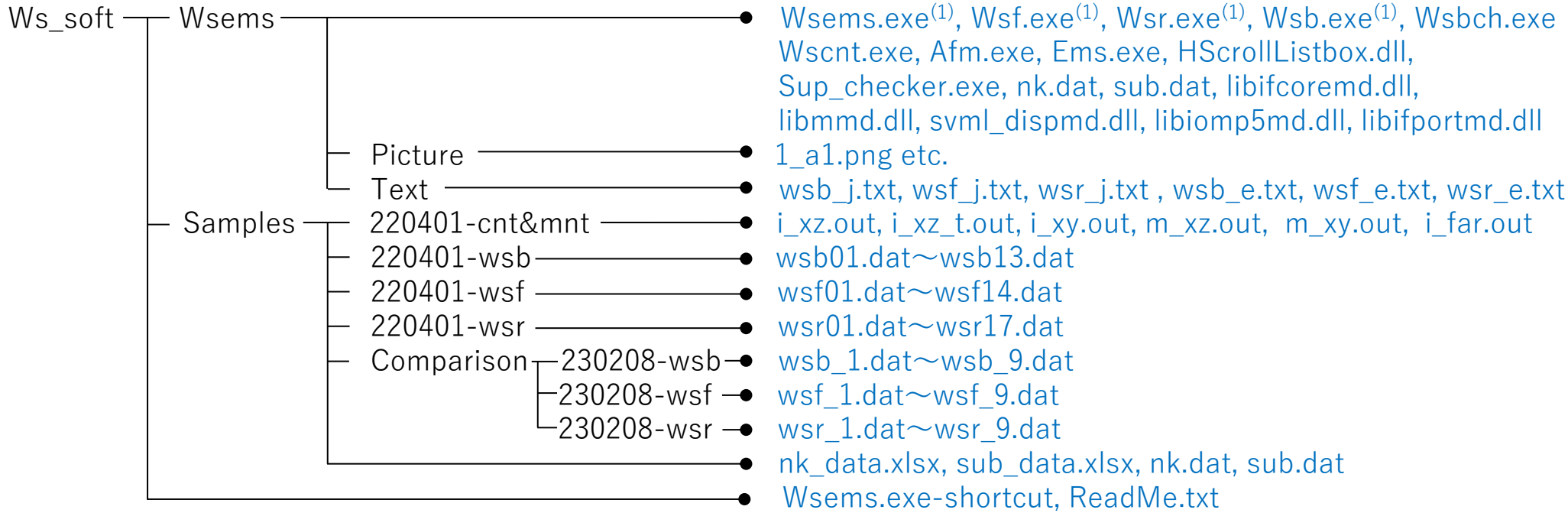
How to use Wsems : Platform for Ws_soft

1. Operating environment and distribution status

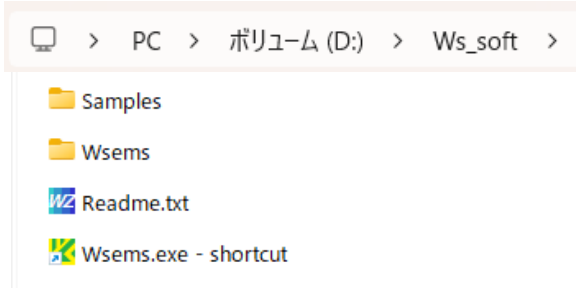
1. Operating environment (supported OS): Windows 64bit 7,8,10,11 Edition
2. Status at the time of distribution



(note 1) Wsf.exe, Wsr.exe, and Wsb.exe are execution programs for FDTD, RCWA, and BPM, and Wsems.exe is an integrated operating program for those wave analysis programs.

2. Method of installation and uninstallation

1. Copy the uncompressed folder of “Ws_soft” below a drive (i.e., c or d drive) to install the software.

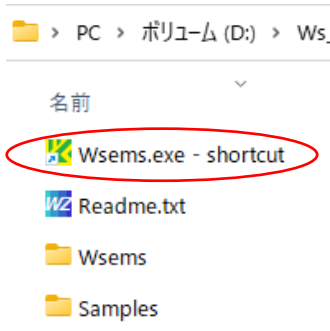


2. Remove the folder of Ws_soft from the drive to uninstall the software.

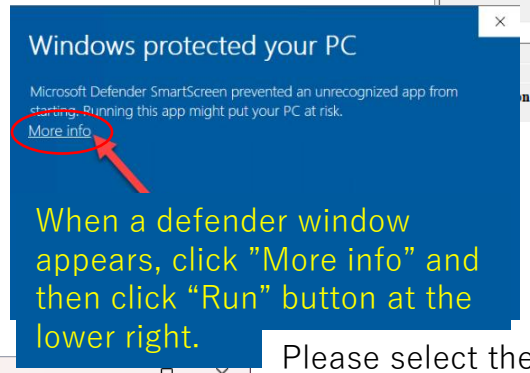
3. Example of using sample data (1)

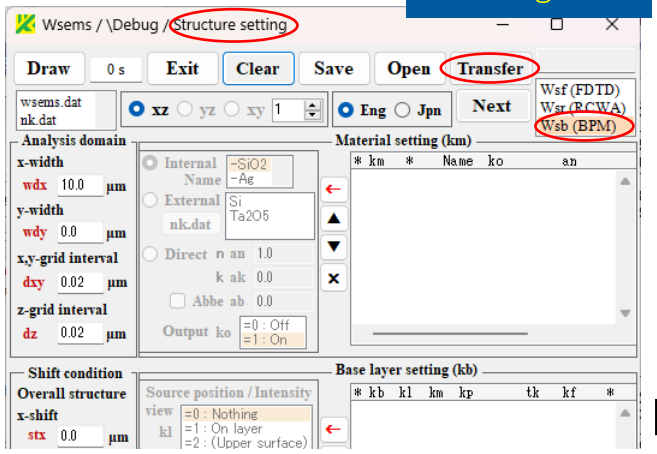
At first, load a sample data (wsb01.dat) for Wsb and perform calculations

Input data consists of a structural information and a light source information. First, extract the structural information from sample input data.



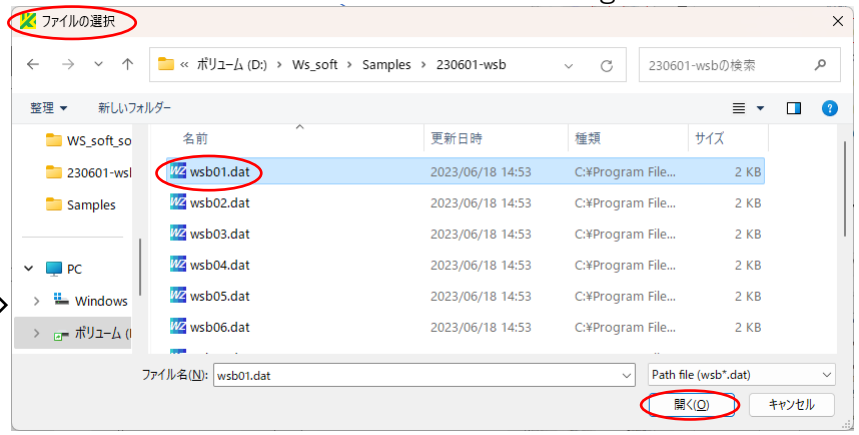
(1) Double-click on the Wsems.exe-shortcut. Structure setting window appears.





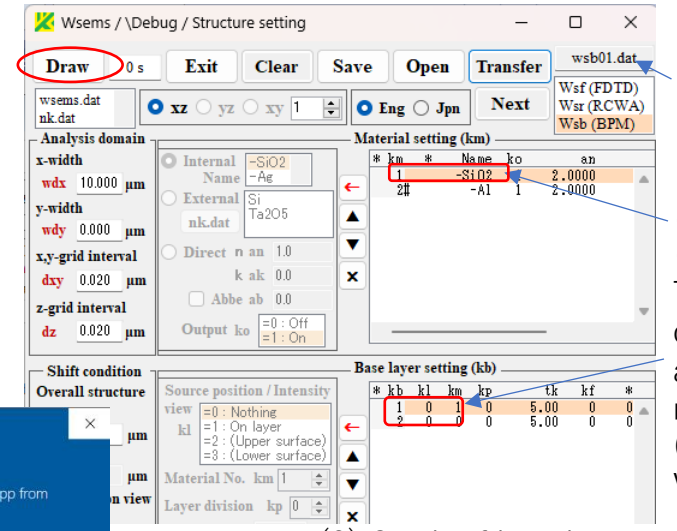
(2) Select "Wsb(BPM)" in the window, and click the Transfer button.

Please select the correct directory. The other status will make the box empty.



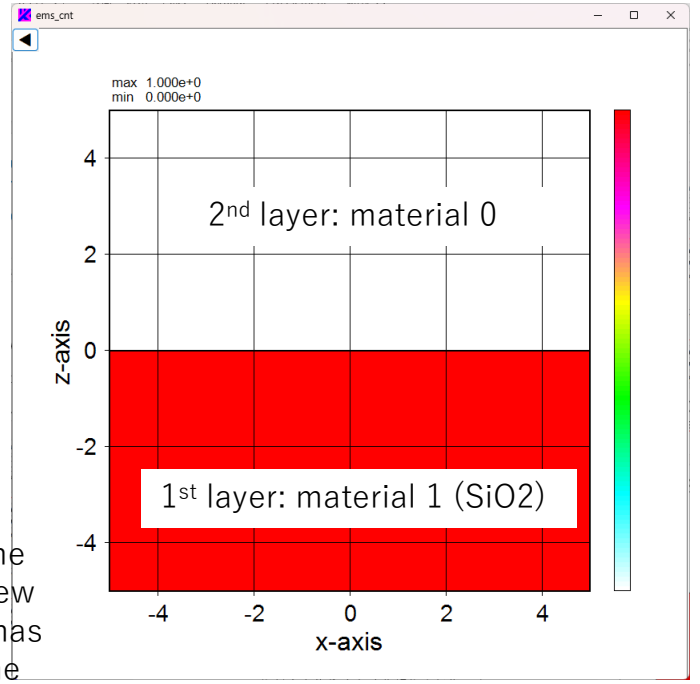
(3) On the file selection window, select a file (wsb01.dat) from the 230601-wsb directory and click the Open button. Extract structural information from the file contents and reflect it in the Structure setting window.

(4) When click the Draw button, an xz-section structure is drawn by wscnt.

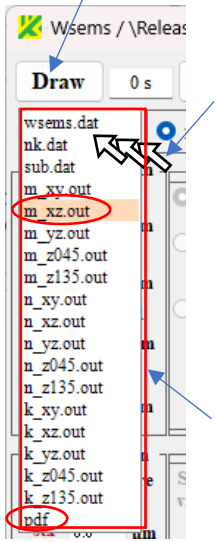


The selected file name is displayed.

Material 1 is defined as SiO2 (internal definition).
The 1st layer is made of material 1 (SiO2), and the 2nd layer is made of material 0 (undesignated : Vacuum).



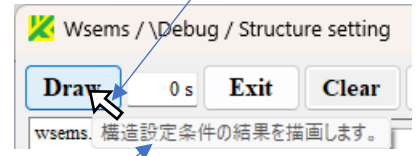
When contents of the result file box are new (just after drawing has been performed), the back color is gray. Otherwise, pink.



When the pointer is placed over the result file box, the box expands downwards. When clicking "m_xz.out" in the box, the xz-section structure as the same as above is drawn. When clicking "pdf" , the pdf file on the web site is called out.

When the pointer is placed on the control button, a tooltip appears to confirm the operation. The tooltip disappears after 3 seconds.

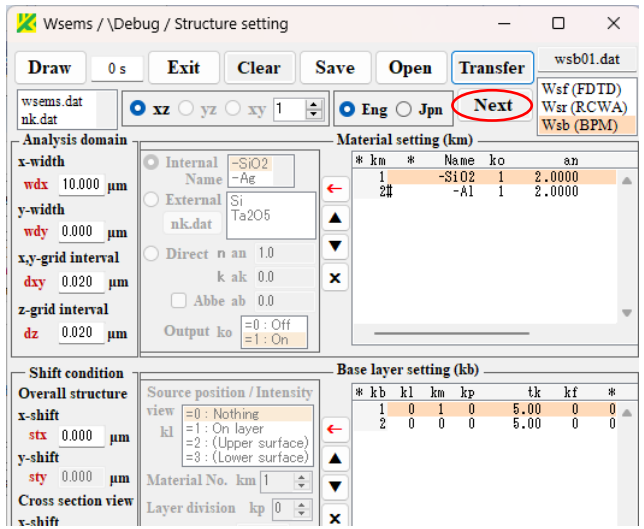
Result file box



tooltip

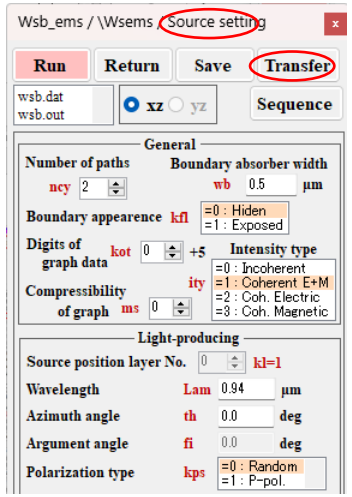
4. Example of using sample data (2)

Next, load light source information from the input data.

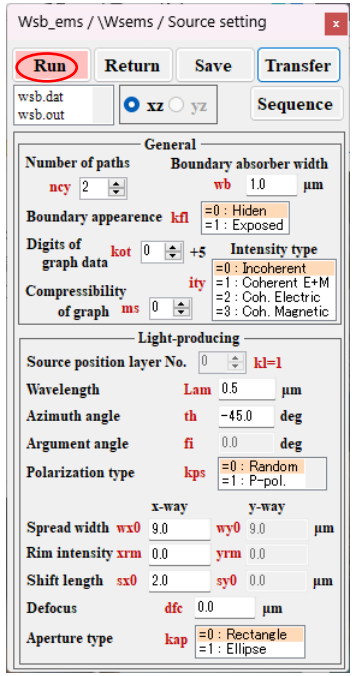


Please select the correct directory. The other status will make the box empty.

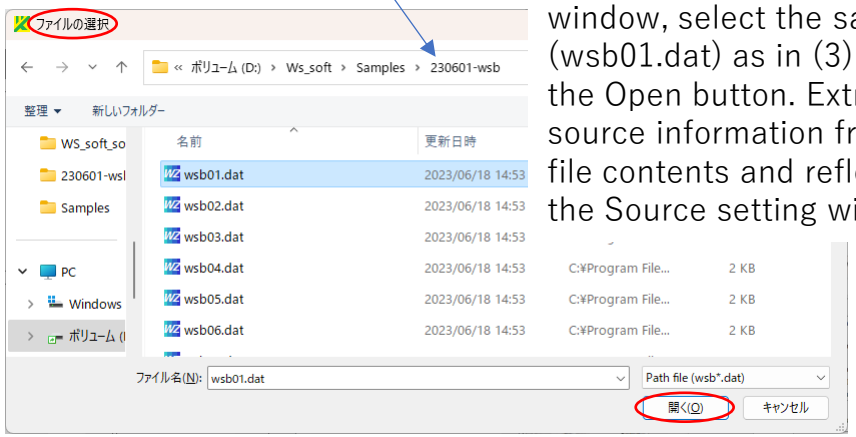
(5) Click the Next button to open the Source setting window.



(6) Click the Transfer button.

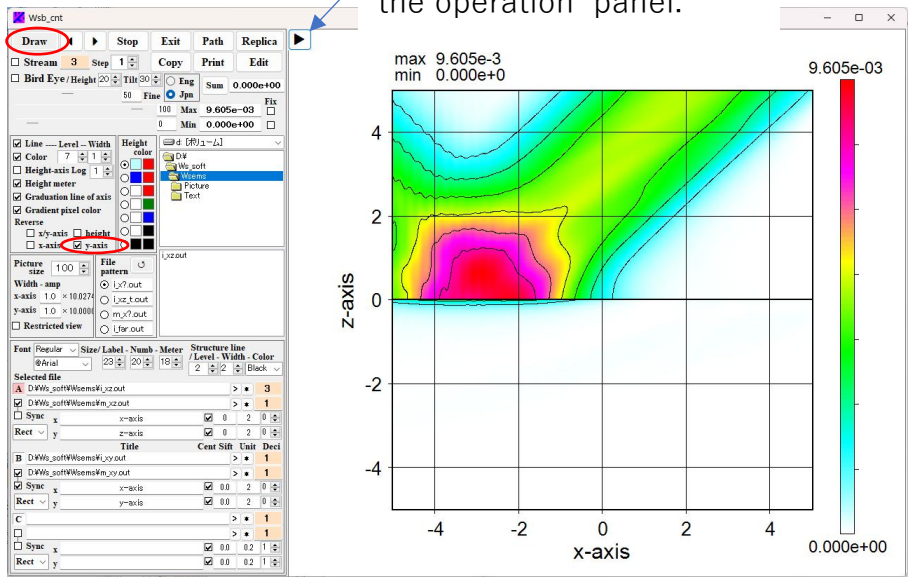


(7) On the file selection window, select the same file (wsb01.dat) as in (3) and click the Open button. Extract light source information from the file contents and reflect it in the Source setting window.

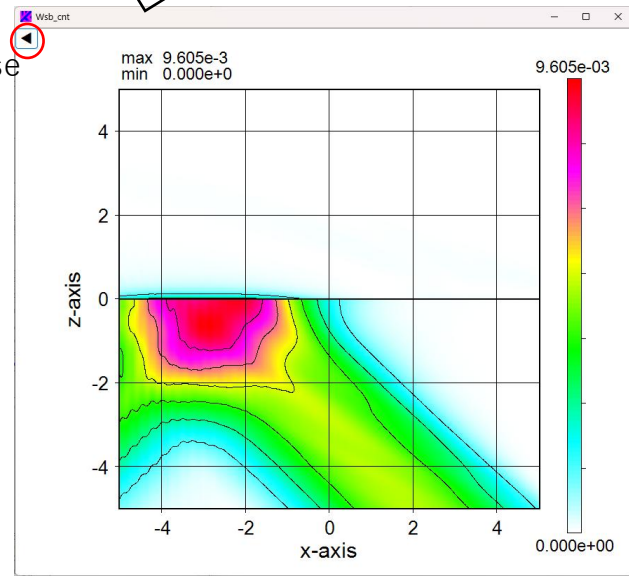


(8) After clicking the Run button, a Dos window appears. After it disappears, the wave calculation results are drawn by Wscnt.

Clicking ▶ button hides the operation panel.



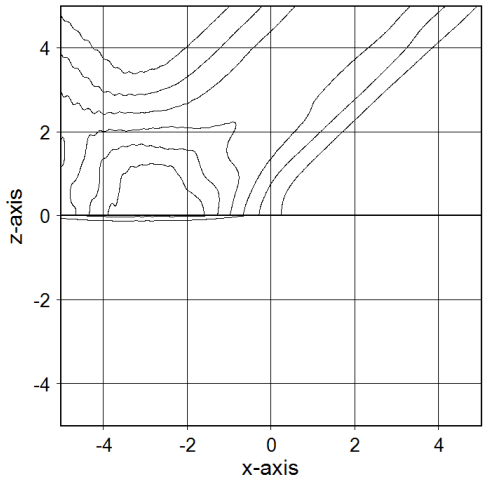
(9) Check y-axis box in the operation panel that appears by clicking the ◀ button and click the Draw button. The image will be upside down (see “How to use Wscnt” at our site).



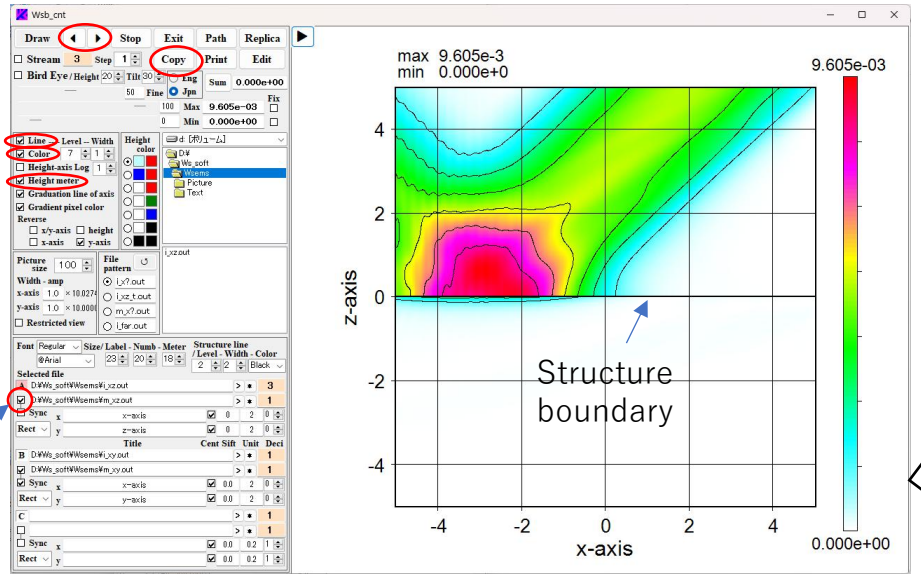
Wscnt画面

5. A side trip (about Wscnt)

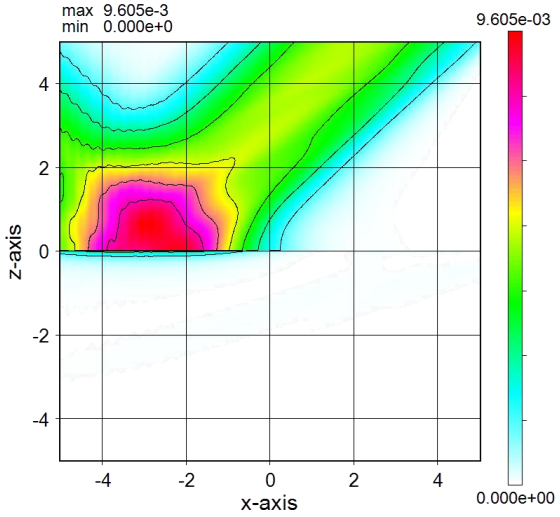
Here, let's briefly explain the operation of Wscnt.



Uncheck the Color box and Height meter box, and then click the Draw button.

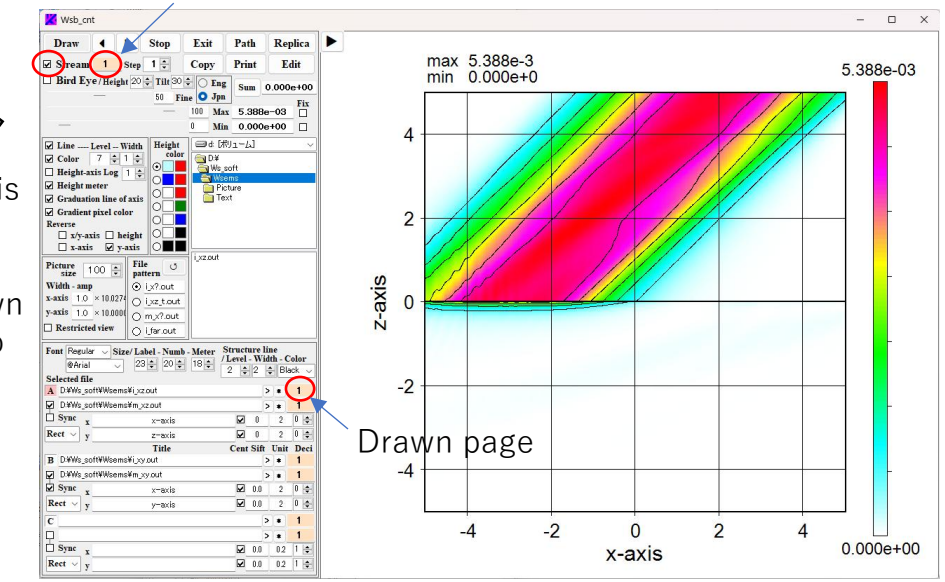


Uncheck the box indicated by arrow A and click the Draw button to draw without structure lines.



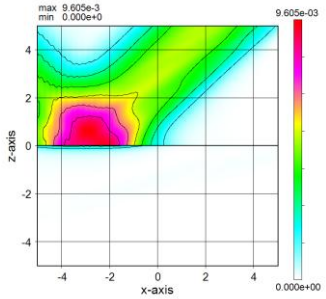
Clicking ◀ or ▶ button changes the displayed page, and the image is drawn page by page.

Drawn page

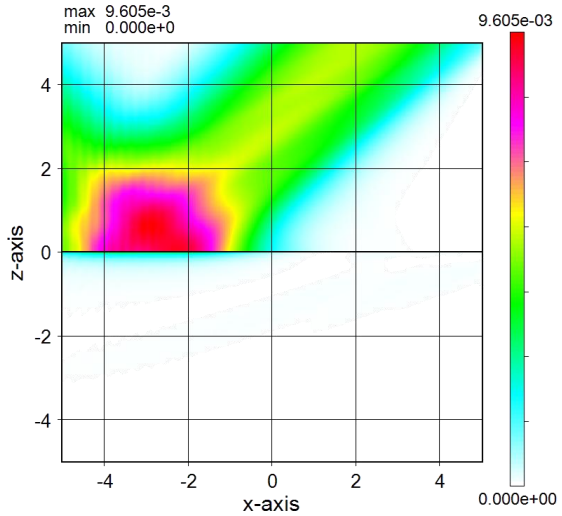


When the Stream box is checked and the Draw button is clicked, the displayed page is drawn in order from page 1 to the last.

Click the Copy button to copy the displayed image to the clipboard.

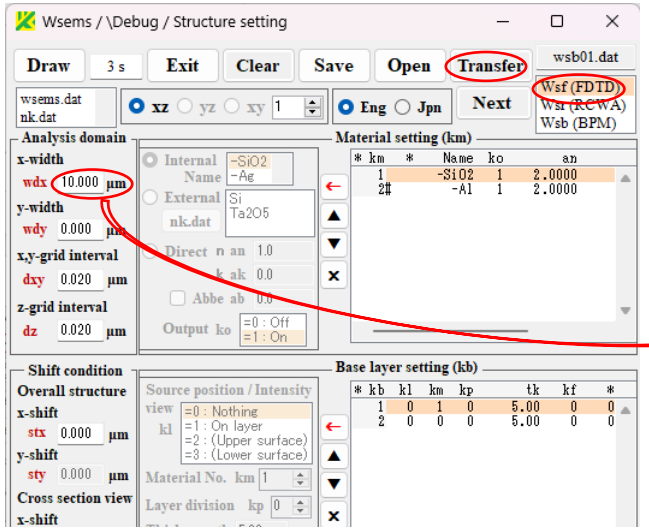


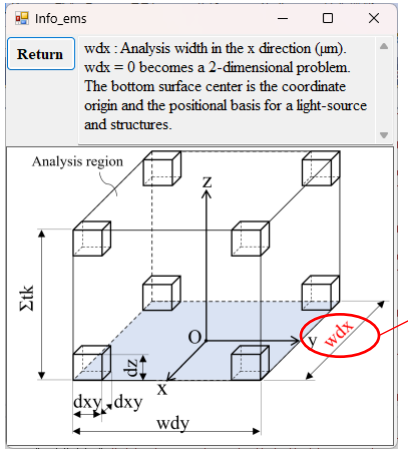
Uncheck the Line box and click the Draw button.



6. Example of using sample data (3)

Next, load a sample data (wsf08.dat) for Wsf and perform calculations.

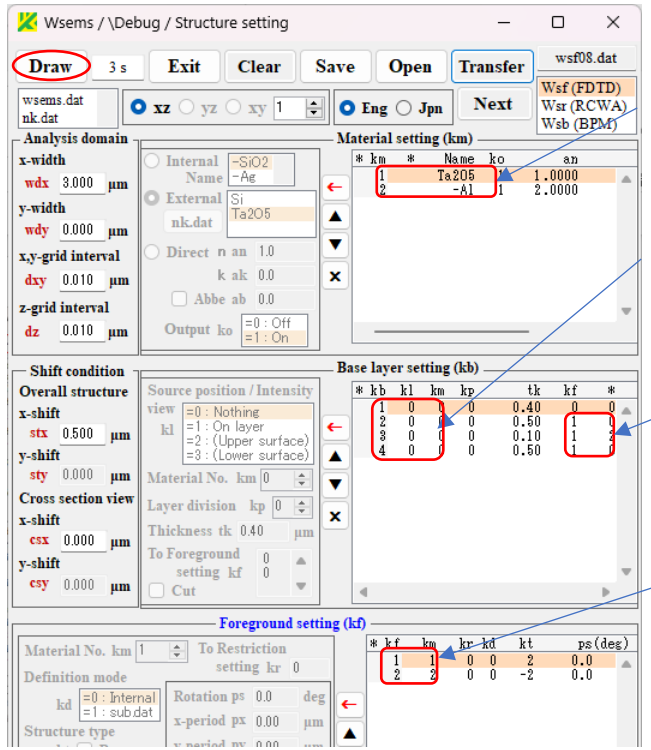




The corresponding parameters are displayed in red.

Double-click on a parameter to see its descriptive information. Information is provided to all control buttons or boxes of an enable state by using tooltips or info-windows.

(11) On the file selection window, select a file (wsf08.dat) from the 230601-wsf directory and click the Open button. Extract structural information from the file contents and reflect it in the Structure setting window.



Material definition where material 1 is Ta2O5 (external definition) and material 2 is Al (internal definition).

Base layer definition with material 0 (Vacuum) from layer 1 to layer 4.

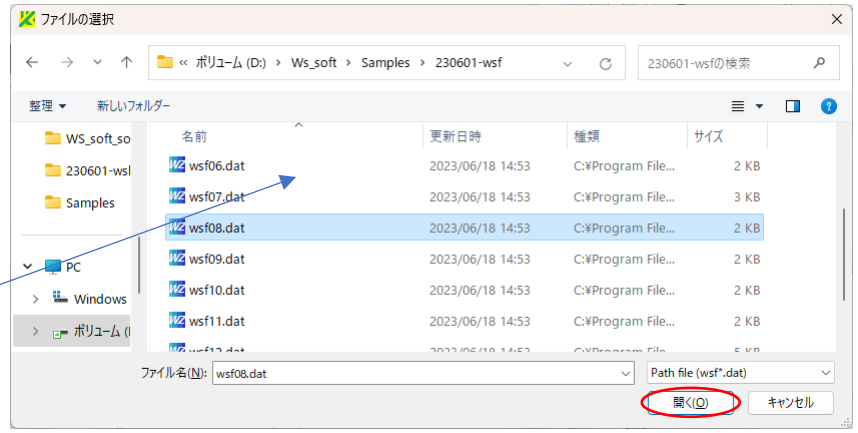
Foreground structure 1 is defined in layer 2 and 4, and structures 1 and 2 in layer 3.

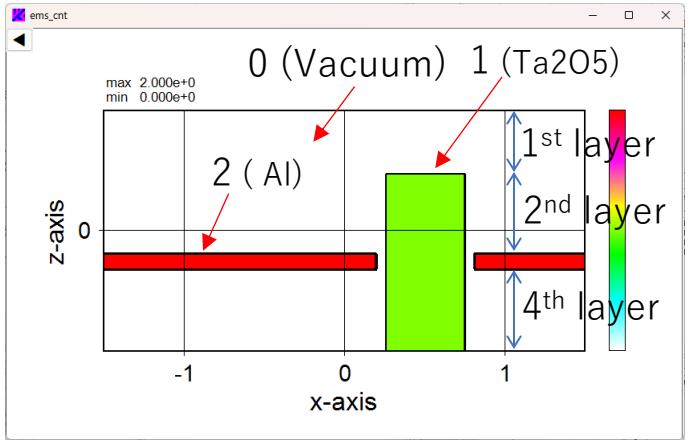
Foreground structure 1 is made of material 1 (Ta2O5) and structure 2 is made of material 2 (Al).

(12) Click the Draw button, and an xz-section structure is drawn by wscnt.

(10) Select “Wsf(FDTD)” in the Structure setting window, and click the Transfer button.

Please select the correct directory. The other status will make the box empty.

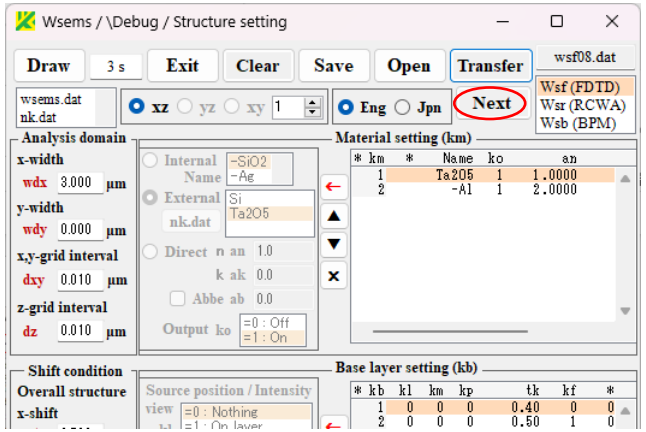




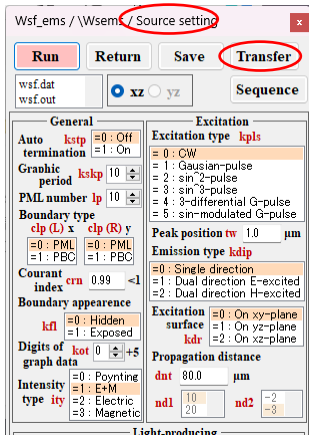
Wscnt window (upside down)

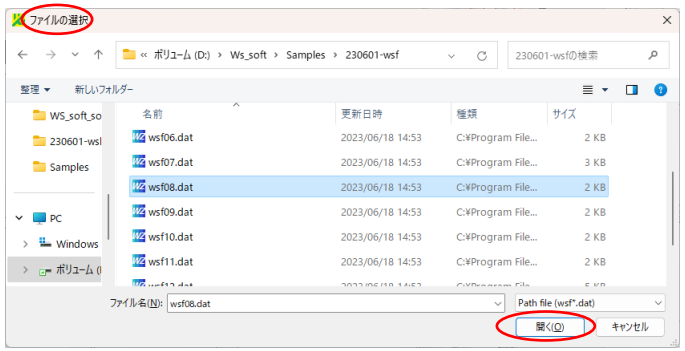
Wscnt expresses the material distribution by assigning a material number (0~2) to each position and treating it as contour values: red (=2) for Al, yellow-green (=1) for Ta2O5, and white (=0) for Vacuum.

7. Example of using sample data (4)



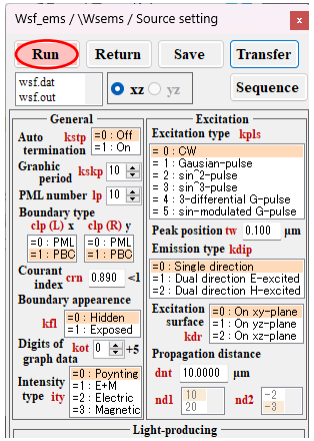
(13) Click the Next button to open the Source setting window.



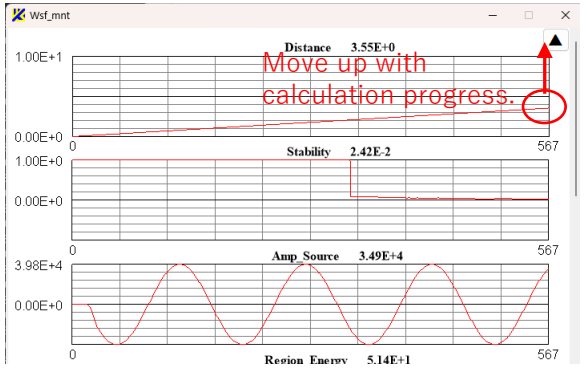


(14) Click the Transfer button.

(15) On the file selection window, select the same file (wsf08.dat) as in (11) and click the Open button. Extract light source information from the file contents and reflect it in the Source setting window.

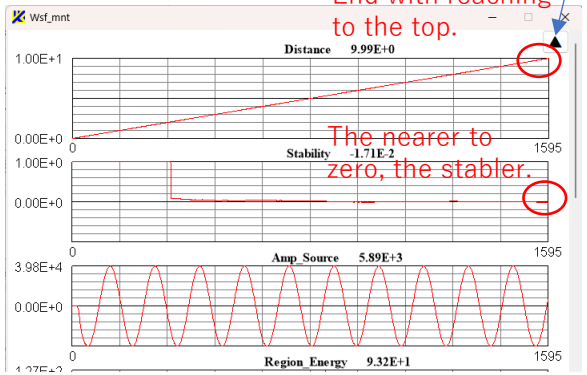


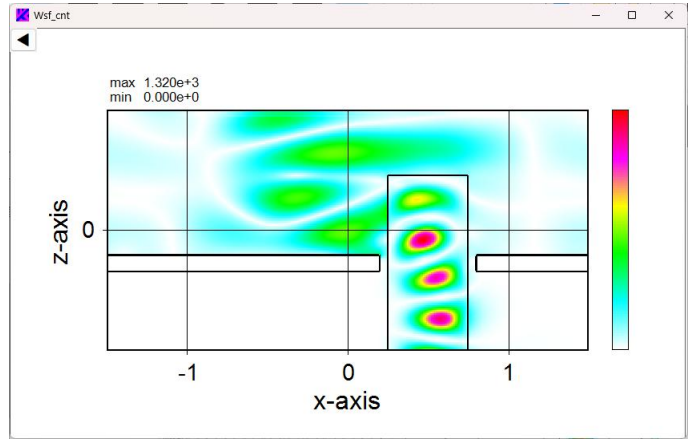
(16) After clicking the Run button, a Dos window appears, and the wave calculation results are alternately drawn by Wsmnt and Wscnt.

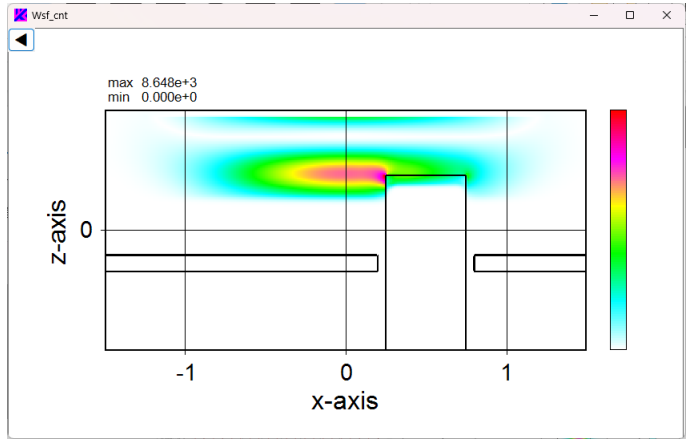


Wsmnt window

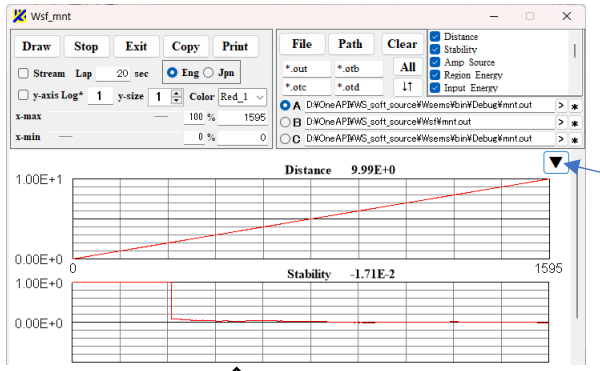
(17) When the calculation is completed, the Dos window disappears, and the last results remain.







Wscnt window (upside down)



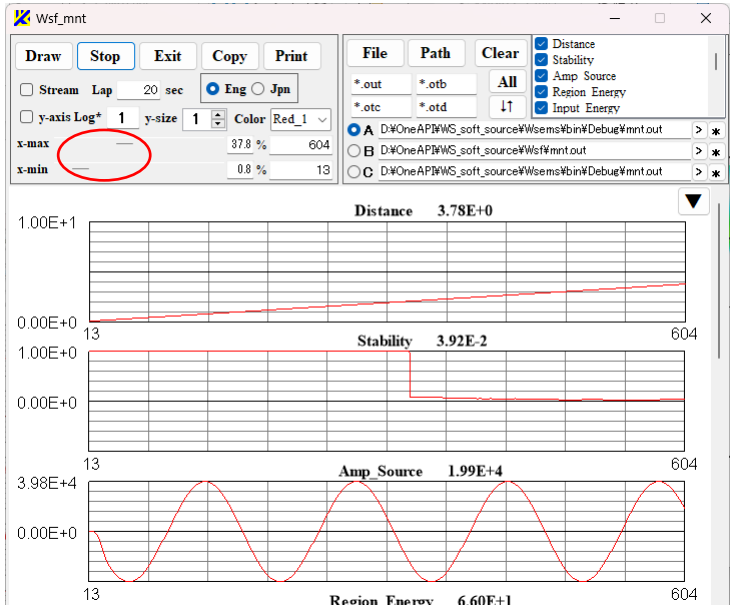
Clicking the ▼ button hides the operation panel.

