How to use Wsf ：Electromagnetic field simulator by FDTD

1. Preparation before use and use conditions

1． Operating environment (supported OS): Windows 64bit 7,8,10,11 Edition

2． Status at the time of distribution

Included files

- Ws_soft
  - Wsems → Wsems.exe, HScrollListbox.dll, Wsbch.exe, Wscnt.exe, Sup.exe(1)
Wsf.exe, Wsr.exe, Wsb.exe, Afm.exe, Ems.exe
nk.dat, sub.dat
    - Picture → 1_a1.png etc.
    - Text → wsb_j.txt, wsf_j.txt, wsr_j.txt , wsb_e.txt, wsf_e.txt, wsr_e.txt
  - Install → w_ifort_runtime_p_2022.2.0.3790.exe
  - Samples
    - 220401-cnt&mnt → i_xz.out, i_xz_t.out, i_xy.out, m_xz.out, m_xy.out, i_far.out
    - 220401-wsb → wsb01.dat～wsb13.dat
    - 220401-wsf → wsf01.dat～wsf14.dat
    - 220401-wsr → wsr01.dat～wsr17.dat
    - Comparison
      - 230208-wsb → wsb_1.dat～wsb_9.dat
      - 230208-wsf → wsf_1.dat～wsf_9.dat
      - 230208-wsr → wsr_1.dat～wsr_9.dat
    - → nk_data.xlsx, sub_data.xlsx, nk.dat, sub.dat
  - → Wsems.exe_shortcut, ReadMe.txt

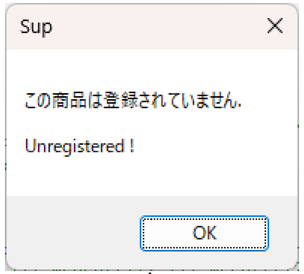
（note 1） Sup.exe is a file for determining registration, which should be stored in the same folder Wsems as other exe files.

3． Installation Procedure

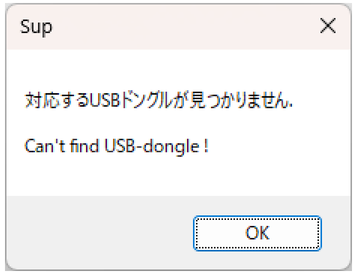
3.1 Copy the folder Ws_soft to a drive (e.g., drive D).

3.2 Click on w_ifort_runtime_p_2022.2.0.3790.exe to install the runtime.

①



②



4． Uninstallation procedure

Delete the folder Ws_soft.

5． Restriction on use

- If 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 restrictions.
- 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.

2. Input/output and relationships between other software

Stored in the same folder as Wsf.exe

Input file

wsf.dat

(Required) Basic input data

crv.exe

Converting a spherical shape to wsf.dat format

Subsidiary data

nk.dat

External Optical-constant dispersion data

sub.dat

External Shape Data

afm.exe

Converting AFM data to sub.dat format

Execution file

wsf.exe

Calculating and generating (overwriting) the output file in the same folder by clicking.

Wsbch.exe

Editing and performing continuous calculations

Output file

wsf.out — Basic output data

wsf1.out — Detected output data (edited by Wsbch.exe and visualized by Excel)

mnt.out — Monitoring data for output status (visualized by Wsmnt.exe)

When designated by CW (kpls=0): i_far.out — Far field intensity distribution from top/bottom surfaces (visualized by Wscnt.exe)

When designated by kff>0: 360far.out — All-around far-field intensity distribution (visualized by Excel)

When designated by pulse (kpls≠0):

- flow_t.out — Outflow from top/bottom surfaces against elapsed time (visualized by Wsmnt.exe)
- flow_f.out — Wavelength characteristics of outflow from top/bottom surfaces (visualized by Wsmnt.exe)

Output for wdx>0 (xz cross-section)	Output for wdx×wdy >0 (xy cross-section)	Output for wdy>0 (yz cross-section)	
n_xz.out	n_xy.out	n_yz.out	Refractive index distribution
m_xz.out	m_xy.out	m_yz.out	Material number distribution
i_xz_t.out	i_xy_t.out	i_yz_t.out	Intensity distribution in time series
i_xz.out	i_xy.out	i_yz.out	Intensity distribution time average
a_xz.out	a_xy.out	a_yz.out	absorption distribution time average

Distribution data on cross-section (visualized by Wscnt.exe)

Wscnt.exe

Wsmnt.exe

Visualizing output data

3. Contents of output files

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.

4. Execution method

Among the three methods, we strongly recommend (1) because it allows setting numerical data without worrying about input rules.

(1) Method by using wsems.exe (most recommended). In detail, see “How to use Wsems”.

(2) Method by clicking wsb.exe directly

Wsems —— Wsf.exe, wsf.dat

Samples —— 220401-wsf —— wsf01.dat

Rename, overwrite, and click Wsf.exe

The vertical alignment of wsf.dat is easier to be edited if the font is set to Courier New in Notepad. However, note that it is not possible to distinguish between full-width and half-width spaces.

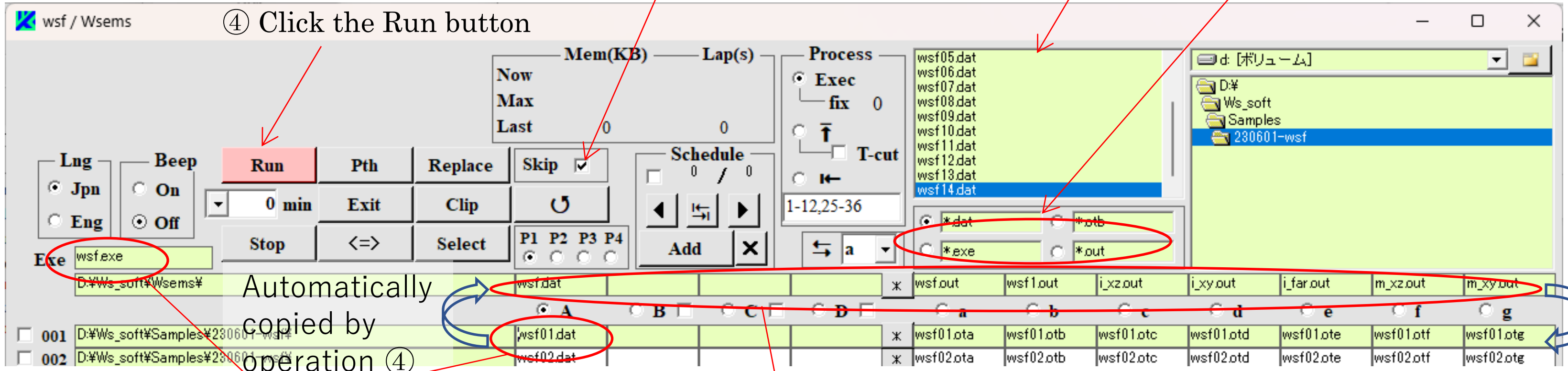
(3) Method using wsbch.exe (steps ① to ④ below)

③ Uncheck the box

File list box

File pattern

④ Click the Run button



Automatically copied by operation ④

Automatically copied after calculations are completed

① After clicking the box and selecting the file pattern, select the wsf.exe and wsr01.dat files from the file list.

