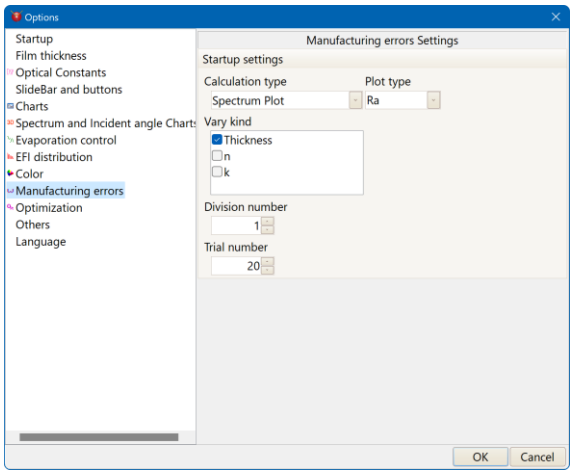
3.13.1.9. Color settings

Initial settings for color calculation.



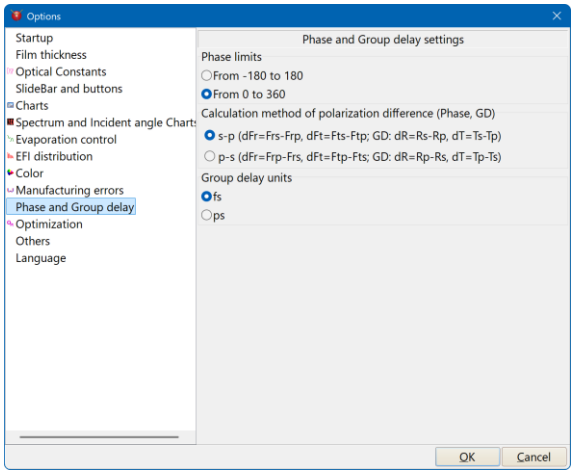
3.13.1.10. Manufacturing errors settings

Initial settings for manufacturing errors.



3.13.1.11. Phase and Group delay settings

Configure the settings for phase and group delay.



[Phase limits]

Select whether to calculate the phase in the range of -180° to +180° or 0° to 360°.

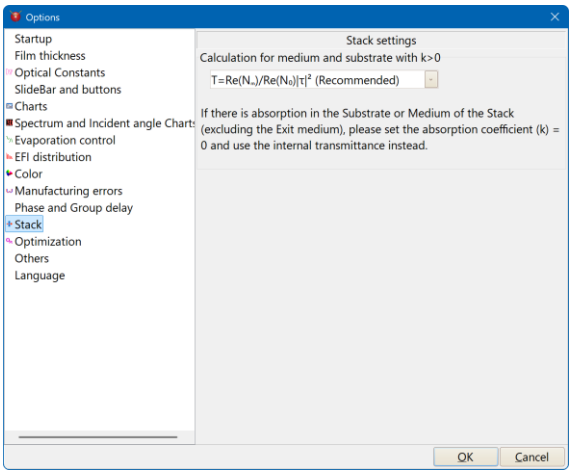
[Calculation method of polarization difference (Phase, GD)]

Select whether to calculate the phase difference as s-polarization minus p-polarization or p-polarization minus s-polarization.

[Group delay units]
Select whether to use fs or ps as the unit for group delay.

3.13.1.12. Stack settings

Configure the settings for stack.



[Calculation for medium and substrate with k>0]

1. $T=Re(N_m)/Re(N_0)|\tau|^2$
2. $T=Re(N_m/N_0)|\tau|^2$
3. $k_0=0$

In Stack configurations, intermediate Media or Substrates might have an absorption coefficient ($k \neq 0$).

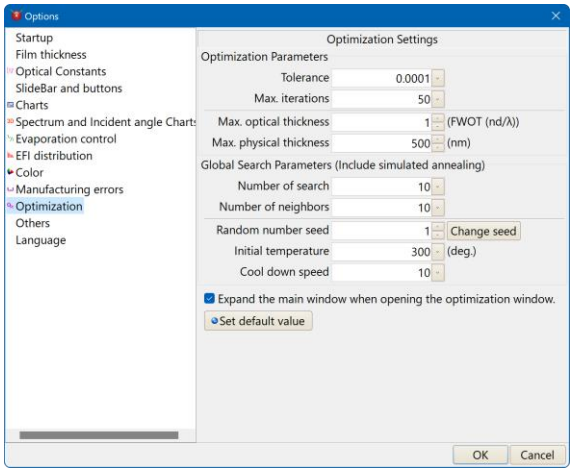
Specify the calculation method for such cases:

1: Recommended.

2: Attempts to preserve R+T=1 as much as possible, even in unrealistic configurations such as k≠0 with internal transmittance=0 (or zero thickness).

3: Always treat the incident Medium as having k=0 in calculations.

3.13.1.13. Optimization settings



【Optimization Parameters】

[Tolerance]
The range between the target value and the searched value that is acceptable. Default value is 1.0E-4.

[Max. iterations]
Define the maximum number of iterations of the optimization process. When this number of iterations has been reached, the optimization process will terminate. Default value is 50.

[Max. optical thickness]
Maximum optical thickness of each layer. If optimization max value of the layer is not zero, then optimization max value has priority over this value.

[Max. physical thickness]
Maximum physical thickness of each layer. If optimization max value of the layer is not zero, then optimization max value has priority over this value.

【Global search parameters (Include simulated annealing)】

[Number of searches]
Define the number of times of global search. This value should be larger than the number of results values at least. Default value is 10.

[Number of neighbors]
Define the number of times of nearest neighbor search during annealing. Default value is 10.

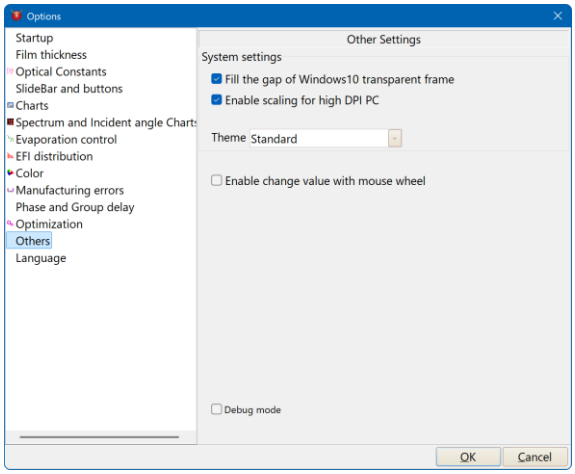
[Random number seed]
Define the starting point for the random number generation process. If you want to take a different result then change this value. If this value is 0, then the different seed will be used every time. Default value is 1. (0 to 2147483646).

[Initial temperature]
Define the initial temperature when the annealing starts. Default value is 300. Final temperature is always 0.

[Cool down speed]
Define the cooling down speed during annealing. Default value is 10.

For set the default value all optimization parameters, click [Set default value].

3.13.1.14. Other settings



[System settings]

Fill the gap of Windows10 transparent frame:

If checked, fill the gap of Windows10 transparent frame.