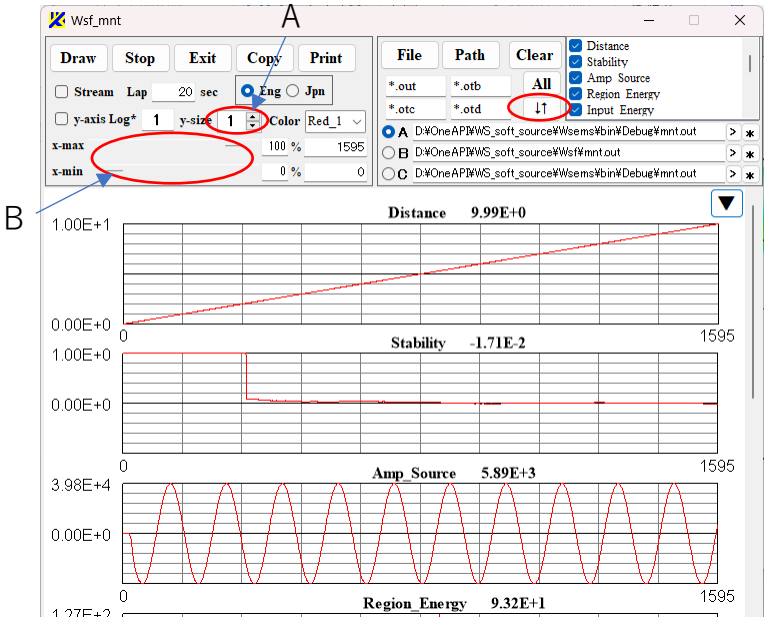
(18) When the ▲ button is clicked, the Wsmnt operation panel appears above, and the drawing results can be manipulated.

8. A side trip (about Wsmnt)

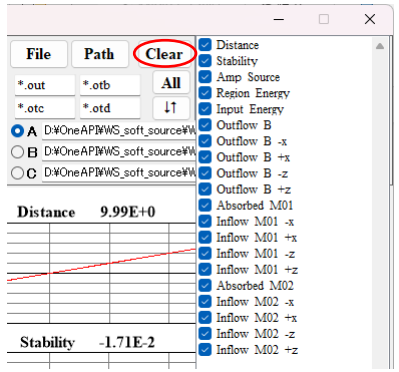
While deviating a bit from the current topic, let's briefly explain Wsmnt operations.

When the scroll bar indicated by arrow B is scrolled and the Draw button is clicked, the horizontal display area is limited.

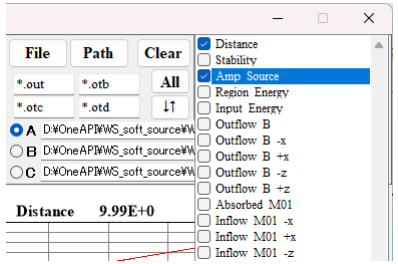




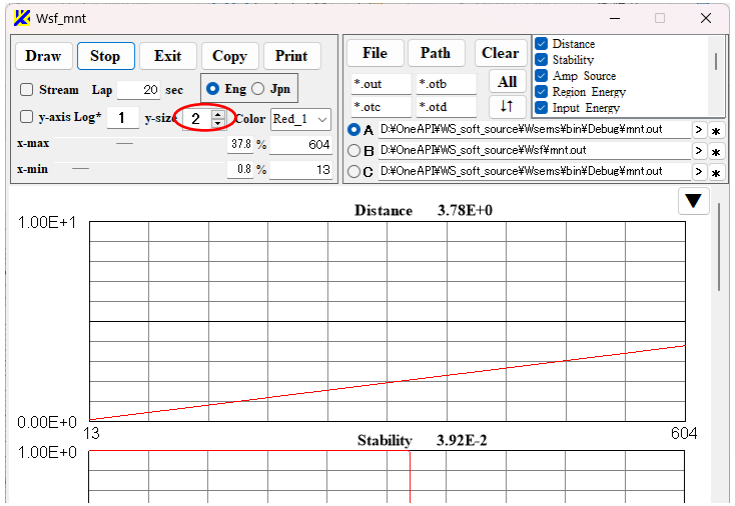
By clicking the ⇅ button, the list box on the right extends down (if clicked again, it returns to the original size).



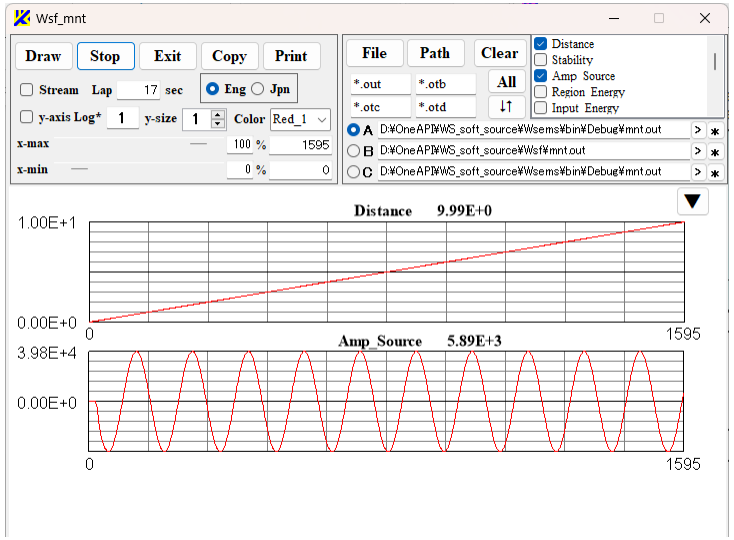
After clicking the Clear button, select items from the list box.



Setting the box indicated arrow A to 2 doubles the vertical scale of the drawing.



Click the Draw button to draw the selected items.



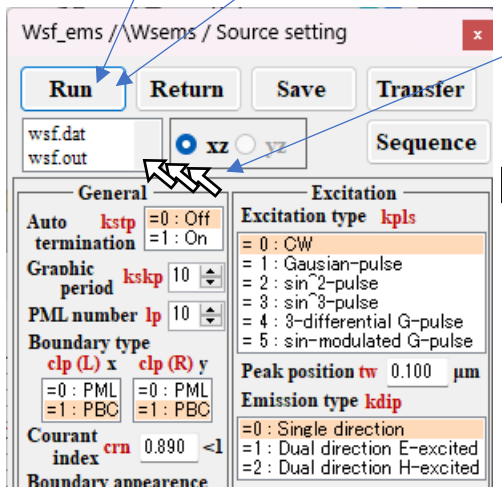
9. Example of using sample data (5)

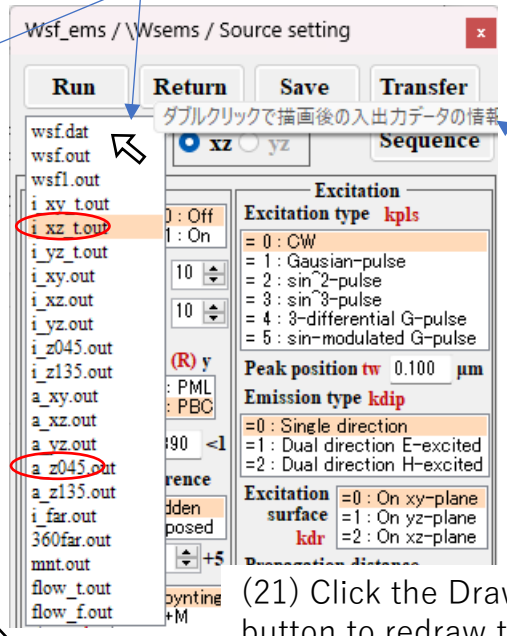
When contents of the result file box are new (just after calculation has been performed), the back color is gray. Otherwise, pink.

Calculation results (*.out) can be reconfirmed using the result file box.
The input data (*.dat) used in the calculation can be also checked.

(19) When the pointer is placed over the result file box, a tooltip appears, and the box expands downwards.

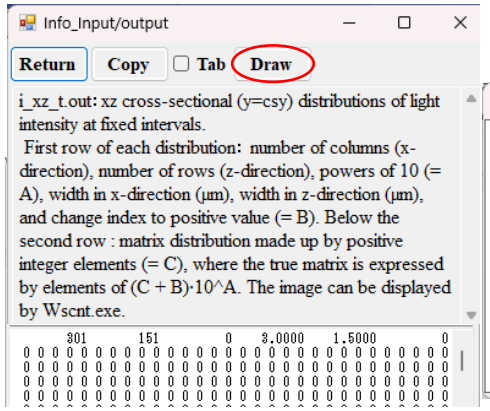
Result file box

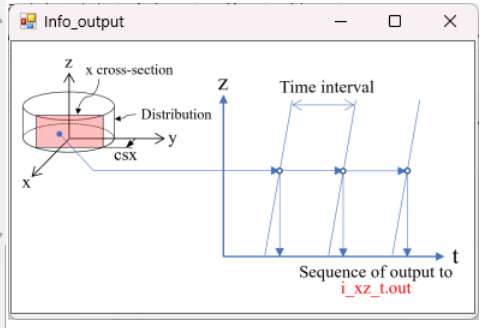




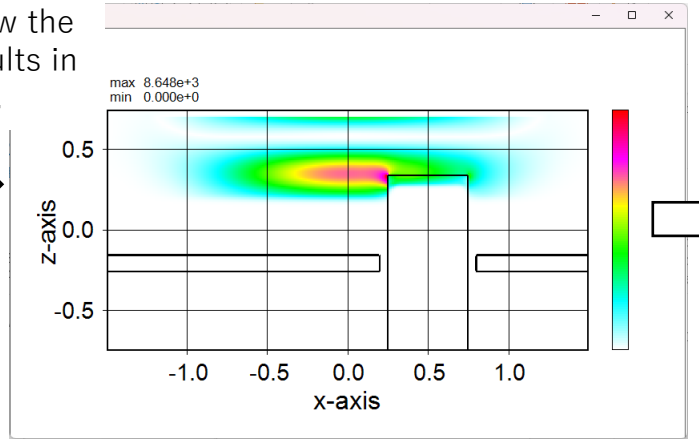
tooltip

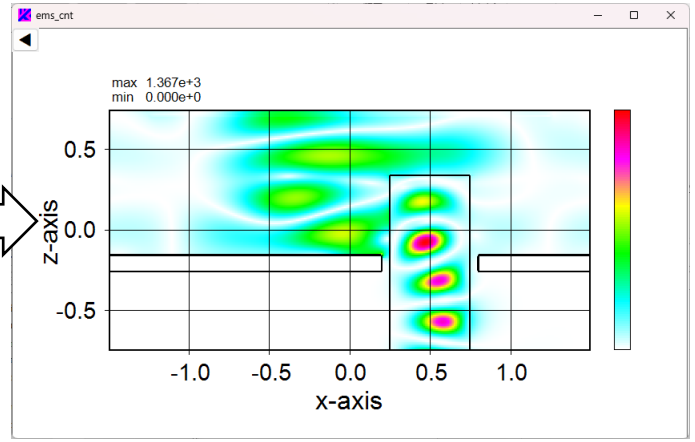
(20) Double-click one of the files (i_xz_t.out) in Result File box to display an information box (Info).



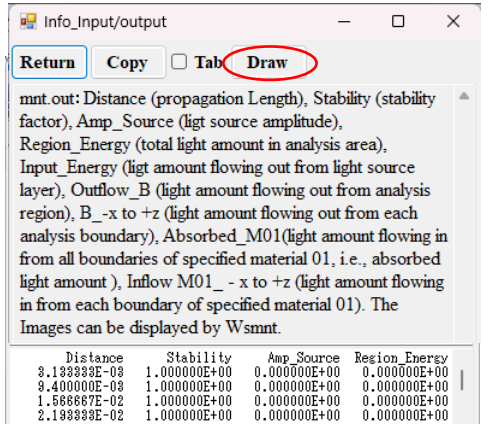


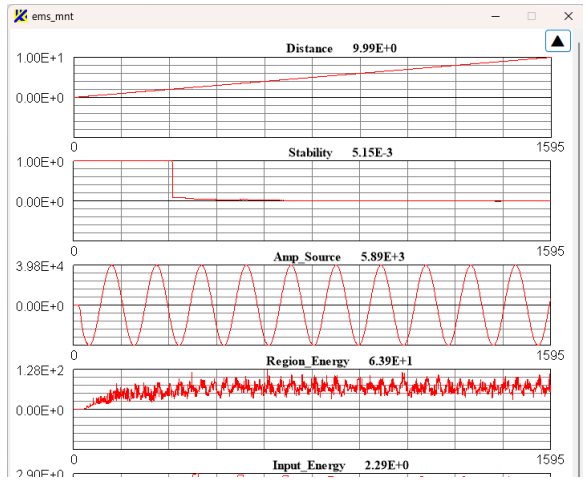
(21) Click the Draw button to redraw the calculation results in order by Wscnt.





(22) Double-click one of the files (mnt.out) in the Result file box to display an information box (Info).

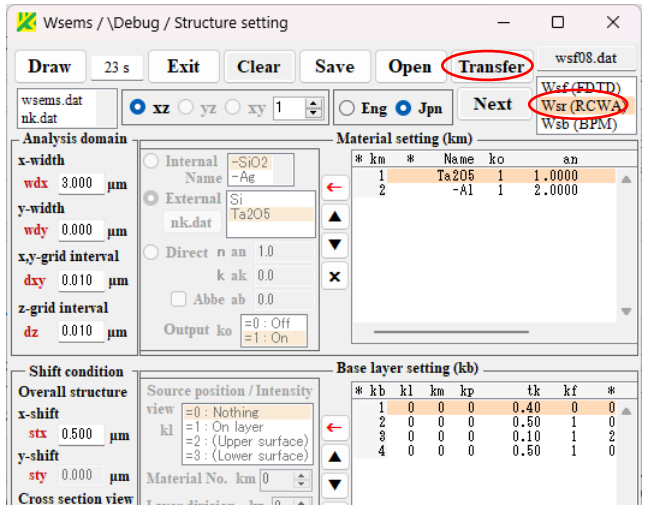




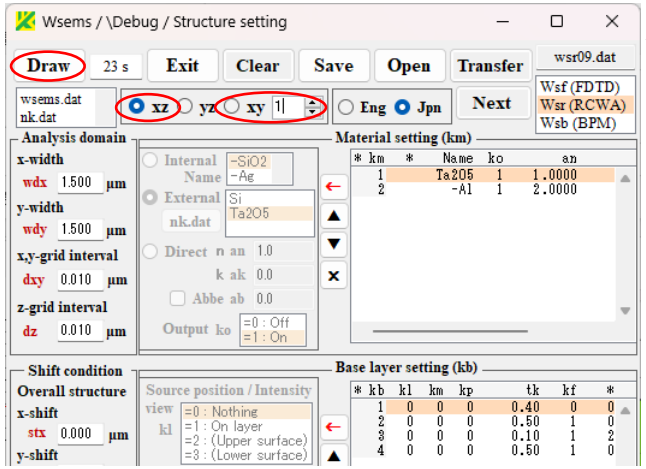
(23) Clicking the Draw button redraws the calculation results by Wsmnt.

10. Example of using sample data (6)

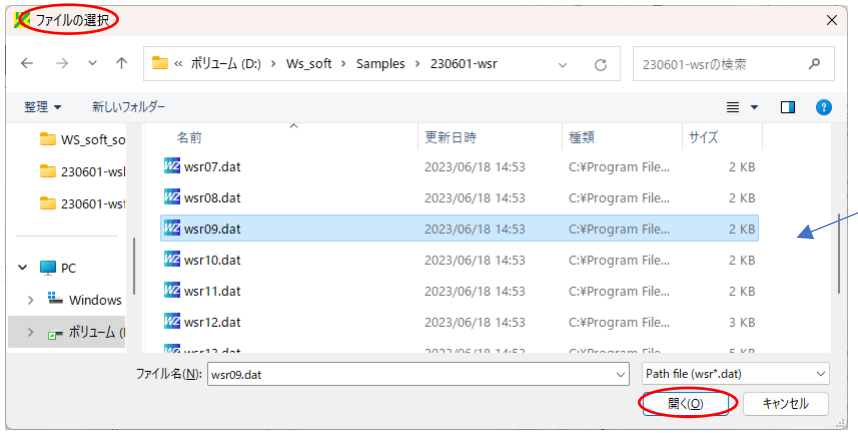
At last, load a sample data (wsr09.dat) for Wsr and perform calculations



(24) Select “Wsr(RCWA)” in the Structure setting window, and click the Transfer button.

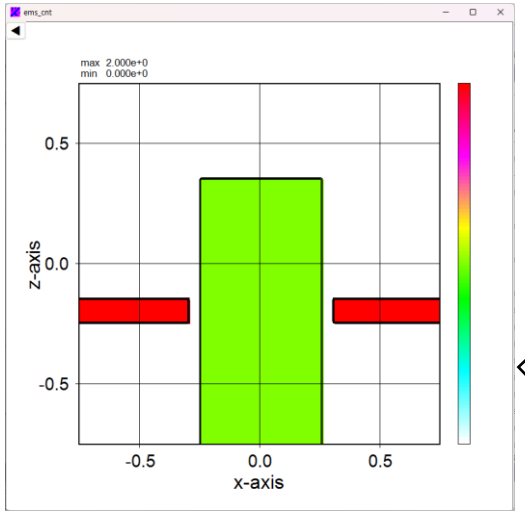


(25) On the file selection window, select a file (wsr09.dat) from the 230601-wsr directory and click the Open button.

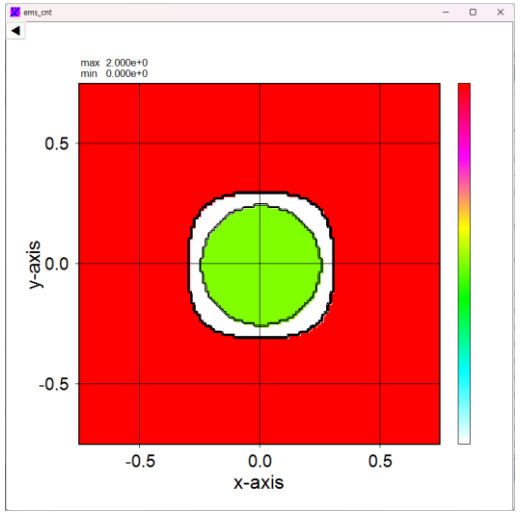


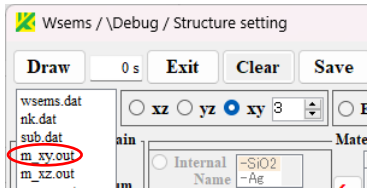
Please select the correct directory. The other status will make the box empty.

(27) Check the xz button and click the Draw button to draw an xz-section structure by Wscnt.

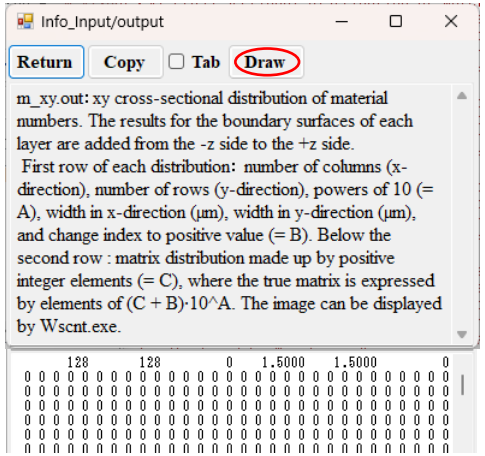


(26) Check the xy button, specify 3rd layer, and click the Draw button to draw an xy cross-sectional structure for 3rd layer by Wscnt.



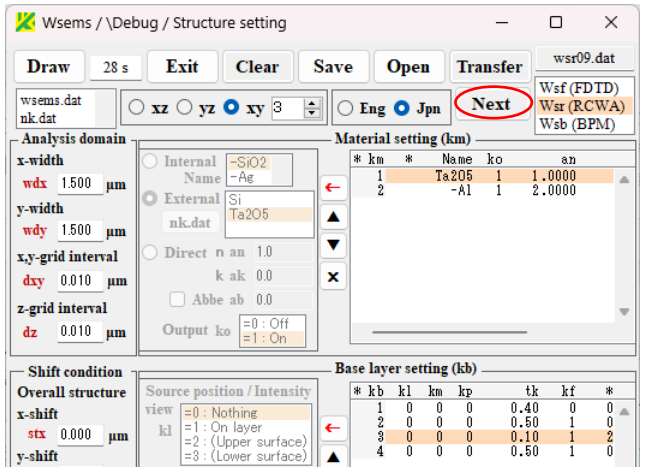


(28) Double-click one of the files (m_xy.out) in Result File box to display an information box (Info).

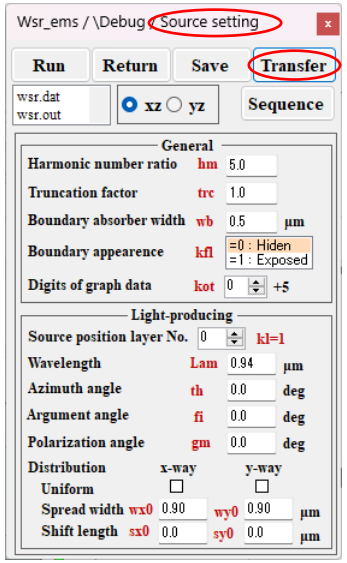


(29) Click the Draw button to continuously draw the xy cross-sectional structure in base layer order.

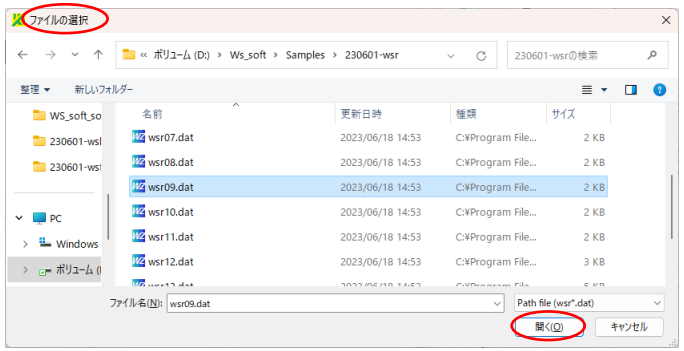
11. Example of using sample data (7)

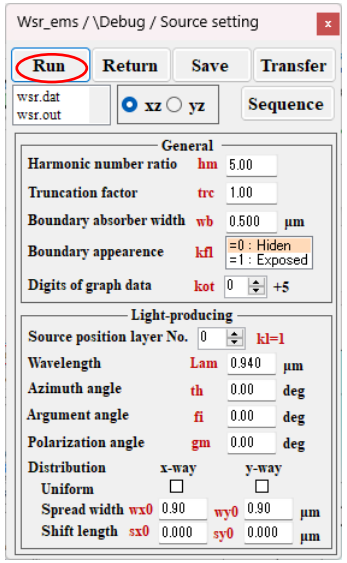


(30) Click the Next button to open the Source setting window.

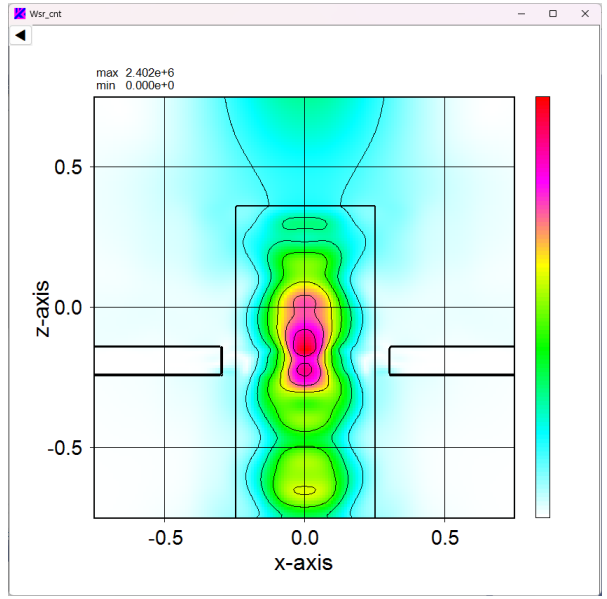


(31) Click the Transfer button.



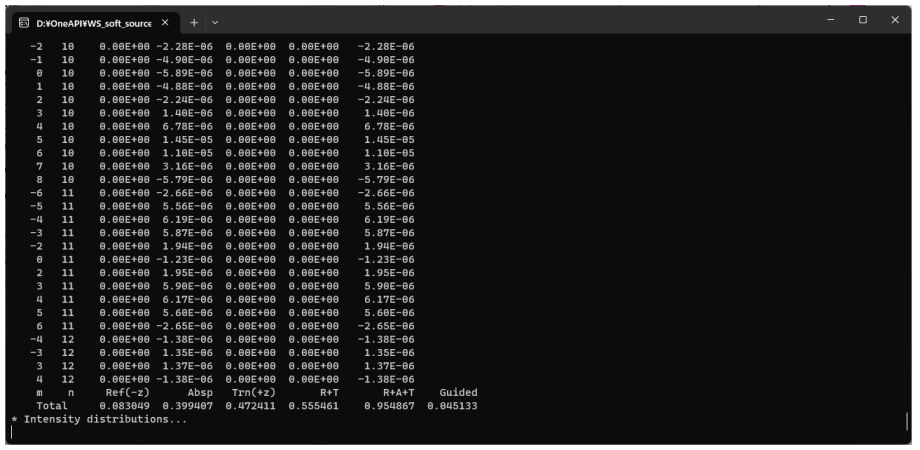


(32) On the file selection window, select the same file (wsr09.dat) as in (25) and click the Open button. Extract light source information from the file contents and reflect it in the Source setting window.



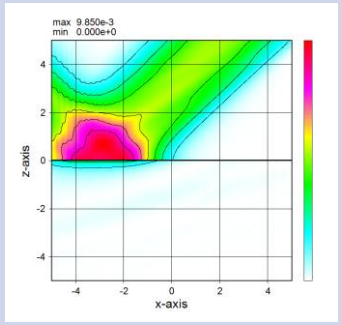
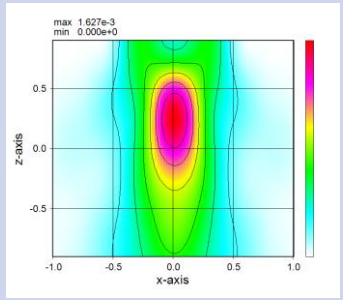
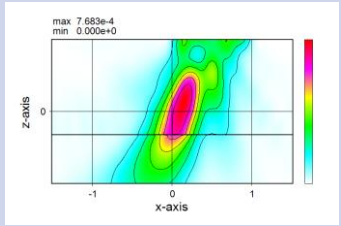
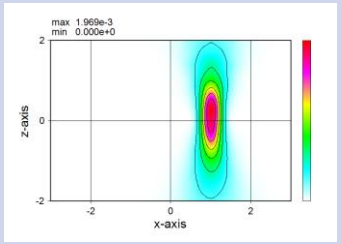
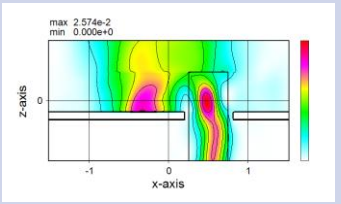
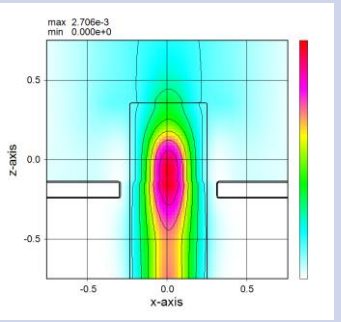
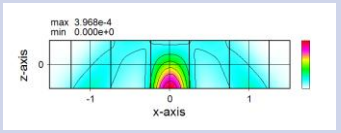
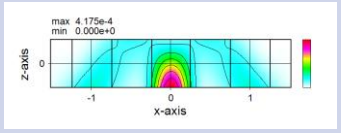
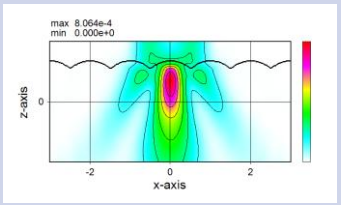
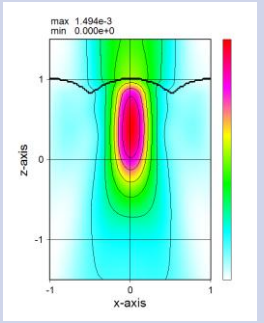
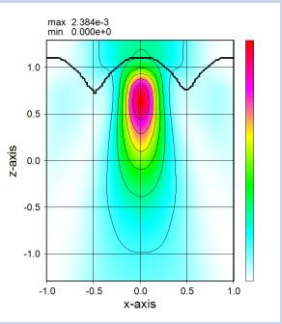
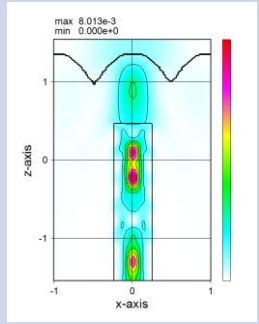
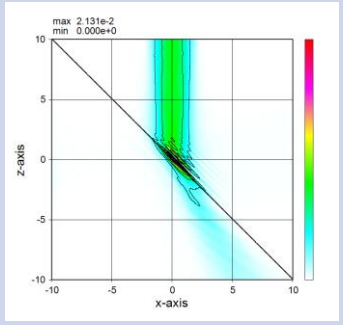
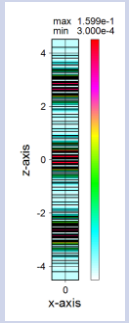
Wscnt window (upside down)

(25) After clicking the Run button, a Dos window appears. After the calculation is completed, it disappears and the wave calculation results are drawn by Wscnt.

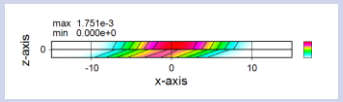
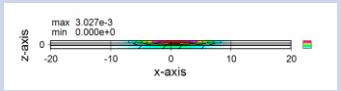
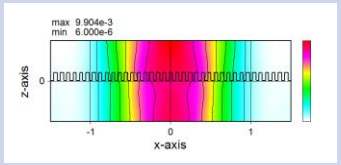
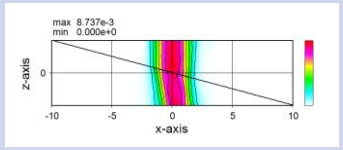
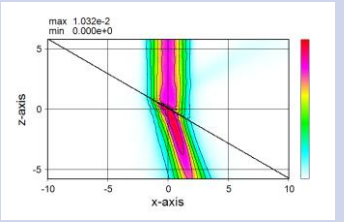
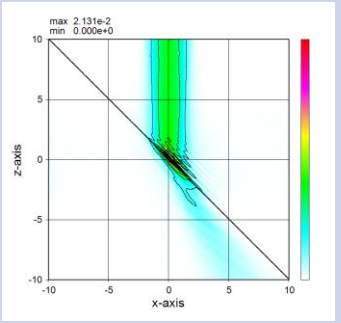
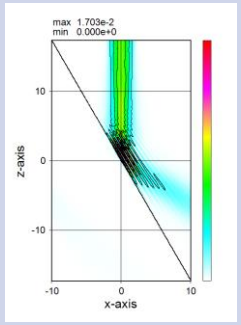
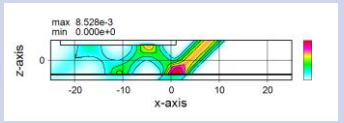
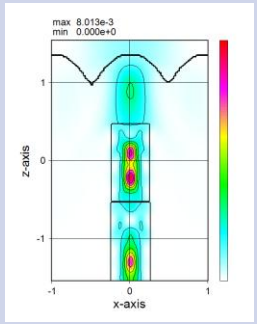


Dos window

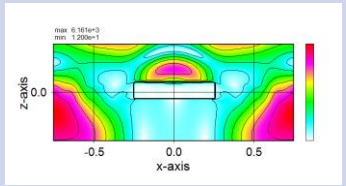
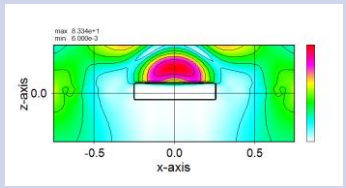
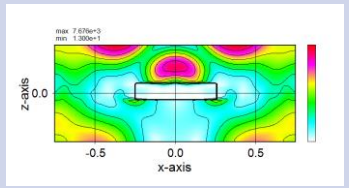
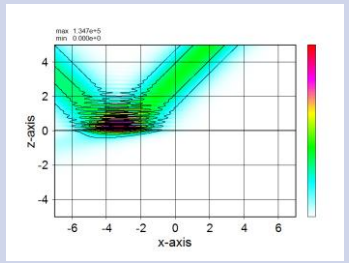
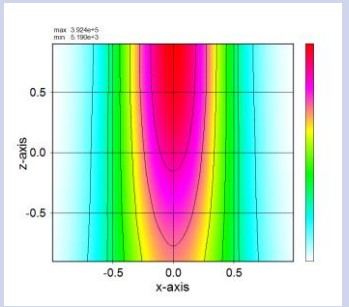
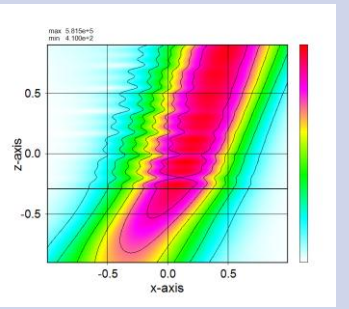
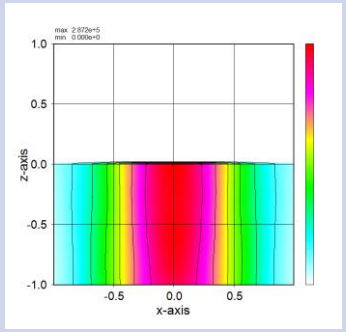
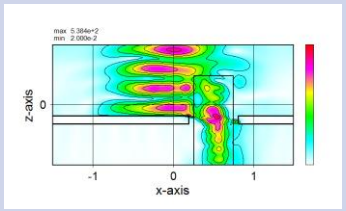
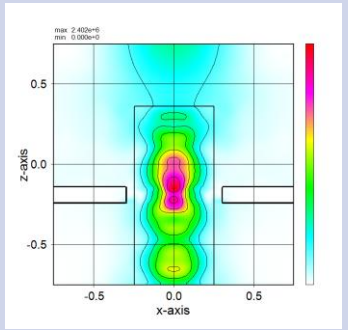
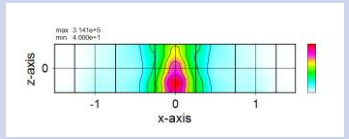
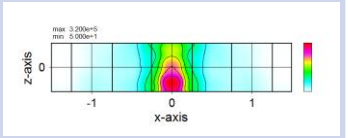
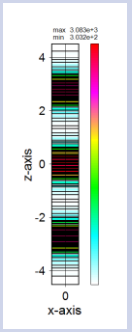
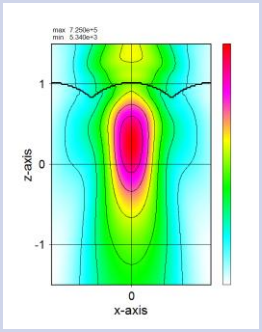
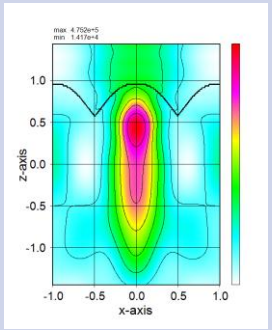
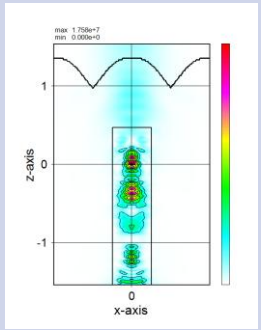
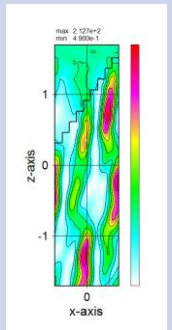
12. Calculation results of sample data (1)

wsb01 2D 3.3s	wsb02 3D 3.1s	wsb03 3D 3.7s	wsb04 3D 4.1s	wsb05 2D 0.8s	wsb06 3D 1.8s
					
wsb07 3D 1.3s	**wsb08 3D 1.3s**	**wsb09 3D 4.2s**	**wsb10 3D 1.6s**	**wsb11 3D 1.3s**	**wsb12 3D 1.9s**
					
wsb13 2D 7.3s	**wsb14 2D 20s**				
					

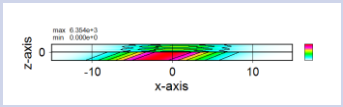
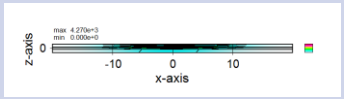
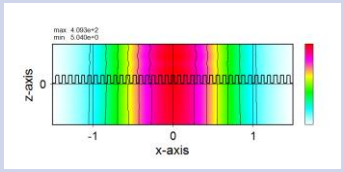
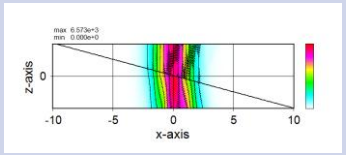
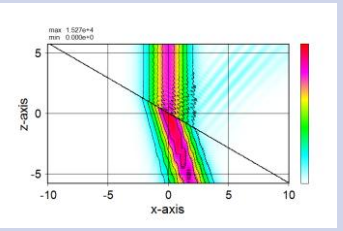
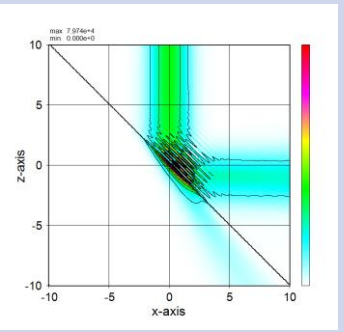
13. Calculation results of sample data (2)