② At first, write directly such like “wsf.dat” after clicking the boxes of A or a - g. After the second time, they are automatically listed.

5. Method of drawing calculation results

During the calculation, wscnt and wsmnt in the same folder start in linkage with the execution of wsf.exe, and the calculation results of i_xz_t.out or i_yz_t.out are displayed in real time.

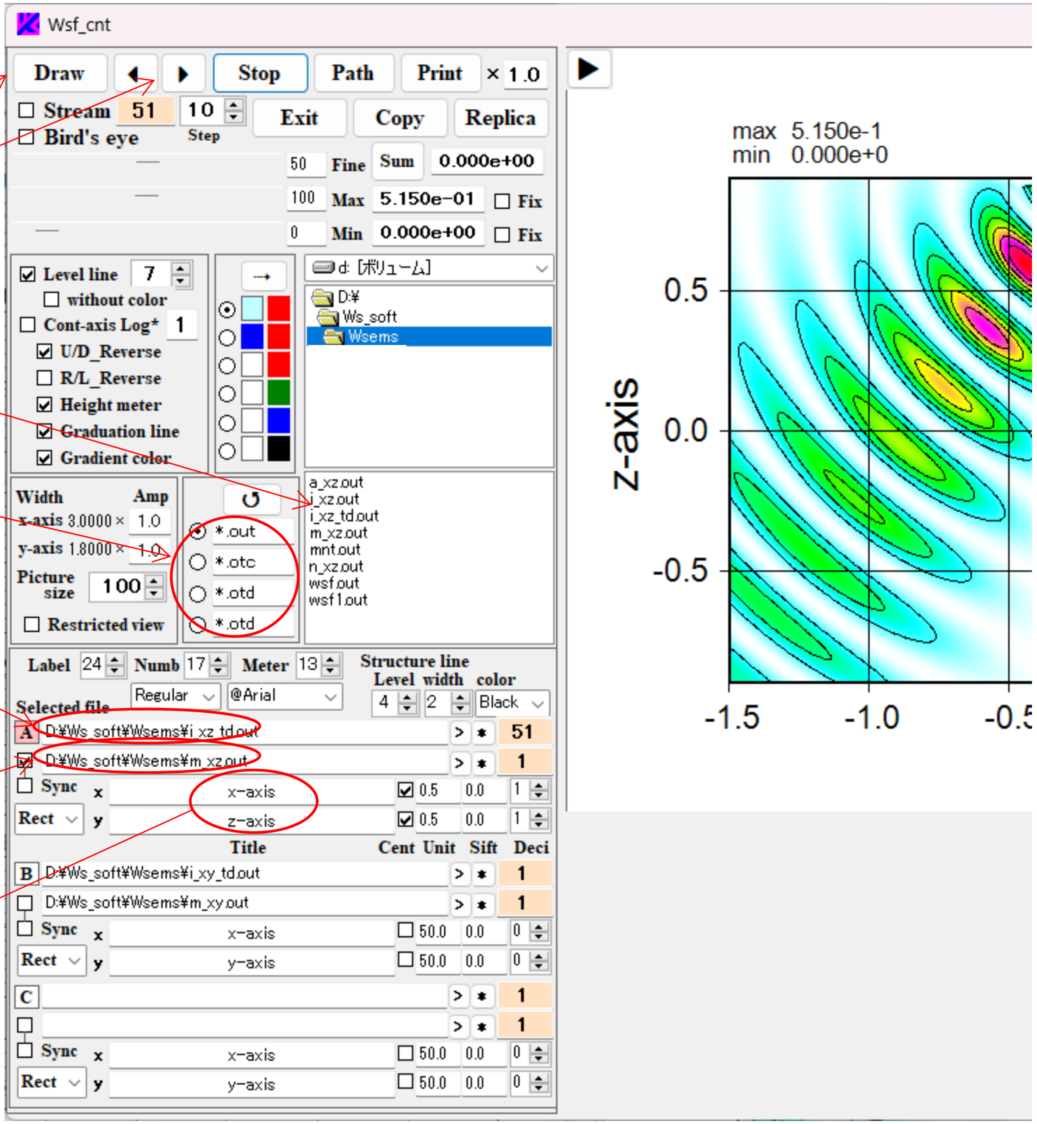
After calculation, output data generated in ¥Ws_soft¥Wsems can be visualized by wscnt.exe in the steps ①~⑤. If registered, limitation of file patterns is removed and "ot?" files generated by wsbch can also be visualized.

④Click Draw button to start drawing.
⑤Click ▶ button to advance frame.

File list box

File pattern

①After click the box, select a file pattern, and choose the file from the file list box.
② To add a structure line, check the checkbox and click the box on the right and select the file from the file list box.
③ Click on the box and type in directly.



6. Input rules for input file (wsf09.dat)

The following pages can be ignored when using Wsems.

Numeric data input rules

- Input numbers must be one-byte numbers. A space is a half-width space, and Tab code is not acceptable.
- The right end of the input numerals should be aligned with the vertical line on the right end of the variable label (or the * mark) above.
- The number without a decimal point is an integer type, and that with a decimal point (5 or less digits) is a real number type.

```
Digit 1     10          20          30          40          50          60
** wsf.dat
*      kstp        kskp          lp        clp(0,1)    crn(<1.0)   kfl         kot         ity
          0          10          10          11        0.89           0           0           0
*      kpls          tw(um)    kdip        kdr(0-2)    dnt(um)     nd1         nd2
          0         0.1           0           0           0        10.0          10          -3
*      ksct          lx          ly          lz
          0          20          20          20
*       kff         nff         thf(deg)    fif(deg)    krm         nrm         rm1(um)     rm2(um)
          0          90      -180.0         0.0           0         100        0.92        0.96
*       wdx(um)     wdy(um)     dxy(um)      dz(um)
        3.0         0.0        0.01        0.01
*       Lam(um)      th(deg)     fi(deg)     gm(deg)
       0.94         0.0         0.0         0.0
*       wx0(um)     wy0(um)     xrm(rim)    yrm(rim)    sx0(um)     sy0(um)     kpx         kpy
        2.5         2.5         0.0         0.0         0.0         0.0           0           0
*       stx(um)     sty(um)     csx(um)     csy(um)
        0.5         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
```

Examples of incorrect input.