Enable scaling for high DPI PC:

If checked, change font size according to Windows scaling setting for each monitor.

Theme:

Normally, select Standard. If you have a slow PC, selecting Classic may speed up the screen display.

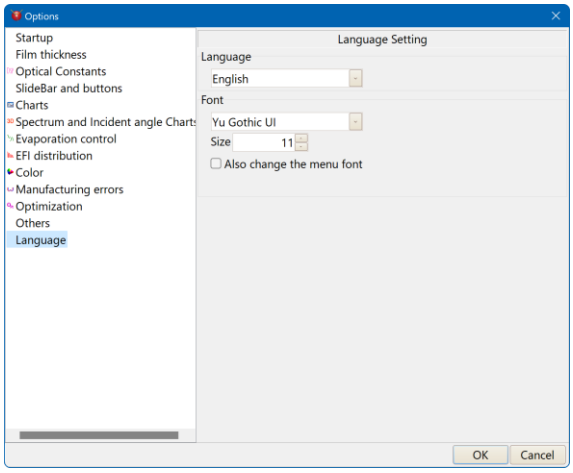
“Enable change values with mouse wheel"

When checked, values such as film thickness can be changed using the mouse wheel.
*Not only the film thickness, but almost all values of TFV can be changed using the mouse wheel. Please be careful not to operate incorrectly.

“Debug mode”

Not used. Do not check this box.

3.13.1.15. Language settings



Select the display language of TFV
You can select English, Japanese or Chinese-Traditional.
You can select font and font size.

4. Built-in glass and film material

4.1. Glass

SCHOTT 164 kinds Jan, 2019 Catalog	BAFN6, BK7G18, F2, F2G12, F2HT, F4, F5, FK3, FK5HTi, K5G20, K7, K10, KZFS12, KZFSN4, KZFSN5, LAFN7, LAK9G15, LAKL12, LASF35, LASFN9, LF5, LF5G15, LF5G19, LF5HTi, LITHOSIL-Q, LITHOTEC-CAF2, LLF1, LLF1HTi, N-BAF3, N-BAF4, N-BAF10, N-BAF51, N-BAF52, N-BAK1, N-BAK2, N-BAK4, N-BAK4HT, N-BALF4, N-BALF5, N-BASF2, N-BASF64, N-BK7, N-BK7HT, N-BK7HTi, N-BK10, N-F2, N-FK5, N-FK51, N-FK51A, N-FK58, N-K5, N-KF9, N-KZFS2, N-KZFS4, N-KZFS4HT, N-KZFS5, N-KZFS8, N-KZFS11, N-LAF2, N-LAF3, N-LAF7, N-LAF21, N-LAF32, N-LAF33, N-LAF34, N-LAF35, N-LAF36, N-LAK7, N-LAK8, N-LAK9, N-LAK10, N-LAK12, N-LAK14, N-LAK21, N-LAK22, N-LAK33A, N-LAK33B, N-LAK34, N-LASF9, N-LASF9HT, N-LASF31, N-LASF31A, N-LASF40, N-LASF41, N-LASF43, N-LASF44, N-LASF45, N-LASF45HT, N-LASF46, N-LASF46A, N-LASF46B, N-PK51, N-PK52A, N-PSK3, N-PSK53, N-PSK53A, N-SF1, N-SF2, N-SF4, N-SF5, N-SF6, N-SF6HT, N-SF6HTultra, N-SF8, N-SF10, N-SF11, N-SF14, N-SF15, N-SF19, N-SF56, N-SF57, N-SF57HT, N-SF57HTultra, N-SF64, N-SF66, N-SK2, N-SK2HT, N-SK4, N-SK5, N-SK10, N-SK11, N-SK14, N-SK15, N-SK16, N-SSK2, N-SSK5, N-SSK8, N-ZK7, N-ZK7A, P-BK7, P-LAF37, P-LAK35, P-LASF47, P-LASF50, P-LASF51, P-PK53, P-SF8, P-SF67, P-SF68, P-SF69, P-SK57, P-SK57Q1, P-SK58A, P-SK60, SF1, SF2, SF4, SF5, SF6, SF6G05, SF6HT, SF10, SF11, SF14, SF15, SF56A, SF57, SF57HHT, SF57HT, SF57HTultra, SF66, SFL6, SFL57, Zerodur
OHARA 222 kinds Aug-3, 2020 Catalog	BAL15Y, BAL35Y, BSL7Y, BSM51Y, LAH80, L-BAL35, L-BAL35P, L-BAL42, L-BAL42P, L-BAL43, L-BBH1, L-BBH2, L-BSL7, L-LAH53, L-LAH81, L-LAH83, L-LAH84, L-LAH85, L-LAH85V, L-LAH86, L-LAH87, L-LAH90, L-LAH91, L-LAH94, L-LAL12, L-LAL13, L-LAL15, L-LAM60, L-LAM69, L-LAM72, L-NBH54, L-PHL1, L-PHL2, L-TIH53, L-TIM28, L-TIM28P, PBH55, PBH56, PBL1Y, PBL6Y, PBL25Y, PBL26Y, PBL35Y, PBM2Y, PBM8Y, PBM18Y, S-APL1, S-BAH10, S-BAH11, S-BAH27, S-BAH28, S-BAH32, S-BAL2, S-BAL3, S-BAL11, S-BAL12, S-BAL14, S-BAL22, S-BAL35, S-BAL41, S-BAL42, S-BAL50, S-BAM3, S-BAM4, S-BAM12, S-BSL7, S-BSM2, S-BSM4, S-BSM9, S-BSM10, S-BSM14, S-BSM15, S-BSM16, S-BSM18, S-BSM21, S-BSM22, S-BSM25, S-BSM28, S-BSM36, S-BSM71, S-BSM81, S-BSM93, S-FPL51, S-FPL51Y, S-FPL53, S-FPL55, S-FPM2, S-FPM3, S-FPM4, S-FSL5, S-FSL5Y, S-FTL10, S-FTM16, S-LAH51, S-LAH52, S-LAH52Q, S-LAH53, S-LAH53V, S-LAH54, S-LAH55, S-LAH55V, S-LAH55VS, S-LAH58, S-LAH59, S-LAH60, S-LAH60MQ, S-LAH60V, S-LAH63, S-LAH63Q, S-LAH64, S-LAH65, S-LAH65V, S-LAH65VS, S-LAH66, S-LAH71, S-LAH79, S-LAH88, S-LAH89, S-LAH92, S-LAH93, S-LAH95, S-LAH96, S-LAH97, S-LAH98, S-LAH99, S-LAL7, S-LAL7Q, S-LAL8, S-LAL9, S-LAL10, S-LAL11, S-LAL12, S-LAL12Q, S-LAL13, S-LAL14, S-LAL18, S-LAL19, S-LAL20, S-LAL21, S-LAL52, S-LAL54, S-LAL54Q, S-LAL56, S-LAL58, S-LAL59, S-LAL60, S-LAL61, S-LAM2, S-LAM3, S-LAM7, S-LAM51, S-LAM52, S-LAM54, S-LAM55, S-LAM58, S-LAM59, S-LAM60, S-LAM61, S-LAM66, S-LAM73, S-NBH5, S-NBH8, S-NBH51, S-NBH52, S-NBH52V, S-NBH53, S-NBH53V, S-NBH55, S-NBH56, S-NBH57, S-NBH58, S-NBM51, S-NPH1, S-NPH1W, S-NPH2, S-NPH3, S-NPH4, S-NPH5, S-NPH7, S-NPH53, S-NSL2, S-NSL3, S-NSL5, S-NSL36, S-PHM51, S-PHM52, S-PHM52Q, S-PHM53, S-TIH1, S-TIH3, S-TIH4, S-TIH6, S-TIH10, S-TIH11, S-TIH13, S-TIH14, S-TIH18, S-TIH20, S-TIH23, S-TIH53, S-TIH53W, S-TIH57, S-TIL1, S-TIL2, S-TIL6, S-TIL25, S-TIL26, S-TIL27, S-TIM1, S-TIM2, S-TIM3, S-TIM5, S-TIM8, S-TIM22, S-TIM25, S-TIM27, S-TIM28, S-TIM35, S-TIM39, S-YGH51, S-YGH52, TIH53
HOYA 217 kinds Mar-14, 2020 Catalog	ADC1, BAC4, BACD2, BACD4, BACD5, BACD11, BACD14, BACD15, BACD16, BACD18, BACED5, BAF10, BAF11, BAFD7, BAFD8, BAFD15, BSC7, E-ADF10, E-ADF50, E-BACD10, E-BACED20, E-BAF8, E-C3, E-CF6, E-F1, E-F2, E-F3, E-F5, E-F8, E-FD1, E-FD1L, E-FD2, E-FD4, E-FD4L, E-FD5, E-FD7, E-FD8, E-FD10, E-FD10L, E-FD13, E-FD15, E-FD15L, E-FD80, E-FDS1, E-FDS1-W, E-FDS2, E-FDS3, E-FEL1, E-FEL2, E-FEL6, E-FL5, E-FL6, E-LAF7, FC5, FCD1, FCD1B, FCD10, FCD10A, FCD100, FCD500, FCD505, FCD515, FCD600, FCD705, FD60, FD60-W, FD110, FD140, FD225, FDS16-W, FDS18, FDS18-W, FDS20-W, FDS24, FDS24-W, FDS30, FDS90, FDS90(P), FDS90-SG, FF5, FF8, LAC7, LAC8, LAC9, LAC10, LAC12, LAC13, LAC14, LACL60, LAF2, LAF3, LAFL2, LBC3N, M-BACD5N, M-BACD12, M-BACD15, MC-BACD5N, MC-BACD12, MC-FCD1-M20, MC-FCD500-20, MC-FD80, MC-FDS2, MC-FDS910-50, MC-LAC130, MC-NBF1, MC-NBFD130, MC-NBFD135, MC-PCD4-40, MC-PCD51-70, MC-TAF1, MC-TAF31-15, MC-TAF101-100, MC-TAF105, MC-TAF401, MC-TAFD51-50, MC-TAFD305, MC-TAFD307, M-FCD1, M-FCD500, M-FD60, M-FD80, M-FDS1, M-FDS2, M-FDS910, M-LAC8, M-LAC14, M-LAC130, M-LAF81, M-NBF1, M-NBFD10, M-NBFD82, M-NBFD130, MP-BACD5N, MP-BACD12, MP-BACD15, M-PCD4, M-PCD51, M-PCD55AR, MP-FCD1-M20, MP-FCD500-20, MP-FD80, MP-FDS1, MP-FDS2, MP-FDS910-50, MP-LAC8-30, MP-LAC14-80, MP-LAC130, MP-LAF81, MP-NBF1, MP-NBFD10-20, MP-NBFD130, MP-PCD4-40, MP-PCD51-70, MP-PCD55AR, MP-TAC60-90, MP-TAC80-60, MP-TAF31-15, MP-TAF101-100, MP-TAF105, MP-TAF401, MP-TAFD51-50, MP-TAFD305, MP-TAFD307, MP-TAFD405, M-TAC60, M-TAC80, M-TAF1, M-TAF31, M-TAF101, M-TAF105, M-TAF401, M-TAFD51, M-TAFD301, M-TAFD305, M-TAFD307, M-TAFD405, NBF1, NBF2, NBFD3, NBFD10, NBFD11, NBFD12, NBFD13, NBFD15, NBFD15-W, NBFD25, NBFD29, NBFD30, NBFD32, PCD4, PCD40, PCD51, TAC2, TAC4, TAC6, TAC8, TAF1, TAF2, TAF3, TAF3D, TAF4, TAF5, TAFD5F, TAFD5G, TAFD25, TAFD30, TAFD32, TAFD33, TAFD35, TAFD37, TAFD37A, TAFD40, TAFD40-W, TAFD45, TAFD55, TAFD55-W, TAFD65
CDGM 314 kinds	BAF2, BaF3, BaF4, BaF5, BaF6, BaF7, BaF8, D-FK61, D-FK61A, D-FK95, D-K9, D-K9GT, D-K9L, D-K59, D-LaF050, D-LAF50, D-LaF53, D-LAF79, D-LAF82L, D-LaK5, D-LAK6, D-LAK70, D-PK3, D-