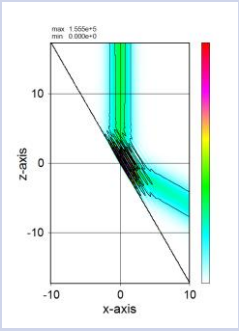
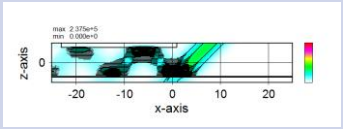
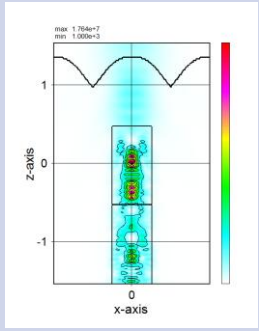
wsb_1 2D 1.1s	wsb_2 2D 1.4s	wsb_3 2D 0.9s	wsb_4 2D 3.1s	wsb_5 2D 3.4s	wsb_6 2D 6.9s
					
wsb_7 2D 10.2s	**wsb_8 2D 6.2 s**	**wsb_9 3D 2.0 s**			
					

14. Calculation results of sample data (3)

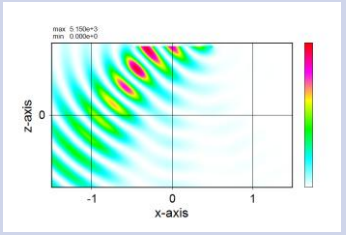
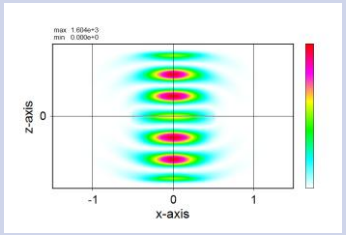
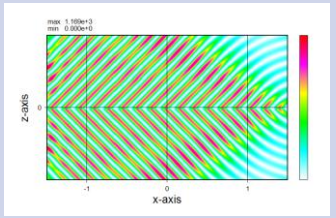
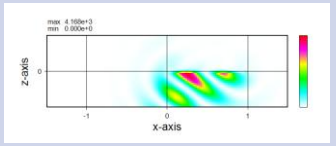
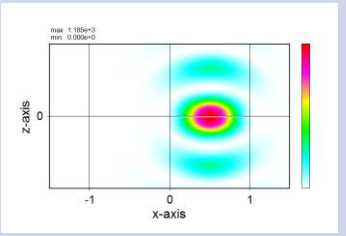
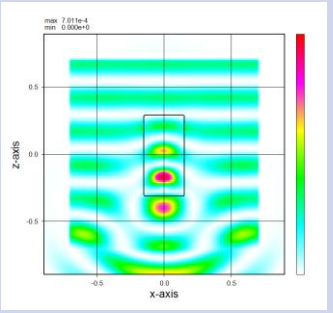
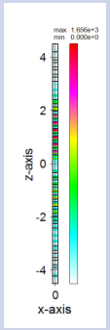
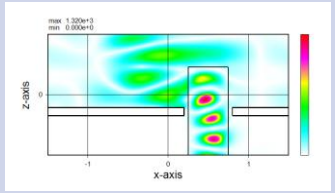
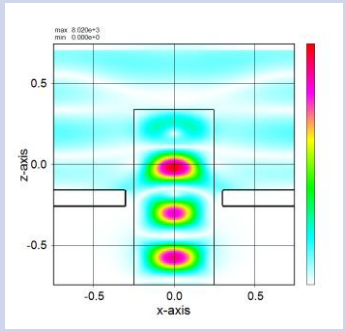
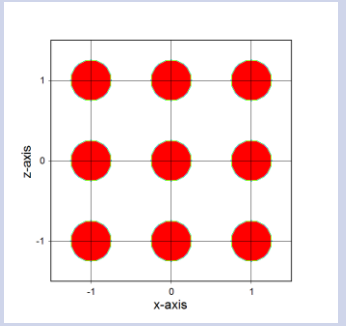
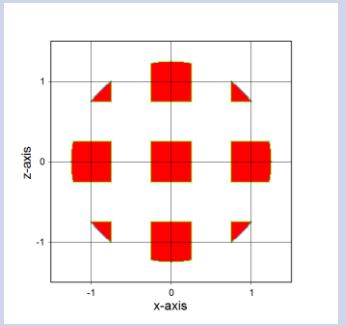
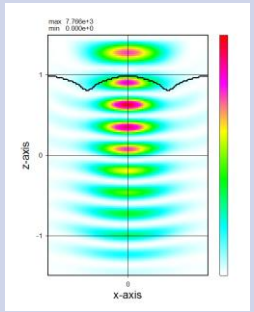
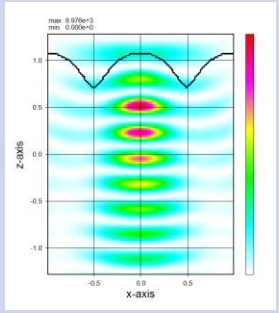
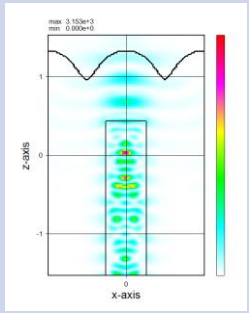
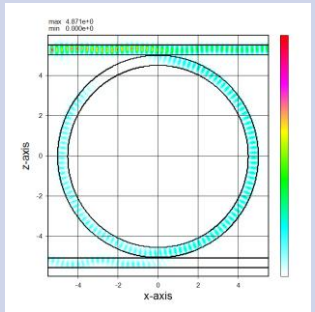
wsr01 3D 2.6s	wsr02 2D 0.6s	wsr03 3D 2.5s	wsr04 2D 36.7s	wsr05 3D 975s	wsr06 3D 965s
					
wsr07 3D 892s	**wsr08 2D 0.9s**	**wsr09 3D 19.7s**	**wsr10 3D 13.7s**	**wsr11 3D 13.8s**	**wsr12 2D 1.6s**
					
wsr13 3D 214s	**wsr14 3D 29.7s**	**wsr15 3D 194s**	**wsr16 2D 1.0 s**		
					

15. Calculation results of sample data (4)

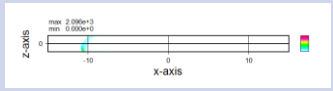
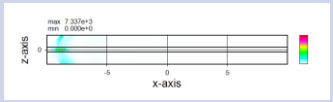
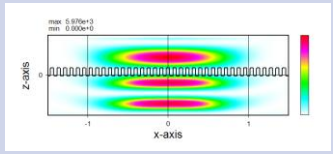
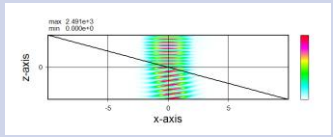
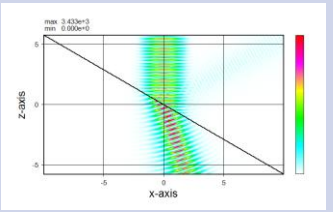
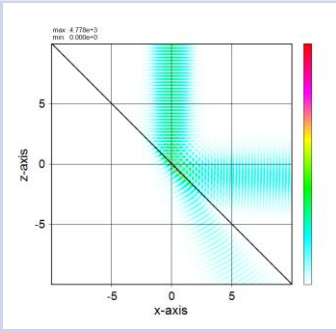
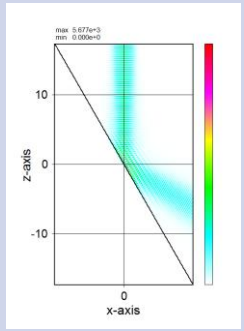
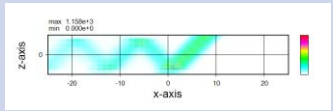
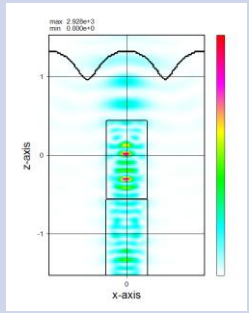
wsr_1 2D 6.2 s	wsr_2 2D 16.0s	wsr_3 2D 0.6s	wsr_4 2D 132s	wsr_5 2D 142s	wsr_6 2D 181s
					

wsr_7 2D 246s	wsr_8 2D 152s	wsr_9 3D 197s			
					

16. Calculation results of sample data (5)

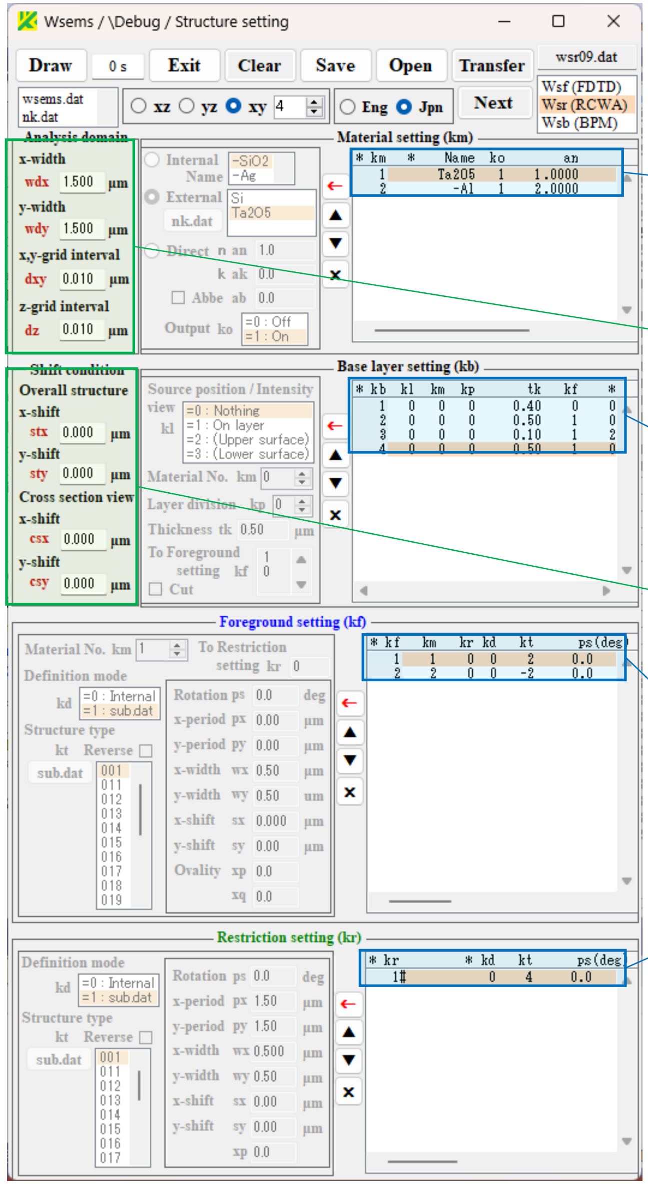
wsf01 2D 9.3 s	wsf02 3D 1498s	wsf03 2D 7.4s	wsf04 3D 112s	wsf05 3D 2539s	wsf06 2D 141s
					
wsf07 2D 1456s	**wsf08 2D 20.0s**	**wsf09 3D 1389s**	**wsf10 3D 9.0s**	**wsf11 3D 9.0s**	**wsf12 3D 181s**
					
wsf13 3D 159s	**wsf14 3D 387s**	**wsf15 2D 48s**			
					

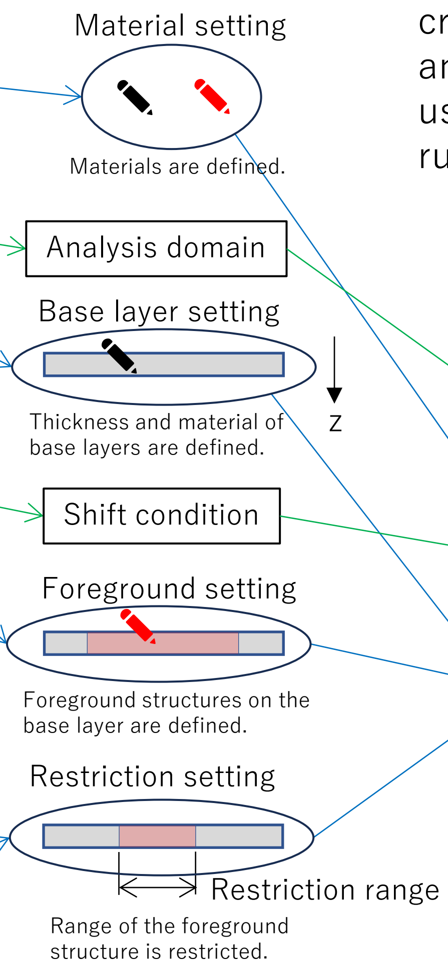
17. Calculation results of sample data (6)

wsf_1 2D 195s	wsf_2 2D 399s	wsf_3 2D 10.3s	wsf_4 2D 64.5s	wsf_5 2D 145s	wsf_6 2D 412s
					
wsf_7 2D 786s	**wsf_8 2D 802s**	**wsf_9 3D 517s**			
					

18. Relationships between Wsems window and input data

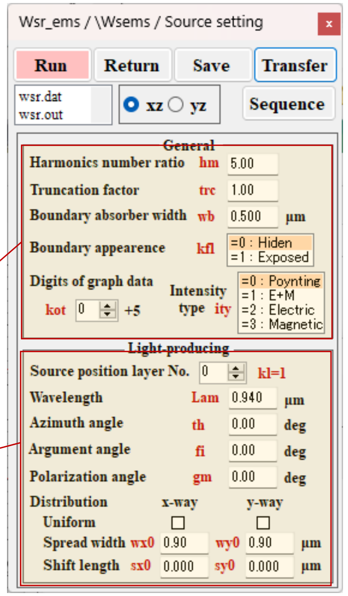
Structure setting 画面





Input data to perform a wave calculation program is created from the two windows (of Structure setting and Source setting) that make up Wsems. With the use of Wsems, you don't care about cumbersome rules for creating the input data.

Source setting window



Input data (wsr09.dat for example)

General

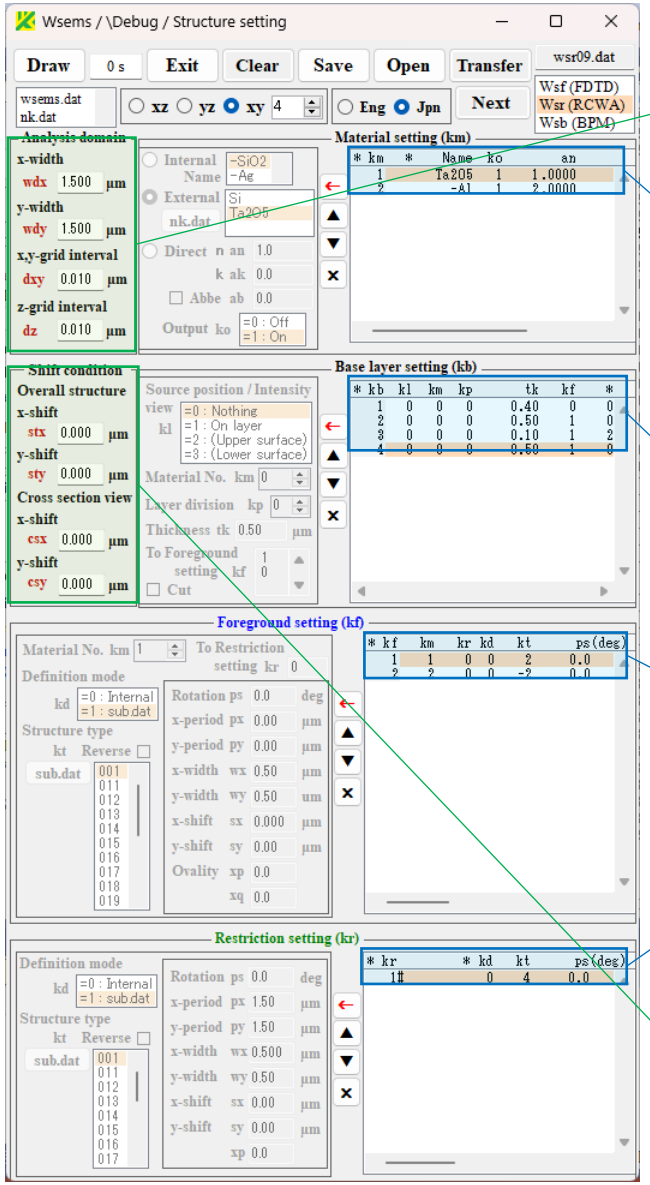
Light-producing

```
** wsr.dat
*         hm         trc         wb(um)    kfl(0,1)   kot        ity
          5.0        1.0         0.5       0          0          0
*         wdx(um)    wdy(um)     dxy(um)   dz(um)
          1.5        1.5         0.01      0.01
*         Lam(um)    th(deg)     fi(deg)   gm(deg)
          0.94       0.0         0.0       0.0
*         alx        aly         sx0(um)   sy0(um)
          0.3        0.3         0.0       0.0
*         stx(um)    sty(um)     csx(um)   csy(um)
          0.0        0.0         0.0       0.0
* km  *   Name  ko     an        ab        ak
  1       Ta205  1    1.0000     0.00      0.0000
  2        -Al   1    2.0000     0.00      0.0000
* kr            * kd   kt    ps(deg)  px(um)  py(um)  wx(um)  wy(um)  sx(um)  sy(um)  xp
  1#              0    4     0.0      1.50    1.50    0.500   0.50    0.00    0.00    0.0
* kf   km   kr  kd   kt    ps(deg)  px(um)  py(um)  wx(um)  wy(um)  sx(um)  sy(um)  xp   xq
  1    1    0   0    2     0.0      0.00    0.00    0.50    0.50    0.000   0.00    0.0  0.0
  2    2    0   0    -2    0.0      0.00    0.00    0.60    0.60    0.000   0.00    1.0  0.0
* kb  kl  km  kp     tk    kf    *    *    *    *    *    *    *    *    *    *    *    *    *    *    *    *
  1   0   0   0     0.40   0     0
  2   0   0   0     0.50   1     0
  3   0   0   0     0.10   1     2
  4   0   0   0     0.50   1     0
```

19. How to edit structural conditions (1)

The optical structure to be analyzed is defined in the Structure setting window of Wsems according to the following procedure.

Structure setting 画面



Analysis domain ⇨ (1) Define the size of the analysis area and grid size.

⇩

Material setting

Materials are defined. ⇨ (2) Define the materials to be used.

⇩

Base layer setting

Thickness and material of base layers are defined. ⇨ (3) Consider the structure as multi-layers and define the material and thickness of each layer (base layer). Invoke multiple structures (foreground structures) formed above the base layers.

z

⇩

Foreground setting

Foreground structures on the base layer are defined. ⇨ (4) Define the materials and shapes of the foreground structures. Invoke shapes restricting the foreground structures.

⇩

Restriction setting

Restriction range

Range of the foreground structure is restricted. ⇨ (5) Define the restriction shapes.

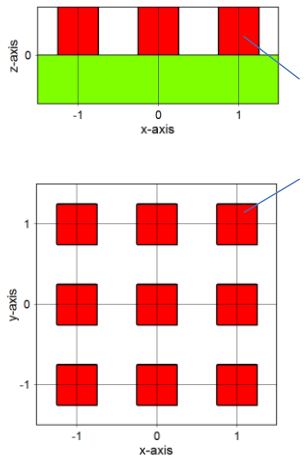
⇩

Shift condition ⇨ (6)If there is a shift of overall structures, define it.

20. How to edit structural conditions (2)

Taking wsf11.dat as an example, the way the definition proceeds and the relationship between references are concretely shown as follows.

The Structure setting window consists of five definition areas, and the spatial shape of the structure can be defined by setting up in the order of (1)~(5) below.

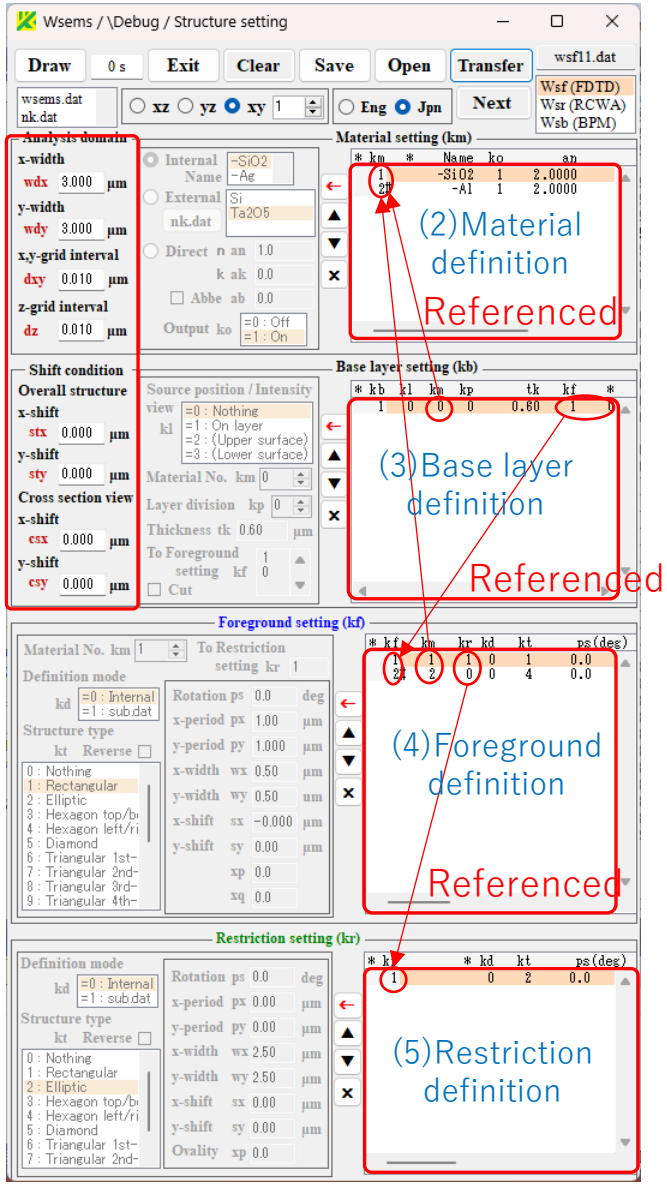


Material km=2

Material km=2

(4)Foreground definition
- Refer to material
- Refer to restriction shape

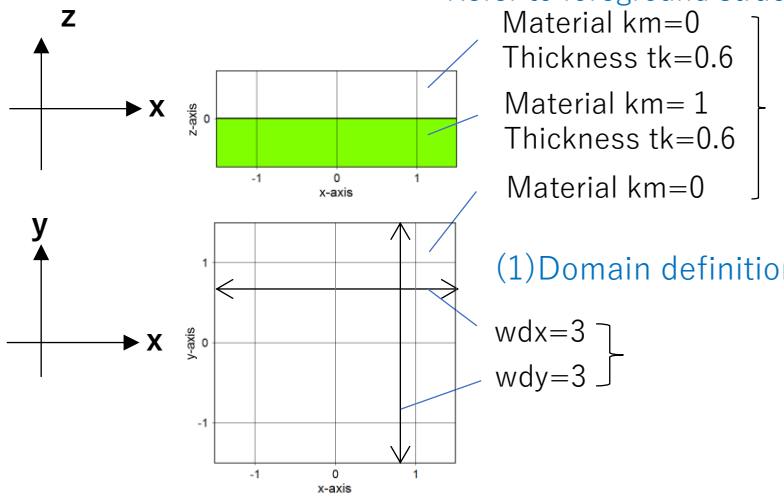
Structure setting window



(1)Domain definition

(2)Material definition

(3)Base layer definition
- Refer to material
- Refer to foreground structure



Material km=0
Thickness tk=0.6

Material km= 1
Thickness tk=0.6

Material km=0

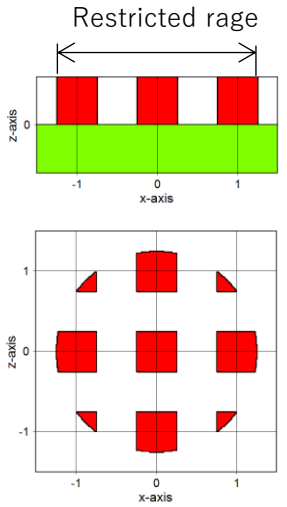
(1)Domain definition

wdx=3

wdy=3

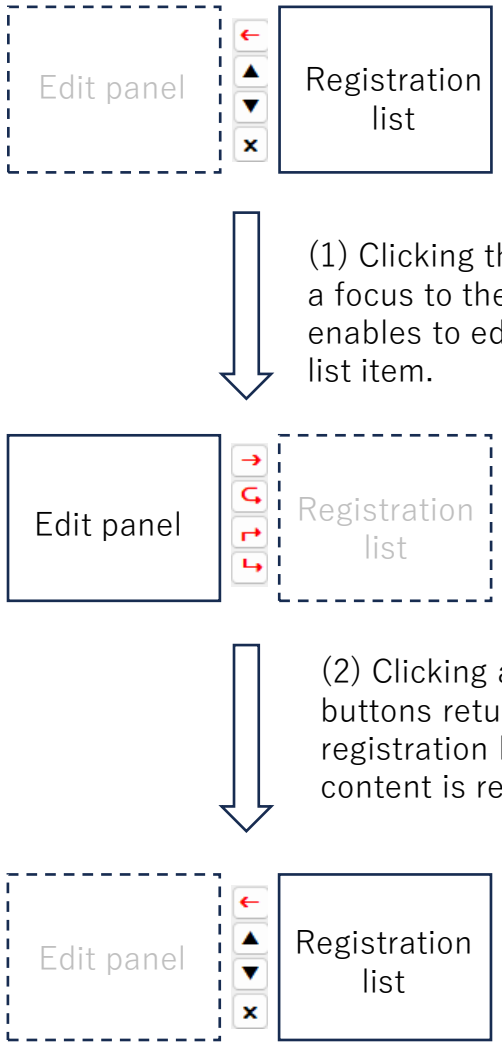
(4)Foreground definition

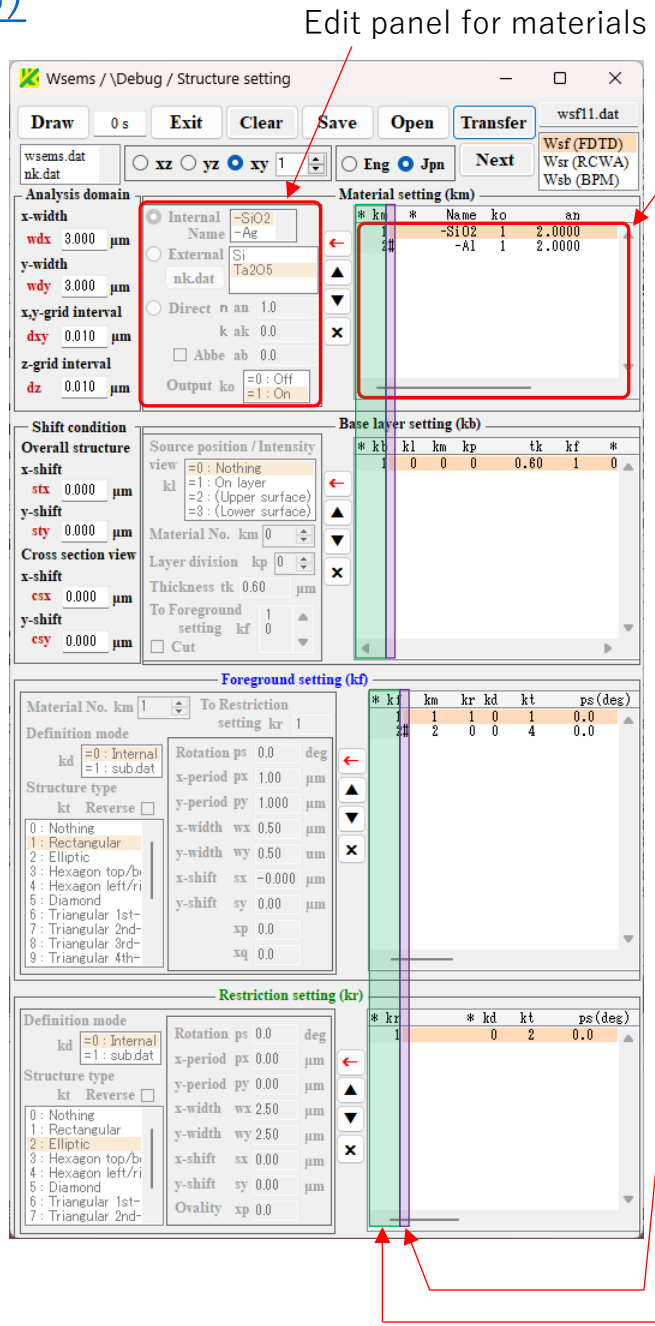
(5)Restriction definition



21. How to edit structural conditions (3)

Definition of material, Base layer, foreground structure, and restriction shape can be set by repeating the operations between registration list and edit panel.





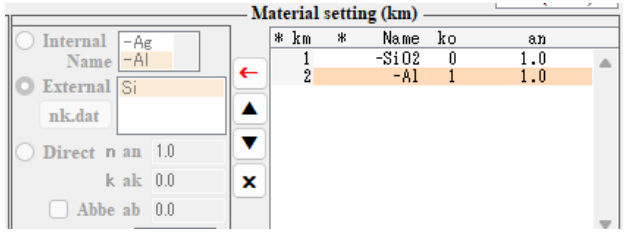
- The 5th column is for data validation.“M” indicates that the material is undefined (i.e., the corresponding line number does not exist in Material Setting), “F” indicates that the foreground structure is undefined (i.e., the corresponding line number does not exist in Forground Setting), and “R” indicates that the restricted shape is undefined (i.e., the corresponding line number does not exist in Restriction Setting). If M, F, or R remains, the data is incomplete and should be corrected. “#” indicates that the line is unnecessary components unreferenced by others, but that it does not need to be corrected.

- The first 4 columns with gray background color are line numbers and are used for citation number by other definition areas.

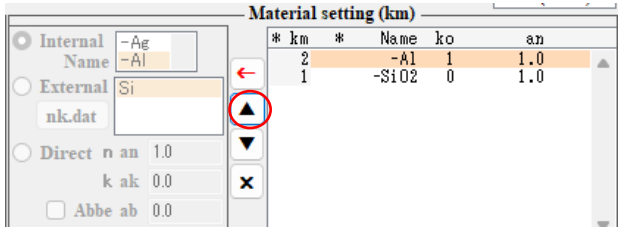
22. How to edit structural conditions (4)

The definition of materials, for example, is as follows (The definitions of Base layers, foreground structures, and limiting shapes are similar).

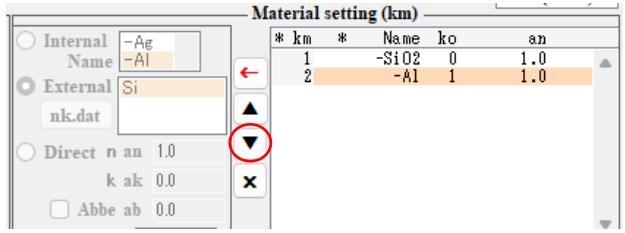
(1) When you click on an item in the list, its Base becomes red to specify the target.



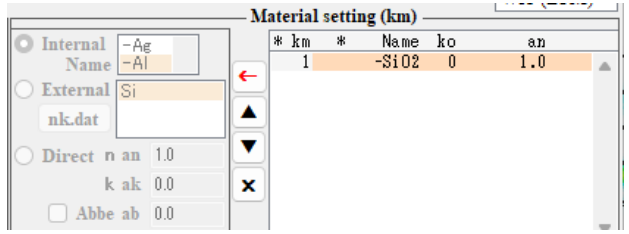
(2) The specified item in the list are moved up with the ▲ button.



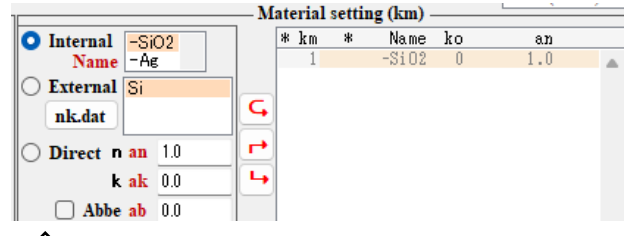
(3) The specified item in the list are moved down with the ▼ button.



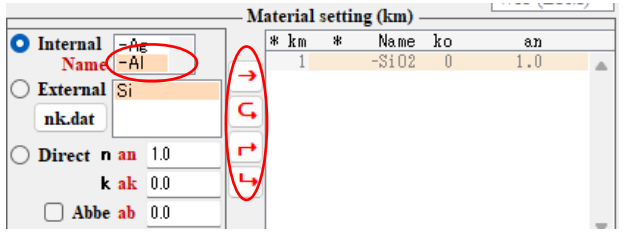
(4) The specified item can be deleted with the X button.



(5) Clicking the ← button shifts the focus to the left side for editing.

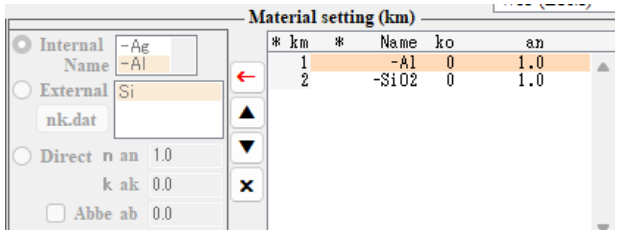


(6) When editing operation is performed on the left side, → button appears.

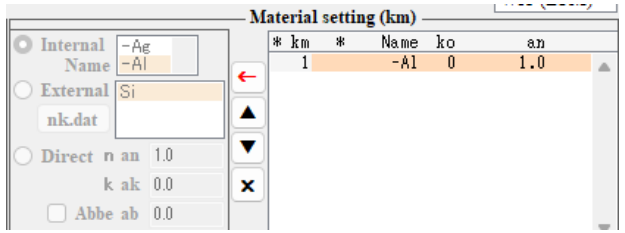


(7) Clicking the ↳ button returns the focus to the right side without reflecting the edited result.

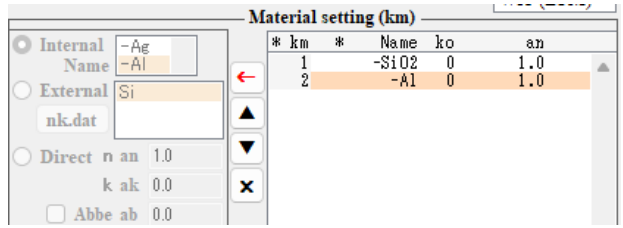
(8) Click the ↱ button to insert the edited result at the upper side.



(9) Clicking the → button overwrites the edited result.

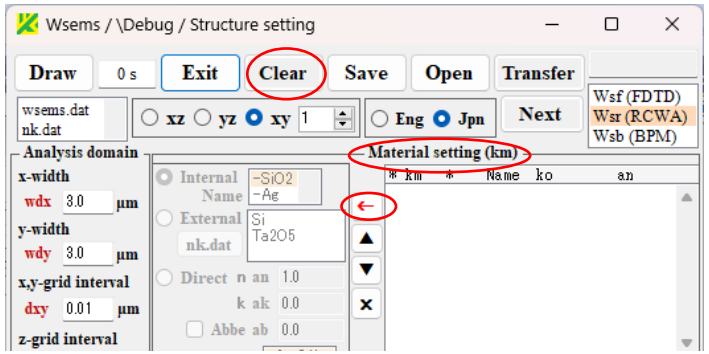


(10) Clicking the ↳ button inserts the edited result at the lower side.

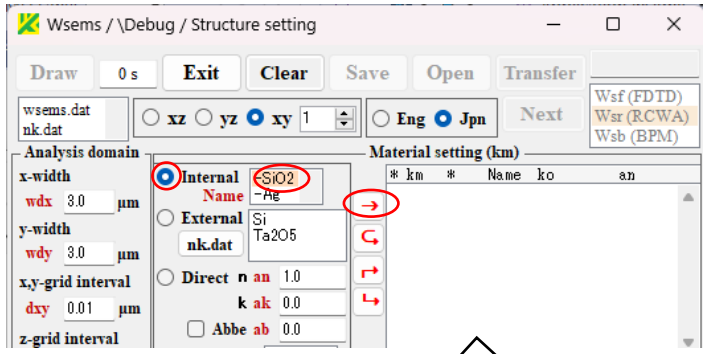


23. How to edit structural conditions (5)

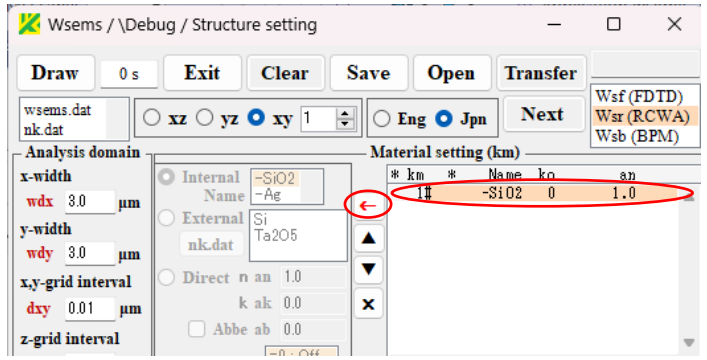
Material conditions are set up here. Nk.dat is editted on the way.



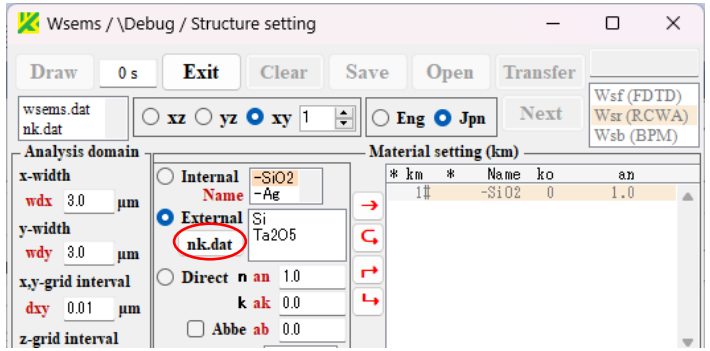
(1) After clicking the Clear button, click the ← button in Material setting to move to the edit panel.



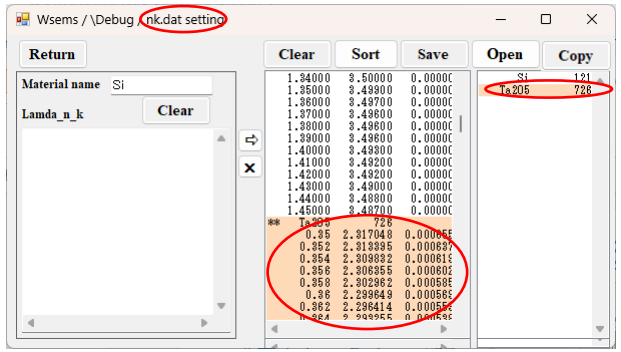
(2) Check the Internal button, select "-SiO2" from its right list, and click the → button to register the Internal material on the list. Since a Base layer and a foreground structure are undefined and there is no reference to the material, "#" is added to the right of the line number.



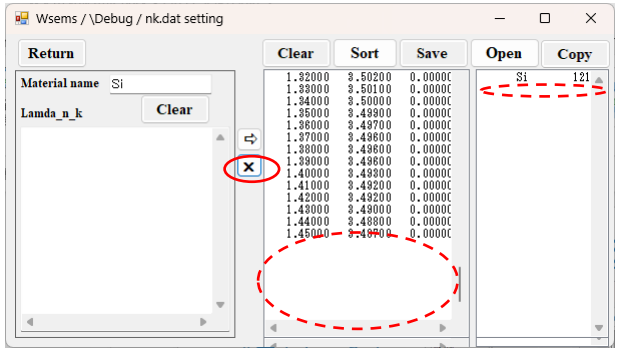
(3) Click ← button to move to the edit panel.



(4) Click the nk.dat button to check the External button and the nk.dat setting window appears.

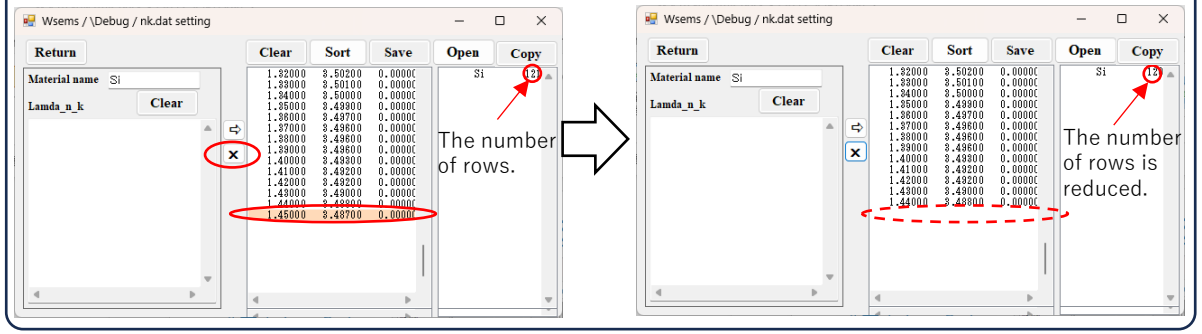


(5) By clicking the material name (Ta2O5) in the rightmost box, the dispersion data (columns of wavelength, refractive index, and extinction coefficient) for the corresponding material are selected and turn blue in the center box. Similarly, by clicking on the line with a material name starting with "**" in the center box, the dispersion data in the following lines are selected.

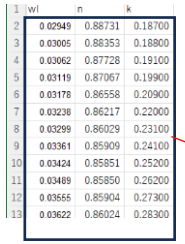


(6) Clicking the × button deletes the material data in the selected range.

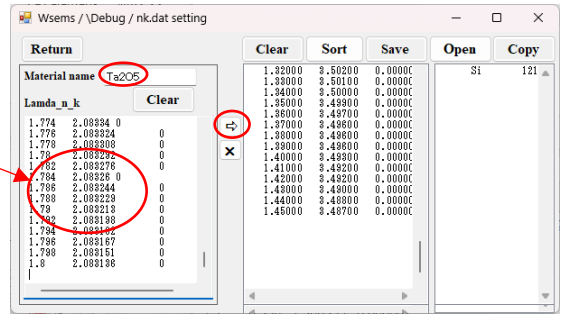
(Supplemental) Rows with a beginning other than ** can be selected individually and deleted with the × button.



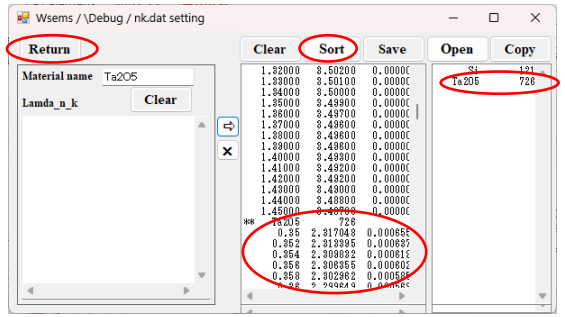
24. How to edit structural conditions (6)



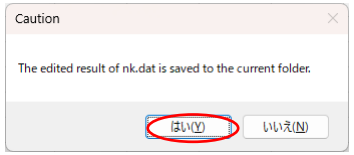
Dispersion data
nk_data.xlsx



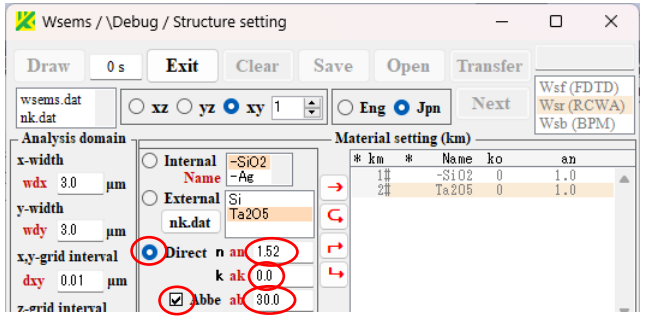
(7) Type "Ta2O5" in the Material name box and paste the dispersion data edited by Excel in the lower box, then click the ⇒ button.