①

```
*      kstp        kskp          lp
         ０          10         　10
```

Full-width digit. A full-width space is contained.

②

```
*       wdx(um)     wdy(um)     dxy(um)
      1.500       1.500       0.020
```

The right edge of the input number deviates from the right of the variable label above.

③

```
* km    *      Name  ko          an
     1  Ta205         1.0           1
```

Beyond the 8-column range. Real number type is put into integer type. Integer type is put into real number type.

④

```
* 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
```

The right edge of the input number deviates from position of the * mark above.

```
* 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
c
     4    0    0    0        0.50    1      0
```

To interrupt a calculation in the middle of layers, insert a line leading "C“ at the interruption position.

Compute time

7. Contents of wsf.dat (wsf01.dat), 11.4

```
Digit 1       10        20        30        40        50        60
** wsf.dat
*       kstp       kskp         lp   clp(0,1)  crn(<1.0) kfl          kot        ity
           0         10         10         00       0.99    0            0          0
*       kpls      tw(um)  kdip       kdr(0-2)  dnt(um)   nd1          nd2
           0        1.0          0          0          0  4.0           10         -3
*       ksct         lx         ly         lz
           0         10         10         10
*        kff        nff   thf(deg)   fif(deg)  krm        nrm      rm1(um)    rm2(um)
           0         90        0.0        0.0          0  100         0.92       0.96
*     wdx(um)    wdy(um)    dxy(um)     dz(um)
         3.0        0.0       0.01       0.01
*     Lam(um)    th(deg)    fi(deg)    gm(deg)
         0.5      -45.0        0.0       90.0
*     wx0(um)    wy0(um)   xrm(rim)   yrm(rim)   sx0(um)    sy0(um)   kpx        kpy
         1.0        1.0        1.0        1.0        0.0        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#       -SiO2  1     2.0000       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    1       0.0       1.00      1.000      0.50      0.50    -0.000      0.00    0.0       0.0
  2#     2    0  0    4       0.0       2.00       2.00      1.00      1.00     0.000      0.00    0.0       0.0
* kb   kl   km   kp      tk   kf    *    *    *    *    *    *    *    *    *    *    *    *    *    *    *    *
   1    0    0    0    0.60    0    0
   2    0    0    0    0.60    0    0
   3    0    0    0    0.60    0    0
                                                   桁数  70        80        90        100       110
```

Sequential numbers must be assigned from 1 (no more than 4 digits)

kstp =0: Calculations continue until the determined propagation distance dnt.
=1: Calculations terminate when the stability factor stably falls below 0.001.

kskp Number of skips when light intensity is output to i_*_t.out. The larger the number, the faster the calculations, but the coarser the single frame advance.

lp Number of layers of absorbing boundary PML. The smaller the number, the faster the calculations, the larger the reflection from the boundaries.

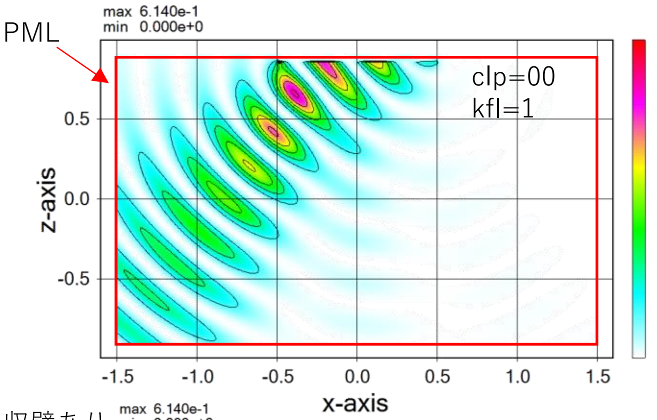
clp Boundary conditions of x and y surfaces, where 1st digit is for x-direction and 2nd digit is for y-direction. = 0 : PML, = 1 : PBC.

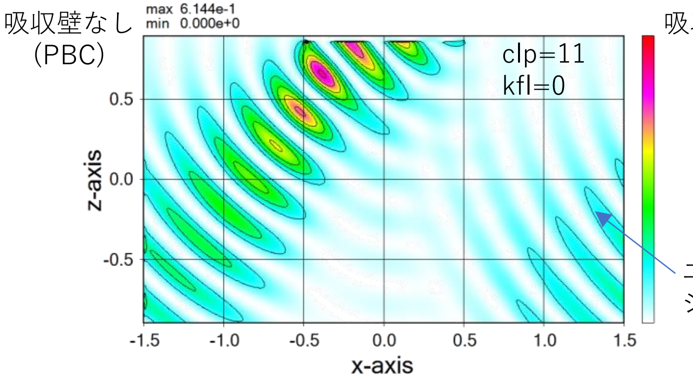
crn Courant index,i.e., time ratio to Courant criterion. Normally about 0.99, smaller (about 0.9) for dispersed materials to suppress divergence in calculations.

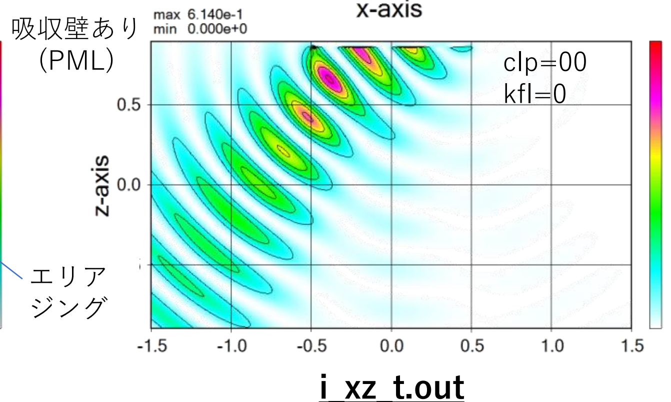
kfl = 0 : Drawing without PML. = 1 : Drawing with PML.

kot Distributions such as intensity, absorption, and refractive index are output in a maximum of (kot+5) digits.

ity Definition of intensity distribution. =0 : magnitude of Poynting Vector,
=1 : electric & magnetic fielf intensity, =2 : electric fielf intensity, =3 : magnetic fielf intensity.