Sep, 2020 Catalog	QK3L, D-ZF10, D-ZF93, D-ZK2, D-ZK2L, D-ZK3, D-ZK3L, D-ZK79, D-ZLaF50, D-ZLAF52LA, D-ZLaF61, D-ZLAF67, D-ZLaF81, D-ZLaF85A, D-ZLaF85L, D-ZPK1A, D-ZPK3, F1, F2, F3, F4, F5, F6, F7, F13, H-BaF2, H-BAF3, H-BaF4, H-BAF5, H-BAF6, H-BaF7, H-BAF8, H-BaK1, H-BaK2, H-BaK3, H-BaK4, H-BAK5, H-BaK6, H-BaK7, H-BaK7A, H-BaK7GT, H-BaK8, H-F1, H-F2, H-F4, H-F13, H-F51, H-FK61, H-FK61B, H-FK71, H-FK71A, H-FK95N, H-K1, H-K2, H-K3, H-K5, H-K6, H-K7, H-K8, H-K90GTi, H-K9L, H-K9L_, H-K9LGT, H-K10, H-K11, H-K12, H-K50, H-K51, H-K51A, H-KF6, H-LaF1, H-LAF2, H-LaF3, H-LAF3A, H-LaF3B, H-LaF4, H-LaF4GT, H-LaF6L, H-LAF6LA, H-LAF7, H-LaF10L, H-LAF10LA, H-LaF50A, H-LaF50B, H-LaF51, H-LAF52, H-LaF53, H-LaF54, H-LAF55, H-LaF62, H-LAFL5, H-LaK1, H-LAK2, H-LAK2A, H-LaK3, H-LaK4L, H-LAK5A, H-LAK6A, H-LaK7, H-LaK7A, H-LAK8A, H-LaK8B, H-LAK10, H-LAK11, H-LAK12, H-LaK50, H-LAK50A, H-LaK51, H-LaK51A, H-LaK52, H-LaK53, H-LAK53A, H-LaK53B, H-LaK54, H-LAK59, H-LAK59A, H-LAK61, H-LAK67, H-QF1, H-QF3, H-QF6, H-QF6A, H-QF8, H-QF14, H-QF50, H-QF50A, H-QF56, H-QK1, H-QK3, H-QK3L, H-QK3LGTi, H-TF3L, H-TF5, H-TF8, HWS1, HWS2, HWS3, HWS4, HWS5, HWS6, HWS7, HWS27, H-ZBAF1, H-ZBaF3, H-ZBAF4, H-ZBaF5, H-ZBaF16, H-ZBAF20, H-ZBAF21, H-ZBaF50, H-ZBaF52, H-ZF1, H-ZF1A, H-ZF2, H-ZF3, H-ZF4, H-ZF4A, H-ZF4AGT, H-ZF5, H-ZF6, H-ZF7L, H-ZF7LA, H-ZF7LAGT, H-ZF10, H-ZF11, H-ZF12, H-ZF13, H-ZF13GT, H-ZF39, H-ZF50, H-ZF52, H-ZF52A, H-ZF52GT, H-ZF52TT, H-ZF62, H-ZF62GT, H-ZF71, H-ZF71GT, H-ZF72A, H-ZF72AGT, H-ZF73, H-ZF73GT, H-ZF88, H-ZF88GT, H-ZK1, H-ZK2, H-ZK3, H-ZK3A, H-ZK4, H-ZK5, H-ZK6, H-ZK7, H-ZK7A, H-ZK8, H-ZK9, H-ZK9A, H-ZK9B, H-ZK10, H-ZK10L, H-ZK11, H-ZK14, H-ZK20, H-ZK21, H-ZK50, H-ZK50GT, H-ZLaF1, H-ZLaF2A, H-ZLAF3, H-ZLaF4LA, H-ZLaF4LB, H-ZLaF50A, H-ZLaF50B, H-ZLAF50D, H-ZLaF50E, H-ZLaF51, H-ZLaF52, H-ZLaF52A, H-ZLaF53, H-ZLAF53A, H-ZLAF53B, H-ZLaF53BGT, H-ZLaF55, H-ZLAF55A, H-ZLaF55C, H-ZLaF55D, H-ZLaF56, H-ZLAF56A, H-ZLaF56B, H-ZLAF66, H-ZLaF66GT, H-ZLAF68, H-ZLaF68B, H-ZLaF68C, H-ZLaF68N, H-ZLAF69, H-ZLaF69A, H-ZLaF71, H-ZLaF71AGT, H-ZLAF75, H-ZLaF75A, H-ZLaF75B, H-ZLAF76, H-ZLaF76A, H-ZLAF78, H-ZLAF78A, H-ZLaF78B, H-ZLaF85L, H-ZLAF89L, H-ZLAF90, H-ZLaF92, H-ZPK1, H-ZPK1A, H-ZPK2, H-ZPK2A, H-ZPK3, H-ZPK5, H-ZPK7, K4A, K50, QF1, QF3, QF5, QF6, QF8, QF50, QF50GTi, TF3, ZBaF1, ZBaF2, ZBaF4, ZBaF17, ZBaF20A, ZBaF21A, ZBaF51, ZF1, ZF2, ZF3, ZF4, ZF5, ZF6, ZF7, ZF7L, ZF7LGT, ZF8, ZF10, ZF11, ZF12, ZF13, ZF50, ZF51, ZF52
HIKARI 302 kinds Apr-1, 2020 Catalog	E-BAF3, E-BAF4, E-BAF8, E-BAF10, E-BAF11, E-BAF12, E-BAK1, E-BAK2, E-BAK4, E-BALF4, E-BASF2, E-BASF6, E-BASF7, E-BASF8, E-BK7, E-F1, E-F2, E-F3, E-F5, E-F8, E-F16, E-FK01, E-FK5, E-FKH1, E-FKH2, E-K3, E-K5, E-KF6, E-KZFH1, E-LAF01, E-LAF02, E-LAF2, E-LAF3, E-LAF04, E-LAF05, E-LAF7, E-LAF09, E-LAF010, E-LAF11, E-LAF016, E-LAFH2, E-LAFH3, E-LAK01, E-LAK02, E-LAK04, E-LAK06, E-LAK7, E-LAK8, E-LAK09, E-LAK9, E-LAK10, E-LAK011, E-LAK12, E-LAK13, E-LAK14, E-LAK18, E-LAKH1, E-LASF01, E-LASF02, E-LASF03, E-LASF04, E-LASF05, E-LASF08, E-LASF09, E-LASF010, E-LASF013, E-LASF014, E-LASF015, E-LASF016, E-LASF017, E-LASF