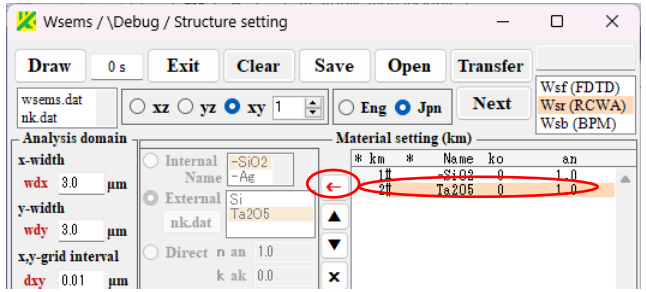
(8) Material name (Ta2O5) and data are registered in the list. If there is a necessity to sort the order in the list, click Sort button.



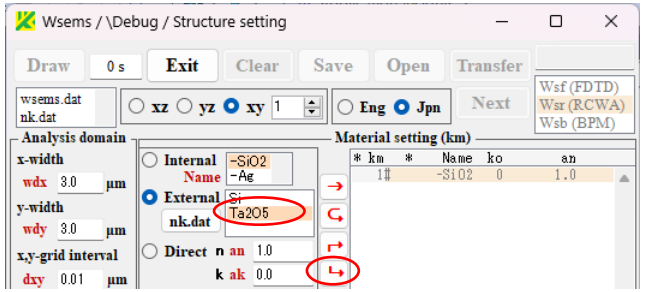
(9) Click the Return button to display the Causion box and press Yes button there.



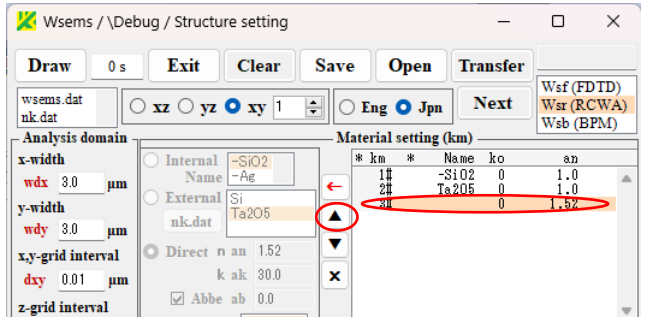
(11) The material of “Ta2O5” is registered. Click the ← button again to move to the edit panel.



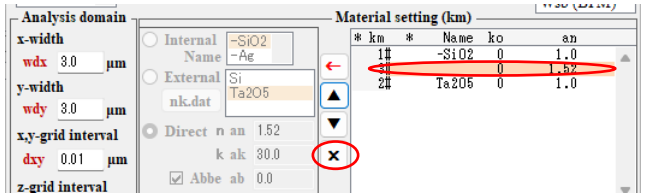
(10) Select Ta2O5 from the right list of External button and click the ↪ button.



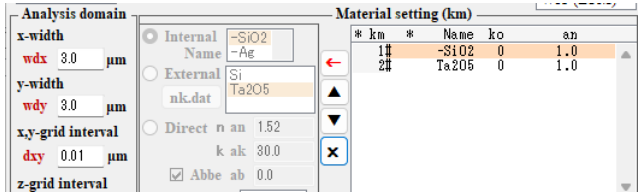
(12) Click the Direct button, edit the right boxes of Direct button (refractive index an=1.52, extinction coefficient ak=0.0, Abbe number ab=30.0 if checked) and click the ↪ button.



(13) Material with n=1.52 is registered in the list in the above example. Use the ▲▼ buttons to move up and down the registration items in the list.

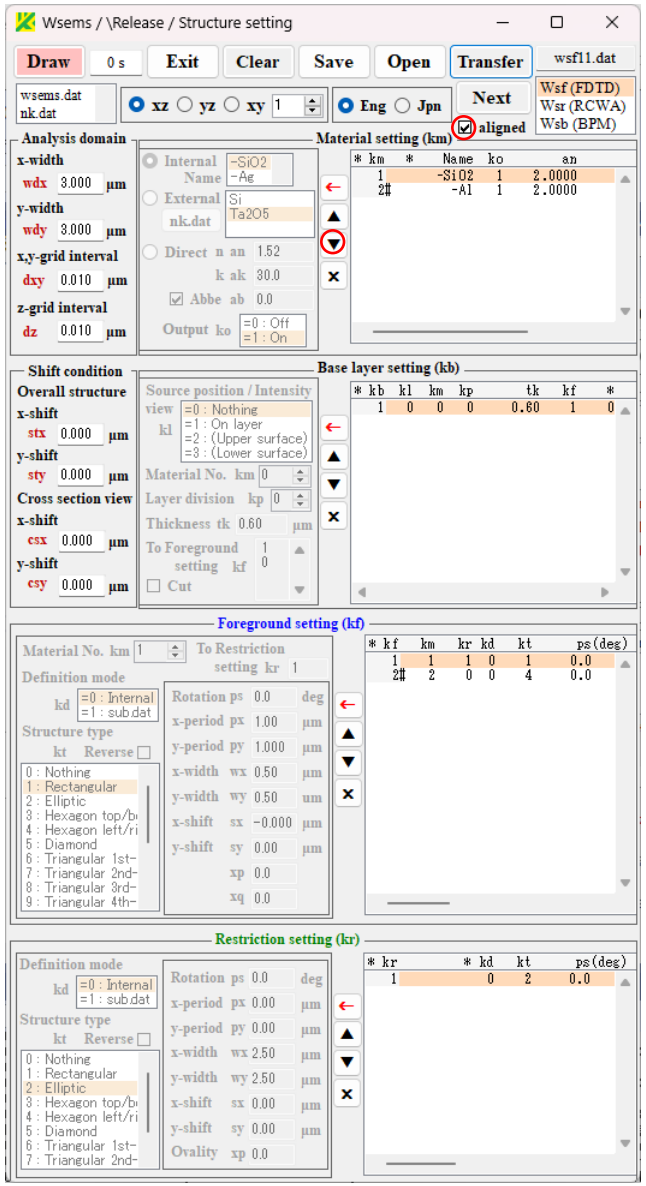


(14) Registered items can be deleted with the × button.



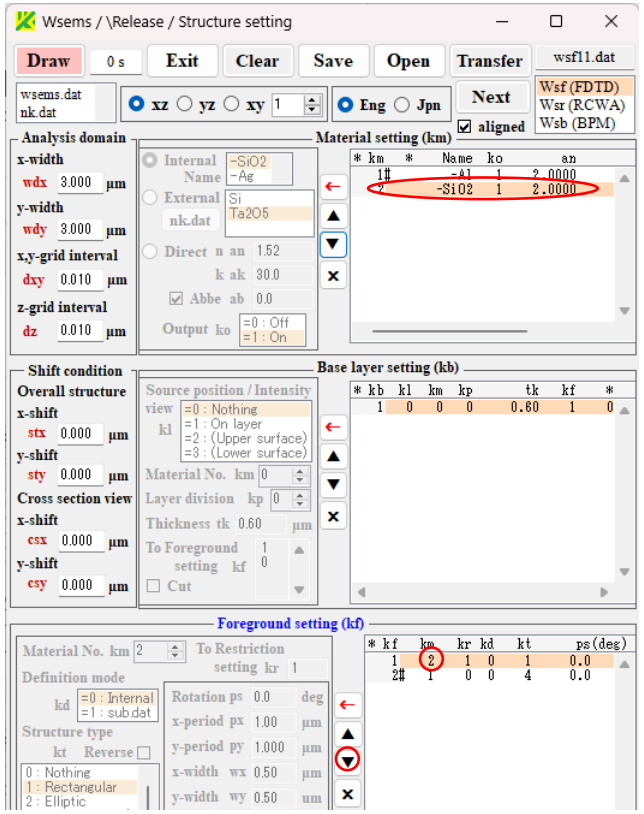
(note) If you remove some registered items by mistake, overwrite “nk.dat” in “¥Samples” to that in “¥Wsems” and operate the step (4), and you can go back to the state of the step (8).

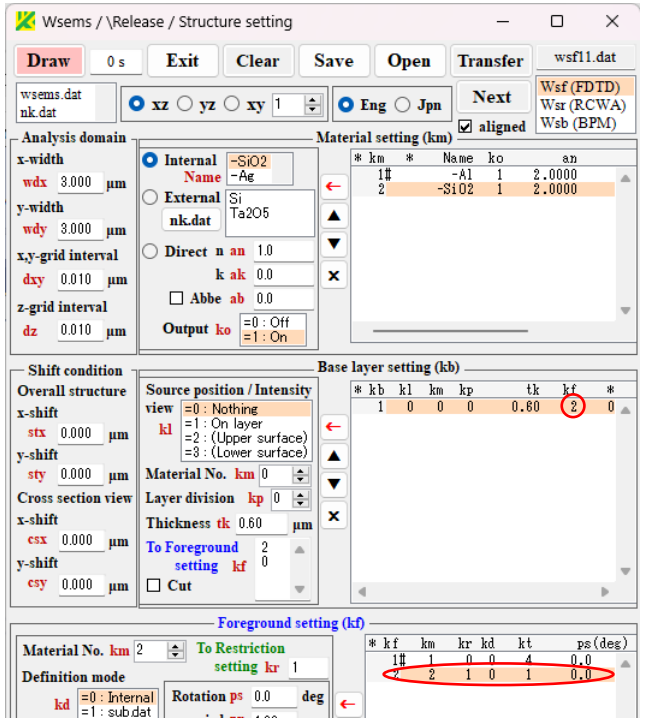
25. How to edit structural conditions (7)



(1) On setting window of wsf11.dat, in confirmation of checking the aligned box, click on the ▼ button in the Material setting field.

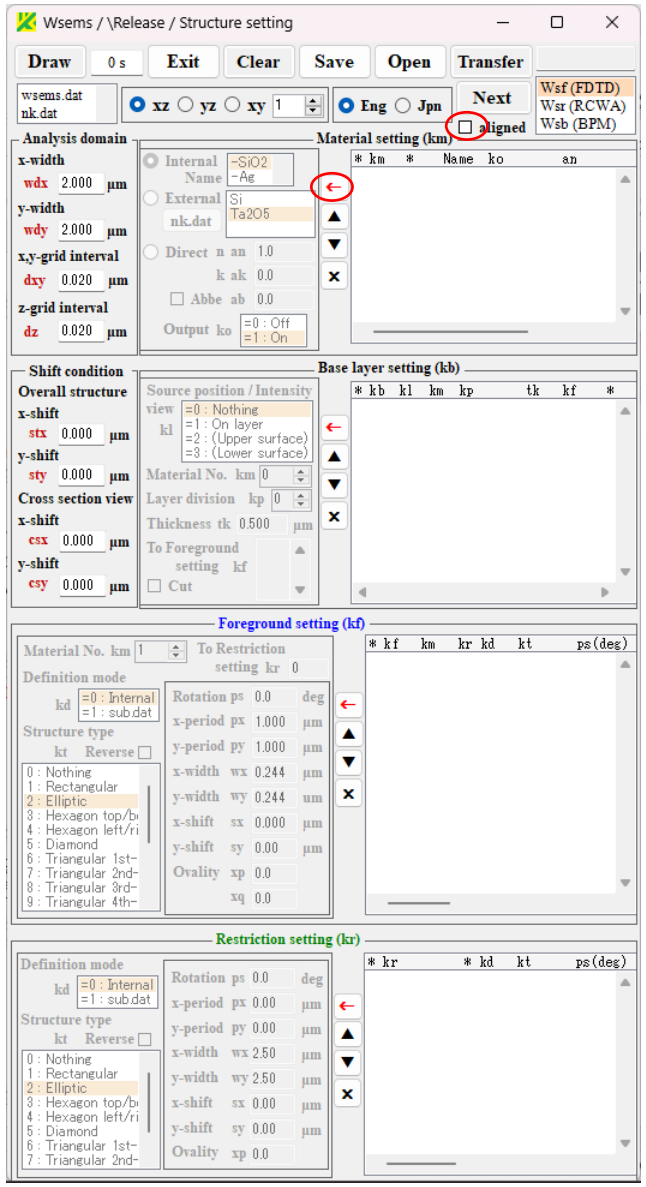
(2) The material line of SiO2 move from the 1st line to the 2nd line. In conjunction with the change, km changes from 1 to 2 in Foreground setting field.



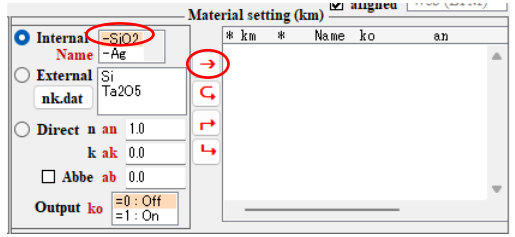


(3) Click on ▼ button in Foreground setting field to move the 1st line to the 2nd line. In conjunction with the change, kf changes from 1 to 2 in Material setting field.
In this form, when the aligned box is checked, the line numbers designated in other setting fields (row count n) are aligned to the line number changed in each setting field. If the designated line does not exist, it is set to n+1. When unchecked, the numbers are not aligned. In case of editing an existing data, check the box, and in case of editing data from the first, uncheck it.

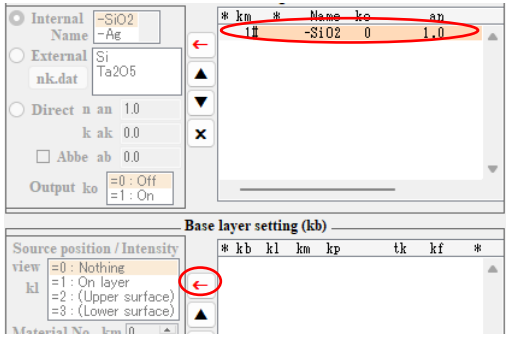
26. How to edit structural conditions (8)



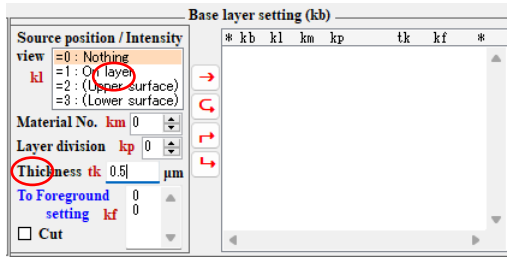
(1)Uncheck the Align button and click on the ← button in the Material setting field.



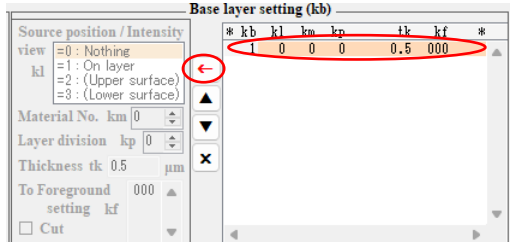
(2)Select “-SiO2” in the internal box and click on the → button to register the 1st line.



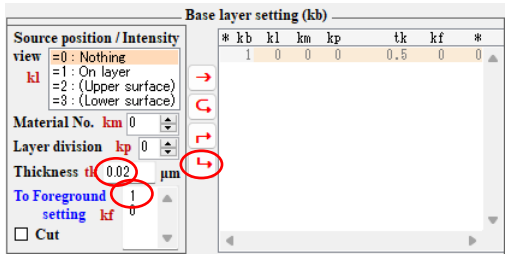
(3) Click on the ← button in the Base setting field.



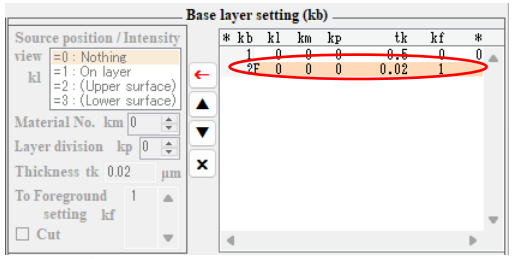
(4) Set the Thickness box to tk=0.5 and click on the → button to register the 1st line.



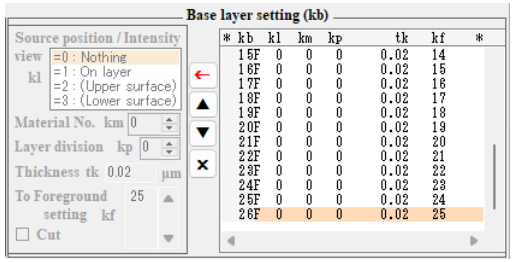
(5) Click on the ← button.



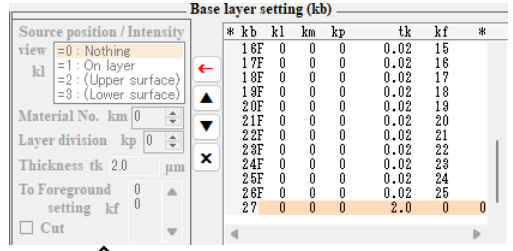
(6) Set the boxes to tk=0.02 and kf=1 and click on the ↳ button to register the 2nd line.



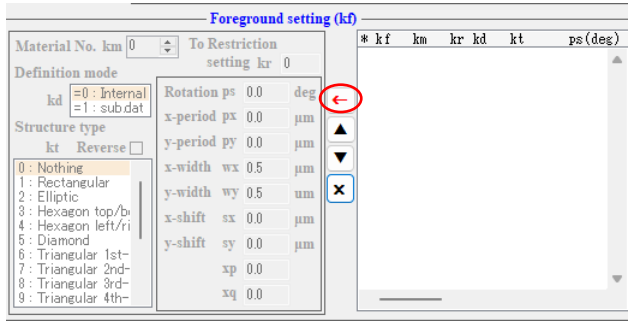
(7)Advance the value of kf by 1 and repeat the process of (5) and (6) until kf becomes 25.



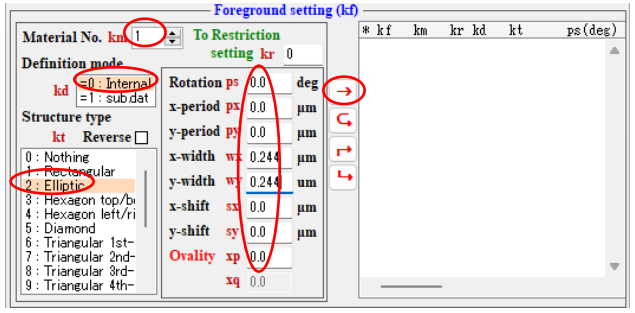
(8)Set the boxes to tk=2.0 and kf=0 and click on the ↳ button to register the last line.



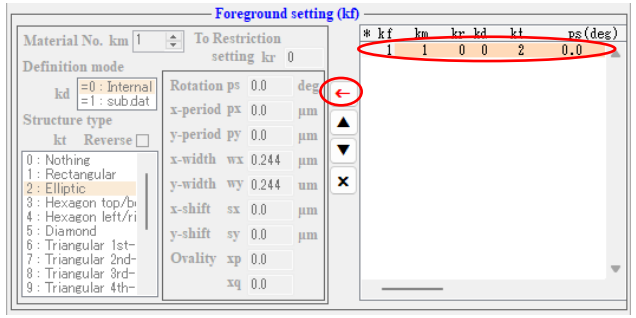
27. How to edit structural conditions (9)



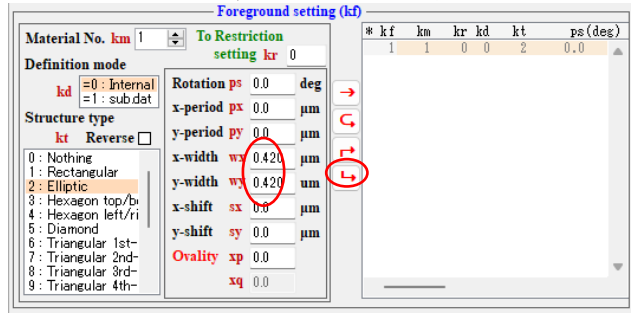
(9) Click on the ← button in the Foreground setting field.



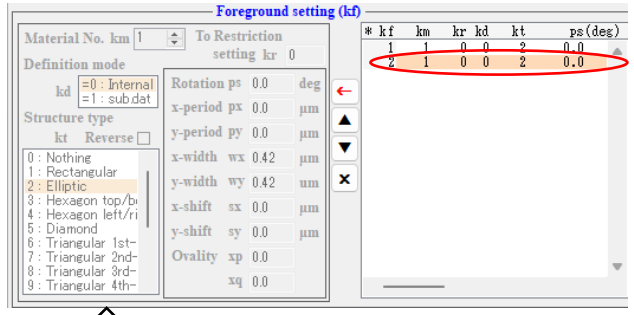
(10)Set the boxes to km=1, kd=0, kt=2, px=py=1.0, wx=wy=0.244, sx=sy=0.0 and click on the → button to register the 1st line.



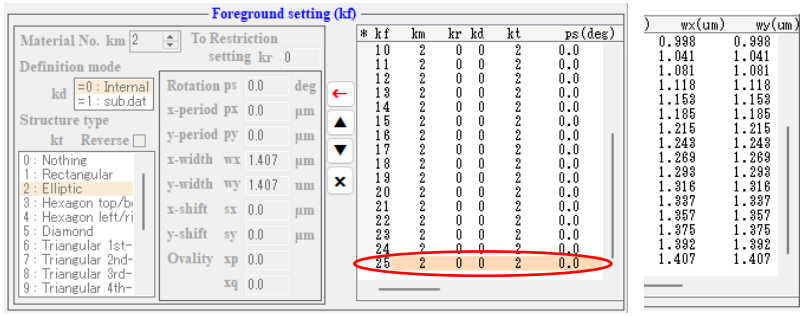
(11) Click on the ← button.



(12) Set the boxes to wx=wy=0.420 and click on the ↳ button to register the 2nd line.

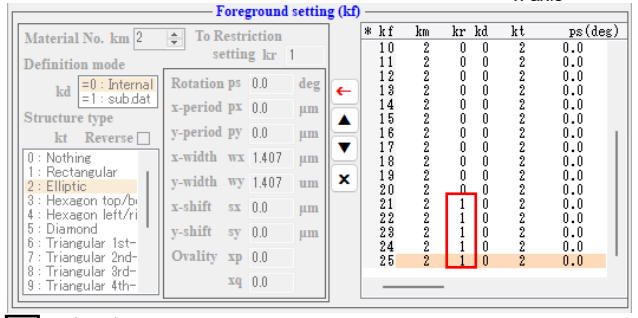


(13)Repeat the process of (11)～(12) keeping the relationship of wx=wy=2*r(i) and set the values of wx and wy for the line number i until i reaches 25. Sectional radius r(i) is a solution of combined equations of spherical surface (z=r(i)^2/2a) and step surface (z=(i-1/2)*dz) where curvature radius is a=0.75 μm and step width is dz=0.02 μm.

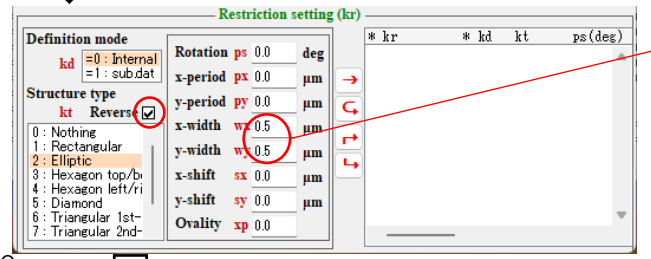


(14) Click the Draw button to draw the cross-section view (Wsf12.dat)。

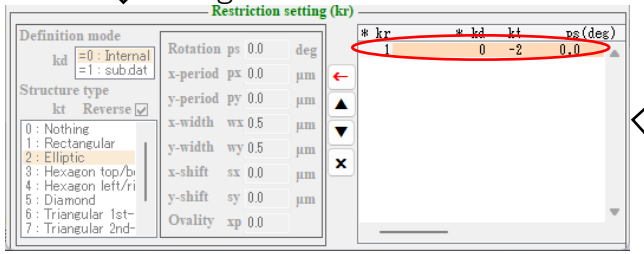
(15) Change the values in the 1 to 7 lines to kr=1.



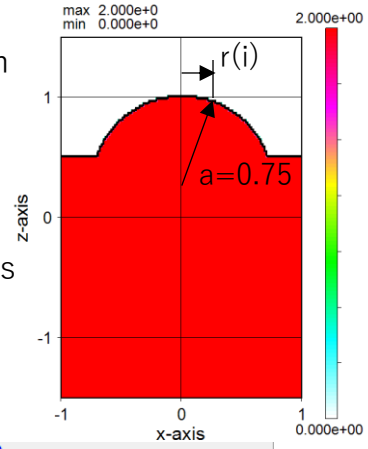
(16) Click on the ← button in the Restriction setting field and set the values as below.

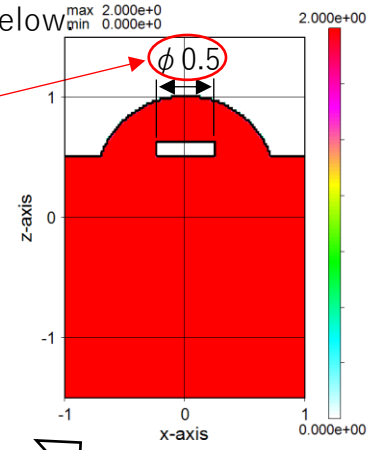


(17) Click on the → button to register the 1st line.



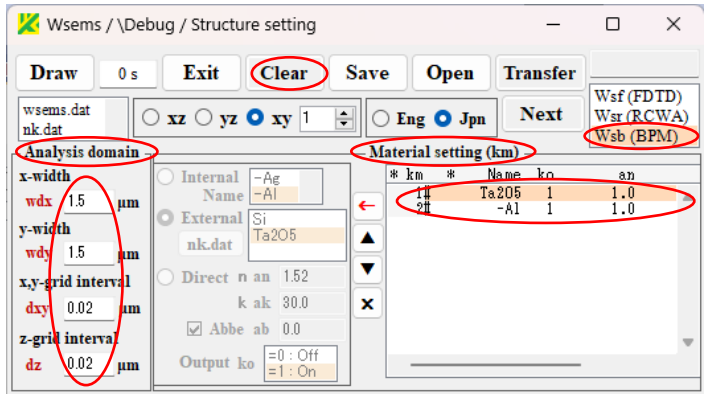
(18) Click on the Draw button to draw the cross-section view.



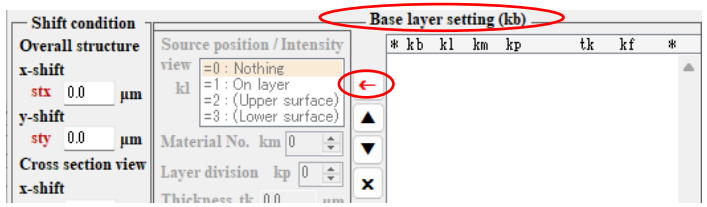


28. Reproduction and execution of wsb06.dat (1)

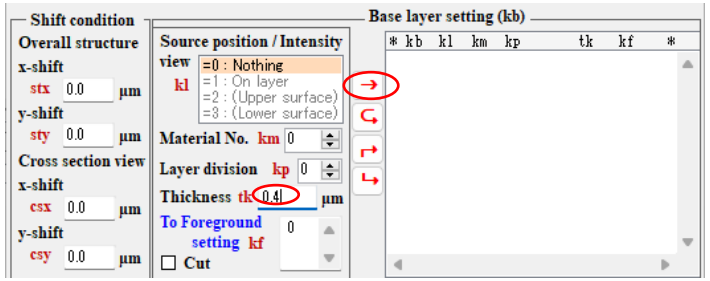
To reproduce wsb06.dat, set up structural conditions and execute it after defining source conditions.



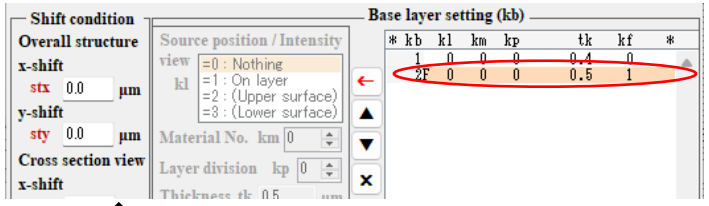
(1) Click Clear button and select “Wsb (BPM)”. In Analysis domain, wdx and wdy are set to 1.5 and dxy and dz to 0.02. “Ta2O5” and “-Al” are registered in the list of Material setting.



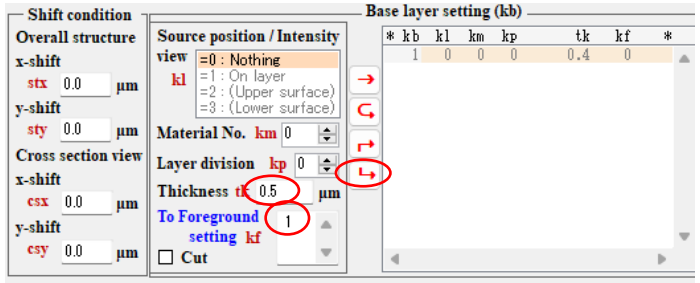
(2) Click the ← button in Base layer setting to move to the edit panel.



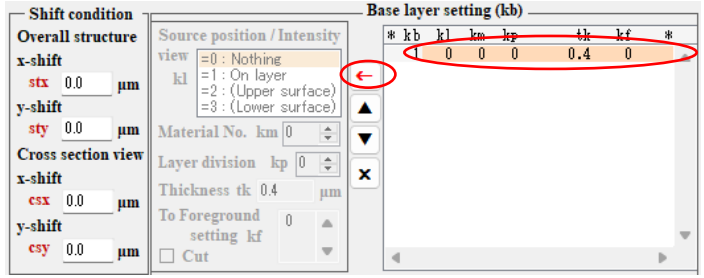
(3) Set Thickness tk to 0.4 and click the → button. The first Base layer is registered in the list.



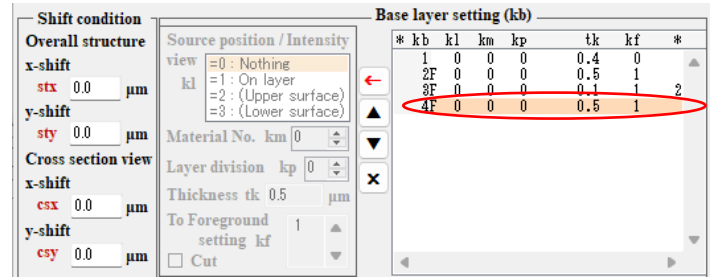
(5) Set tk to 0.5 and kf to 1, and click the ↳ button. The second Base layer is registered in the list.



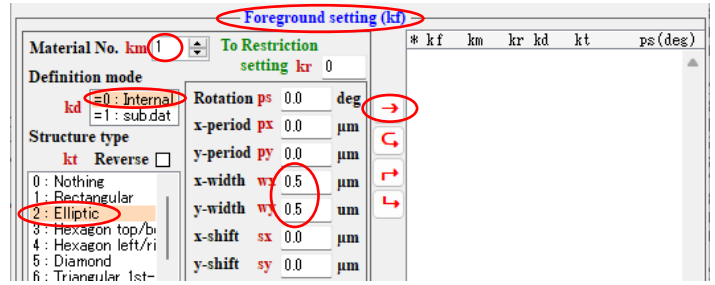
(4) Click the ← button to move to the edit panel.



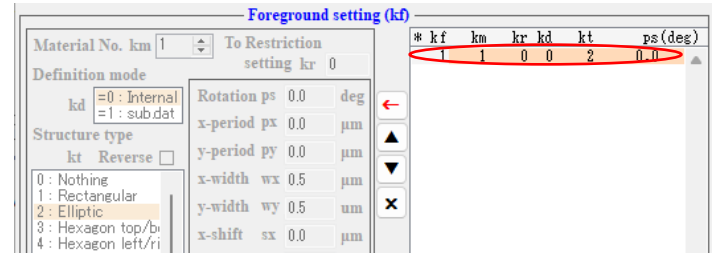
(6) Repeat the same process as (4) to (5) above with tk=0.1, kf=1, 2 and tk=0.4, kf=1, and register up to the 4th Base layer in the list. Since the foreground structure is undefined, “F” follows to the right of the line number in lines 2 - 4 (or "M" follows if the material is undefined).



(7) Click the ← button in Foreground setting to move to the edit panel. km is set to 1, kd to 0 (Internal), kt to 2 (Elliptic), and wx,wy to 0.5.

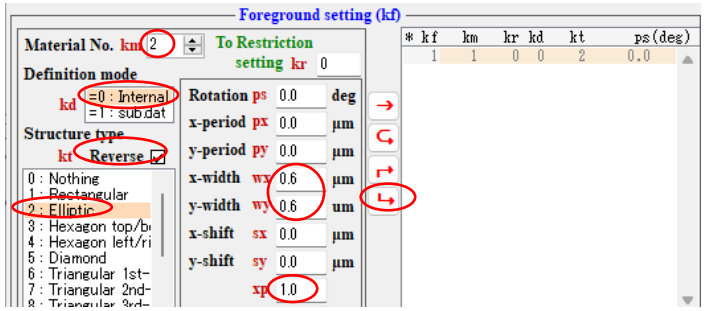


(8) Click the → button to register the 1st foreground structure in the list.

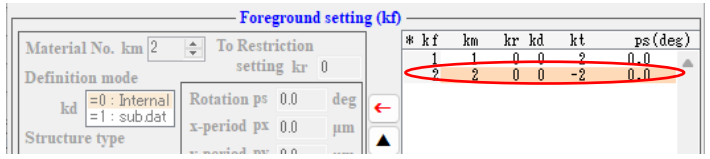


29. Reproduction and execution of wsb06.dat (2)

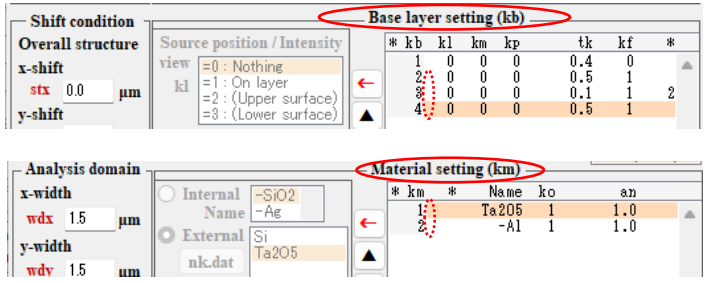
(9) Click the ← button to move to the edit panel. Set km to 2, kd to 0 (Internal), kt to 2 (Elliptic) with checked Reverse box, wx and wy to 0.6, and xp to 1.0.



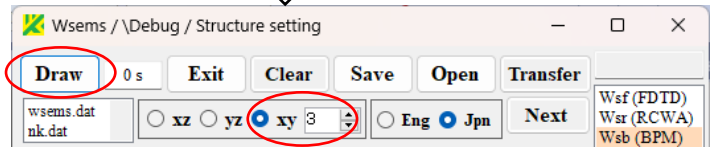
(10) Click the ↳ button to register the 2nd foreground structure in the list.



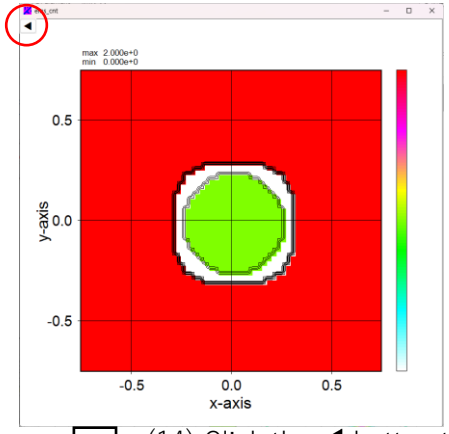
(11) The labels "F" in the Base layer setting list disappear because all foreground structures have been defined. The labels "#" in the Material setting list also disappear because the all materials are now referenced.



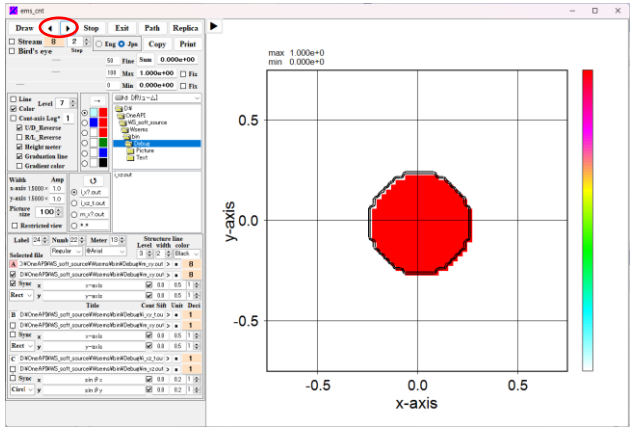
(12) Check the xy button and set the right box to 3.



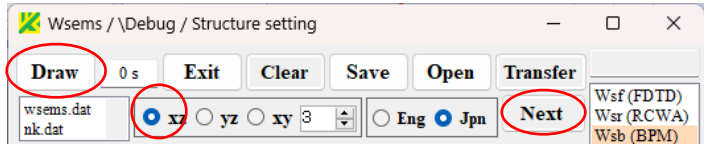
(13) Click the Draw button to draw the xy cross-section of the 3rd layer structure.



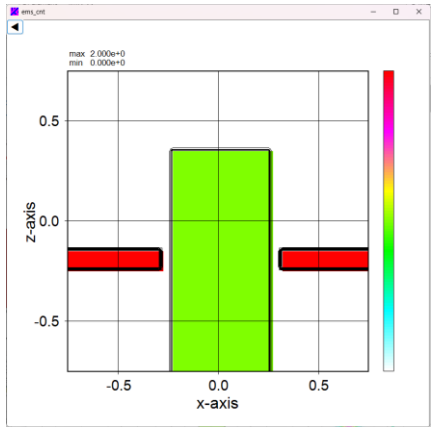
(14) Click the ◀ button to display the Wscnt operation window. Click the ◀▶ buttons on the left top of the window to change a layer number in the cross-sectional view.



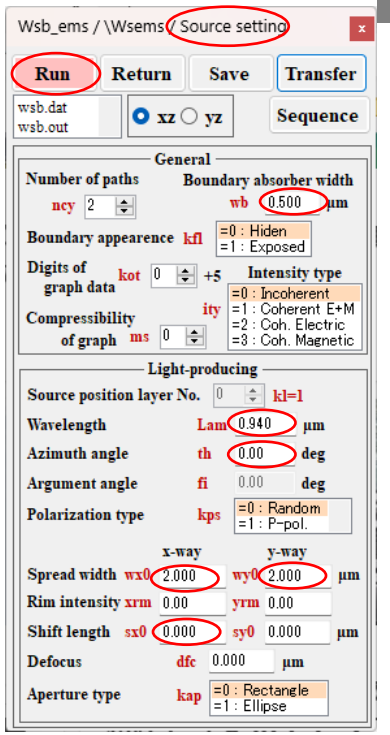
(15) Check the xz button.



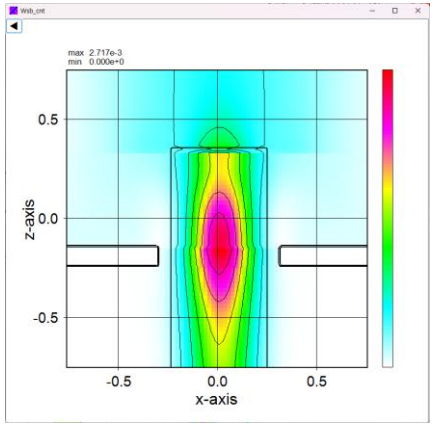
(16) Click the Draw button to draw the xz cross-section of the structure.



(17) Click the Next button to open the Source setting window and set each parameter as follows.

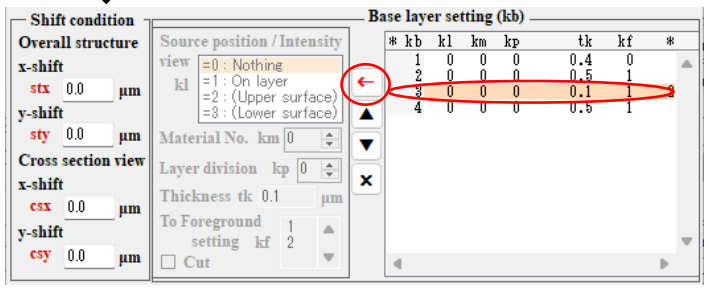


(18) Click the Run button to draw an xz cross-section of the calculated light intensity distribution.