i_xz_t.out

8. Contents of wsf.dat (wsf02.dat), 1719s

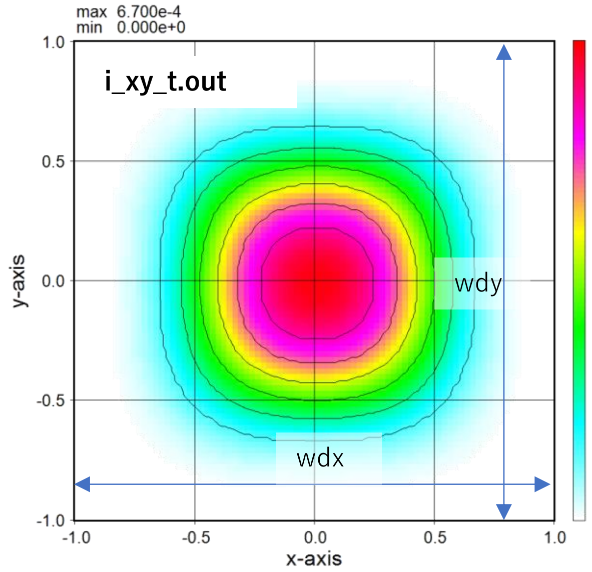
```
Digit 1     10         20         30         40         50         60
      ** wsf.dat
      *    kstp       kskp         lp     clp(0,1)  crn(<1.0) kfl         kot        ity
              0         10         10         00      0.89      0           0          0
      *    kpls         tw(um)   kdip     kdr(0-2)  dnt(um)  nd1         nd2
              0        0.1          1          0      1.0      10          -3
      *    ksct         lx         ly         lz
              0         10         10         10
      *     kff        nff        thf(deg)   fif(deg)  krm       nrm        rm1(um)    rm2(um)
              0         90        0.0        0.0        0      100       0.92       0.96
      *     wdx(um)    wdy(um)    dxy(um)     dz(um)
            3.0        3.0       0.01       0.01
      *     Lam(um)     th(deg)    fi(deg)    gm(deg)
            0.5        0.0        0.0        0.0
      *     wx0(um)    wy0(um)    xrm(rim)   yrm(rim)  sx0(um)   sy0(um)    kpx        kpy
            1.0        1.0        0.1        0.1       0.0       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#        -SiO2    1     2.0000       0.00     0.0000
          2#          -Al    1     2.0000       0.00     0.0000
      * kr           * kd      kt        ps(deg)   px(um)     py(um)     wx(um) 桁数 wy(um) 70   sx(um) 80  sy(um) 90  xp 100      110
          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     1  0       1        0.0      1.00      1.000       0.50        0.50      -0.000        0.00       0.0       0.0
          2#   2     0  0       4        0.0      2.00       2.00       1.00        1.00       0.000        0.00       0.0       0.0
      * kb  kl  km  kp       tk   kf    *    *    *    *    *    *    *    *    *    *    *    *    *    *    *    *
         1   0   0   0     0.60    0    0
         2   1   0   0     0.60    0    0
         3   0   0   0     0.60    0    0
```

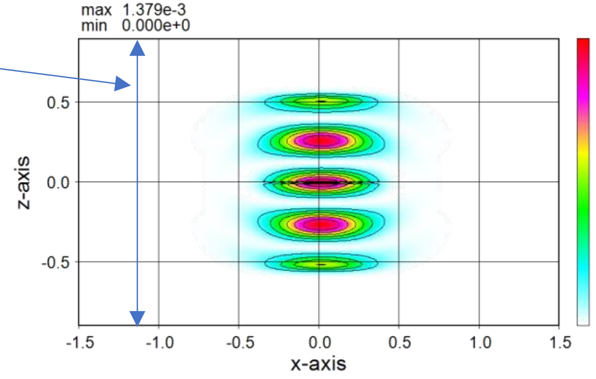
wdx Analysis width in the x direction (um). wdx=0 becomes a 2-dimensional problem.
The center of the width is the positional basis for the light source and structures.
The number of grid intervals is nx=int(wx/dx).

wdx Analysis width in the y direction (um). wdy=0 becomes a 2-dimensional problem.
The center of the width is the positional basis for the light source and structures.
The number of grid intervals is ny=int(wy/dy).

dxy Grid interval in x, y-direction (um).

dz Grid interval in z-direction (um). For layers where the layer thickness tk divided by dz is not an integer, the grid interval becomes tk divided by an integer obtained by rounding up tk/dz.





i_xz_t.out

Base layers

Up to 10000 lines can be input as far as the last line or the line starting from "c" appears. Optical constants above the top layer or below the bottom layer is the same ones as the top or the bottom layer, respectively, and then no boundary reflections from there.

kl =1: light source at the central layer. If all of kl are 0, the top surface of the first layer for cos(th)>0, or the lower surface of the last layer for cos(th)<0 is the light source position.
=2: The intensity distribution is output to i_xy_t.out at the upper surface of the layer.

km Construction material number referred in km designation field. km=0 means vacuum (n=1.0).

kp Not operated (operated in wsb).

tk Layer thickness (um)

kf =0: No reference
>0: Structure shape number referred in kf designation field. The referred shape structures are overwritten on the layer.
This numbers are represented by four digits, up to 100 set per line.

9. Contents of wsf.dat (wsf03.dat), 9.5s

```
Digit 1       10        20        30        40        50        60
 ** wsf.dat
 *      kstp      kskp        lp   clp(0,1) crn(<1.0) kfl       kot       ity
           0        10        10        00      0.99    0         0         0
 *      kpls     tw(um)   kdip      kdr(0-2)  dnt(um) nd1       nd2
           0       1.0         1         0       4.0   10        -3
 *      ksct        lx        ly        lz
           0        10        10        10
 *       kff       nff   thf(deg)  fif(deg)  krm       nrm    rm1(um)   rm2(um)
           0        90       0.0       0.0     0       100      0.92      0.96
 *      wdx(um)   wdy(um)   dxy(um)    dz(um)
         3.0       0.0      0.01      0.01
 *      Lam(um)    th(deg)   fi(deg)   gm(deg)
        0.25     -45.0       0.0       0.0
 *      wx0(um)   wy0(um)   xrm(rim)  yrm(rim)  sx0(um)   sy0(um)   kpx       kpy
         3.0       3.0       1.0       1.0       0.0       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#        -SiO2   1    2.0000      0.00    0.0000
   2#          -Al   1    2.0000      0.00    0.0000
                                                     桁数   70        80        90       100       110
 * 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   1       0.0      1.00     1.000      0.50      0.50    -0.000      0.00     0.0       0.0
   2#    2    0  0   4       0.0      2.00      2.00      1.00      1.00     0.000      0.00     0.0       0.0
 * kb  kl  km  kp        tk   kf    *    *    *    *    *    *    *    *    *    *    *    *    *    *    *    *
   1    0   0   0      0.60    0    0
   2    1   0   0      0.60    0    0
   3    0   0   0      0.60    0    0
```

kpls Light source oscillation conditions.