021, E-LASFH2, E-LASFH6, E-LASFH9, E-LASFH13, E-LASFH15, E-LASFH17, E-LASKH2, E-LF5, E-LF6, E-LF7, E-LLF1, E-LLF2, E-LLF6, E-PKH1, E-PSK02, E-PSK03, E-PSKH1, E-SF1, E-SF2, E-SF03, E-SF4, E-SF5, E-SF6, E-SF7, E-SF8, E-SF10, E-SF11, E-SF13, E-SF14, E-SF15, E-SFH1, E-SFH2, E-SFS3, E-SK2, E-SK4, E-SK5, E-SK10, E-SK11, E-SK12, E-SK14, E-SK15, E-SK16, E-SK18, E-SSFH1, E-SSK1, E-SSK5, E-SSK8, J-BAF3, J-BAF4, J-BAF8, J-BAF10, J-BAF11, J-BAF12, J-BAK1, J-BAK2, J-BAK4, J-BALF4, J-BASF2, J-BASF6, J-BASF7, J-BASF8, J-BK7, J-BK7A, J-F1, J-F2, J-F3, J-F5, J-F8, J-F16, J-FK01, J-FK01A, J-FK5, J-FKH1, J-FKH2, J-K3, J-K5, J-KF6, J-KZFH1, J-KZFH4, J-KZFH6, J-KZFH7, J-KZFH9, J-LAF01, J-LAF02, J-LAF2, J-LAF3, J-LAF04, J-LAF05, J-LAF7, J-LAF09, J-LAF010, J-LAF016, J-LAF016HS, J-LAFH3, J-LAFH3HS, J-LAK01, J-LAK02, J-LAK04, J-LAK06, J-LAK7, J-LAK7R, J-LAK8, J-LAK09, J-LAK9, J-LAK10, J-LAK011, J-LAK12, J-LAK13, J-LAK14, J-LAK18, J-LASF01, J-LASF02, J-LASF03, J-LASF05, J-LASF05HS, J-LASF08, J-LASF08A, J-LASF09, J-LASF09A, J-LASF010, J-LASF013, J-LASF014, J-LASF015, J-LASF015HS, J-LASF016, J-LASF017, J-LASF021, J-LASF021HS, J-LASFH2, J-LASFH6, J-LASFH9, J-LASFH9A, J-LASFH13, J-LASFH13HS, J-LASFH15, J-LASFH15HS, J-LASFH16, J-LASFH17, J-LASFH17HS, J-LASFH21, J-LASFH22, J-LASFH23, J-LASFH24, J-LASFH24HS, J-LASKH2, J-LF5, J-LF6, J-LF7, J-LLF1, J-LLF2, J-LLF6, J-PKH1, J-PSK02, J-PSK03, J-PSKH1, J-PSKH4, J-PSKH8, J-SF1, J-SF2, J-SF03, J-SF03HS, J-SF4, J-SF5, J-SF6, J-SF6HS, J-SF7, J-SF8, J-SF10, J-SF11, J-SF13, J-SF14, J-SF15, J-SFH1, J-SFH1HS, J-SFH2, J-SFH4, J-SFH5, J-SFS3, J-SK2, J-SK4, J-SK5, J-SK10, J-SK11, J-SK12, J-SK14, J-SK15, J-SK16, J-SK18, J-SSK1, J-SSK5, J-SSK8, P-FK01S, P-FKH2S, P-LAF010S, P-LAK13S, P-LAK52S, P-LASF03S, P-LASFH11S, P-LASFH12S, P-LASFH18S, P-LASFH19S, P-PSKH1S, P-PSKH2S, P-SF6S, P-SK5S, P-SK12S, Q-FK01AS, Q-FK01S, Q-FKH1S, Q-FKH2S, Q-LAF010S, Q-LAFPH1S, Q-LAK13S, Q-LAK52S, Q-LAK53S, Q-LASF03S, Q-LASFH11S, Q-LASFH12S, Q-LASFH58S, Q-LASFH59S, Q-LASFPH2S, Q-LASFPH3S, Q-PSKH1S, Q-PSKH2S, Q-PSKH4S, Q-PSKH52S, Q-SF6S, Q-SK12S, Q-SK15S, Q-SK52S, Q-SK55S
SUMITA 143 kinds Jul-15, 2020 Catalog	K-BaF8, K-BaF9, K-BaFn1, K-BaFn3, K-BaSF4, K-BaSF5, K-BaSF12, K-BK7, K-BOC30, K-BPG2, K-CaFK95, K-CD45, K-CD120, K-CD300, K-CSK120, K-FIR98UV, K-FIR100UV, K-FK5, K-GFK68, K-GFK70, K-GIR79, K-GIR140, K-LaF2, K-LaF3, K-LaFK50, K-LaFK50T, K-LaFK55, K-LaFK58, K-LaFK60, K-LaFK63, K-LaFK65, K-LaFn1, K-LaFn2, K-LaFn3, K-LaFn5, K-LaFn9, K-LaFn11, K-LaK6, K-LaK7, K-LaK8, K-LaK9, K-LaK10, K-LaK11, K-LaK12, K-LaK13, K-LaK14, K-LaK18, K-LaKn2, K-LaKn7, K-LaKn12, K-LaKn14, K-LaSFn1, K-LaSFn2, K-LaSFn3, K-LaSFn4, K-LaSFn6, K-LaSFn7, K-LaSFn8, K-LaSFn8W, K-LaSFn9, K-LaSFn10, K-LaSFn14, K-LaSFn16, K-LaSFn17, K-LaSFn21, K-LaSFn22, K-LaSFn23, K-LaSKn1, K-LCV93, K-LCV161, K-PBK40, K-PBK50, K-PBK60, K-PFK80, K-PFK85, K-PFK90, K-PG325, K-PG375, K-PG395, K-PMK30, K-PSFn1, K-PSFn2, K-PSFn3, K-PSFn4, K-PSFn5, K-PSFn166, K-PSFn173, K-PSFn185, K-PSFn190, K-PSFn202, K-PSFn203, K-PSFn214, K-PSFn214P, K-PSK11, K-PSK100, K-PSK200, K-PSK300, K-PSK400, K-PSK500, K-PSKn2, K-