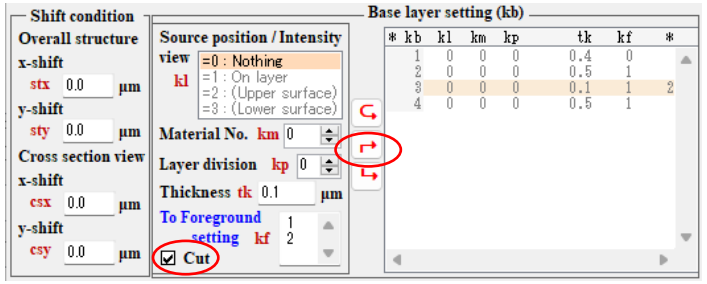


30. Reproduction and execution of wsb06.dat (3)

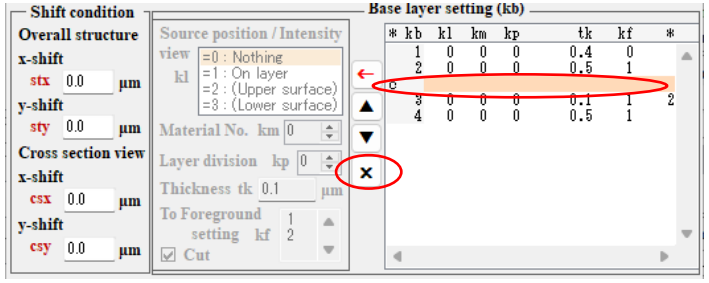
(19) Select the 3rd layer in Base Layer setting and click the ← button to move to the edit panel.



(20) Check the "Cut" box and click on the ↱ button.

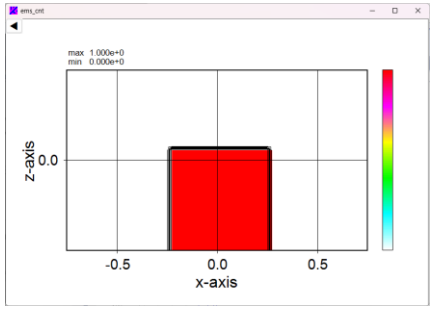


(21) A "c" line is inserted under the 2nd layer in the list.

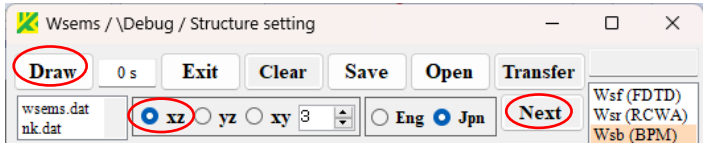


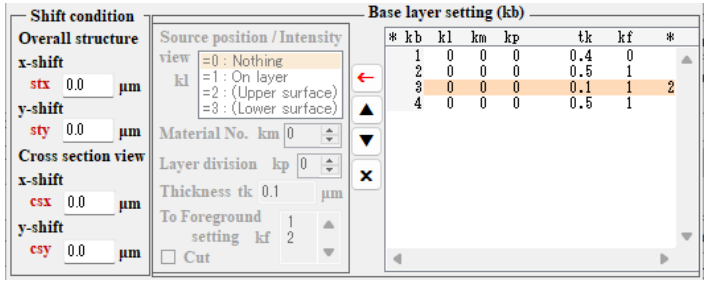
(22) Click the xz button.

(26) A "c" line can be deleted by clicking × button.

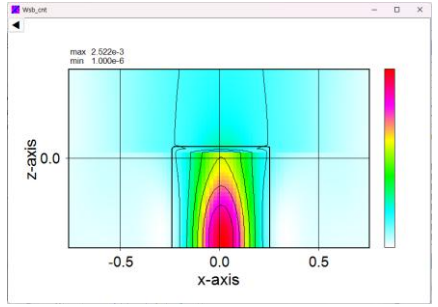


(23)By clicking Draw button, xz cross-sectional view of structures up to 2nd layer is drawn.

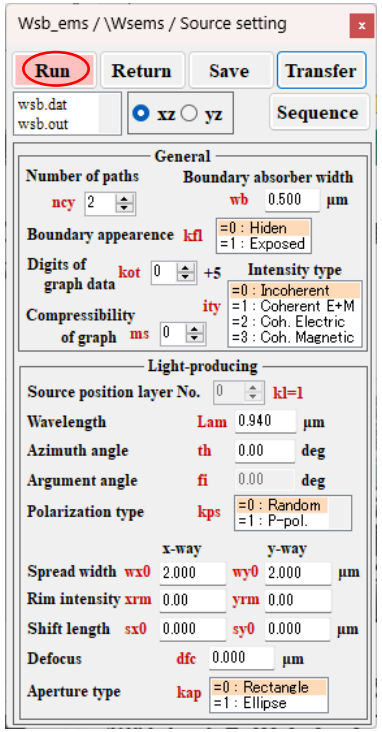




(24) Click the Next button.

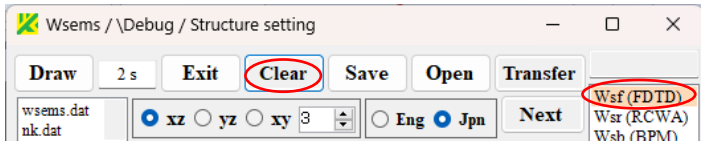


(25) By clicking Run button, calculation for structures up to 2nd layer is performed and the result of xz cross-sectional intensity distribution is drawn.

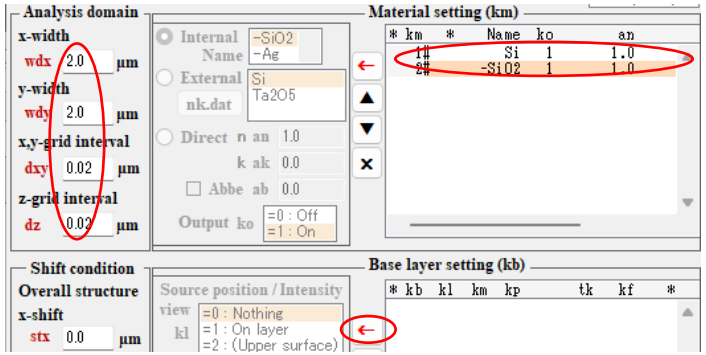


31. Reproduction and execution of wsf14.dat (1)

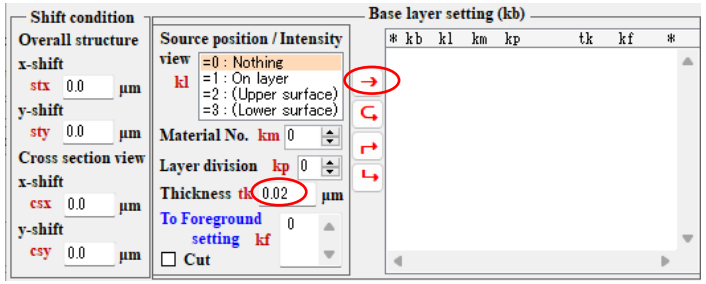
To reproduce wsf14.dat, set up structural conditions and execute it after defining source conditions. By the way, edit sub.dat as an auxiliary data.



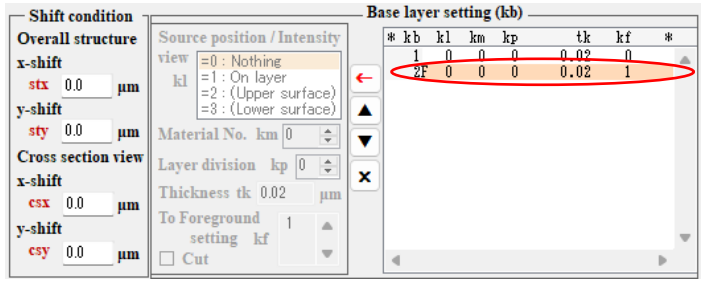
(1) Click Clear button and select “Wsf(FDTD)”.



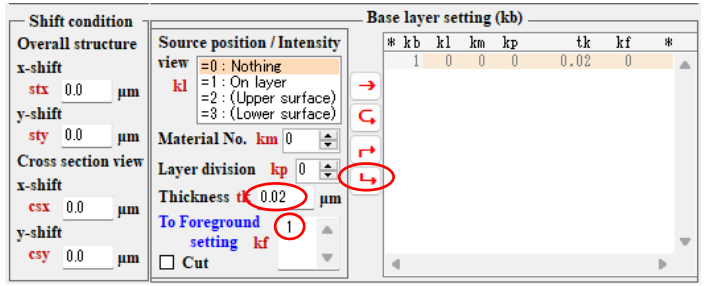
(1) Set wdx and wdy to 2.0, dxy and dz to 0.02. Register “Si” and “-SiO2” in Material setting. Click the ← button in Base layer setting to move to the edit panel.



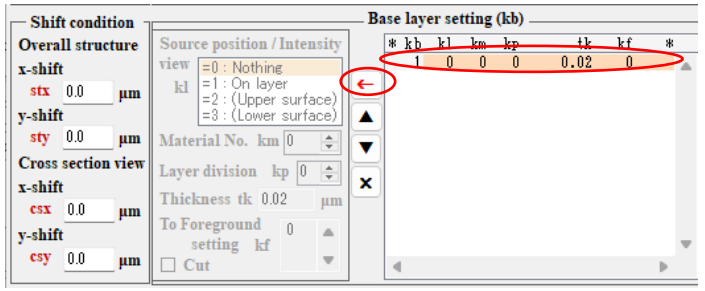
(3) Set tk to 0.2 and click the → button. Register the 1st Base layer in the list.



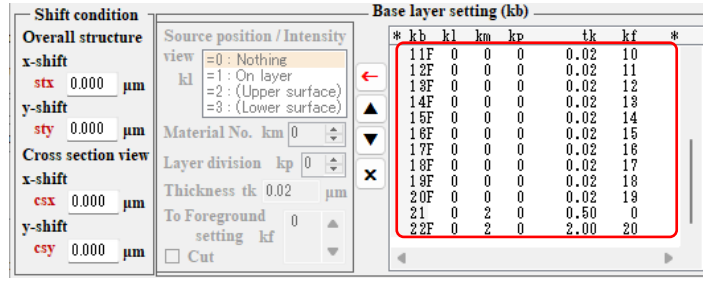
(5) Set tk to 0.02 and kf to 1, and click the ↳ button. Register the 2nd Base layer in the list.



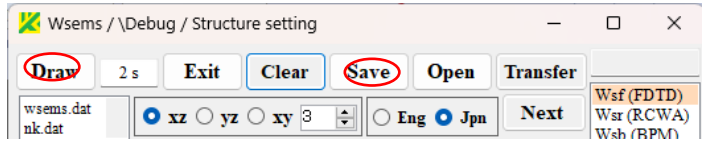
(4) Click the ← button to move to the edit panel.



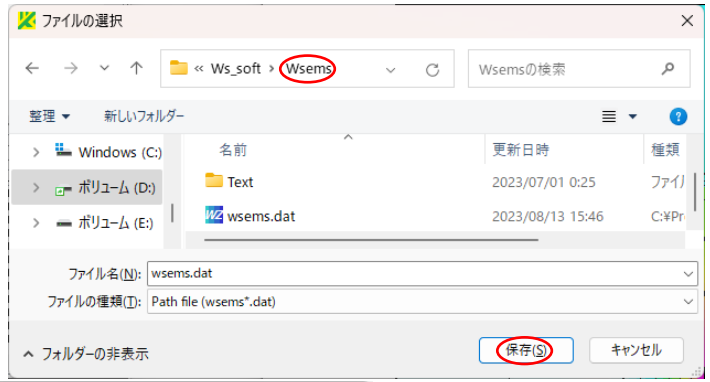
(6) Repeat the same process as (4)-(5) above and register Base layers up to 22 in the list. Set tk to 0.02 for layer 2 – 20 where kf increases by 1 from 1 to 20, and set to tk=0.5 , kf=0, km=2 at layer 21, and tk=2.0 , kf=0, km=2 at layer 22.

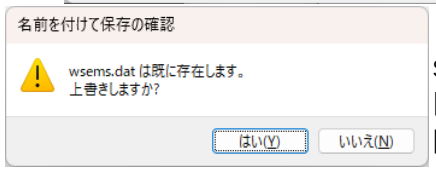


(7) The operation in (6) above is complicated and may be done as follows.



(8) Click the Draw button (or click the Save button and save the structural information to a file (wsems.dat) of the working folder, i.e., ¥ws_soft¥wsems).

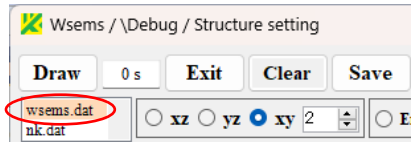


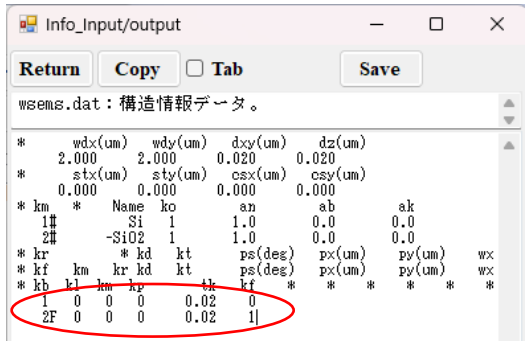


If the Causion window appears, select "Yes".
By clicking the Draw or Save button, wsems.dat is updated in the Result file box .

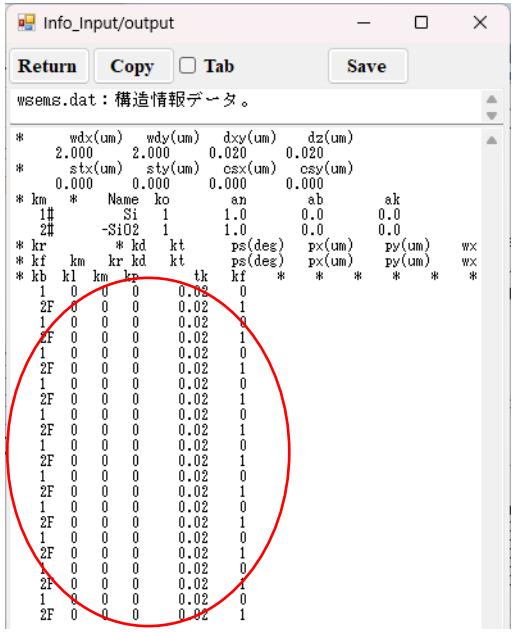
32. Reproduction and execution of wsf14.dat (2)

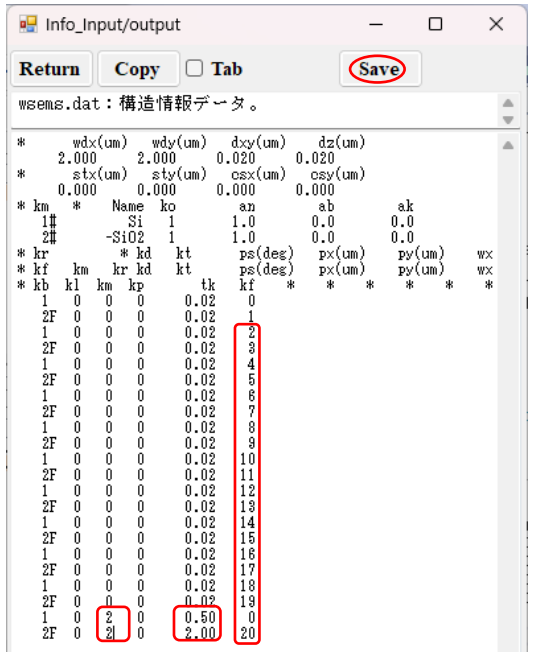
(9) Double-click wsems.dat in Result file box to display the information box (Info).





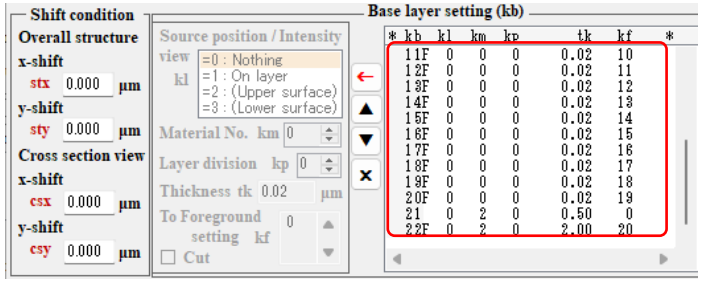
(10) Repeat copying and pasting the 1st and 2nd layers up to 22 layers.



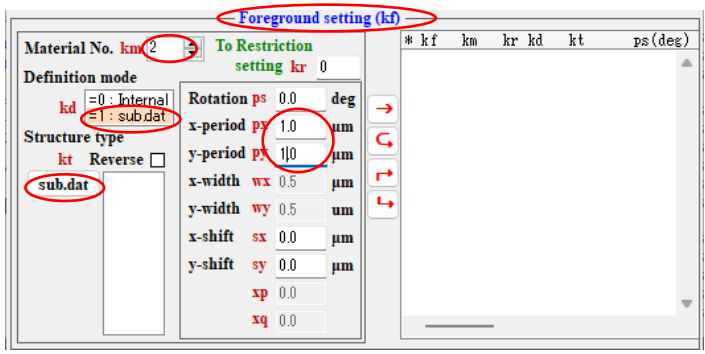


(11) Change kf to 2~19 by increasing by 1 for layers 3~20, 0 for layer 21, 20 for layer 22, tk to 0.5 for layer 21, 2.0 for layer 22, and km to 2 for layers 21 and 22. However, be sure to use half-width input and to prevent deviation in input position, as these may cause malfunctions.

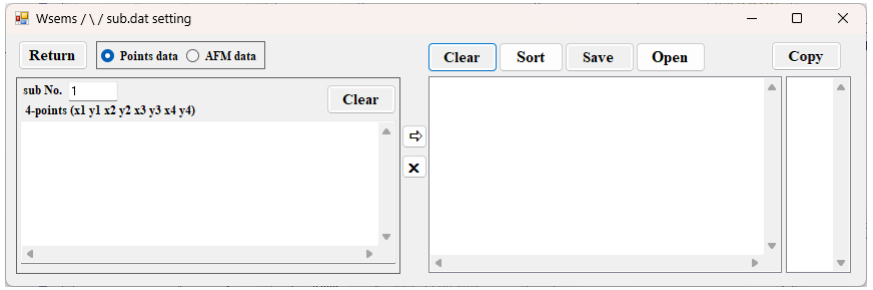
(12) When the Save button is clicked, the serial number is automatically modified and registered in Base layer setting with the same result as in (6).



(13) Click the ← button in Foreground setting to set km to 2, kd to 1 (“sub.dat”) and px and py to 1.0.

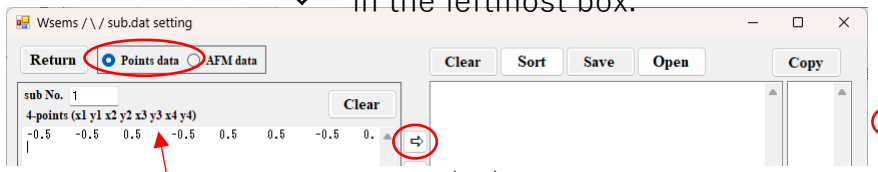


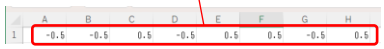
(14) Click the “sub.dat” button to open the sub.dat setting window.



33. Reproduction and execution of wsf14.dat (3)

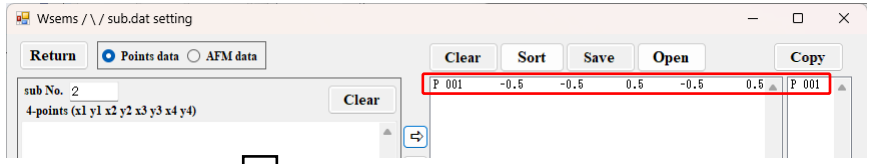
(15) Check “Points data” button and paste a part of “sub_data.xlsl” in the leftmost box.



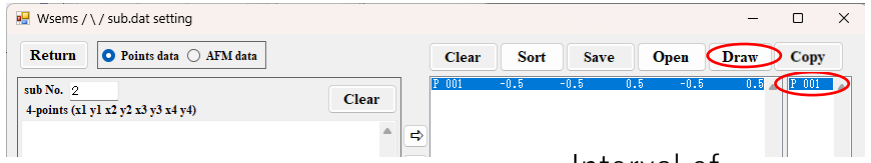


sub_data.xlsx

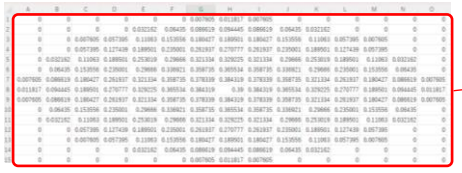
(16) Click the ⇒ button. The 1st data is registered in the two list boxes on the right.



(17) Click the top of the list in the rightmost box to select the 1st item.



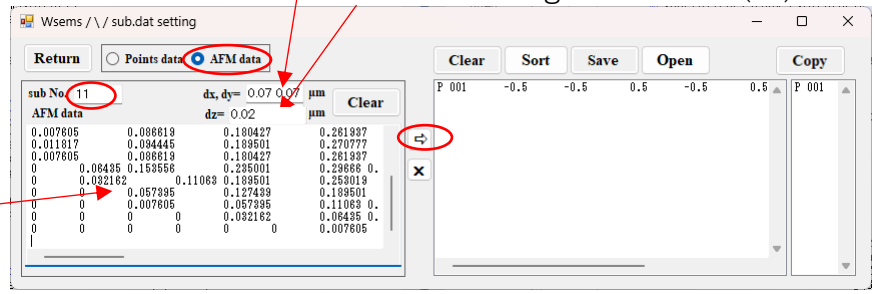
(18) Check the “AFM data” button and set the “sub No.” box to 11 (you may use the allocated number 2). Paste a part of “sub_data.xlsl” in the leftmost box.



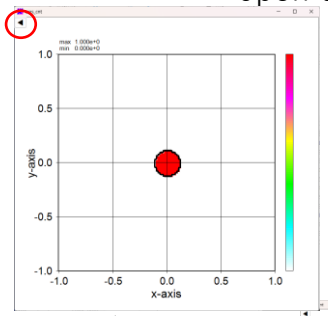
sub_data.xlsx

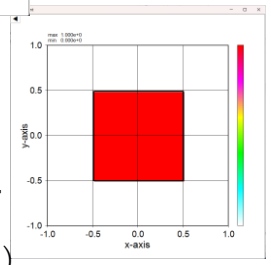
Interval of measurement points by AFM in xy direction

Interval in height direction (※)



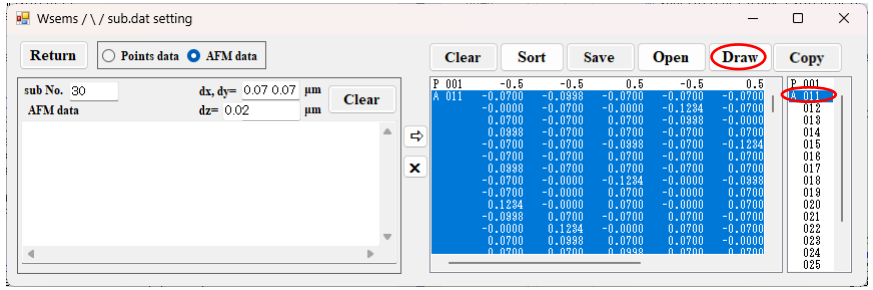
(18) Click the Draw button to draw the cross-sectional shape.



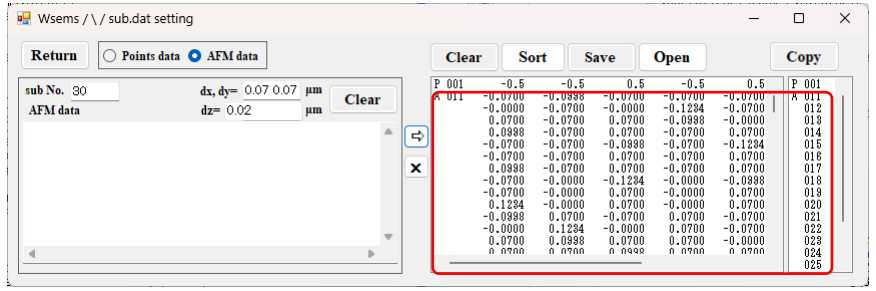


(21) Click the Draw button to draw a cross-sectional shape. If you click another line, you can see its sectional shape,

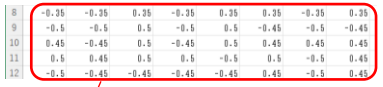
(19) Click the ⇒ button. The 2nd data is registered as allocated numbers from 11 to 29 in the right list boxes.



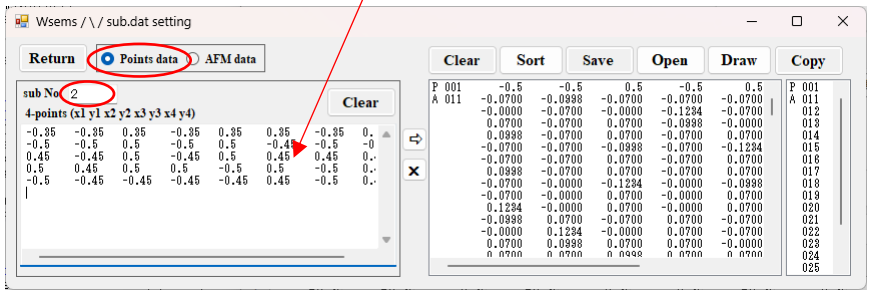
(20) Click on the 2nd line (Sub No. 11) of the list in the rightmost box to select the 2nd item .



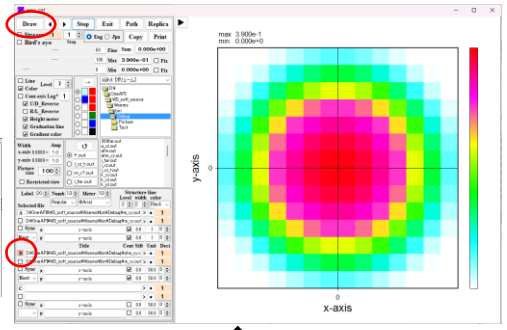
(22) Check the “Point data” button and set the “sub No.” box to 2. Paste a part of “sub_data.xlsl” in the leftmost box.



sub_data.xlsx



(21’) Click ◀ button to open the operation panel.

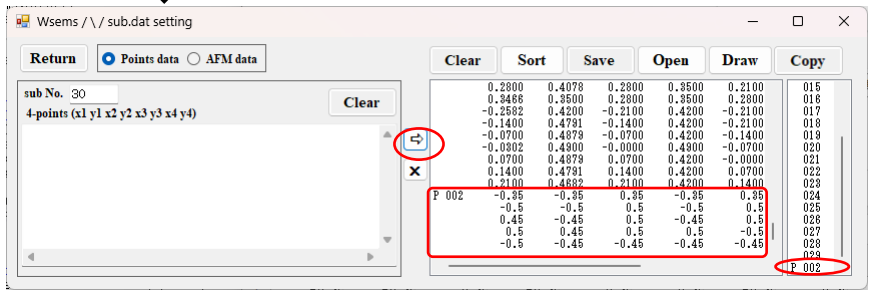


(21”) Select the B button and click the Draw button. Contour drawing of AFM data is displayed (afm_xy.out).

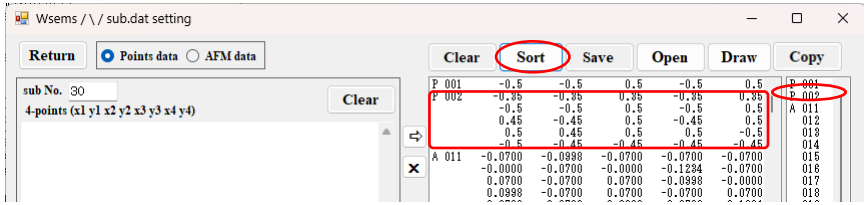
(※) Space-separated, azimuth angle of the plane normal with the z-axis (theta), angular angle of the plane normal around the z-axis(phi), and rotation angle of the measured image around the plane normal can be added in degree. In case of omission, they are treated as zero.

34. Reproduction and execution of wsf14.dat (4)

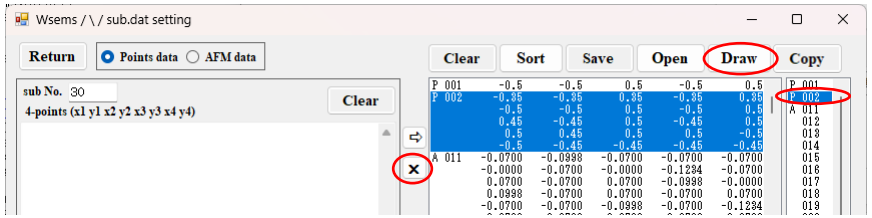
(23) Click the ⇒ button. Add Sub No. 2 data to the two list boxes on the right.



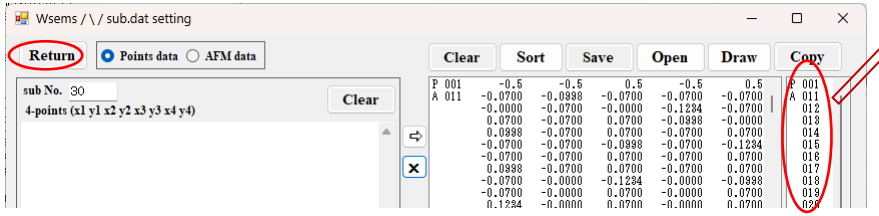
(24) Click the Sort button to sort the list in ascending order of sub. No.



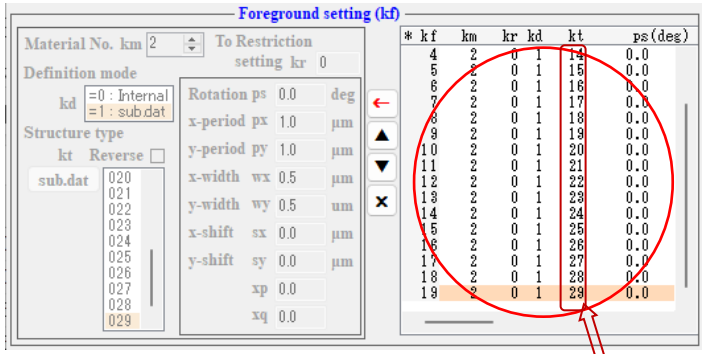
(25) Click on the 2nd line (Sub No. 2) of the rightmost list box to select the 2nd item.

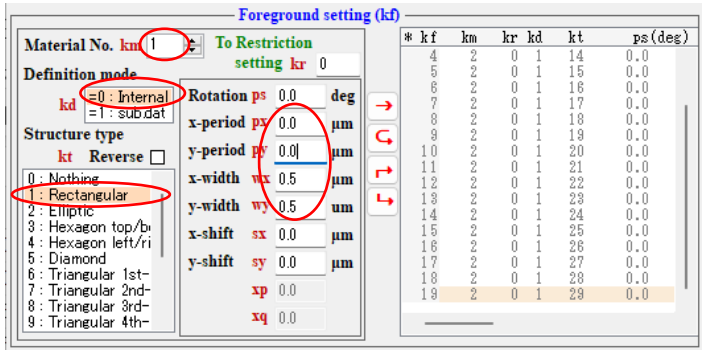


(27) If you want to delete Sub No.2, click the ×button in a state of a reversed background color.



(30) Click the ← button at the 19th line (kf=19) to move to the edit panel, and set km=1, kd=0 (“Internal”), kt=1 (“Rectangular”), and px=py=0.0, wx=wy=0.5.

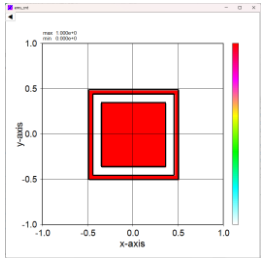


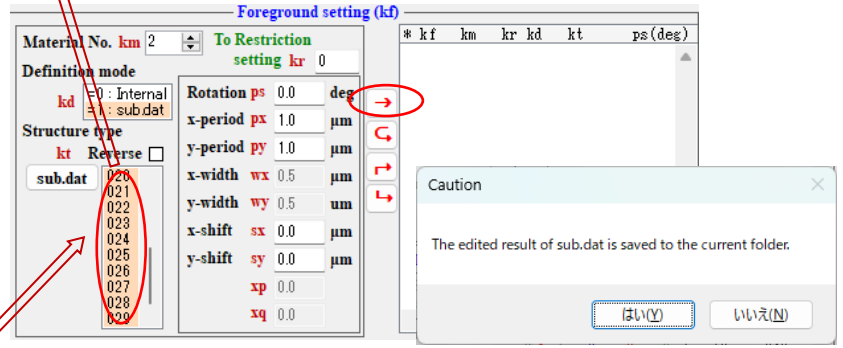


(24) In the list of “sub.dat”, select 11 for kt and click the → button. Register the 1st foreground structure in the list.

(29) Drag 11~29 in the kt list on the right side of the sub.dat button and click the → button with km=2 and px=py=1.0. Register the foreground structures of kf=1~19 in the list. The numbers of kt in the foreground structures call the serial numbers of sub.dat.

(26) Click the Draw button to draw a cross-sectional shape.



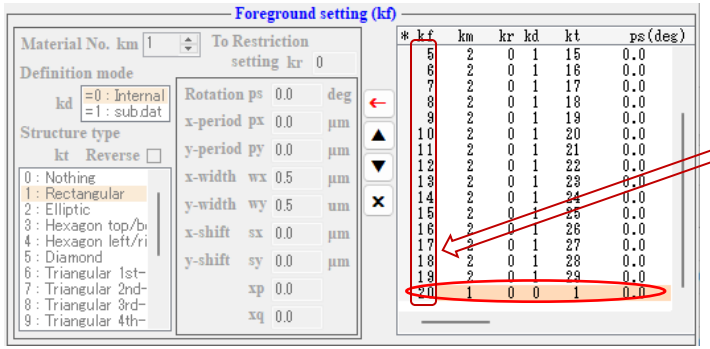


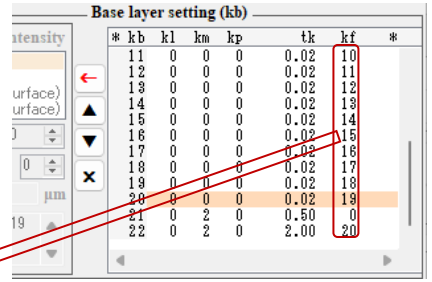
(28) Click the Return button to display Causion window. Press Yes button there, and return to the Foreground setting window.

The contents of the right box list are registered as the serial number of sub.dat.

35. Reproduction and execution of wsf14.dat (5)

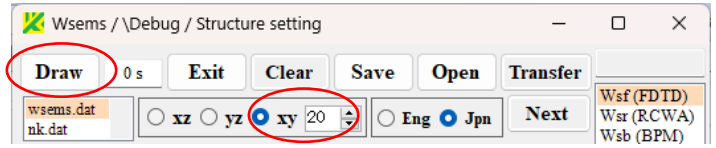
(31) Click the ↳ button to register the foreground structure of the 20th line.



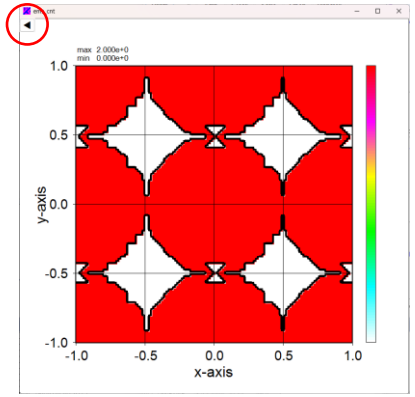


ベース層のkfの番号でその上に構成される前景構造を呼び出している。

(32) Check the xy button and set the right box to 20.

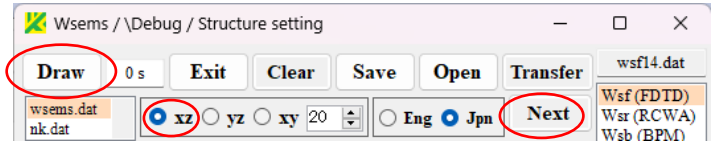


(33) Click the Draw button, and draw the xy cross-section of the 20th layer structure.

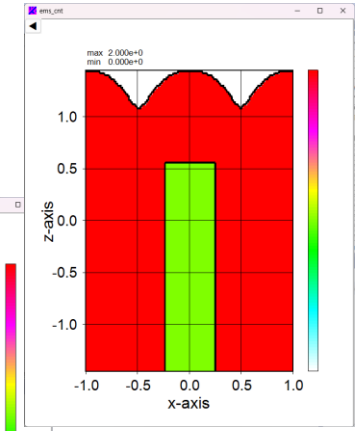


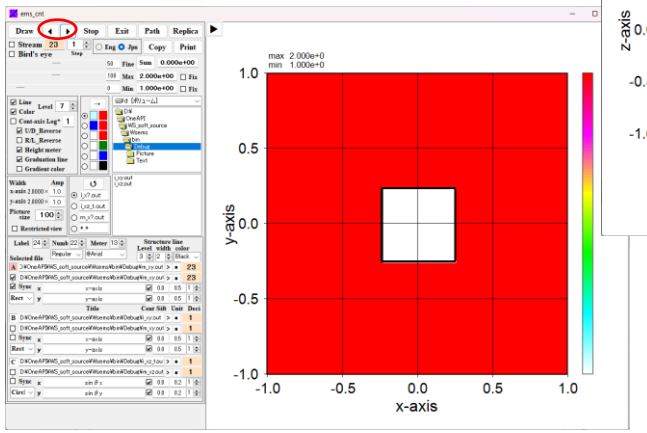
(34) On the Wscnt operation panel that appears by clicking the ◀ button, click the ◀▶ buttons to change the layer number in the cross-sectional view.

(35) Check xz button

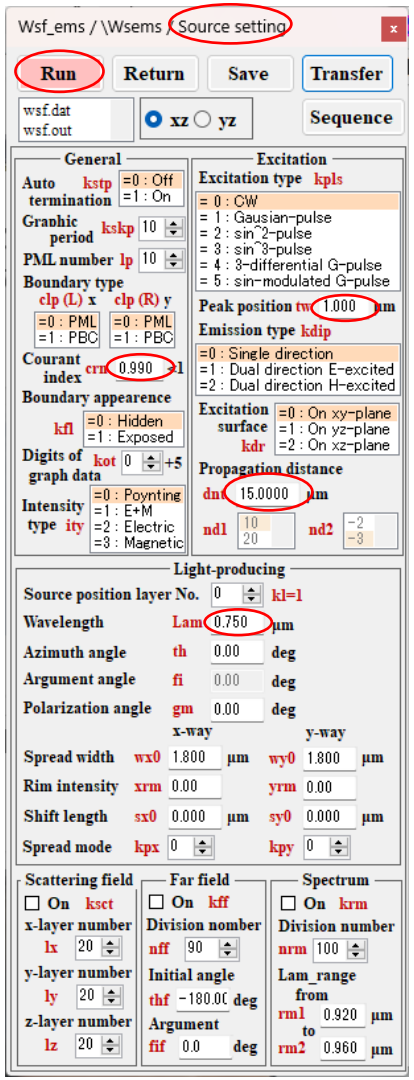


(36)Click the Draw button to draw the xz cross-section of the structure.

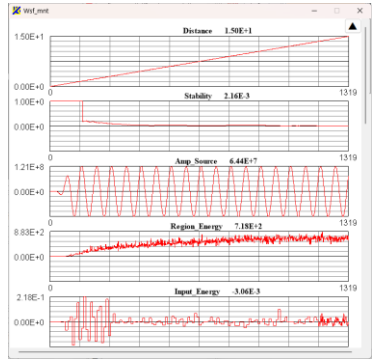


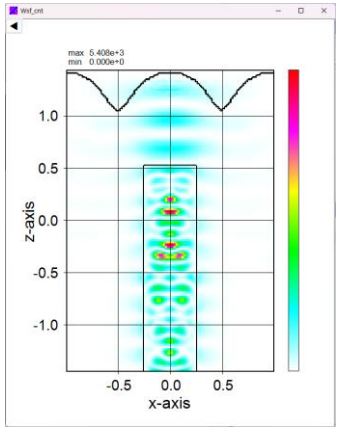


(37)Click the Next button to open the Source setting window and set each parameter as follows.



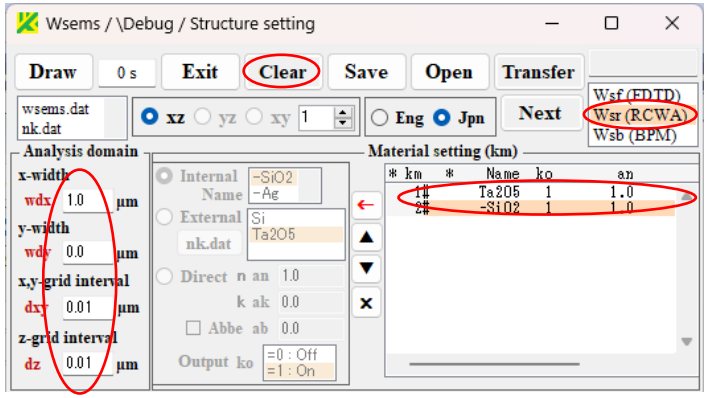
(38) Click the Run button to start calculations. The wave calculation results are alternately drawn by Wsmnt and Wscnt.