= 0: Continuous wave CW, which increases around cosine curve before tw, peaks at tw, and becomes constant after tw. It's suitable for light amount analysis.

= 1: Gauss-pulse modulated, which peaks at tw and becomes 1/e maxmum full width at tw/2.

= 2: Sin^2-pulse modulated, which peaks at tw and becomes 1/2 maxmum full width at tw/2.

= 3: Sin^3-pulse modulated, which peaks at 0.5*tw and 1.5*tw and becomes 1/√8 maxmum full width around each peaks.

= 4: Gauss-envelope sin-modulated, which peaks at tw and becomes 1/e maximum full width at tw/2. As it includes no DC component, suitable for frequency response analysis.

= 5: Gauss-envelope cos-modulated, which peaks at tw and becomes 1/e maxmum full width at tw/2.

tw peak time distance or pulse width (um, converted by propagation distance)

kdip Radiation direction of light source.

= 0: Single direction (EH-oscillation),

= 1: Dual direction (E-oscillation)

= 2: Dual direction (H-cscillation)

kdr Spread direction of Light source.

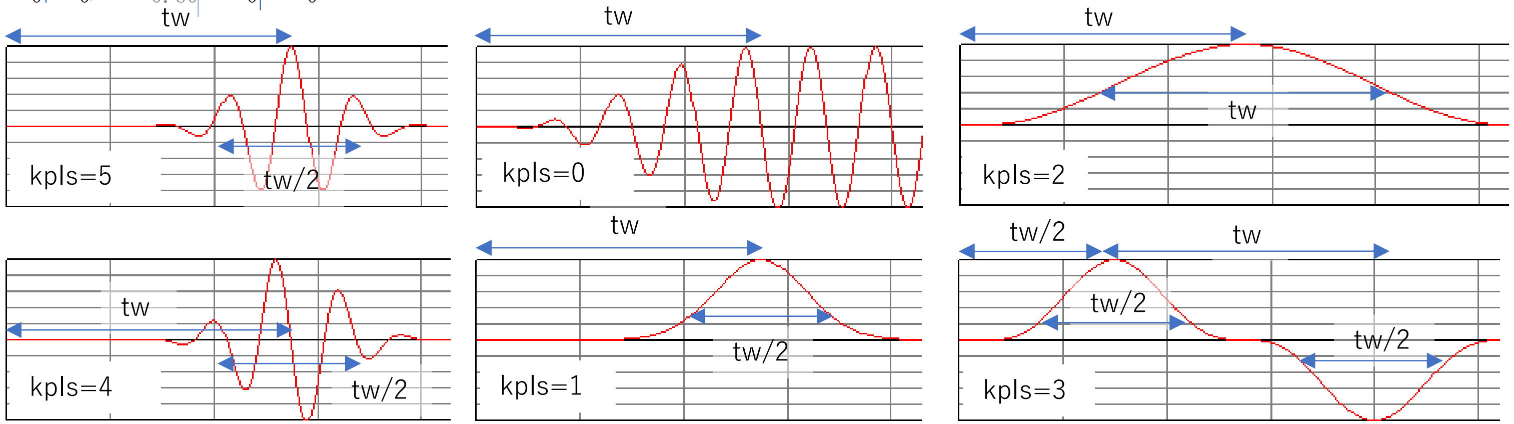
= 0: in xy-plane

= 1: in yz-plane

= 2: in xz-plane

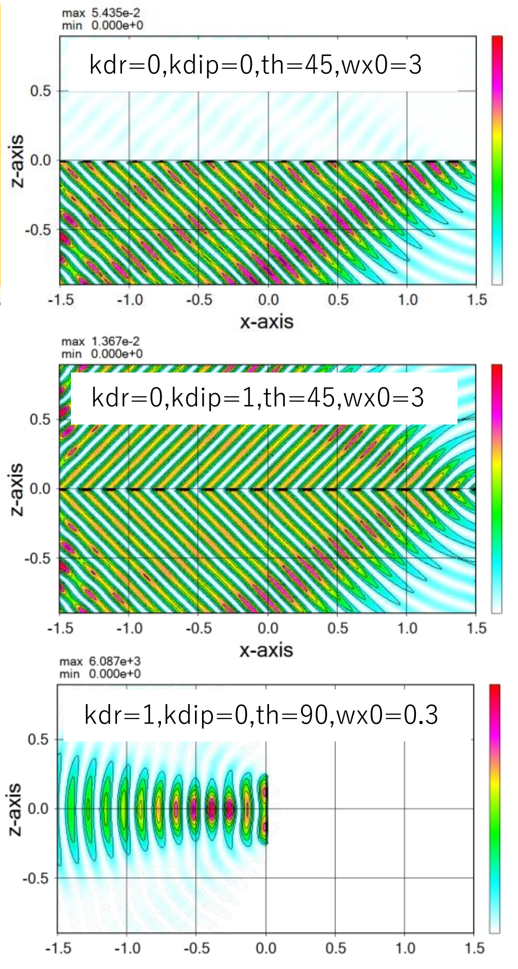
dnt Propagation distance(μm, in vacuum), which equals step numbers by time step

To obtain a meaningful result, set the propagation distance dnt large enough for CW oscillation until the calculation is stable, and for pulsed oscillation until the amount of light remaining in the analysis region is sufficiently attenuated.