	SFLD1, K-SFLD2, K-SFLD4, K-SFLD5, K-SFLD6, K-SFLD8, K-SFLD8W, K-SFLD10, K-SFLD11, K-SFLD14, K-SFLD66, K-SFLDn3, K-SFLDn3W, K-SK4, K-SK5, K-SK7, K-SK14, K-SK15, K-SK16, K-SK16RH, K-SK18, K-SK18RH, K-SKF6, K-SKLD100, K-SKLD120, K-SKLD200, K-SSK1, K-SSK3, K-SSK4, K-SSK9, K-VC78, K-VC79, K-VC80, K-VC82, K-VC89, K-VC90, K-VC91, K-VC99, K-VC100, K-VC179, K-VC181, K-VC185, K-ZnSF8
Others 19 kinds	Al2O3(Subst), ALON(Subst), APEL, CaF2, GaAs(Subst), Ge(Subst), PCHMA, PEI, PMMA, PMMA1, Polycarbonate, Polystyrene, Quartz, SAN, Si(Subst), ZEONEX-330R, ZEONEX-480R, ZEONEX-E48R, ZnSe(Subst)

4.2. Film material

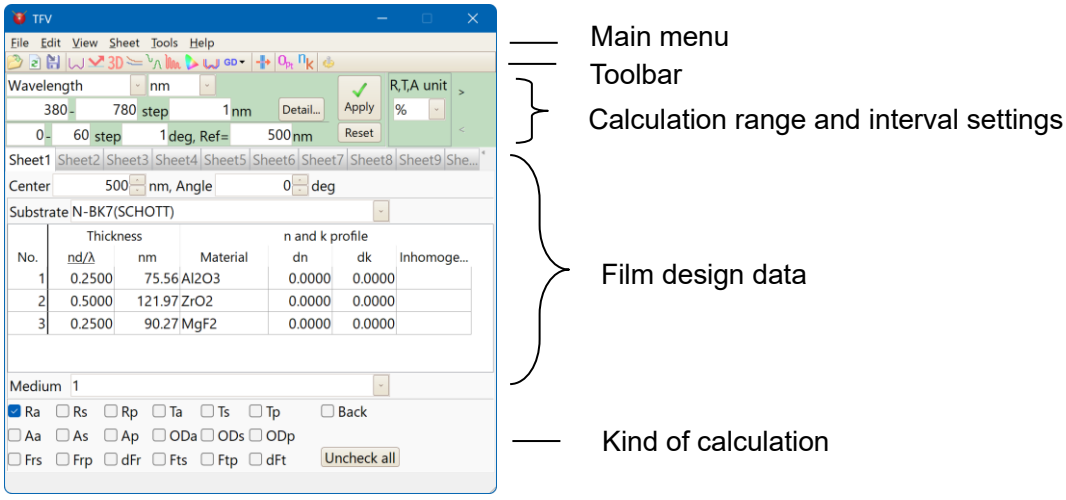
Ag, Al2O3, AL, Au, Cr, Cu, H2, H4, LaF3, M3, M3-RT, MgF2, Nb2O5, Nb2O5-RT, OH5, OH5-RT, OS50, OS50-RT, SiO2, Ta2O5, Ta2O5-RT, Ti, TiO2, Zn, ZnS, ZrO2, Cytop

Al2O3(KTM), HfO2(KTM), LaF3(KTM), Ti3O5(KTM), ZrO2(KTM), ZRT2(KTM)
※ KTM: Kyoto Thin-Film Materials institute

The catalog data or the literature data is used.