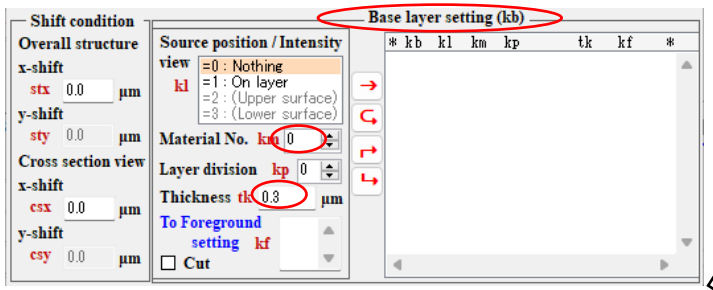


36. Reproduction and execution of wsr12.dat (1)

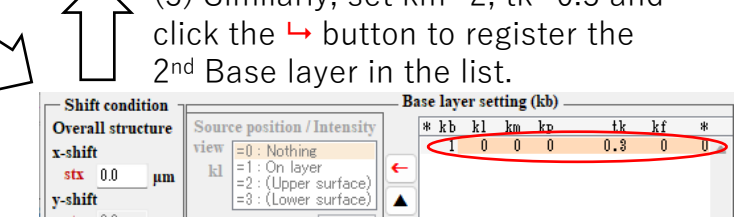
To reproduce wsr12.dat, let's set up structural conditions and execute it after defining source conditions.



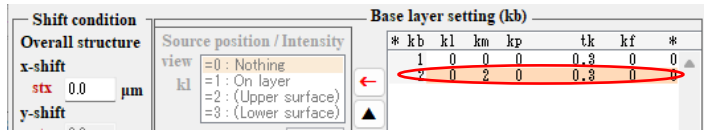
(1) Click Clear button and select Wsr(RCWA). Set wdx=1.0, wdy=0.0, and xy=dz=0.01. Register "Ta2O5" and "-SiO2" in Material setting. Click the ← button in Base layer setting to move to the edit panel.



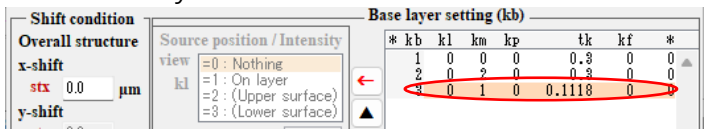
(2) Set km=0, tk=0.3 and click the → button. Register the 1st Base layer in the list



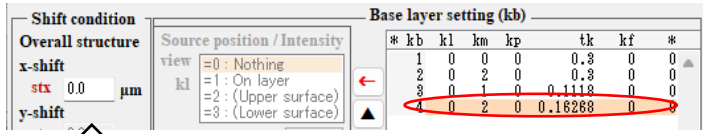
(3) Similarly, set km=2, tk=0.3 and click the ↳ button to register the 2nd Base layer in the list.



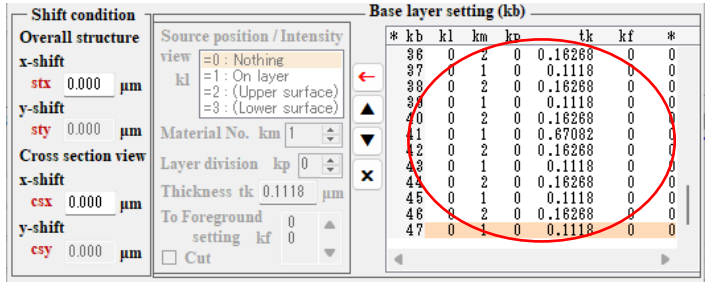
(4) Set km=1, tk=0.1118 and click the ↳ button to register the 3rd Base layer in the list.



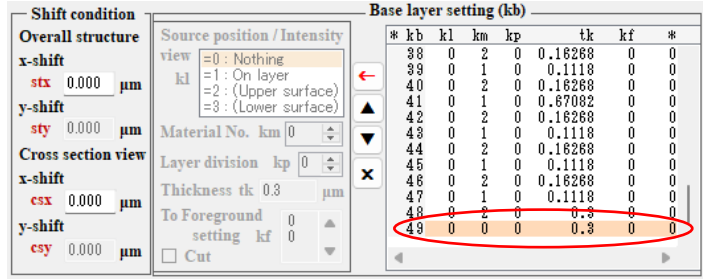
(5) Set km=2, tk=0.16268 and click the ↳ button to register the 4th Base layer in the list.



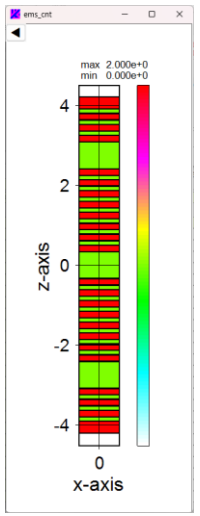
(6) Repeat the same process as previous (4)-(5) (however, tk=0.67082 for layer No. 9, 25, and 41) to register Base layers up to the 47th in the list. The way shown in (7) of page 29 is also available.



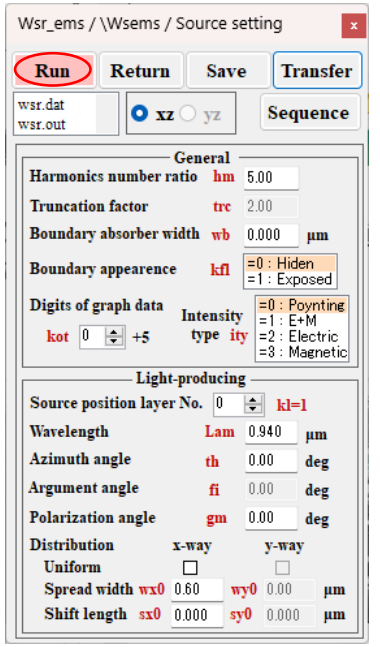
(7) Set km=2, tk=0.3 to register the 48th Base layer and km=0, tk=0.3 to register the 49th Base layer.



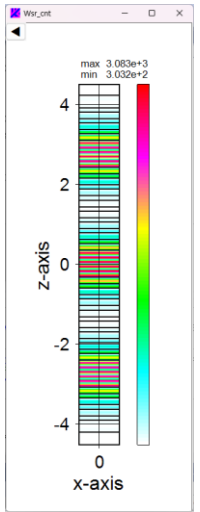
(8)Click the Draw button to draw the xz cross-section of the structure.



(9)Click the Next button to open the Source setting window and set each parameter as follows.

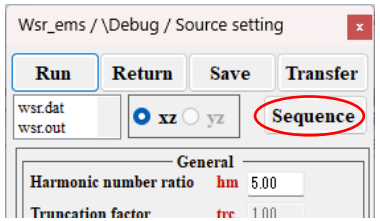


(10) Click the Run button to draw an xz cross-section of the calculated light intensity distribution.

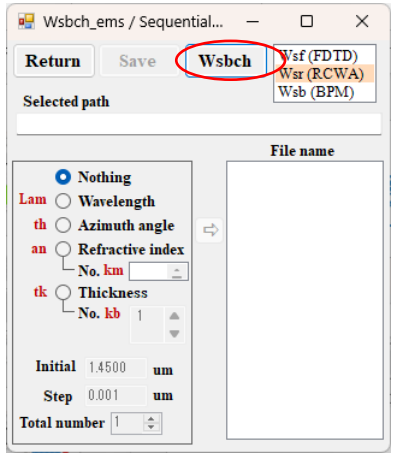


37. Reproduction and execution of wsr12.dat (2)

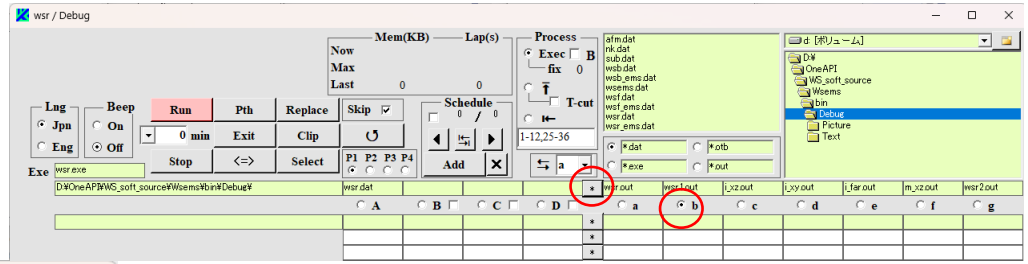
Next, let's perform continuous calculations with wavelength as a parameter.



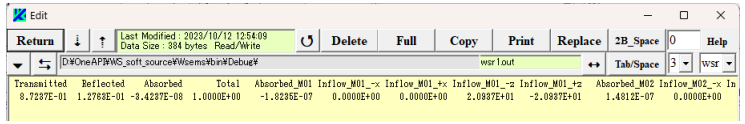
(11)Click the Sequence button to open the Sequential window.

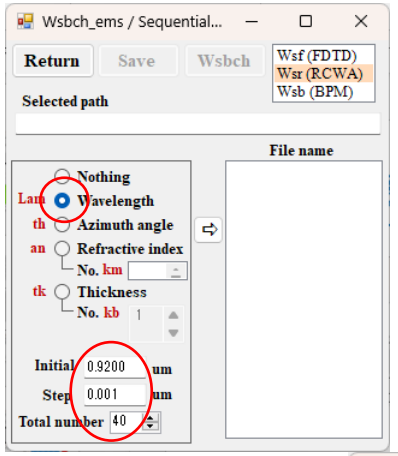


(12)Click the Wsbch button to open the Wsbch window (see "How to use Wsbch" at our site).



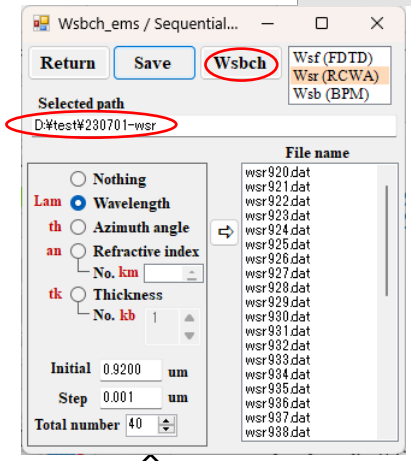
(13) Check the "b" button and click the "*" button to open the Edit window, where you can view the calculation results (wsr1.out)※.
※ See P43-45 about output contents.



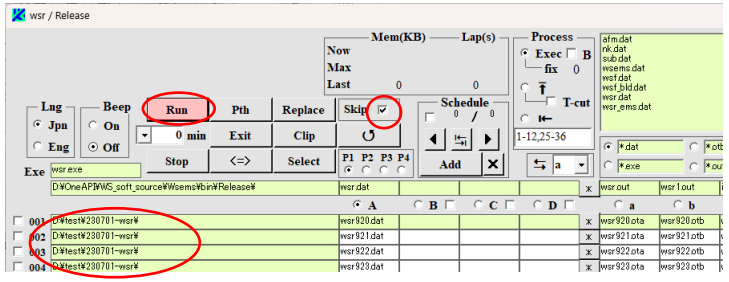


(14)Check Wavelength button and set each parameter as follows.

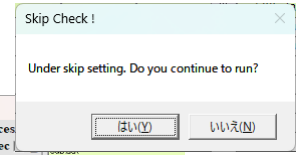
(16) Click the Save button, select a folder on the selection window, and click the OK button (if you create a new folder, type a folder name and press an Enter key to confirm the input).



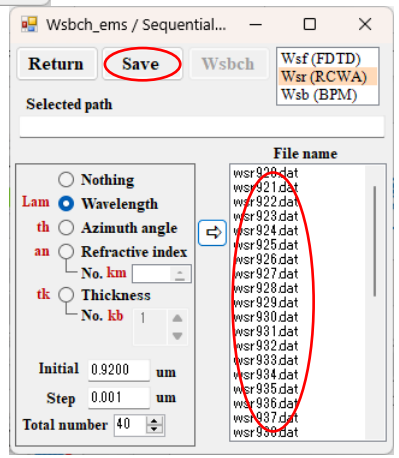
(18) Click the Wsbch button to open the Wsbch window where data for continuous calculations are set .

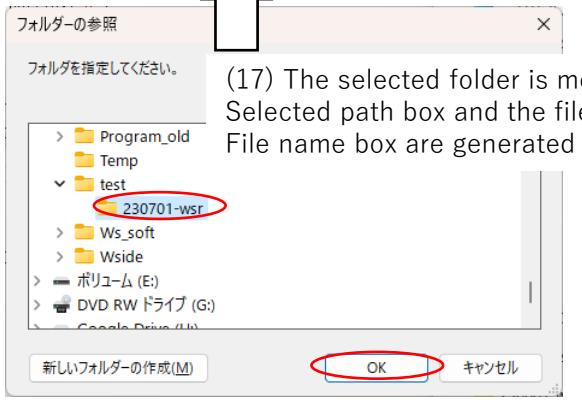


(19) Click the Run button, a confirmation window appears, and click "Yes" there to start continuous calculations. If the calculation has already been performed, it will be skipped. If recalculation is required, uncheck the Skip box before clicking the Run button. Data for which calculations have been completed will be checked in the left-most box in sequence.

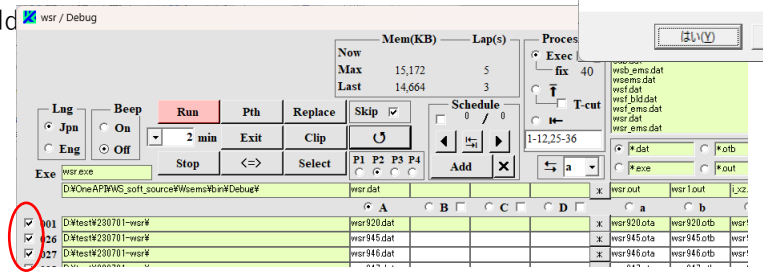


(15) Click the ⇒ button to register file names. 40 files beginning with wavelength 0.920 in increments of 0.001 are generated in the File name list and file names corresponding to the parameters are automatically allocated.



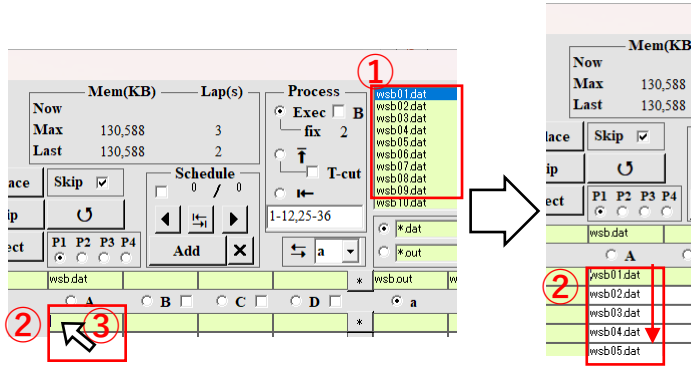


(17) The selected folder is mentioned in Selected path box and the files listed on the File name box are generated in the fold

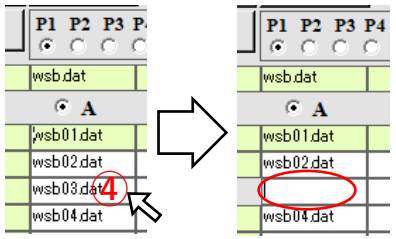


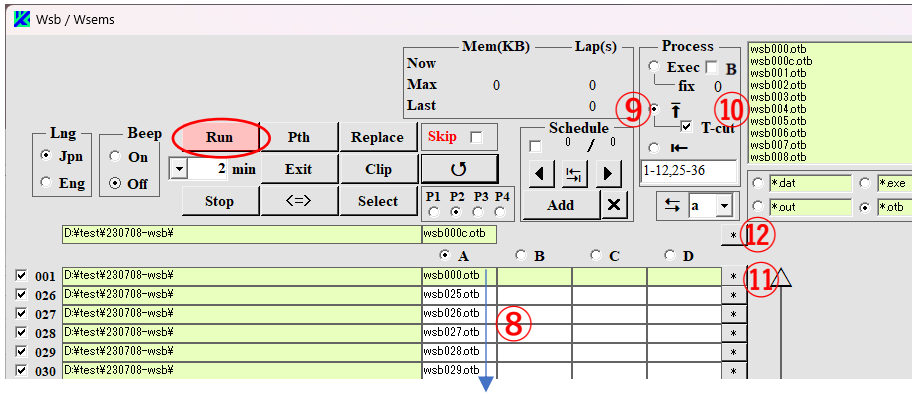
38. A side trip (about Wsbch)

Let's briefly explain the operation of Wsbch.

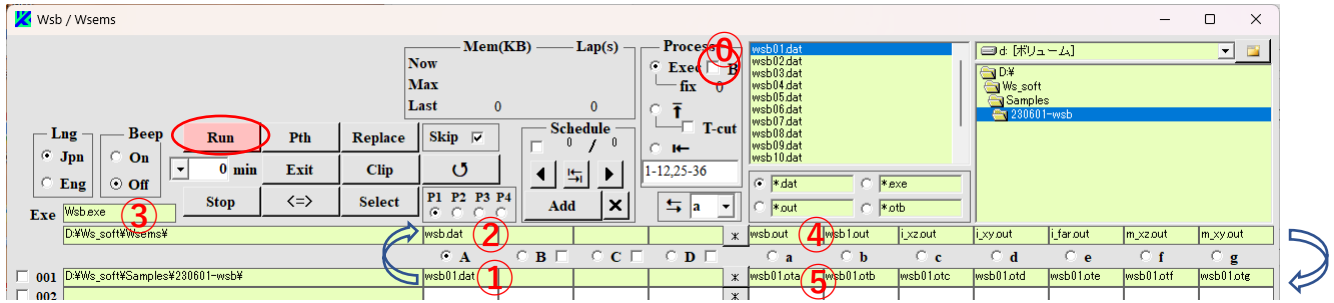


(1) If you want to register the files in the list ① to the input file box ② in column A, click the top box ③ and press Enter key. If you want to delete an individual list, click the corresponding box ④.

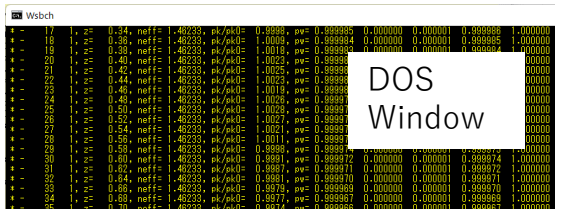


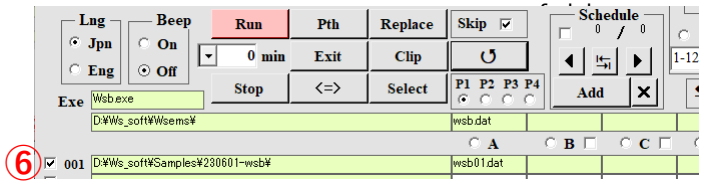


(5) To merge the output results, line up the targets in column A box ⑧, check button ⑨ (with checked T_Cut box ⑩ in Process box), and click the Run button .

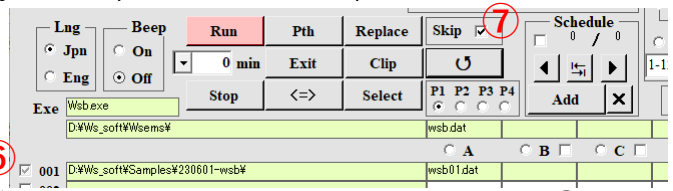


(2) When the Run button is clicked, the Dos window appears, and the calculation begins. If you want to prevent a bust state due to opening windows, you can hide the Dos (or Wscnt) window by checking the box B ⓪ in Process box. The calculation flow is as follows: input file ① (wsb01.dat, etc.) in calculation folder is copied to input file ② (wsb.dat) in exe folder including exe file ③ (wsb.exe). By executing the exe file, output files ④ (wsb.out, etc.) are generated in the exe folder, and they are copied back to output files ⑤ (wsb01.ota, etc.) in calculation

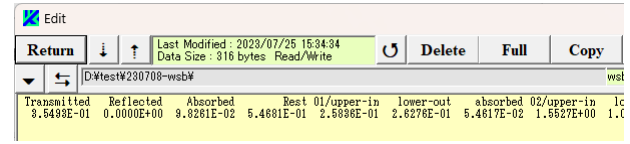




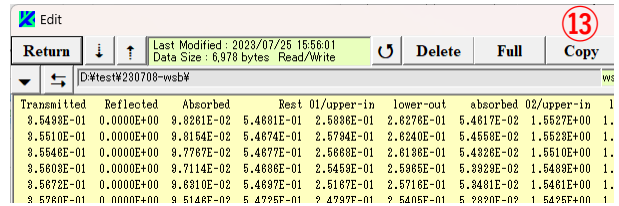
(3) When the calculation is completed, the Dos window disappears, the box ⑥ is checked, and the next row calculation begins.



(4) If the output file already exists, box ⑥ is checked in gray and the calculation is skipped to the next row. If you need to calculate the current row, uncheck Skip box ⑦ before starting the calculation.



(6) The file contents that appear when the top button ＊ ⑪ is clicked.

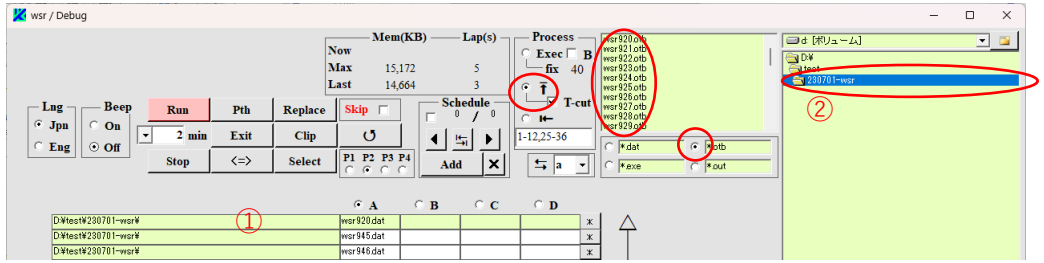


(7) Clicking the * button ⑫ displays the contents of the merged file, where the first line (Transmitted, etc.) for the 2nd and subsequent files is deleted. It can be easily shown graphically by clicking the Copy button ⑬ and pasting it into Excel.

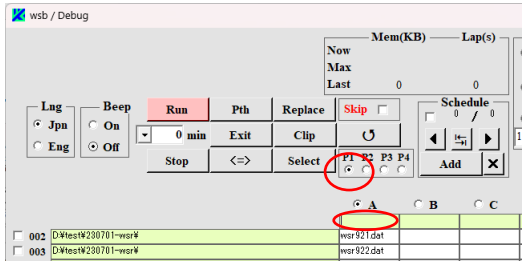
39. Reproduction and execution of wsr12.dat (3)

Last, concatenate the calculated results and paste it to Excel for producing graphs.

(20) After completing the calculations, check the t̄ button. Right-click on the first line ① of the path box to change the directory ② to the same folder as the path box. Set the file pattern to *.otb and display *.otb files in the file list.

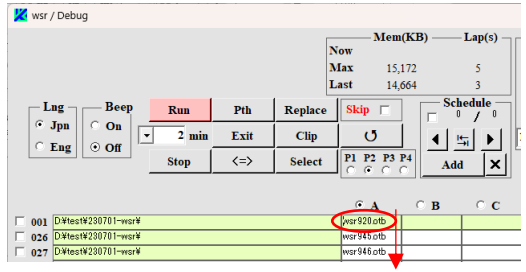


(21) When the first line box of column A is clicked, the display of the box disappears.



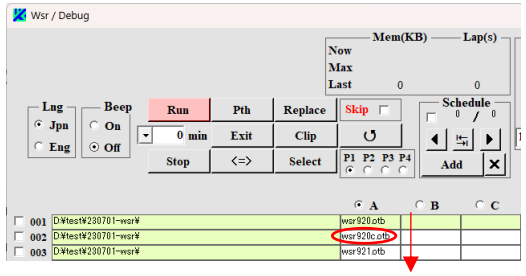
Where an *c.otb file is not included in the list.

(22) By pressing Enter key, the *.otb files are listed in order on column A boxes.

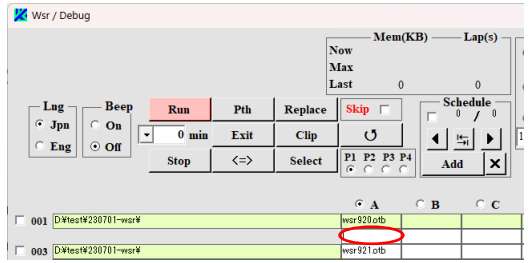


Where an *c.otb file is included in the list.

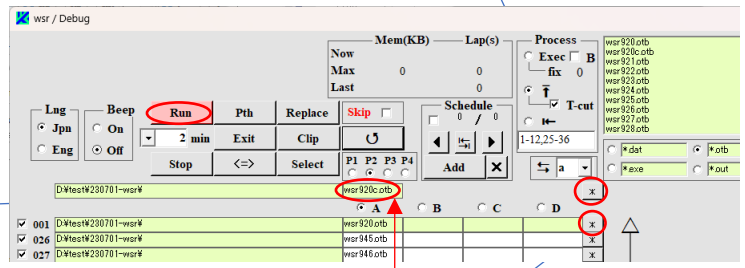
(22') By pressing Enter key, the *.otb files are listed in order on column A boxes.



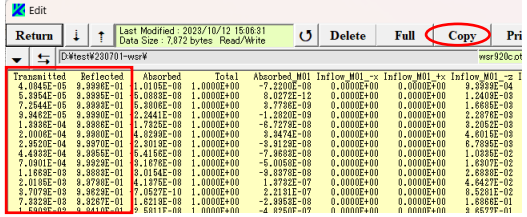
(22") Click on the box listing the *c.otb file to delete its display.



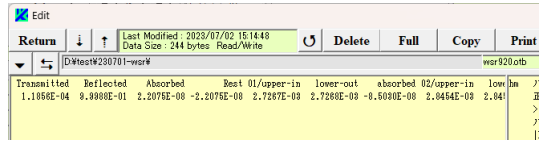
(23) When the Run button is clicked, the *.otb files in column A boxes are concatenated in order, and the concatenated result is stored in the box that appears above the top line with the file name *c.otb.



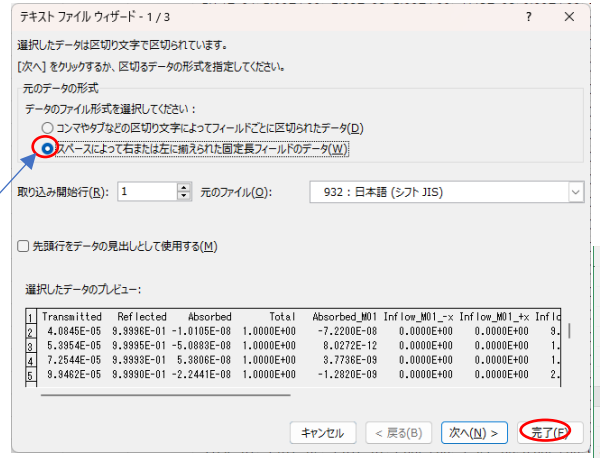
(24) Clicking on the * button to the right of the *c.otb file box brings up an Edit window, where the concatenated results are viewed .



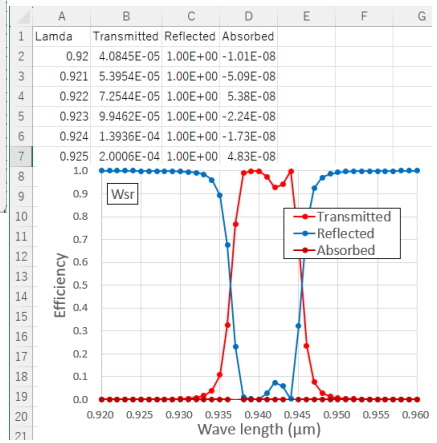
(24') Clicking on an * button to the right of the column A boxes brings up an Edit window, where the contents of the *.otb file are viewed individually.



Check this button in Text File Wizard of Excel and press the confirmation button.



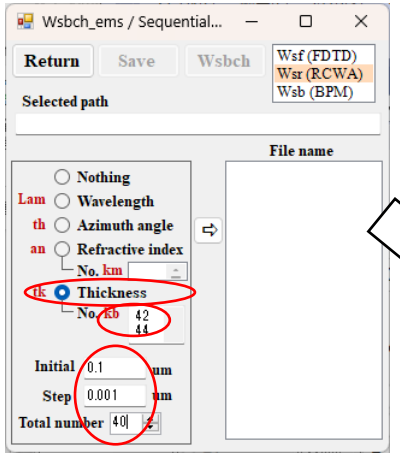
(25) Click the Copy button to paste the contents into Excel.



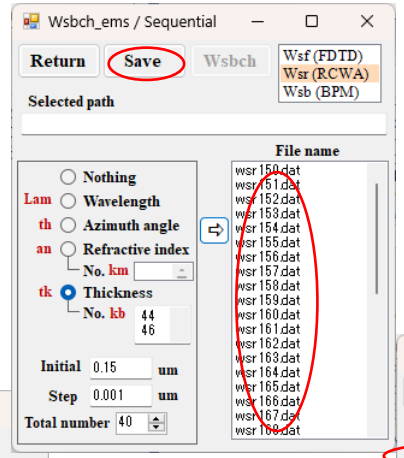
40. Reproduction and execution of wsr12.dat (4)

Let's perform continuous calculations with layer thickness for multiple layers (22 layers of SiO2) as a parameter.

(26)Check Thickness button and set each parameter as follows. kb is set to even numbers from 4 to 46 corresponding to the line number of alternately stacked layers of SiO2.

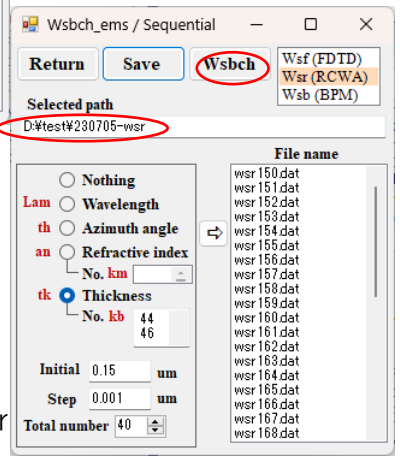


(27) Click the ⇒ button to register file names. 40 files beginning with thickness 0.15 in increments of 0.001 are generated and file names corresponding to the parameters are automatically allocated.

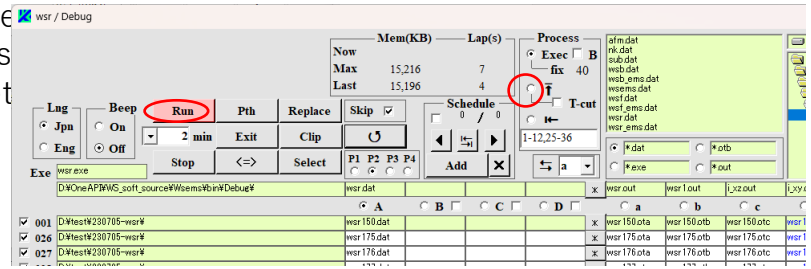


(28) Click the Save button, select a folder (if needed, create a new folder) on the selection window, and click the OK button.

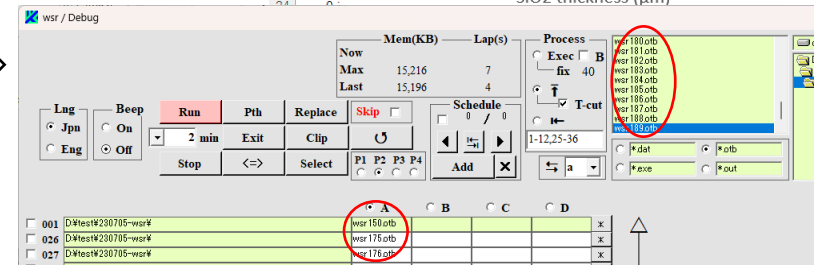
(29) The selected folder is mentioned in Selected path box and the files listed on the File name box are generated in the folder



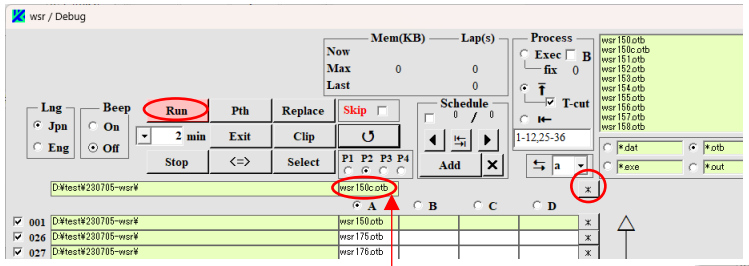
(30) Click the Wsbch button to open the Wsbch window where data for continuous calculations are set



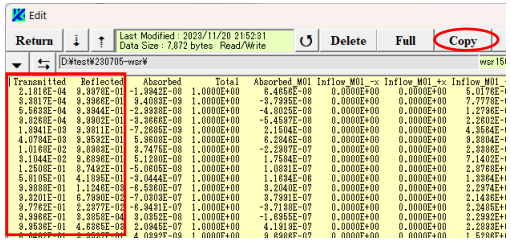
(31) Click the Run button to perform continuous calculations. After calculations are completed, check the T̄ button, and list the calculated *.otb files on column A boxes (see (20) – (22)).



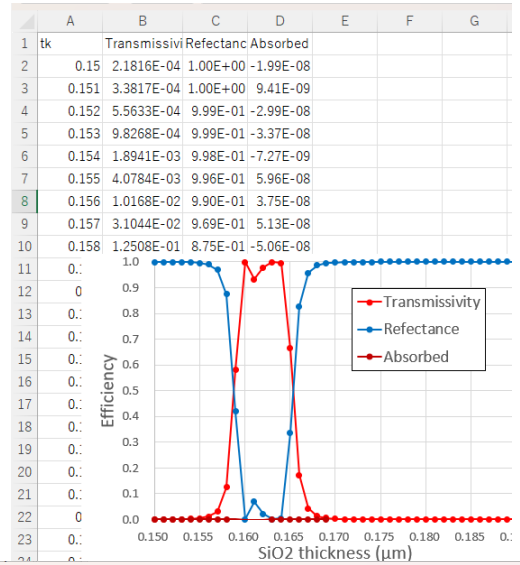
(32) Click the Run button to concatenate contents of the *.otb files listed in column A boxes.



(33) Click the * button on the right of the concatenated box and open the Edit window to view the results of the concatenation.



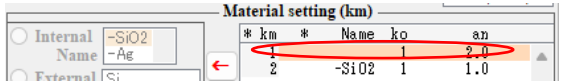
(34) Click the Copy button and paste the content into Excel.



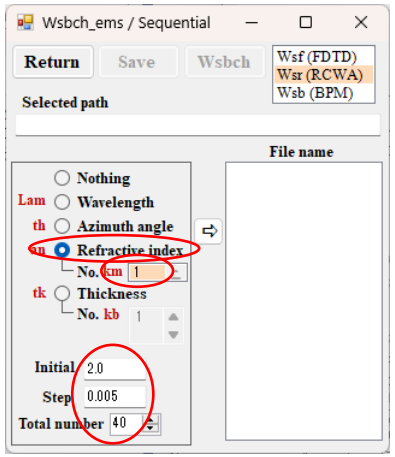
41. Reproduction and execution of wsr12.dat (5)

Let's perform continuous calculations with refractive index by direct definition as a parameter.

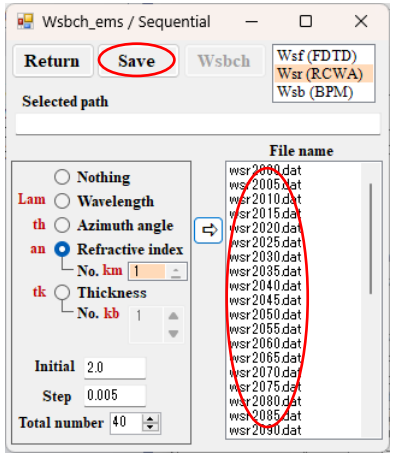
(35) Change material of km=1 to an=2.0 in Direct input.



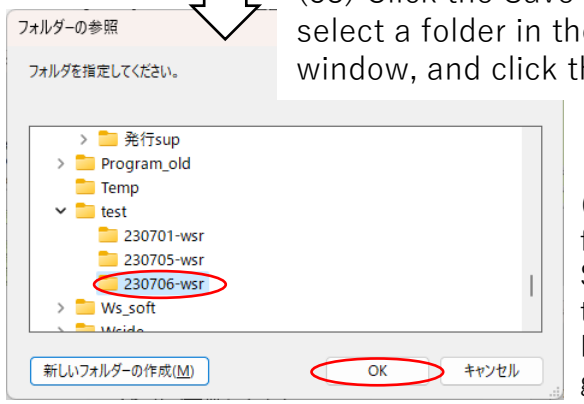
(36)Check the Refractive index button, select km=1, and set each parameter as follows.



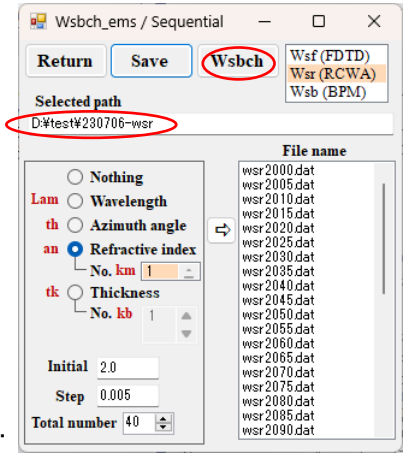
(37) Click ⇒ button to register File names. 40 files beginning with refractive index 2.00 in increments of 0.005 are generated and file names corresponding to the parameters are automatically allocated.



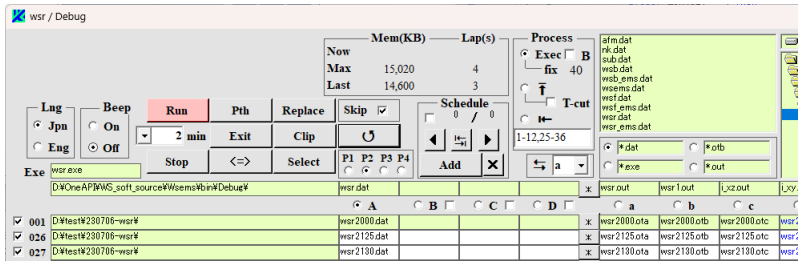
(38) Click the Save button to select a folder in the selection window, and click the OK button.



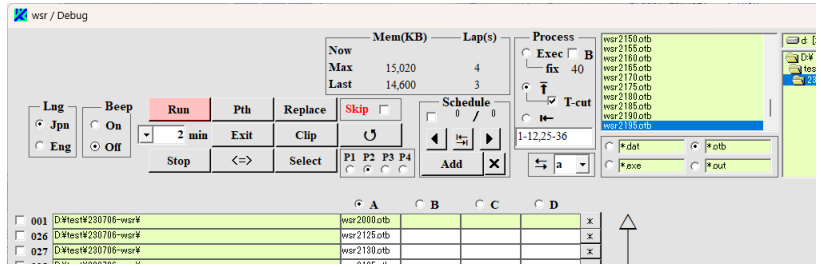
(39) The selected folder is mentioned in Selected path box and the files listed on the File name box are generated in the folder.



(40) Click the Wsbch button to open the Wsbch window where data for continuous calculations are set .

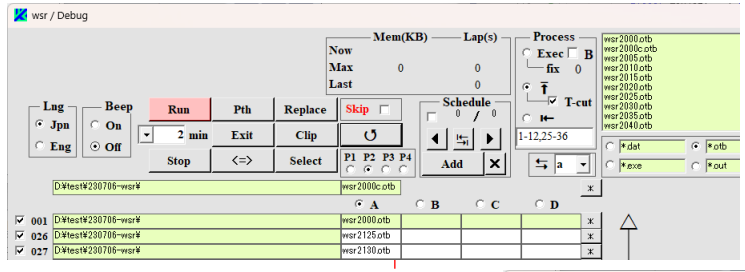


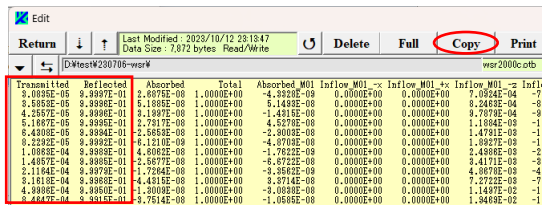
(41) Click the Run button to perform continuous calculations. After calculations are completed, check the ⊼ button, and list the calculated *.otb files on column A boxes (see (20) – (22)).