kdr=1,kdip=0
th=45,wx0=3

mnt.out

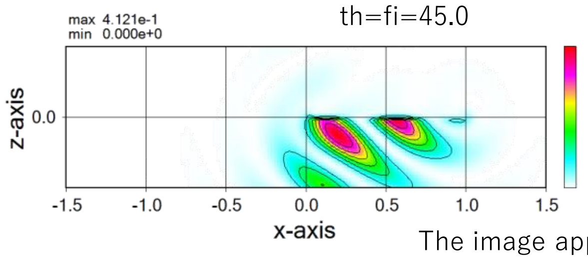


i_xz_t.out

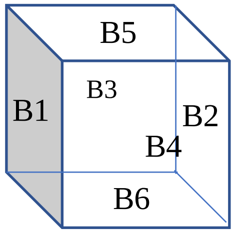
10. Contents of wsf.dat (wsf04.dat), 166s

```
Digit 1      10        20        30        40        50        60
   ** wsf.dat
   *     kstp      kskp        lp   clp(0,1)  crn(<1.0) kfl       kot       ity
            0        10        10        00      0.99     0         0         0
   *     kpls    tw(um)      kdip   kdr(0-2)  dnt(um)   nd1       nd2
            0       1.0         0         0         0   5.0        10        -3
   *     ksct        lx        ly        lz
            0        10        10        10
   *      kff       nff  thf(deg)  fif(deg)  krm       nrm   rm1(um)   rm2(um)
            0        90       0.0       0.0    0       100      0.92      0.96
   *  wdx(um)   wdy(um)   dxy(um)    dz(um)
          3.0       3.0      0.02      0.02
   *  Lam(um)   th(deg)   fi(deg)   gm(deg)
          0.5     -45.0      45.0       0.0
   *  wx0(um)   wy0(um)  xrm(rim)  yrm(rim)  sx0(um)   sy0(um)   kpx       kpy
          1.0       1.0       1.0       1.0      0.5       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#       -SiO2   1   2.0000      0.00   0.0000
      2#         -Al   1   2.0000      0.00   0.0000
                                                        桁数  70        80        90        100       110
   * 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   1       0.0      1.00     1.000      0.50      0.50    -0.000      0.00     0.0       0.0
      2#    2    0  0   4       0.0      2.00      2.00      1.00      1.00     0.000      0.00     0.0       0.0
   * kb   kl   km   kp        tk   kf   *    *    *    *    *    *    *    *    *    *    *    *    *    *    *    *
      1    0    0    0      0.30    0    0
      2    1    0    0      0.30    0    0
      3    0    0    0      0.30    0    0
```

Lam Wavelength (um).
th Azimuth angle of incident light (deg).
kdr=0 : with z-axis. kdr=1 : with x-axis. kdr=2 : with y-axis.
fi Argument angle of incident light (deg).
kdr=0 : with x-ais in xy-plane. kdr=1 : with y-axis in yz plain. kdr=2 : with x-axis in xz-plain.
gm Angle gm (deg) shows polarization direction of light source. that the electric vector E makes with the axis.
kdr=0: gm is an angle between E and x-axis on xy plane.
kdr=1: gm is an angle between E and y-axis on yz plane.
kdr=2: gm is an angle between E and x-axis on xz plane.

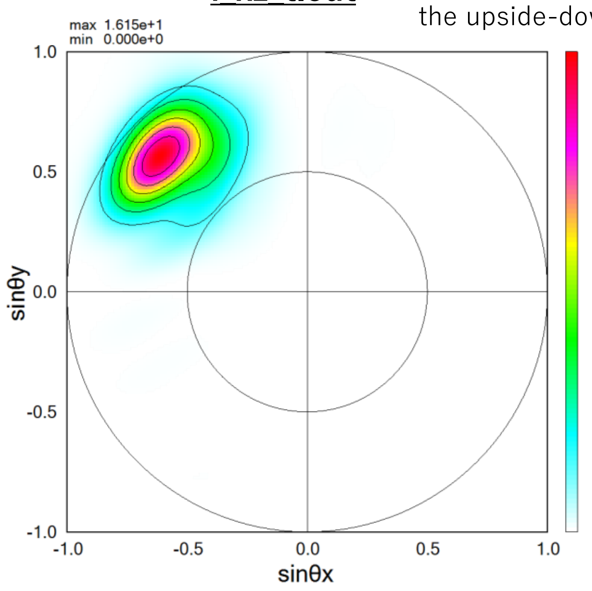


i_xz_t.out



If "U/D_reverse" is checked in wscnt, B5/B6 is reversed as above.

The image appears to be 45 degrees counterclockwise due to the upside-down display.



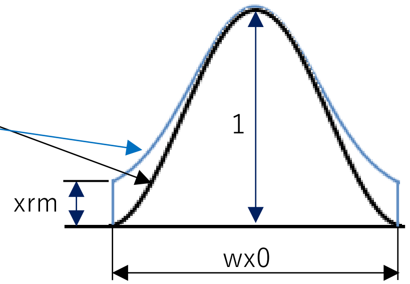
i_far.out

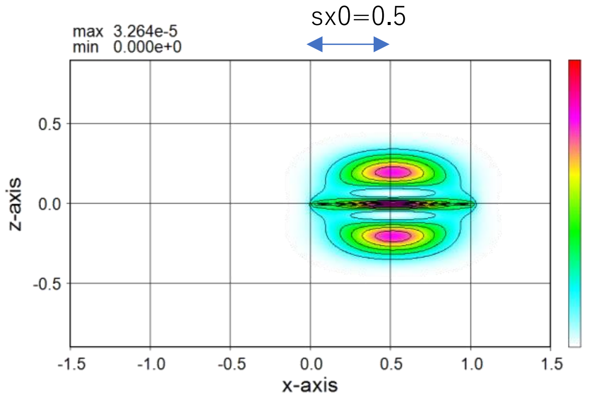
Far-field intensity distribution from the bottom surface, 2nd picture in Wscnt

11. Contents of wsf.dat (wsf05.dat), 2858s

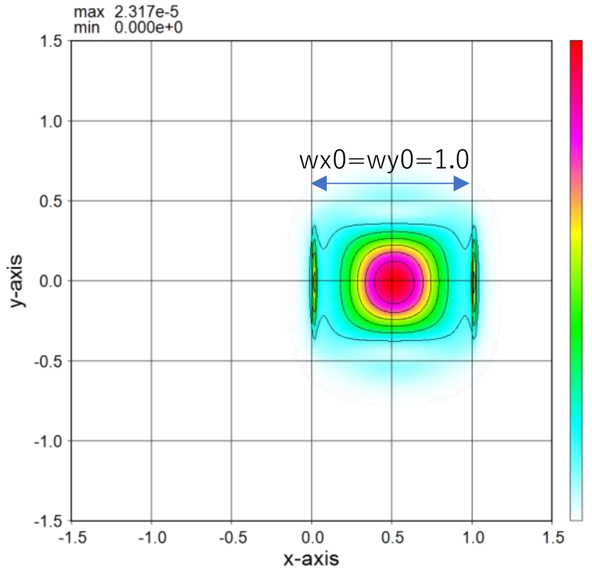
```
Digit 1      10          20          30          40          50          60
** wsf.dat
*      kstp        kskp          lp    clp(0,1)  crn(<1.0)  kfl        kot         ity
          0          10          10          00       0.99        0          0           0
*      kpls          tw(um)    kdip    kdr(0-2)   dnt(um)   nd1        nd2
          0         1.0           1           0        2.0       10         -3
*      ksct          lx          ly          lz
          0          20          20          20
*       kff         nff         thf(deg)    fif(deg)   krm       nrm        rm1(um)     rm2(um)
          0          90      -180.0         0.0          0       100       0.92        0.96
*       wdx(um)     wdy(um)     dxy(um)     dz(um)
        3.0         3.0        0.01        0.01
*       Lam(um)      th(deg)     fi(deg)     gm(deg)
       0.94         0.0         0.0         0.0
*       wx0(um)     wy0(um)     xrm(rim)    yrm(rim)   sx0(um)    sy0(um)    kpx         kpy
        1.0         1.0         0.0         0.0        0.5        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#       -SiO2    1      2.0000        0.00     0.0000
    2#         -Al    1      2.0000        0.00     0.0000
                                                              桁数   70          80          90         100         110
* 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     1         0.0        1.00      1.000       0.50       0.50      -0.000        0.00        0.0         0.0
    2#    2     0  0     4         0.0        2.00       2.00       1.00       1.00       0.000        0.00        0.0         0.0
* kb   kl   km   kp         tk    kf     *     *     *     *     *     *     *     *     *     *     *     *     *     *     *     *
    1   0    0    0       0.60     0     0
    2   1    0    0       0.60     0     0
    3   0    0    0       0.60     0     0
```