5. Reference manual

5.1. Main window



5.1.1. Main menu

In this section, each function of the main menu items are explained.

- File

New	: Create new film data in active sheet. For starting design from scratch.
Open	: Read film data from the file to active sheet. For reading an existing film data file from the disk.
Reload	: Reload the film data from the file to active sheet. For returning the film data to saved data. The edited data are canceled.
Recent files	: Show recent files of film data. Max. 20 files.
Save	: Overwrite save the film data in active sheet to the file.
Save as	: Save the film data in active sheet to the file with a new name.
Open project	: Read project file.
Recent project files	: Show recent project files. Max. 20 files.
Save project	: Overwrite save the project.
Save project as	: Save the project with a new name.
Close project	: Close current project.
Import	: Import data from Essential Macleod and Zemax OpticStudio.
Export	: Create a coating file for Zemax OpticStudio.
Exit	: Exit TFV

- Edit

Copy selected cells to clipboard	:	Copies the contents of the selected cell to the clipboard.
Paste from clipboard to cells	:	Paste the contents of the clipboard to the selected upper left cell as the base point.
Copy layer to clipboard...	:	Copy layer information to clipboard.
Paste layer from clipboard	:	Paste to layer from clipboard.
Insert layer	:	Insert a layer to the film data.
Delete layer	:	Delete a layer from the film data.

Insert period layer	:	Insert a period layer to the film data.
Delete period layer	:	Delete a period layer from the film data.
Expand periodic layers	:	Expand periodic layers
Change to physical thickness (All layers)	:	Change optical thickness to physical thickness.
Change to optical thickness (All Layers)	:	Change physical thickness to optical thickness.
Copy film data to other sheet...	:	Copy the film data to the other sheet
Change center wavelength (fix nd)...	:	Change the center wavelength but not change thickness as keep the same characteristic of the film
Clear film data	:	Clear the film data in active sheet.
Copy film data	:	Copy the film data of active sheet to clipboard (tab separated format). You can paste this copied data to other software.
Inverse layers	:	Inverse layers (Upside down and downside up)
Edit comment...	:	Edit comment of the film data.

- View

Wavelength plot	:	Show the wavelength plot. Wavelength vs. reflectance, transmittance, absorptance and phase shift
Incident angle plot	:	Show the incident angle plot. Incident angle vs. reflectance, transmittance, absorptance and phase shift
3D Wavelength and incident angle plot	:	Show the wavelength and incident angle chart.
Dispersion plot	:	Show the dispersion plot. Wavelength vs. refractive index and absorption coefficient.
Evaporation control	:	Show the evaporation control plot. This is optical monitor chart during evaporation.
EFI distribution	:	Show the electric field intensity plot.
Color calculation	:	Show the xy chromaticity diagram or the a*b* chromaticity diagram and various chromaticity value. The color calculation is always calculated between 380nm and 780nm at interval of 5nm.
Manufacturing errors analyzer	:	Show the manufacturing errors analysis plot. Wavelength or incident angle vs. reflectance, transmittance, absorptance and phase shift. For investigating the influence to the optical characteristic of the error of the thickness, the refractive index and the absorption coefficient in each layer.
Group delay - Spectrum	:	Displays a spectrum graph of group delay.
Group delay - Incident angle	:	Displays a incidence angle graph of group delay.
Stack		Show stack window for calculate total of the both front side and the back side surface.

- Tools

Misc. calculator	:	Execute the miscellaneous thin film calculation tool. Calculate the refractive index from QWOT peak, the total reflectance at the two surfaces of thick film and the three layers equivalent film.
Optimization design	:	Execute the optimization design.
n and k analysis of substrate and monolayer film ...	:	Analyzes n and k of substrate and monolayer film from measured values of reflectance and transmittance.

Edit dispersion data...	:	Create new dispersion data or edit existing dispersion data.
Edit inhomogeneity parameter...	:	Create new inhomogeneity parameters or edit existing inhomogeneity parameters.
Save window position	:	Save the window position.
Clear saved window position	:	Clear the saved window positions.
Options	:	Set up the initial settings and the operation settings.

- Help

User's guide(pdf)	:	Show the User's guide pdf file.
TFV web site	:	Access the TFV web site.
About	:	Show the version information etc.

5.1.2. Toolbar

Often used menu items are in toolbar for quick operation.

Open
Reload
Save as

Wavelength plot
Incident angle plot
Wavelength and Incident angle chart
Dispersion plot
Evaporation control
EFI distribution
Color calculation
Mismatch analyzer
GD GD

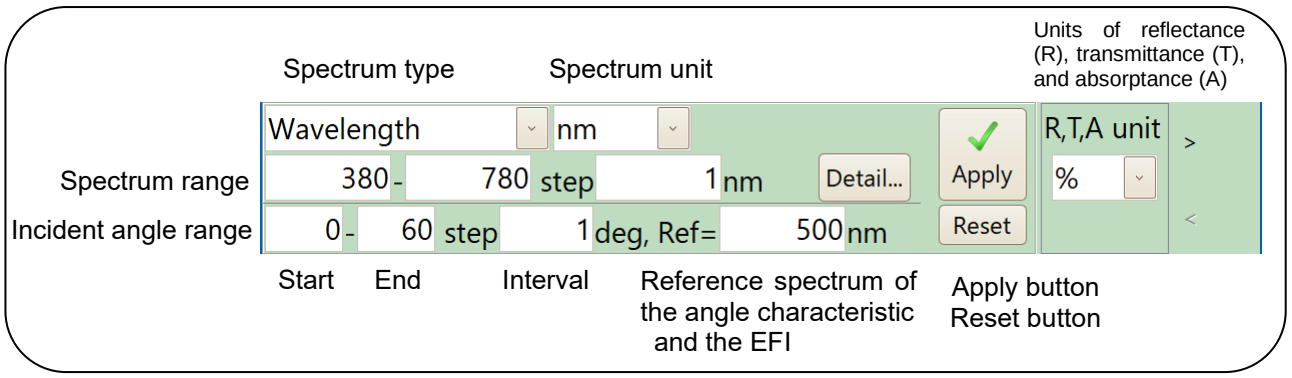
Stack

Optimization design
n and k analysis of substrate and monolayer film

Options

5.1.3. Calculation ranges and calculation intervals settings

Change the calculation wavelength ranges and the calculation wavelength intervals, the calculation incident angle ranges and the calculation incident angle intervals etc.
By changing the range of here, the x-axis of the chart will be changed.



- Spectrum type and unit (Upper row)
  Select the spectrum type and units for the spectrum graph, 3D graph, and manufacturing error graph.
  The supported spectrum types are shown in the table on the right.