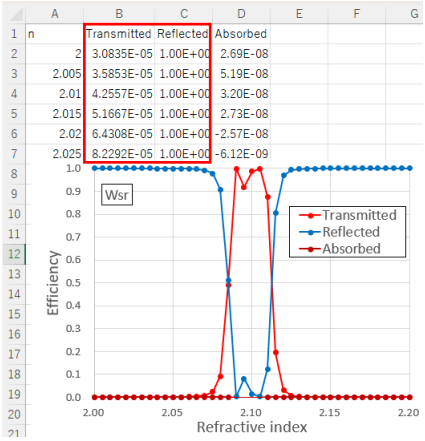
(42) Click the Run button to concatenate contents of the *.otb files listed in column A boxes.

(43) Click the * button on the right of the concatenated box and open the Edit window to view the results of the concatenation.





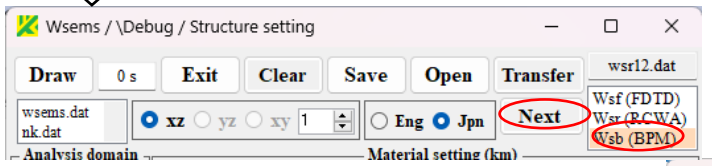
(44) Click the Copy button and paste the content into Excel.



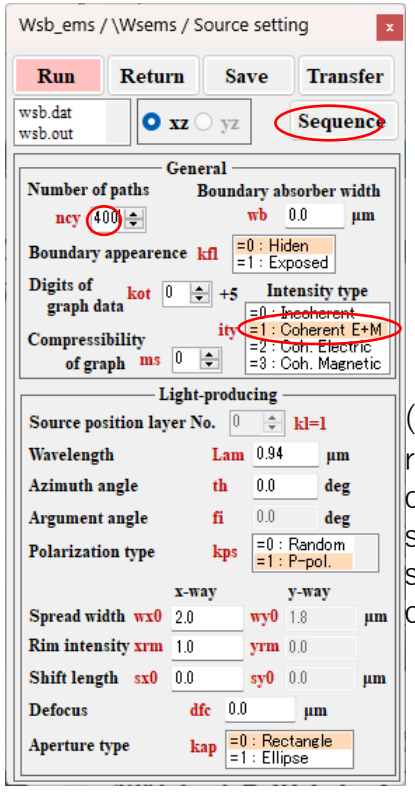
42. Reproduction and execution of wsb13.dat

Let's move on to Wsb using the same structural conditions, define the light source conditions, and perform a calculation (return of Wsb14.dat).

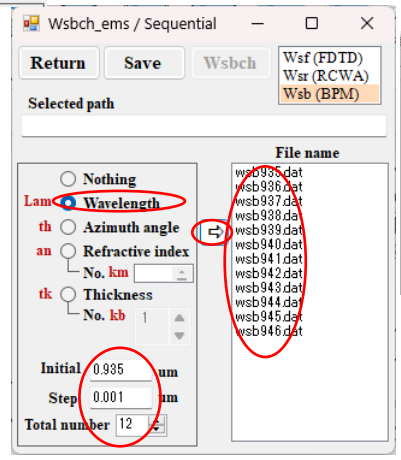
(1) Select Wsb(BPM) in Structure setting.
wdx in Structure setting is set to 0.1



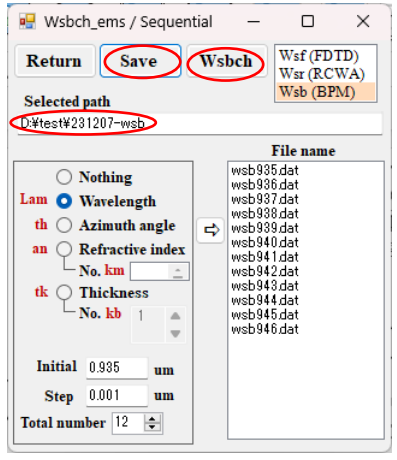
(2) Click Next button to open the Source setting window, and set each parameter as shown on the below (ncy=400 and ity=1).



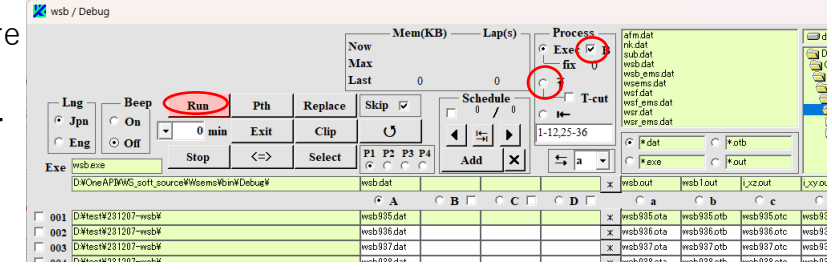
(3)Check Wavelength button and set each parameter as the right.



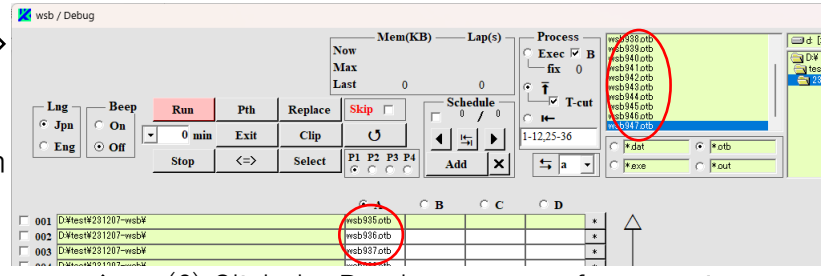
(4) Click the ⇒ button to register file names and click the Save button to select a folder in the selection window, and click the OK button.



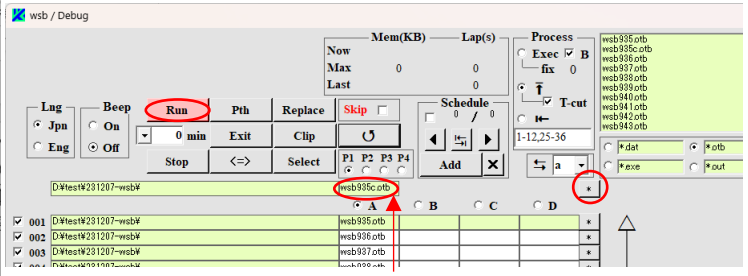
(5) Click the Wsbch button to open the Wsbch window where data for continuous calculations are set .



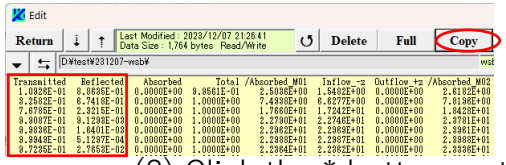
(6) Click the Run button to perform continuous calculations (where B-box is checked to prevent a bust state due to opening windows of wscnt). After calculations are completed, check the t̄ button, and list the calculated *.otb files on column A boxes (see (20) – (22)).



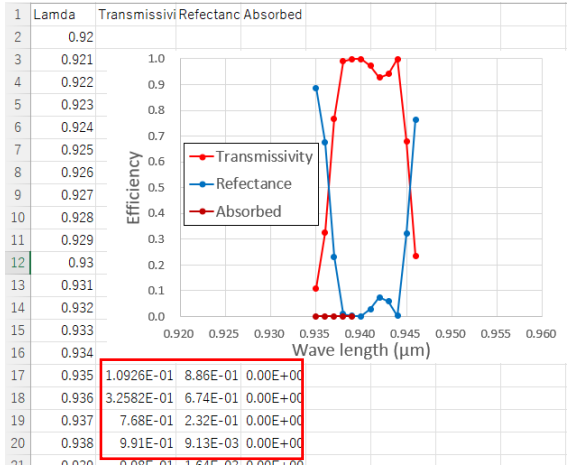
(7) Click the Run button to concatenate contents of the *.otb files listed in column A boxes.



(8) Click the * button on the right of the concatenated box and open the Edit window to view the results of the concatenation.



(9) Click the Copy button and paste the content into Excel.

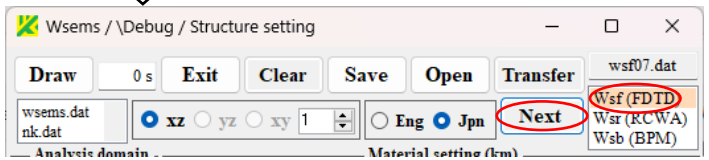


(10)For other range than wavelength 0.935-956, calculation results diverge due to an exceeding multiple reflection.

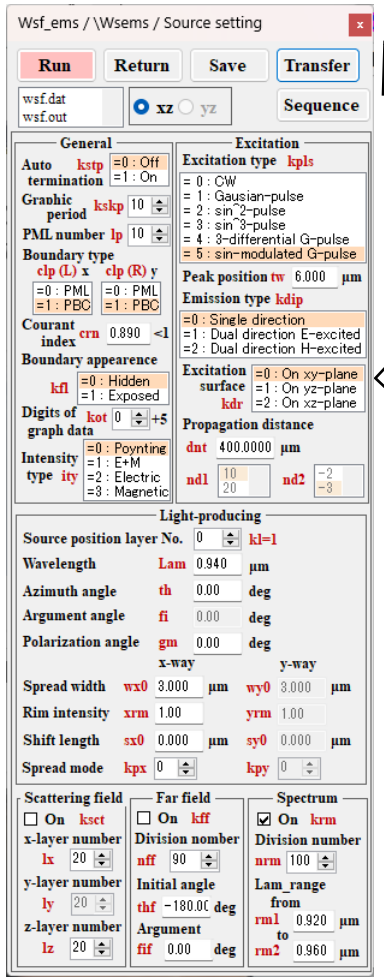
43. Reproduction and execution of wsf07.dat

Let's move on to Wsf using the same structural conditions, define the light source conditions, and perform a calculation using frequency analysis (return of Wsf07.dat).

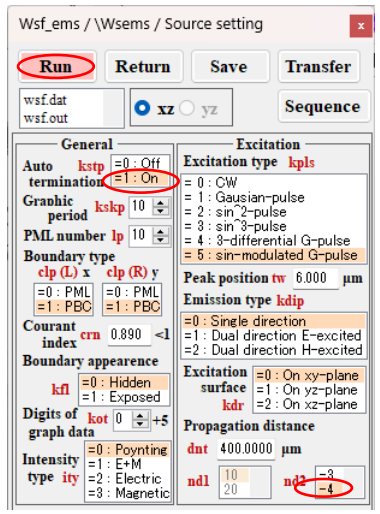
(1) Select Wsf(FDTD) in Structure setting.
wdx in Structure setting is set to 0.1



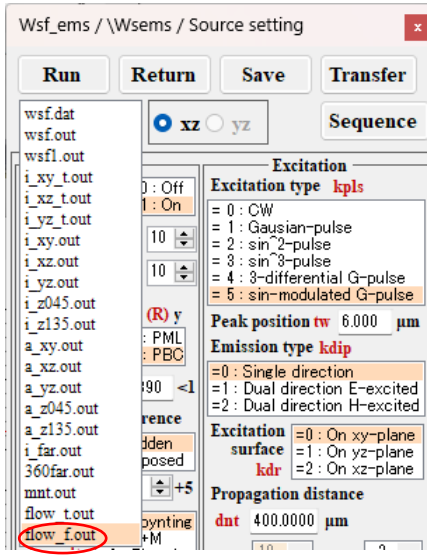
(2) Click Next button to open the Source setting window, and set each parameter as shown on the left .

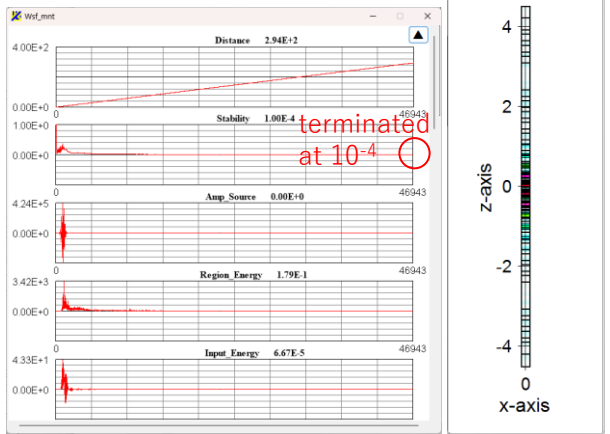


(3) You can run the program as it is, but let's try the auto-termination. Set kstp=1 and md2=-4.

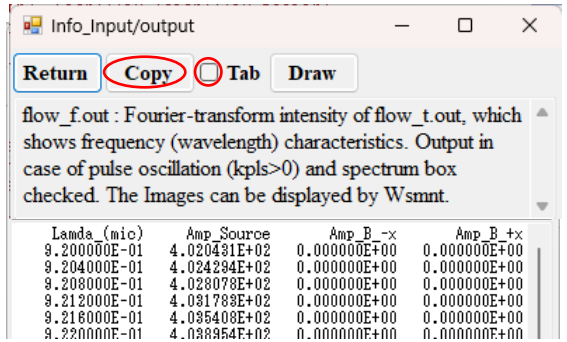


(4) Click the Run button.
At the start of calculation, the xz cross-section of the light intensity distribution is plotted.



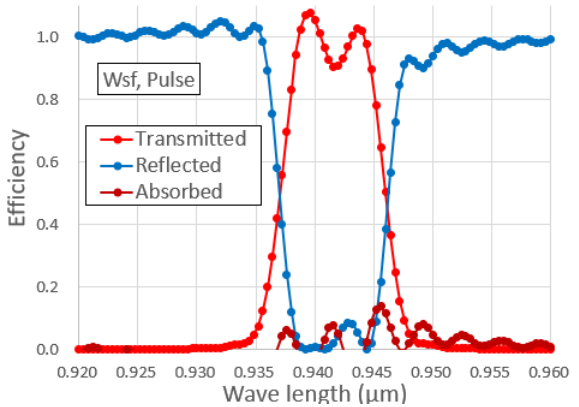


(5) Place the pointer over Result file box to expand it and double-click flow_f.out.



(6) Check the Tab button, click the Copy button, and paste it into Excel.

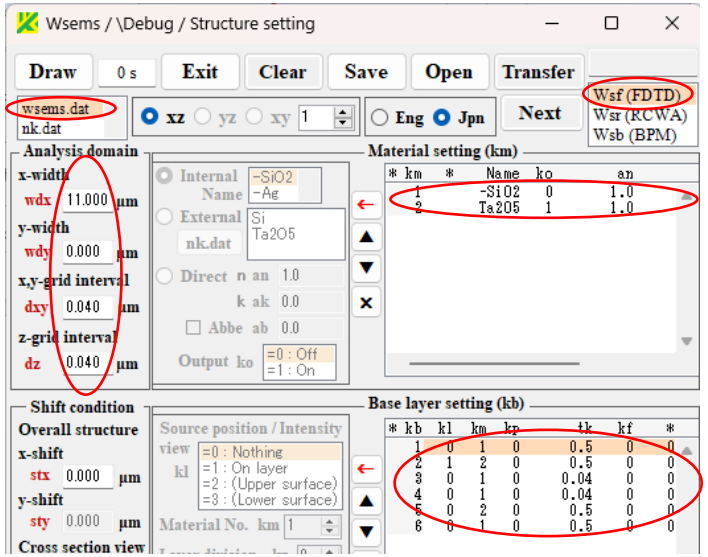
	A	B	C	D	E	F	G
1	Lamda_(n	Amp_Source	Amp_B_-z	Amp_B_+z	Transmitted	Reflected	Absorbed
2	9.20E-01	4.02E+02	4.04E+02	2.39E-02	5.94E-05	1.01E+00	-5.92E-03
3	9.20E-01	4.02E+02	4.03E+02	3.10E-02	7.70E-05	1.00E+00	-9.93E-04
4	9.21E-01	4.03E+02	4.01E+02	3.05E-02	7.56E-05	9.96E-01	4.38E-03
5	9.21E-01	4.03E+02	4.01E+02	2.27E-02	5.64E-05	9.94E-01	6.11E-03
6	9.22						
7	9.22						
8	9.22						
9	9.22						
10	9.22						
11	9.22						
12	9.22						
13	9.22						
14	9.25						
15	9.25						
16	9.26						
17	9.26						
18	9.26						



(7) Normalize Amp_B_-z and Amp_B_+z by Amp_Source to get reflectance and transmissivity and add both and subtract from 1 to get absorption coefficient. The accuracy increases as the propagation distance (Distance).

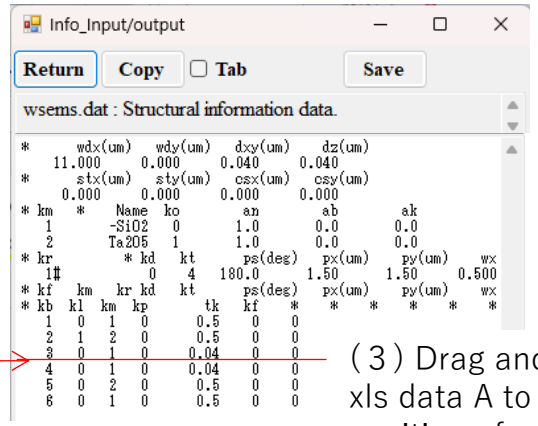
44. Reproduction and execution of wsf15.dat (1)

With the goal of creating wsf15.dat with a complex stacked structure, set the structural conditions, define the light source conditions, and run the calculation.

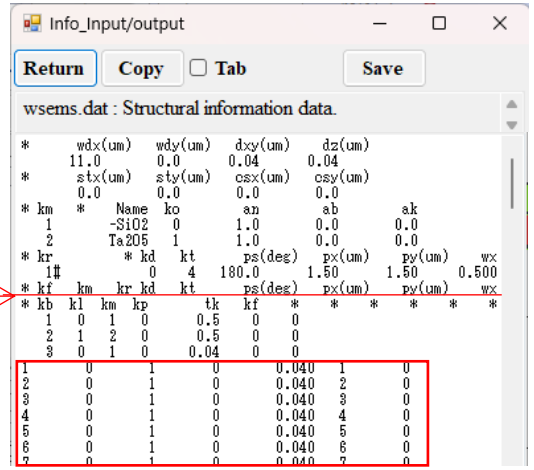


(1) Select Wsf(FDTD) in Structure setting, and set Domain, Material and Base layer as above.

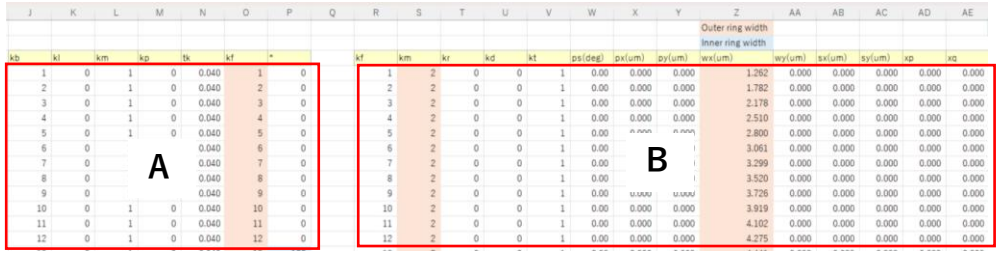
(2) Double-click wsems.dat in Result file box.



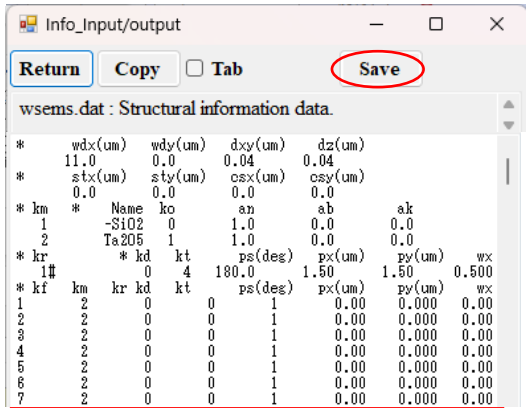
(3) Drag and paste xls data A to the position of arrow →.



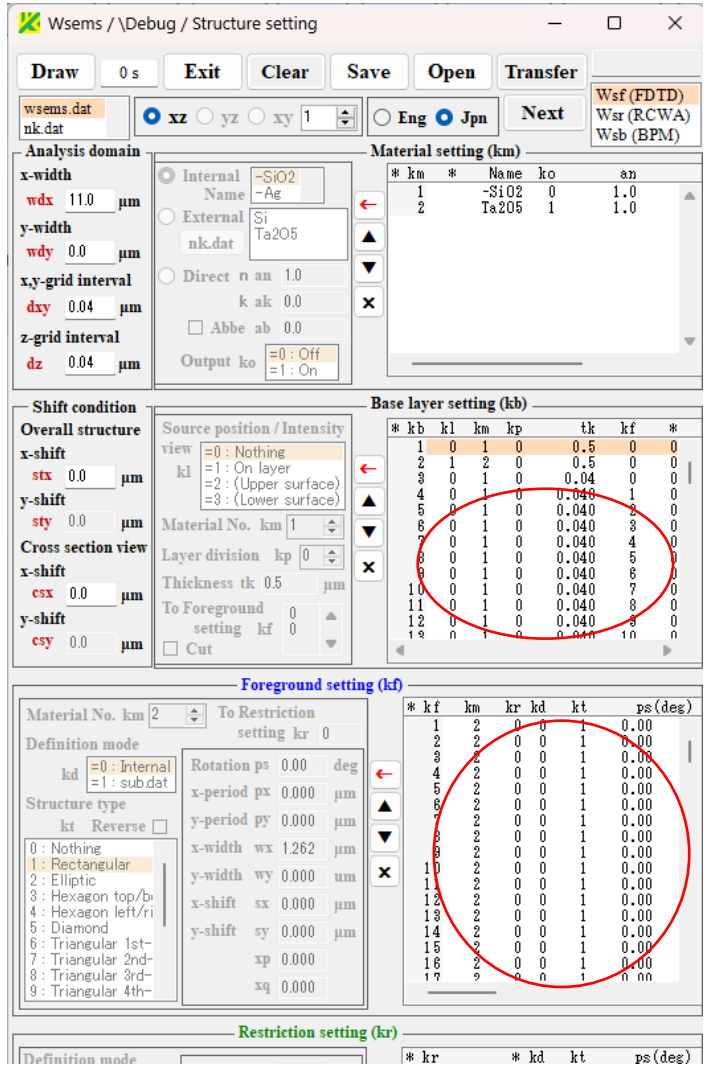
(4) Drag and paste the xls data B to the → position.



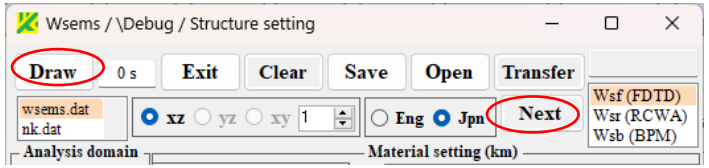
¥samples¥Wsems_data.xlsx



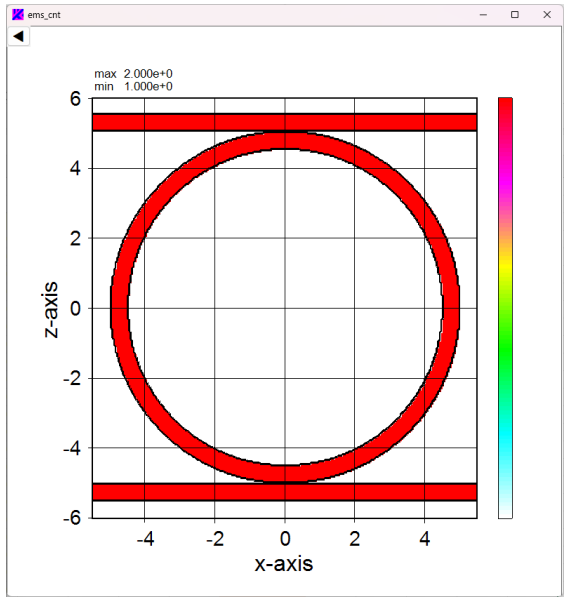
(5) Click the Save button. The additional parts are aligned and reflected in the lists of the Base layer and Foreground.



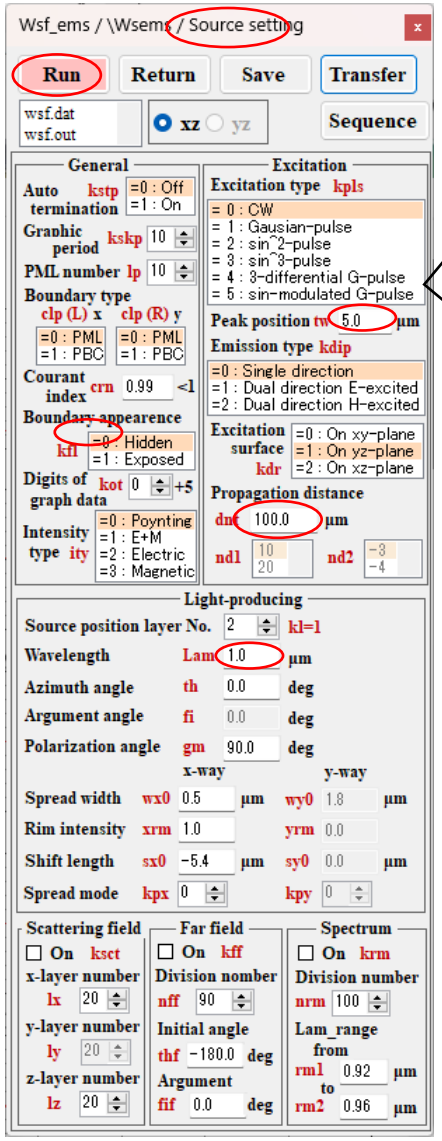
45. Reproduction and execution of wsf15.dat (2)



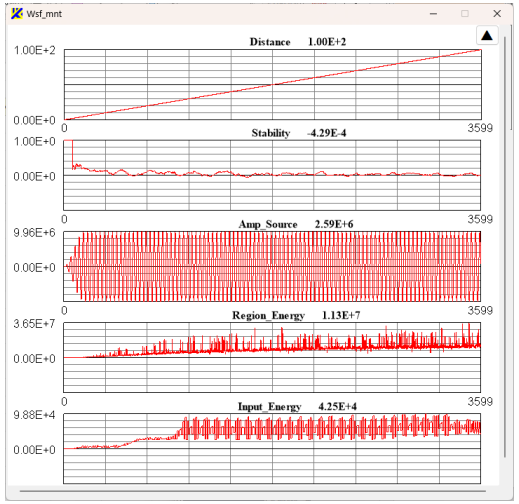
(6) Click the Draw button to draw the xz cross-section of the structure.

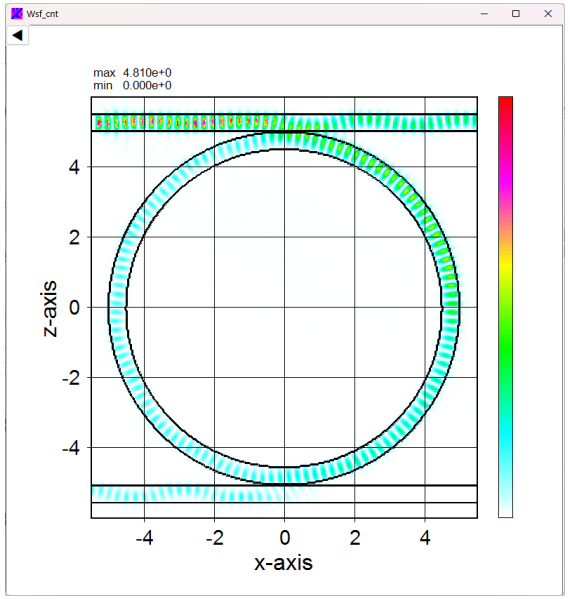


(7) Click the Next button to open the Source setting window, and set each parameter as shown on the right.



(8) By clicking the Run button, calculation of Wsf is performed with appearance of a Dos window. At the same time, the calculation status and the xz cross-section of intensity distribution are drawn by Wsmnt and Wscnt.

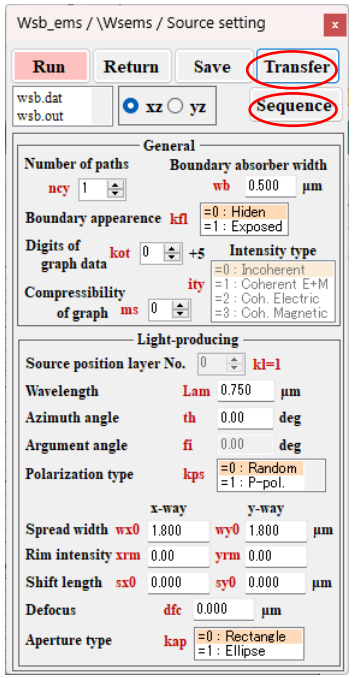




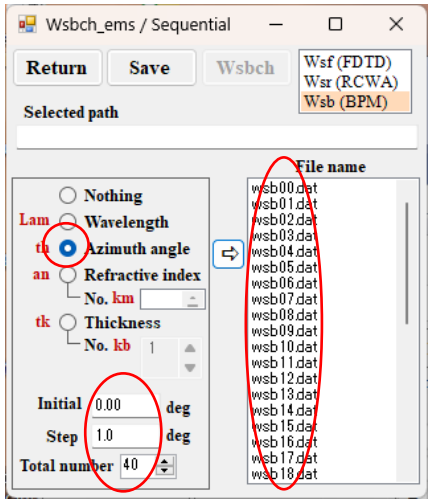
46. How to summarize output results (1)

Let's calculate material absorption and inflow/outflow light amount from the material surfaces as an example of wsb_9.dat. By assigning a different material number to the same material, the detected light amount can be output separately. However, since the material number exceeds 3, product registration is required.

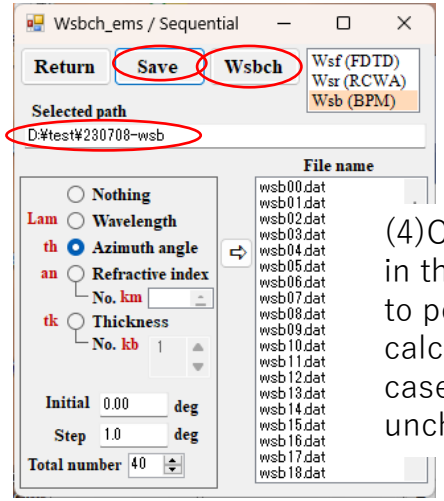
(1) Select a file (wsb_9.dat) from Transfer button in both windows of Structure setting and Source setting.



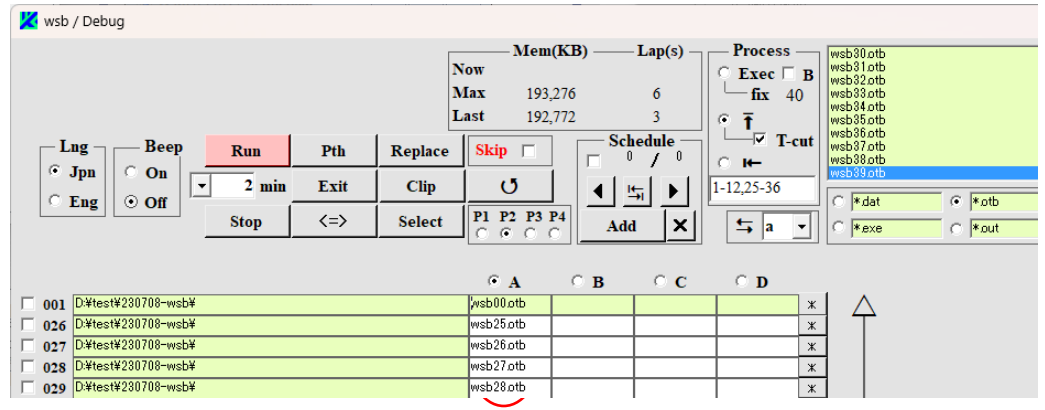
(2)Click Sequence button, select Azimuth angle button in the Sequential window, set each parameter as follows, and click ⇒ button. 40 file names are registered on the list box.



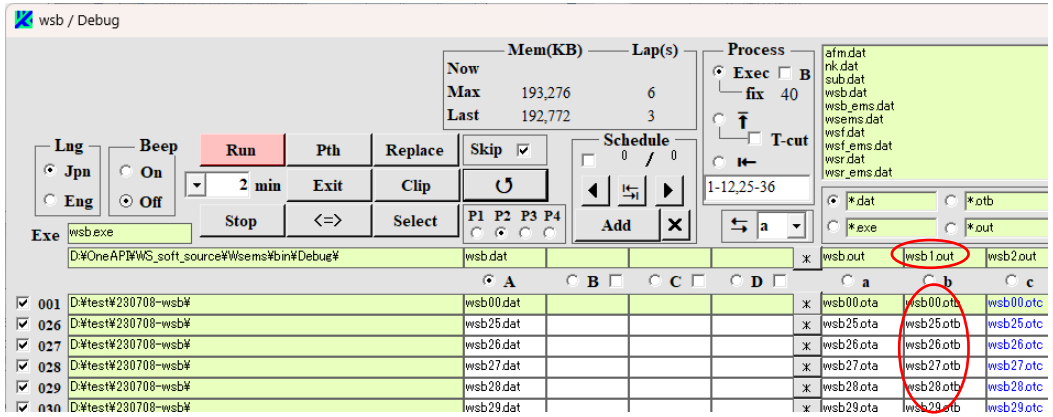
(3)Click the Save button, create and select a destination path, and click the Wsbch button.



(4)Click the Run button in the Wsbch window to perform continuous calculations (in the case of recalculation, uncheck the Skip box).



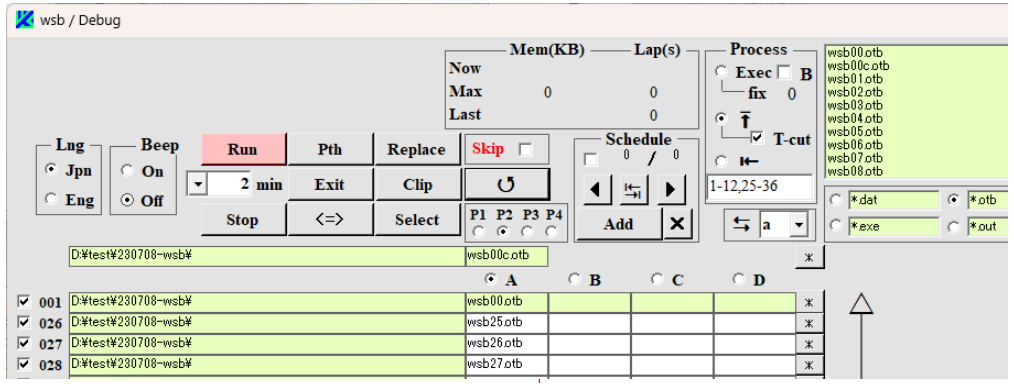
(5) After calculations are completed, check the t̄ button, select *.otb as the file pattern, and list the resulting files of *.otb on column A boxes.



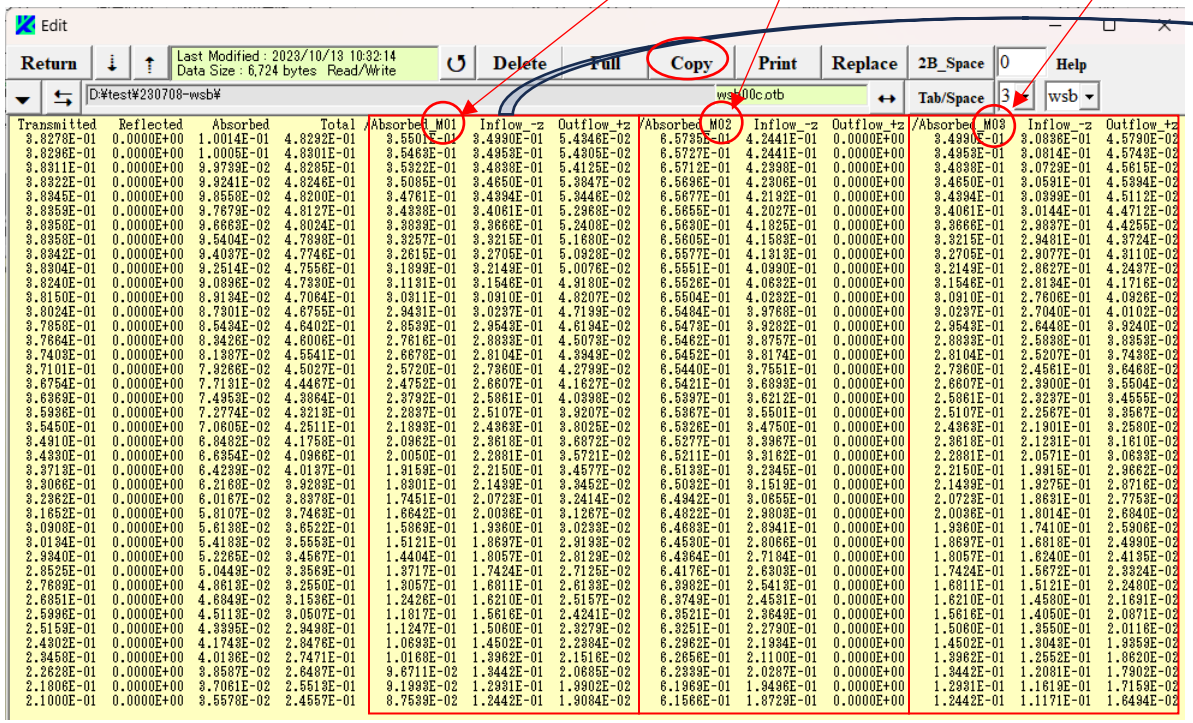
The amounts of light detected for each material number are listed in the output file wsb1.out of wsb.exe (see "How to use wsb" on the HP). In the above wsbch setup, the output results are also stored in the *.otb file in column b.

47. How to summarize output results (2)

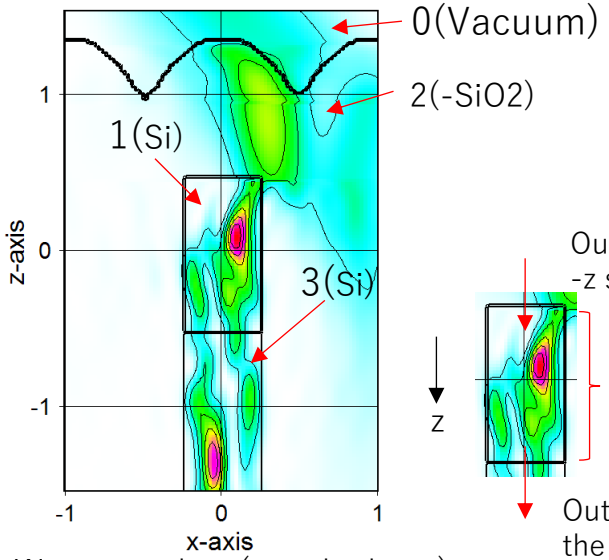
(6) Click the Run button to concatenate the *.otb files in column A boxes.



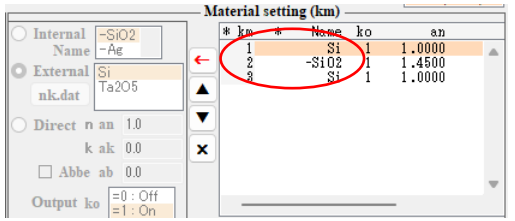
(7) Click the * button to the right of the concatenated box to open the Edit window



1(Si) 2(-SiO2) 3(Si)



Wscnt window (upside down)



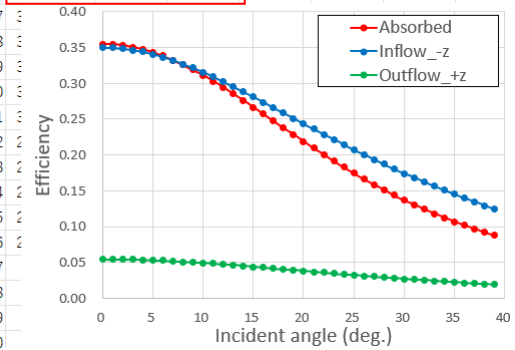
Outflow_-z : Light amount inflowing from the -z side surface (vertical component)

Absorbed light amount

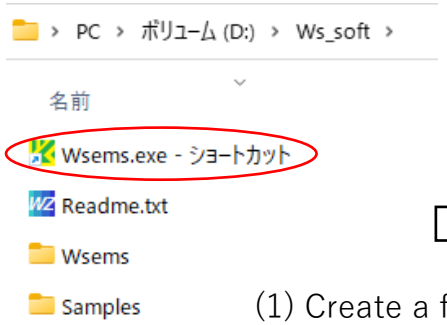
Outflow_+z : Light amount outflowing from the +z side surface (vertical component)

(8) Click the Copy button and paste the content into Excel.