wx0 Light source spread in x-direction (um).
wy0 Light source spread in y-direction (um).
xrm =1 : uniform intensity in x-direction.
=0 : cos-intensity distribution. Full width half maximum = wx0/2
=0～1 : rim intensity ratio of Gaussian distribution in x-direction.
yrm =1 : uniform intensity in y-direction.
=0 : cos-intensity distribution. Full width half maximum = wy0/2.
=0～1 : rim intensity ratio of Gaussian distribution in y-direction.
sx0 Shift length of light source center in x-direction (um).
sy0 Shift length of light source center in y-direction (um).





i_xz_t.out



i_xy_t.out

12. Contents of wsf.dat (wsf06.dat), 164s

```
Digit 1        10        20        30        40        50        60
** wsf.dat
*     kstp      kskp        lp   clp(0,1) crn(<1.0)  kfl       kot       ity
         0        10        10        00      0.89         0         0         0
*     kpls    tw(um)     kdip  kdr(0-2)   dnt(um)      nd1       nd2
         0       1.0         0         0         0       8.0        10        -3
*     ksct        lx        ly        lz
         1        20        20        20
*      kff       nff  thf(deg)  fif(deg)       krm       nrm   rm1(um)   rm2(um)
         1        90    -180.0       0.0         0       100      0.92      0.96
*   wdx(um)   wdy(um)   dxy(um)    dz(um)
       1.8       0.0      0.01      0.01
*   Lam(um)   th(deg)   fi(deg)   gm(deg)
       0.5       0.0       0.0       0.0
*   wx0(um)   wy0(um)  xrm(rim)  yrm(rim)   sx0(um)   sy0(um)       kpx       kpy
       3.0       3.0       1.0       1.0       0.0       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     -SiO2   1    1.4623      0.00    0.0000
  2#       -Al   1    2.0000      0.00    0.0000
                                                     桁数   70        80        90       100       110
* 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    1       0.0      0.00     0.000      0.30      0.30    -0.000      0.00       0.0       0.0
  2#     2   0  0    4       0.0      2.00      2.00      1.00      1.00     0.000      0.00       0.0       0.0
* kb  kl  km  kp     tk   kf    *    *    *    *    *    *    *    *    *    *    *    *    *    *    *    *
   1   0   0   0   0.60    0    0
   2   0   0   0   0.60    1    0
   3   0   0   0   0.60    0    0
```

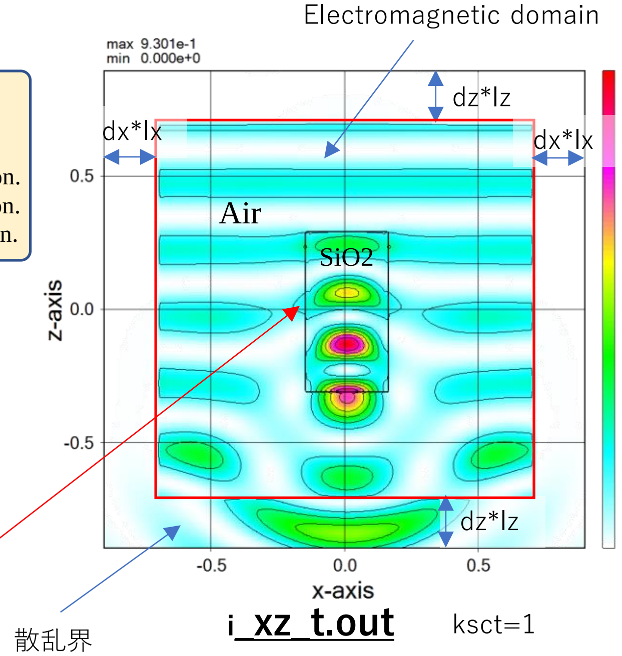
Operated for kdr=0

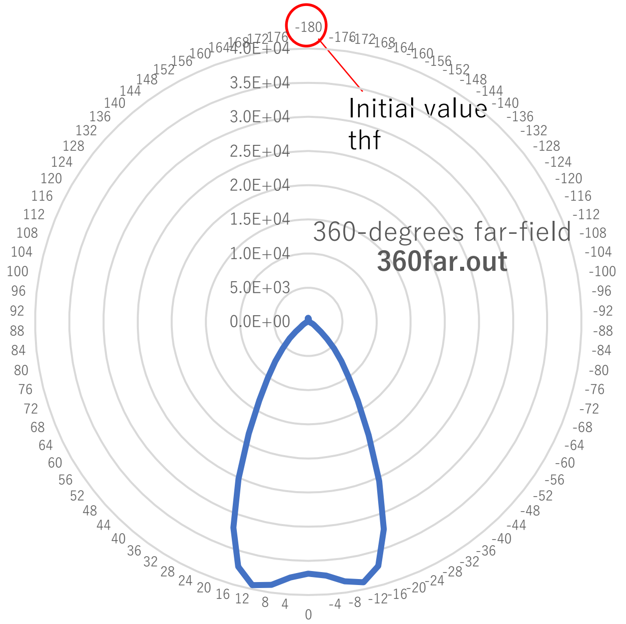
ksct = 0 : Without scattering field.
= 1 : With scattering field.

lx Number of layers of scattering zone in x-direction.

ly Number of layers of scattering zone in y-direction.

lz Number of layers of scattering zone in z-direction.