Spectrum type	Units
Wavelength	Å, nm, μm, mm
Frequency	PHz, THz, GHz
Wave number	cm^{-1}, μm^{-1}, 2π/cm
Angular frequency	rad/fs
Energy	eV, keV
g-Number	

- Spectrum range settings (Middle row)

Set the spectrum calculation range for spectrum graphs, 3D graphs, and manufacturing error graphs.

Start: Calculation start spectrum
End: Calculation end spectrum
Interval: Calculation spectrum interval

In the above settings, Wavelength range is from 380 to 780 nm, Calculation interval is 1 nm.

- Incident angle range settings (Lower row)

Start: Calculation start angle
End: Calculation end angle
Interval: Calculation angle interval
Calculation spectrum (nm) of the angle characteristic and the EFI: Calculation spectrum at the incident angle plot and the EFI distribution.

In the above settings, angle range is from 0 to 60 degrees, calculation interval is 1 degree and wavelength of the incident light is 500nm. In EFI distribution plot, wavelength of the incident light is 500nm.

You can set the multiple spectrum range by “Detail…” button, please refer to “3.4.21 Set multiple spectrum ranges”.

You need click the [apply] button after changing these settings.

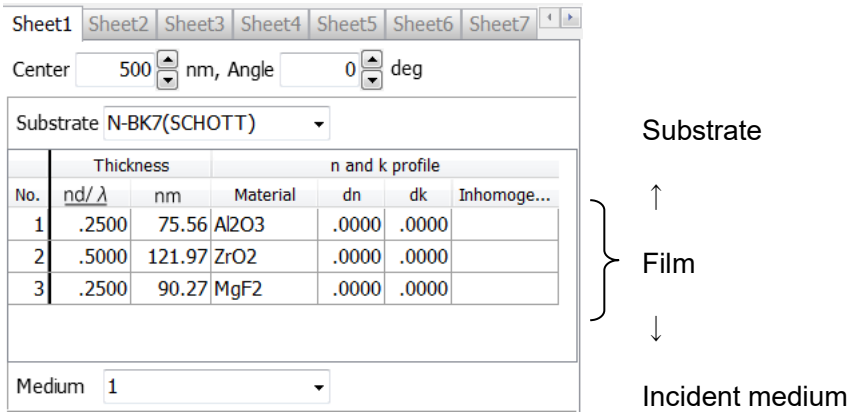
- R,T,A unit

Select the units for reflectance (R), transmittance (T), and absorptance (A) for spectrum graphs, incident angle graphs, 3D graphs, and manufacturing error graphs. The supported units are 0-1, %, and dB.

5.1.4. Film design data

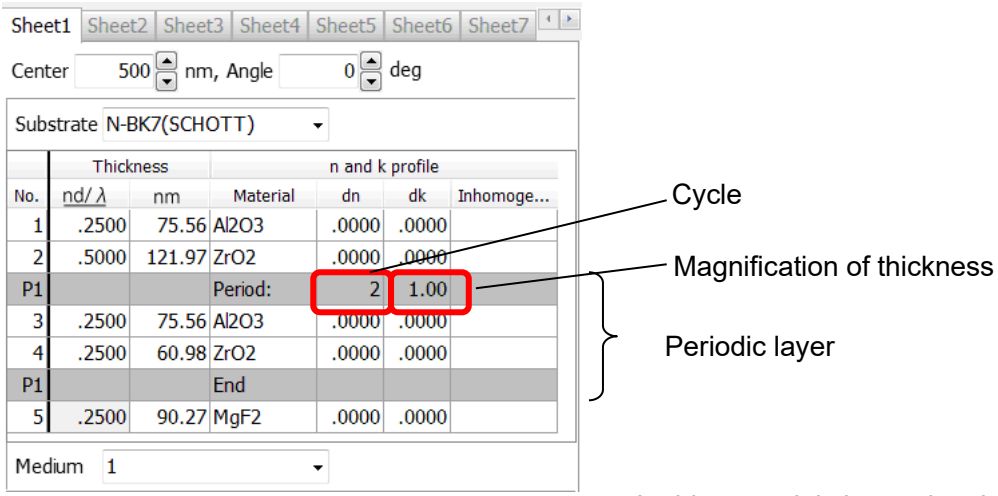
Set up the center wavelength of design, incident angle, substrate, incident medium, film thickness and film material etc.

There are five sheets (Sheet1 - Sheet5) in the main window. The maximum of five film data can be calculated at the same time.



Center	: Center wavelength (reference wavelength) of design. (nm)
Angle	: Incident angle of the light. (deg.)
Substrate	: Kind of substrate Select dispersion data from the drop down list or input the refractive index directly.
No.	: Layer number No.1 is substrate side.
Thickness	: Input optical thickness or physical thickness.
Material	: Kind of film material. Select dispersion data from the drop down list or input the refractive index directly.
dn	: Adjustment of n The refractive index of the film material increases or decreases by this value.
dk	: Adjustment of k The absorption coefficient of the film material increases or decreases by this value.
Inhomogeneity	: Kind of inhomogeneity. Select inhomogeneity data from the drop down list.
Medium	: Incident medium Select dispersion data from the drop down list or input the refractive index directly.

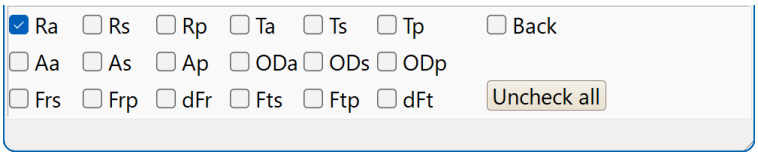
- Periodic layer



In this case, it is becoming the following.
Subst./Al_2O_3/ZrO_2/Al_2O_3/ZrO_2/Al_2O_3/ZrO_2/MgF_2/Air

A period layer is between gray rows (from “Period:” to “End”).
The number on the right-hand side of “Period:” is the cycle of the period layer.
The magnification is multiplied by the thickness in the periodic layer. See: [3.4.13Setting the periodic layer]

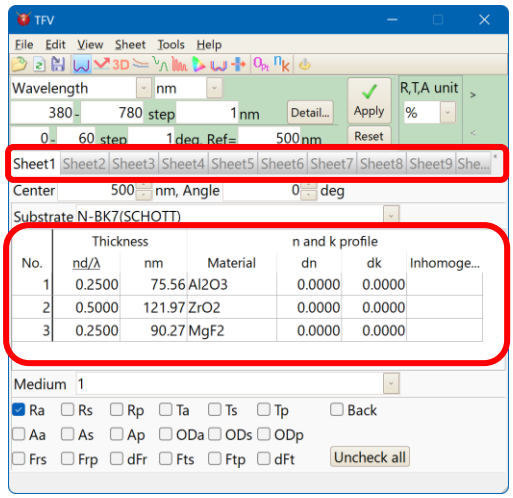
- Kind of the plot on the chart
  The kind of the plot is chosen by the check box located in the bottom of the main window.
  The checked items are displayed on the chart and numerical data.



Press the deselect button to deselect all selections.