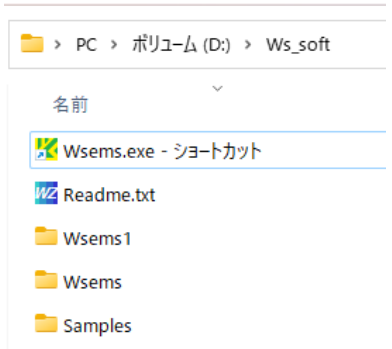
	A	B	C	D
1	Theata	Absorbed	Inflow_-z	Outflow_+z
2	0	3.5501E-01	3.50E-01	5.43E-02
3	1	3.5463E-01	3.50E-01	5.43E-02
4	2	3.5322E-01	3.48E-01	5.41E-02
5	3	3.5085E-01	3.47E-01	5.38E-02
6	4	3.4761E-01	3.44E-01	5.34E-02
7	5	3.4338E-01	3.41E-01	5.30E-02
8	6	3.3839E-01	3.37E-01	5.24E-02



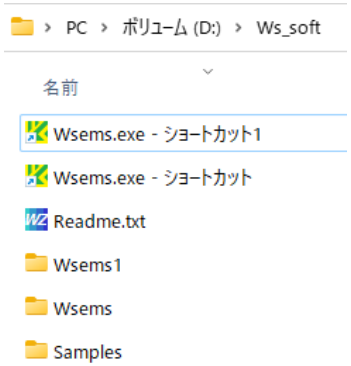
48. How to perform parallel calculations



(1) Create a folder Wsems1 and copy all the contents of the folder Wsems.



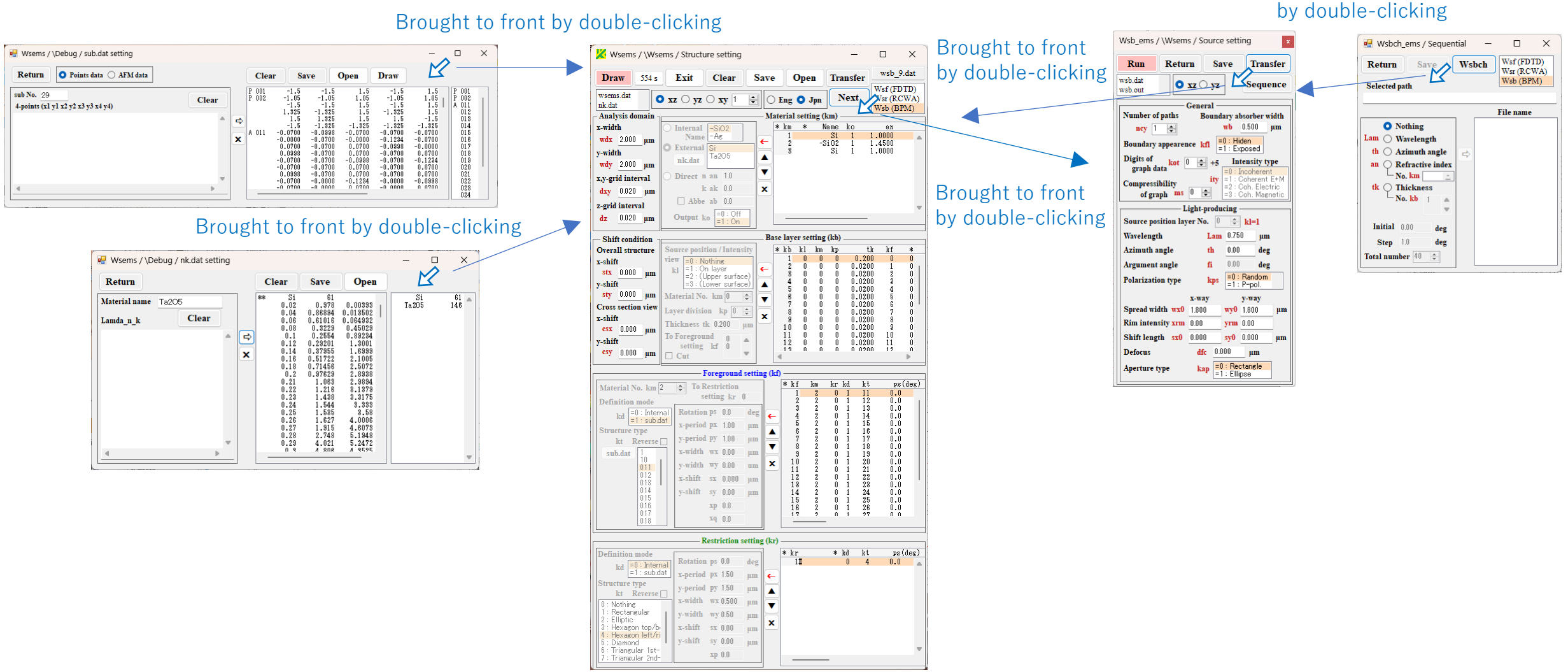
(2) Create a shortcut for Wsems.exe in the Wsems1 folder, rename it Wsems.exe shortcut1, and move it to the upper level (under the folder Ws_soft).



Wsems.exe is prohibited from double-launch of the same file to prevent malfunction, but if stored in a different directory, it can be launched.
In the above settings of (1) and (2), Wsems.exe called by "Wsems.exe shortcut" and "Wsems.exe shortcut 1" and the programs generated from them can be processed in parallel without interference.

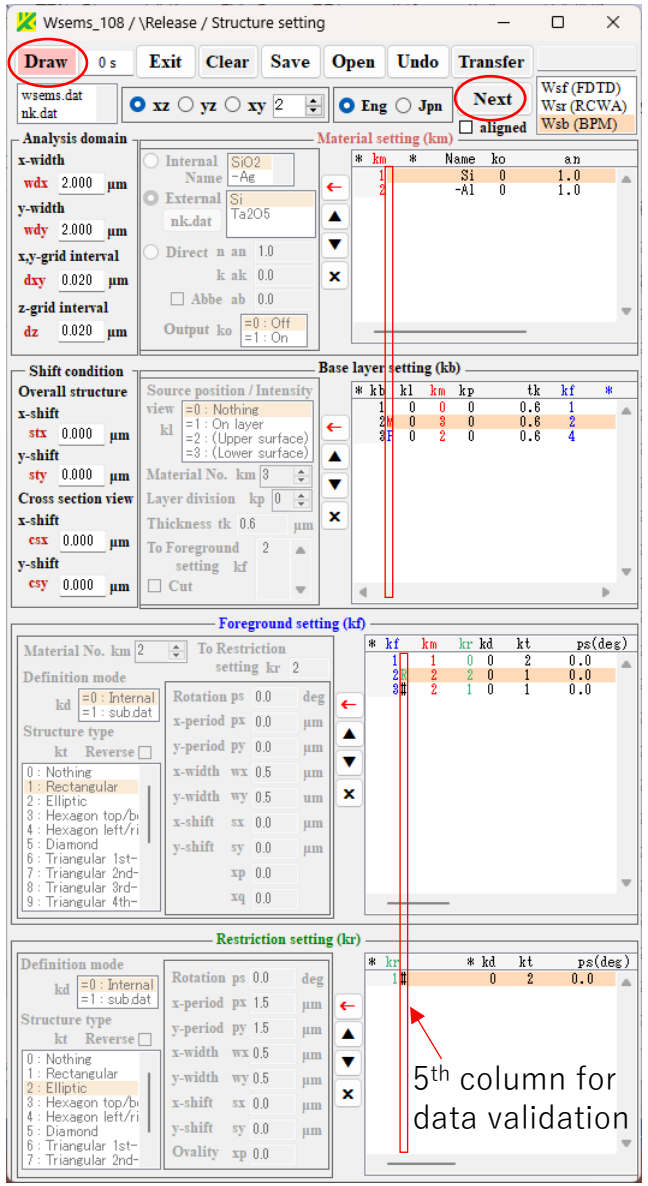
49. Bringing a hide window to front

A parent (or child) window, which hides behind other windows, is brought to front by double-clicking at blank portions of its child (or parent) window .

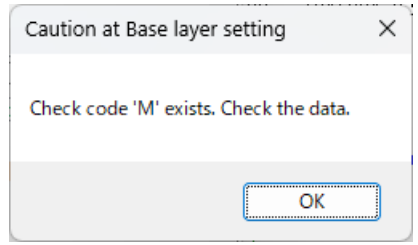


50. Confirmation of wrong input

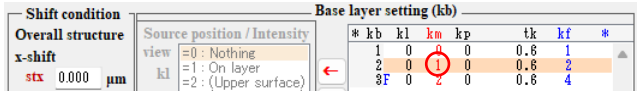
(1)Wrong input can be confirmed by the presence of "M", "F", and "R" in the data validation columns. Please correct the data to eliminate these signs according to the Caution.



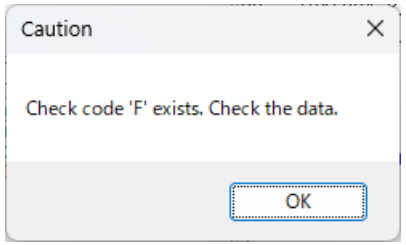
(1)Click on Draw or Next button.



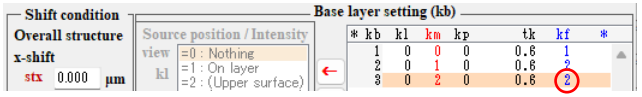
(2)Click on OK button and correct the data so as to erase “M” from the 5th column.



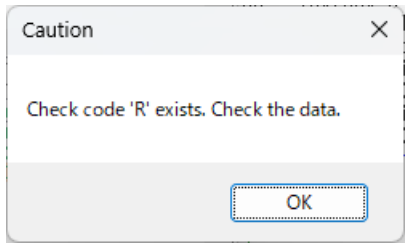
(3)Click on Draw or Next button.



(4)Click on OK button and correct the data so as to erase “F” from the 5th column.



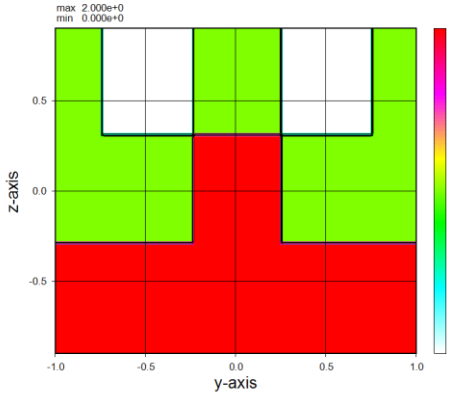
(5)Click on Draw or Next button.



(6) Click on OK button and correct the data so as to erase “R” from the 5th column.

(7)Click on Draw button.

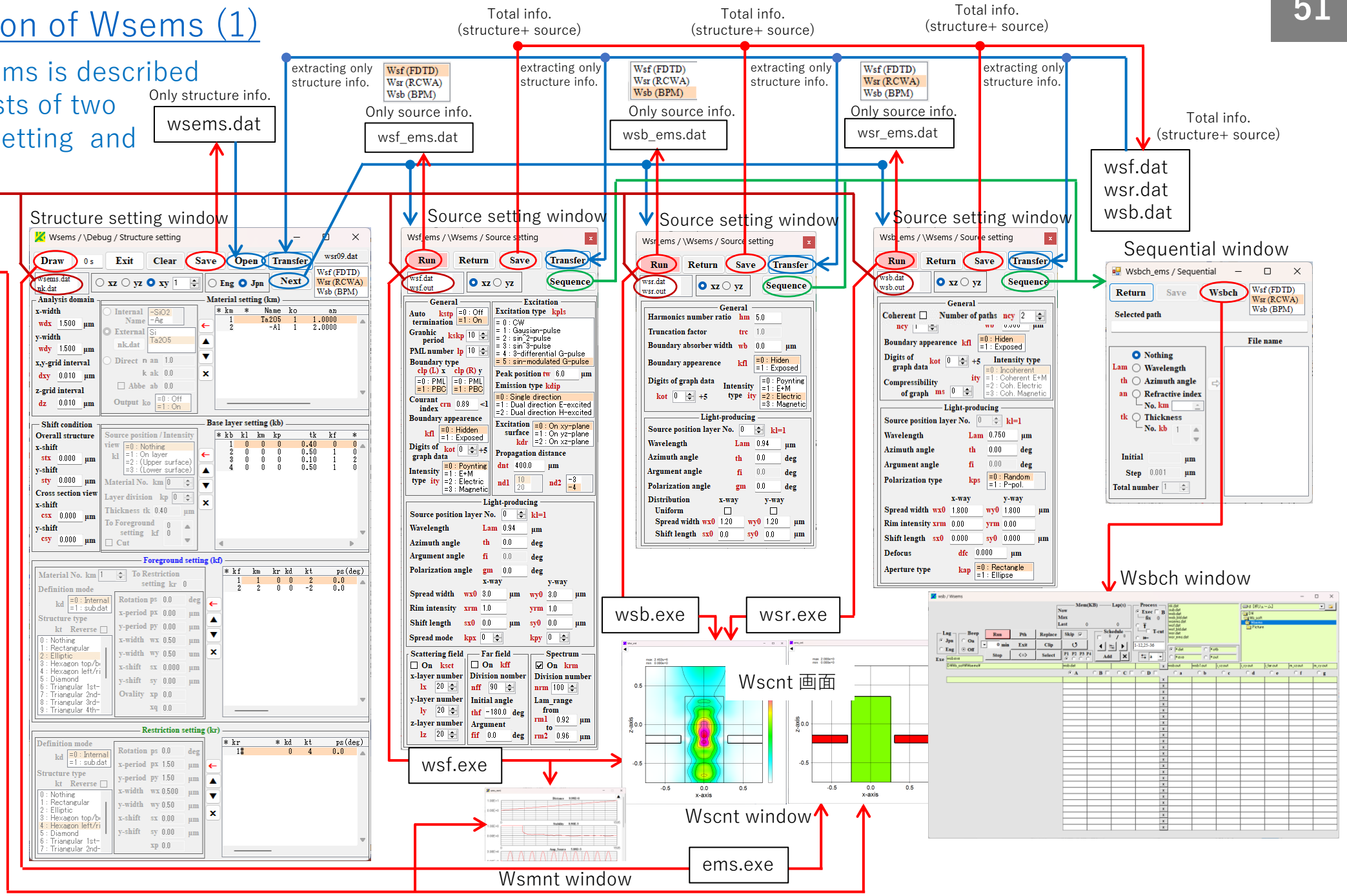
(8) If no caution box appears and a cross-sectional picture is drawn, the data is correctly input. By the way, “#” is not incorrect but only unreferenced.



Wscnt window (upside down)

51. Configuration of Wsems (1)

The structure of Wsems is described below. Wsems consists of two windows: Structure setting and Source setting.

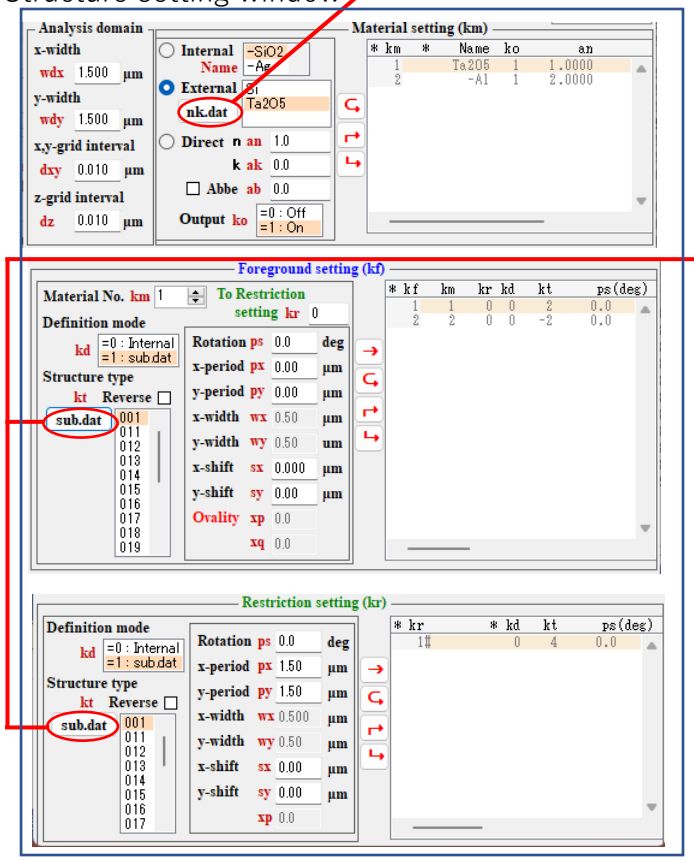


Contents of input data (wsf.dat, wsr.dat, wsb.dat) for the three programs Wsf, Wsr, and Wsb are divided into structure information and light source information which are defined by the Structure setting window and Source setting window, respectively. The output results can be checked in Info window called from Result file boxes, and continuous calculations can be performed by Wsbch called from the Sequential window. Cross sections of structures and intensity distributions are visualized by Wscnt.

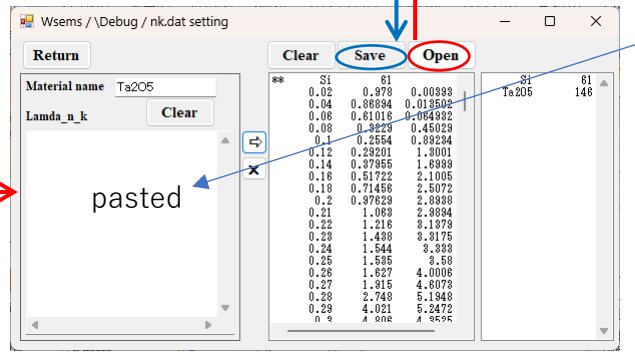
52. Configuration of Wsems (2)

The nk.dat setting window and sub.dat setting window are called from the Structure setting window. In the nk.dat setting window, dispersion data for external reference can be generated by pasting Excel data※. In the sub.dat setting window, 2D figures data can be created by pasting 4 points data or AFM (Atomic Force Microscope) data from Excel※, and the figure shape can be visualized by Wscnt.
(※) Refer to the Excel files in the folder of “¥Ws_soft¥Samples”.

Structure setting window

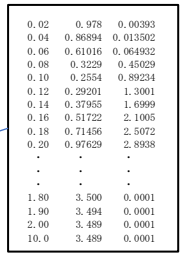


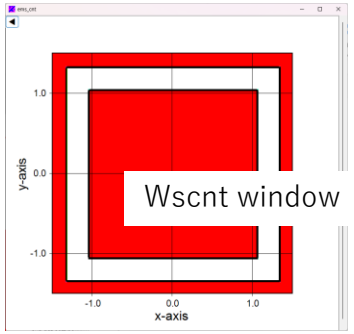
nk.dat setting window



nk.dat

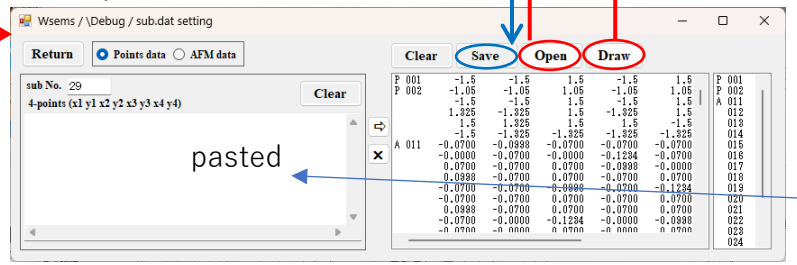
Dispersion data
nk_data.xlsx





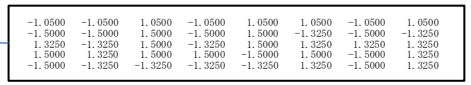
ems.exe

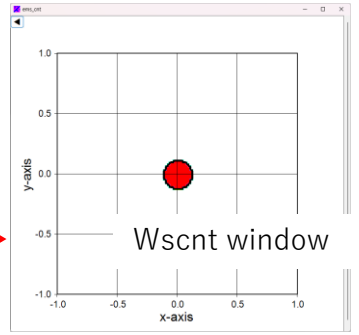
sub.dat setting window
(4 points data)



sub.dat

4 points data sub_data.xlsx



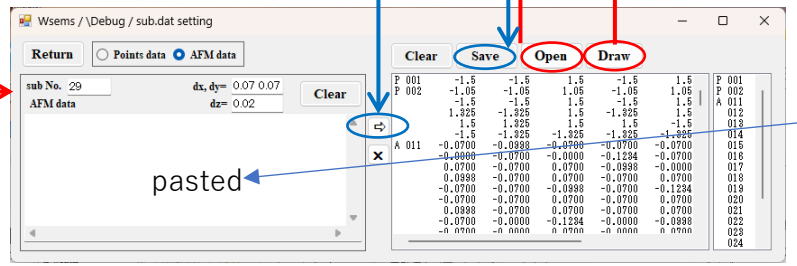


ems.exe

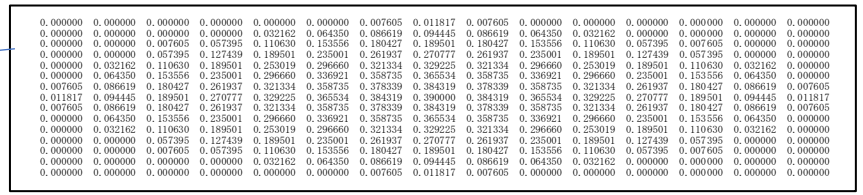
sub.dat setting
window (AFM data)

afm.exe

sub.dat



AFM data sub_data.xlsx



53. Contents of output files for Wsf

wsf.out : Main calculation results. Step (number of time steps), Distance (propagation length), Stability (stability factor), Region_En (total light amount in analysis region), Input_En (input light amount), Outflow_B (light amount flowing out from analysis region), B_-x to +z (light amount flowing out from each analysis boundary), Absorbed_M01(light amount flowing in from all boundaries of specified material 01, i.e., absorbed light amount),M01_ - x to +z (light amount flowing in from each boundary of specified material 01).

wsf1.out : Extracted calculation results : Transmitted (light amount flowing out from +z boundary surface of the analysis area), Reflected (light amount flowing out from -z boundary surface), Absorbed (absorbed light amount within the analysis area), Total (sum of previous three), Absorbed_M01(light amount flowing in from all boundaries of specified material 01, i.e., absorbed light amount),M01_ - x to +z (light amount flowing in from each boundary of specified material 01).

m_xy.out : xy cross-sectional distribution of material numbers. **m_xz.out** : xz cross-sectional (y = csy) distribution of material numbers. **m_yz.out** : yz cross-sectional (x = csx) distribution of material numbers. **m_z045.out** : cross-sectional distribution with 45-degrees rotation around z-axis for material numbers. **m_z135.out** : cross-sectional distribution with 135-degrees rotation around z-axis for material numbers. These images can be displayed by Wscnt.

n_xy.out : xy cross-sectional distribution of refractive indexes. **n_xz.out** : xz cross-sectional (y = csy) distribution of refractive indexes. **n_yz.out** : yz cross-sectional (x = csx) distribution of refractive indexes. **n_z045.out** : cross-sectional distribution with 45-degrees rotation around z-axis for refractive indexes. **n_z135.out** : cross-sectional distribution with 135-degrees rotation around z-axis for refractive indexes. These images can be displayed by Wscnt.

k_xy.out : xy cross-sectional distribution of extinction coefficients. **k_xz.out** : xz cross-sectional (y = csy) distribution of extinction coefficients. **k_yz.out** : yz cross-sectional (x = csx) distribution of extinction coefficients. **k_z045.out** : cross-sectional distribution with 45-degrees rotation around z-axis for extinction coefficients. **k_z135.out** : cross-sectional distribution with 135-degrees rotation around z-axis for extinction coefficients. These images can be displayed by Wscnt.

i_xy_t.out : xy cross-sectional distributions of light intensity (i. e., magnitude of Poynting vector) at fixed intervals. The results for the light source position and the boundary surfaces specified by kl are superimposed from the –z side to the +z side at fixed intervals. **i_xz_t.out** : xz cross-sectional (y=csy) distributions of light intensity at fixed intervals. **i_yz_t.out** : yz cross-sectional (x=csx) distributions of light intensity at fixed intervals. **i_xy.out** : xy cross-sectional time-averaged distributions of light intensity※. The results for the upper and lower surfaces of each layer are superimposed from the -z side to the +z side. **i_xz.out** : xz cross-sectional (y=csy) time-averaged distributions of light intensity. **i_yz.out** : yz cross-sectional (x=csx) time-averaged distributions of light intensity. **i_z045.out** : cross-sectional distribution with 45-degrees rotation around z-axis for light intensity. **i_z135.out** : cross-sectional distribution with 135-degrees rotation around z-axis for light intensity. These images can be displayed by Wscnt.

a_xy.out : xy cross-sectional time-averaged distributions of absorption. The results for the upper and lower surfaces of each layer are superimposed from the -z side to the +z side. **a_xz.out** : xz cross-sectional (y=csy) time-averaged distributions of absorption. **a_yz.out** : yz cross-sectional (x=csx) time-averaged distributions of absorption. **a_z045.out** : cross-sectional distribution with 45-degrees rotation around z-axis for absorption. **a_z135.out** : cross-sectional distribution with 135-degrees rotation around z-axis for absorption. These images can be displayed by Wscnt.

i_far.out : Far-field intensity distributions (-z side and +z side in the order). Output for CW oscillation (kpls=0). **360far.out** : 360-degree far-field distributions. Output for kff>0 and CW oscillation (kpls=0). These images can be displayed by pasting the result to Excel.

mnt.out : Distance (propagation Length), Stability (stability factor), Amp_Source (ligt source amplitude), Region_Energy (total light in analysis area), Input_Energy (ligt amount overflowed from light source layer), Outflow_B (light amount flowing out from analysis region), B_-x to +z (light amount flowing out from each analysis boundary), Absorbed_M01(light amount flowing in from all boundaries of specified material 01, i.e., absorbed light amount), Inflow M01_ - x to +z (light amount flowing in from each boundary of specified material 01). **flow_t.out** : light amplitudes for propagation length at each 6 boundary surfaces for analysis region and materials specifief by ko=1. Output for Pulse oscillation (kpls>0) when the spectrum box is checked. **flow_f.out** : Fourier-transform of light amplitudes for propagation length at each 6 boundary surfaces for analysis region and materials specifief by ko=1. Wavelength characteristics are shown. Output for Pulse oscillation (kpls>0) when the spectrum box is checked. These Images can be displayed with Wsmnt.exe.

※ For ity=0, time-averaged intensity is a magnitude of Poynting vector, for ity=1, an electric and magnetic filed intensity, for ity=2, an electric filed intensity, and for ity=3, a magneticfiled intensity.

54. Contents of output files for Wsr

wsr.out : Main calculation results. Transmitted (light amount flowing out from +z boundary surface of the analysis area), Reflected (light amount flowing out from -z boundary surface), Absorbed_M01(light amount flowing in from all boundaries of specified material 01, i.e., absorbed light amount),M01_ - x to +z (light amount flowing in from each boundary of specified material 01).

wsr1.out : Extracted calculation results : Transmitted (light amount flowing out from +z boundary surface of the analysis area), Reflected (light amount flowing out from -z boundary surface), Absorbed_M01(light amount flowing in from all boundaries of specified material 01, i.e., absorbed light amount),Inflow_M01_ - x to +z (light amount flowing in from each boundary of specified material 01).

wsr2.out : Extracted calculation results, diffraction efficiencies for diffraction orders from -1st to +1st.　R(? ,　?) : Reflective diffraction efficiency (order in x-direction, order in y-direction), T(? , ?) : Transmissive diffraction efficiency (order in x-direction, order in y-direction).

m_xy.out : xy cross-sectional distribution of material numbers. The results of the upper and lower boundary surfaces of each layer are overlayed from the -z side to the +z side. **m_xz.out** : xz cross-sectional (y = csy) distribution of material numbers. **m_yz.out** : yz cross-sectional (x = csx) distribution of material numbers. **m_z045.out** : cross-sectional distribution with 45-degrees rotation around z-axis for material numbers. **m_z135.out** : cross-sectional distribution with 135-degrees rotation around z-axis for material numbers. These images can be displayed by Wscnt.

n_xy.out : xy cross-sectional distribution of refractive indexes. The results of the upper and lower boundary surfaces of each layer are overlayed from the -z side to the +z side. **n_xz.out** : xz cross-sectional (y = csy) distribution of refractive indexes. **n_yz.out** : yz cross-sectional (x = csx) distribution of refractive indexes. **n_z045.out** : cross-sectional distribution with 45-degrees rotation around z-axis for refractive indexes. **n_z135.out** : cross-sectional distribution with 135-degrees rotation around z-axis for refractive indexes. These images can be displayed by Wscnt.

k_xy.out : xy cross-sectional distribution of extinction coefficients. The results of the upper and lower boundary surfaces of each layer are overlayed from the -z side to the +z side. **k_xz.out** : xz cross-sectional (y = csy) distribution of extinction coefficients. **k_yz.out** : yz cross-sectional (x = csx) distribution of extinction coefficients. **k_z045.out** : cross-sectional distribution with 45-degrees rotation around z-axis for extinction coefficients. **k_z135.out** : cross-sectional distribution with 135-degrees rotation around z-axis for extinction coefficients. These images can be displayed by Wscnt.

i_xy.out : xy cross-sectional distributions of light intensity (i. e., magnitude of Poynting vector※).　The results for the upper and lower surfaces of each layer are superimposed from the -z side to the +z side. **i_xz.out** : xz cross-sectional (y=csy) distributions of light intensity. **i_yz.out** : yz cross-sectional (x=csx) distributions of light intensity. **i_z045.out** : cross-sectional distribution with 45-degrees rotation around z-axis for light intensity. **i_z135.out** : cross-sectional distribution with 135-degrees rotation around z-axis for light intensity. These images can be displayed by Wscnt.

a_xy.out : xy cross-sectional distributions of absorption.　The results for the upper and lower surfaces of each layer are superimposed from the -z side to the +z side. **a_xz.out** : xz cross-sectional (y=csy) distributions of absorption. **a_yz.out** : yz cross-sectional (x=csx) distributions of absorption. **a_z045.out** : cross-sectional distribution with 45-degrees rotation around z-axis for absorption. **a_z135.out** : cross-sectional distribution with 135-degrees rotation around z-axis for absorption. These images can be displayed by Wscnt.

i_far.out : Far-field intensity distributions (-z side and +z side in the order). The image can be displayed by Wscnt.

eps.out : Spatial harmonics distribution. Calculated results for all layers are superimposed. The image can be displayed by Wscnt.

※ For ity=0, Intensity is a magnitude of Poynting vector, for ity=1, an electric and magnetic filed intensity, for ity=2, an electric filed intensity, and for ity=3, a magneticfiled intensity.

55. Contents of output files for Wsb

wsb.out : Main calculation results. Step (number of grid steps), Layer (component layer number), z (step position number), neff (effective refractive index of propagating light), pk/pk0 (maximum of intensity ratio), Transmitted (transmissive light amount), Reflected (reflective light amount), Absorbed (absorbed light amount), Scattered (scattered light amount), Total (sum of the previous four), Compens (compensating rate for energy conservation), Absorbed_M01(light amount flowing in from all boundaries of specified material 01, i.e., absorbed light amount), Inflow_M01_-x(light amount flowing in from -x boundary of specified material 01). Outlow_M01_+x(light amount flowing out from +x boundary of specified material 01). Inflow_M01_-z(light amount flowing in from -z boundary of specified material 01). Outlow_M01_+z(light amount flowing out from +z boundary of specified material 01).

wsb1.out : Extracted calculation results. Transmitted (light amount flowing out from +z boundary surface of the analysis area), Reflected (light amount flowing out from -z boundary surface), Absorbed (absorbed light amount of the analysis area), Total (sum of the previous three), Inflow_M01_-x(light amount flowing in from -x boundary of specified material 01). Outlow_M01_+x(light amount flowing out from +x boundary of specified material 01). Inflow_M01_-z(light amount flowing in from -z boundary of specified material 01). Outlow_M01_+z(light amount flowing out from +z boundary of specified material 01).

m_xy.out : xy cross-sectional distribution of material numbers. The results of the upper and lower boundary surfaces of each layer are overlayed from the -z side to the +z side. **m_xz.out** : xz cross-sectional (y = csy) distribution of material numbers. **m_yz.out** : yz cross-sectional (x = csx) distribution of material numbers. **m_z045.out** : cross-sectional distribution with 45-degrees rotation around z-axis for material numbers. **m_z135.out** : cross-sectional distribution with 135-degrees rotation around z-axis for material numbers. These images can be displayed by Wscnt.

n_xy.out : xy cross-sectional distribution of refractive indexes. The results of the upper and lower boundary surfaces of each layer are overlayed from the -z side to the +z side. **n_xz.out** : xz cross-sectional (y = csy) distribution of refractive indexes. **n_yz.out** : yz cross-sectional (x = csx) distribution of refractive indexes. **n_z045.out** : cross-sectional distribution with 45-degrees rotation around z-axis for refractive indexes. **n_z135.out** : cross-sectional distribution with 135-degrees rotation around z-axis for refractive indexes. These images can be displayed by Wscnt.

k_xy.out : xy cross-sectional distribution of extinction coefficients. The results of the upper and lower boundary surfaces of each layer are overlayed from the -z side to the +z side. **k_xz.out** : xz cross-sectional (y = csy) distribution of extinction coefficients. **k_yz.out** : yz cross-sectional (x = csx) distribution of extinction coefficients. **k_z045.out** : cross-sectional distribution with 45-degrees rotation around z-axis for extinction coefficients. **k_z135.out** : cross-sectional distribution with 135-degrees rotation around z-axis for extinction coefficients. These images can be displayed by Wscnt.

i_xy.out : xy cross-sectional distributions of light intensity (i. e., electric & magnetic field intensity ※). The round-trip distributions are summed up at the upper and lower surfaces of each layer and superimposed from the -z side to the +z side. **i_xy_f.out** : xy cross-sectional distributions of total light intensity for forward path (ncy>=3). The distributions for forward-path light are summed up at the upper and lower surfaces of each layer and superimposed from the -z side to the +z side. **i_xy_b.out** : xy cross-sectional distributions of total light intensity for backward path (ncy>=4). The distributions for backward-path light are summed up at the upper and lower surfaces of each layer and superimposed from the -z side to the +z side. **i_xz.out** : xz cross-sectional (y=csy) distributions of light intensity. In case of ity=0, the results for forward path, backward path, 2nd forward path, etc., and the last total are superimposed. In case of ity>0, accumulated intensity distributions are output separately for forward or backward path, and the distribution for overall paths is added on to the end (the same applies hereafter). **i_yz.out** : yz cross-sectional (x=csx) distributions of light intensity. **i_z045.out** : cross-sectional distribution with 45-degrees rotation around z-axis for light intensity. **i_z135.out** : cross-sectional distribution with 135-degrees rotation around z-axis for light intensity. These images can be displayed by Wscnt.

a_xy.out : xy cross-sectional distributions of absorption. The round-trip distributions are summed up at the upper and lower surfaces of each layer and superimposed from the -z side to the +z side. **a_xz.out** : xz cross-sectional (y=csy) distributions of absorption. The results for forward path, backward path, 2nd forward path, ・・・, and the last total are superimposed. **a_yz.out** : yz cross-sectional (x=csx) distributions of absorption. The results for forward path, backward path, 2nd forward path, ・・・, and the last total are superimposed. **a_z045.out** : cross-sectional distribution with 45-degrees rotation around z-axis for absorption. The results for forward path, backward path, 2nd forward path, ・・・, and the last total are superimposed. **a_z135.out** : cross-sectional distribution with 135-degrees rotation around z-axis for absorption. The results for forward path, backward path, 2nd forward path, ・・・, and the last total are superimposed. These images can be displayed by Wscnt.

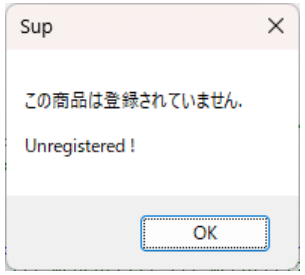
i_far.out : Far-field intensity distributions (-z side and +z side in the order). The image can be displayed by Wscnt.

※ ity=0 : For a round-trip calculation(ncy>1), intensity distributions are defined by incoherent light. The interference between forward and backward light is neglected and overlapped light is treated as intensity sum of them. ity=1 : Intensity distributions are defined as the square of the sum of complex amplitude distributions for an electric and magnetic field. ity=2 : Intensity distributions are defined as the square of the sum of complex amplitude distributions for an electric field. ity=3 : Intensity distributions are defined as the square of the sum of complex amplitude distributions for a magnetic field.

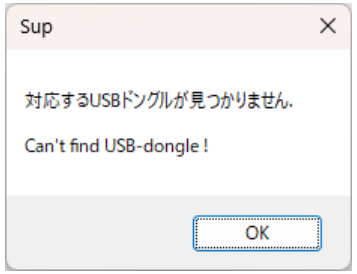
56. Limitation on use

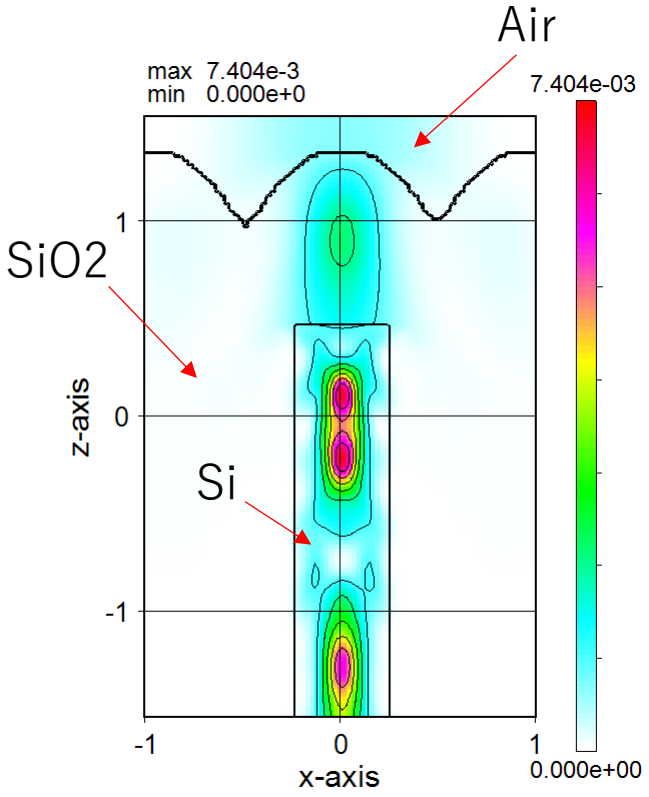
- f a registered USB dongle is connected (or MAC address is registered) and the corresponding sup.exe is installed in the folder “Wsems”, calculation starts without any function limitation.
- If the sup.exe included in the folder “Wsems” does not correspond to the registered USD dongle or registered MAC address, the message ① is displayed for 5 seconds. If the USB dongle is not connected, the message ② is displayed for 5 seconds. Air and two optical materials limit applies. However, to the extent that use is within the limit, the calculation continues.

①

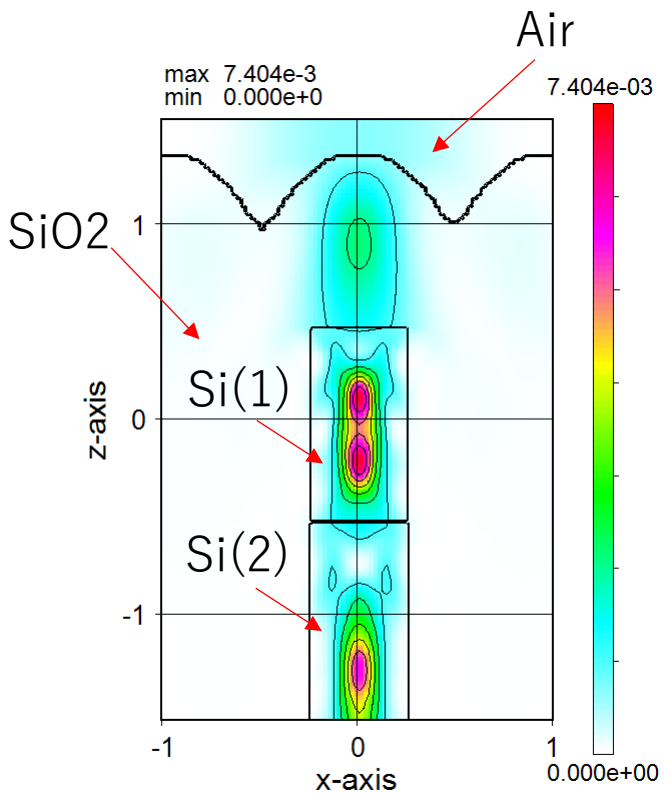


②





No restriction because air and two materials (SiO2 and Si) are used there.



There is restriction because air and three materials (SiO2, Si(1), and Si(2)) are used there.