Ra	:	Reflectance (Average)
Rs	:	Reflectance S-polarization (TE)
Rp	:	Reflectance P-polarization (TM)
Ta	:	Transmittance (Average)
Ts	:	Transmittance S-polarization (TE)
Tp	:	Transmittance P-polarization (TM)
Aa	:	Absorptance (Average)
As	:	Absorptance S-polarization (TE)
Ap	:	Absorptance P-polarization (TM)
ODa	:	Optical density (Average)
ODs	:	Optical density S-polarization (TE)
ODp	:	Optical density P-polarization (TM)
Frs	:	Reflection phase shift S-polarization (TE)
Frp	:	Reflection phase shift P-polarization (TM)
dFr	:	Reflection phase difference
Fts	:	Transmission phase shift S-polarization (TE)
Ftp	:	Transmission phase shift P-polarization (TM)
dFt	:	Transmission phase difference
Back	:	Calc. for incident light from the reverse side

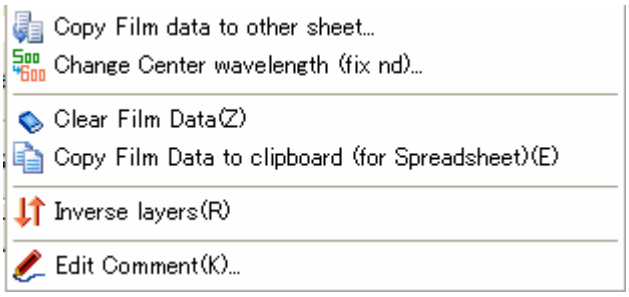
5.1.5. Popup menu on the film data area



If right-clicking on the sheet tab or on the film data cell,
then popup menu will be displayed.

- Popup menu on the sheet tab

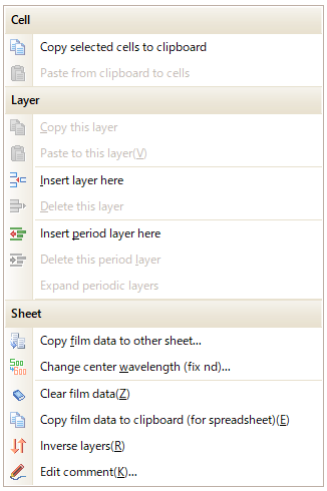
  If you right-click on the sheet tab, then the following popup menu will be displayed.



Copy film data to other sheet...	:	Copy the film data to the other sheet
Change center wavelength (fix nd)...	:	Change the center wavelength but not change thickness as keep the same characteristic of the film
Clear film data	:	Clear the film data on active sheet. Saved film data file does not delete from disk. You want work again on this sheet, then execute [New] or [Open] command.
Copy film data	:	Copy the film data on active sheet to clipboard (tab separated format). You can paste this copied data to other software.
Inverse layers	:	Inverse layers (Upside down and downside up)
Edit comment...	:	Edit comment of the film data.

- Popup menu on the film data cell.

  If you right-click on the film data cell, then the following popup menu will be displayed.



Copy selected cells to clipboard	:	Copies the contents of the selected cell to the clipboard.
Paste from clipboard to cells	:	Paste the contents of the clipboard to the selected upper left cell as the base point.
Copy this layer	:	Copy this layer information to clipboard.
Paste to this layer	:	Paste to this layer from clipboard.
Insert layer here	:	Insert a layer before right-clicked layer.
Delete this layer	:	Delete a right-clicked layer.
Insert period layer here	:	Insert a period layer before right-clicked layer. Set up the number of layers and cycles at displayed dialog box.
Delete this period layer	:	Delete a right-clicked period layer. This command will enable when you right-click the gray row of the period layer.
Expand periodic layers	:	Expand periodic layers
Change to physical thickness (This layer)	:	Change optical thickness to physical thickness only this layer.
Change to optical thickness (This layer)	:	Change physical thickness to optical thickness only this layer.
Change to physical thickness (All layers)	:	Change optical thickness to physical thickness.
Change to optical thickness (All Layers)	:	Change physical thickness to optical thickness.
Copy film data to other sheet...	:	Copy the film data to the other sheet
Change center wavelength (fix nd)...	:	Change the center wavelength but not change thickness as keep the same characteristic of the film
Clear film data	:	Clear the film data on active sheet. Saved film data file does not delete from disk. You want work again on this sheet, then execute [New] or [Open] command.
Copy film data	:	Copy the film data on active sheet to clipboard (tab separated format). You can paste this copied data to other software.
Inverse layers	:	Inverse layers (Upside down and downside up)
Edit comment...	:	Edit comment of the film data.

5.2. Chart window

5.2.1. Popup menu on the chart

If you right-click on the chart, then the following popup menu will be displayed.

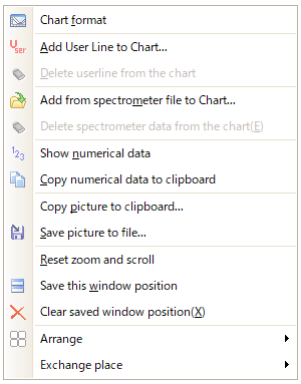


Chart format	:	Change the axes and the color of the chart.
Add user line to chart...	:	Add the user defined line to the charts. Use for the target line of the design or the standard line etc.
Delete User Line from the chart	:	Delete existing user line from the chart.
Add from spectrometer file to Chart...	:	Add from spectrophotometer measured file to the chart.
Delete spectrometer data from the chart	:	Delete existing spectrophotometer line from the chart.
Show numerical data	:	Show the numerical value of calculation results.
Copy numerical data to clipboard	:	Copy the numerical value of calculation results to clipboard (tab separated format). You can paste this copied data to other software.
Copy picture to clipboard	:	Copy the chart as a figure to clipboard. You can paste this copied figure to other software.
Save picture to file	:	Save the chart as a figure to file.
Reset zoom and scroll	:	Restore the zoom and scroll on the chart.
Save this window position	:	Save current window position.
Clear saved window position(X)	:	Clear the saved this window positions.
Arrange	:	Arrange the chart view by R, T, A, OD and Phase. Wavelength plot and incident angle plot only.
Exchange place	:	Exchange chart place of R, T, A, OD and Phase. Wavelength plot and incident angle plot only. Except for merge view.

6. Troubleshooting

Error messages	Causes	Solutions
Hardware key not found.	Hard key has disappeared (That is, unplugged).	Attach the hard key in your PC.
	The different hard key is attached.	Attach the hard key for TFV in your PC.
	PC was in stand-by or suspend mode while TFV was running.	Unplug the hard key and then plug the hard key again.
	PC's connector is out of order.	Plug the hard key in other port. Check whether the LED lamp is on.
	Installation of the hard key driver (Sentinel System Driver) has failed.	Uninstall Sentinel System Driver, and then re-install it using the installation CD. It is necessary to remove the hard key from the PC for certainly installation.
	PC trouble Hard key trouble	Reboot PC or Use other PC. The hard key needs repair.
Error loading program.	TFV program file has broken.	Re-install TFV.
Error loading import library.	TFV linked file does not exist or has broken.	Re-install TFV.
Error importing library function.	TFV linked file has broken.	Re-install TFV.

Please refer to the TFV website for the latest information.

TFV website: https://thinfilmview.com/