Operated for CW-oscillation kpls=0

kff Far-field analysis of 360-degrees.
=0 : Not be conducted. =1 : Be conducted.

nff Number of azimuth angles in the far-field, or number of partitions per single rotation.
Calculated results are output to 360far.out.

thf Starting azimuth angle in the far-field (deg).

fif Argument angle in the far-fileld (deg).

13. Contents of wsf.dat (wsf07.dat), 1275s

The larger the value, the more accurate the analysis. It should be set so as the amount of light remaining in the analysis region is sufficiently attenuated.

The larger the value, the larger the gain variation within the range of wrm.

```
Digit 1       10        20        30        40        50        60
** wsf.dat
*     kstp      kskp        lp  clp(0,1) crn(<1.0) kfl       kot       ity
         0        10        10        11      0.89   0         0         0
*     kpls    tw(um)      kdip kdr(0-2)  dnt(um)   nd1       nd2
         5       6.0         0         0         0  400.0      10        -3
*     ksct        lx        ly        lz
         0        20        20        20
*      kff       nff  thf(deg)  fif(deg)  krm        nrm       rm1(um)   rm2(um)
         0        90    -180.0       0.0    1        100       0.92      0.96
*   wdx(um)   wdy(um)   dxy(um)    dz(um)
       0.2       0.0      0.01      0.01
*  Lam(um)   th(deg)   fi(deg)   gm(deg)
      0.94       0.0       0.0       0.0
*   wx0(um)   wy0(um)  xrm(rim)  yrm(rim)  sx0(um)   sy0(um)   kpx       kpy
       3.0       3.0       1.0       1.0      0.0       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   2.11000      0.00     0.000
   2        -Si02  1    1.0000      0.00    0.0000       桁数  70        80        90        100       110
* 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     1       0.0     0.00    0.000      0.30      0.30    -0.000      0.00      0.0       0.0
* kb   kl   km   kp         tk   kf   *    *    *    *    *    *    *    *    *    *    *    *    *    *    *    *
   1    0    0    0       0.30    0   0
   2    0    2    0       0.30    0   0
   3    0    1    0    0.11180    0   0
   4    0    2    0    0.16268    0   0
        .    .    .
  47    0    1    0    0.11180    0   0
  48    0    2    0       0.30    0   0
  49    0    0    0       0.30    0   0
```

Light source position at top line

−z ↑ Propagation direction cos(th)>0 ↓ +z

Insert a blank line beginning with "c" at the breakpoint to abort reading

Since the alignment of the structural layers is inverted on the z-axis and light propagation is also from −z to +z direction, it is easy to see when pictures displayed in Wscnt are vertically inverted to align a direction.

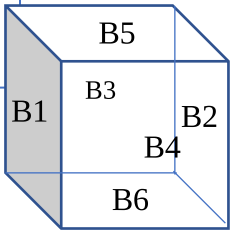
Operated for Pulse-oscillation kpls<>0

krm	Frequency spectrum analysis. =0: Not be conducted. =1: Be conducted.
nrm	Division number of frequency spectrum. Calculated results of time-domain and frequency-domain for six boundaries are output to flow_t.out and flow_f.out, respectively.
rm1	Analyzed starting wavelength (um).
rm2	Analyzed final wavelength (um).

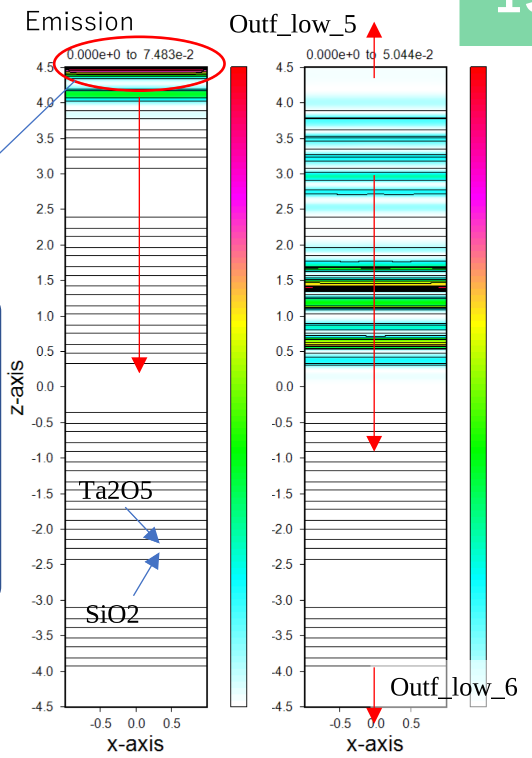
構造層

1	0	0	0	0.30	0	0
2	0	2	0	0.30	0	0
3	0	1	0	0.11180	0	0
4	0	2	0	0.16268	0	0
5	0	1	0	0.11180	0	0
6	0	2	0	0.16268	0	0
7	0	1	0	0.11180	0	0
8	0	2	0	0.16268	0	0
9	0	1	0	0.67082	0	0
10	0	2	0	0.16268	0	0
11	0	1	0	0.11180	0	0
12	0	2	0	0.16268	0	0
13	0	1	0	0.11180	0	0
14	0	2	0	0.16268	0	0
15	0	1	0	0.11180	0	0
16	0	2	0	0.16268	0	0
17	0	1	0	0.11180	0	0
18	0	2	0	0.16268	0	0
19	0	1	0	0.11180	0	0
20	0	2	0	0.16268	0	0
21	0	1	0	0.11180	0	0
22	0	2	0	0.16268	0	0
23	0	1	0	0.11180	0	0
24	0	2	0	0.16268	0	0
25	0	1	0	0.67082	0	0
26	0	2	0	0.16268	0	0
27	0	1	0	0.11180	0	0
28	0	2	0	0.16268	0	0
29	0	1	0	0.11180	0	0
30	0	2	0	0.16268	0	0
31	0	1	0	0.11180	0	0
32	0	2	0	0.16268	0	0
33	0	1	0	0.11180	0	0
34	0	2	0	0.16268	0	0
35	0	1	0	0.11180	0	0
36	0	2	0	0.16268	0	0
37	0	1	0	0.11180	0	0
38	0	2	0	0.16268	0	0
39	0	1	0	0.11180	0	0
40	0	2	0	0.16268	0	0
41	0	1	0	0.67082	0	0
42	0	2	0	0.16268	0	0
43	0	1	0	0.11180	0	0
44	0	2	0	0.16268	0	0
45	0	1	0	0.11180	0	0
46	0	2	0	0.16268	0	0
47	0	1	0	0.11180	0	0
48	0	2	0	0.30	0	0
49	0	0	0	0.30	0	0

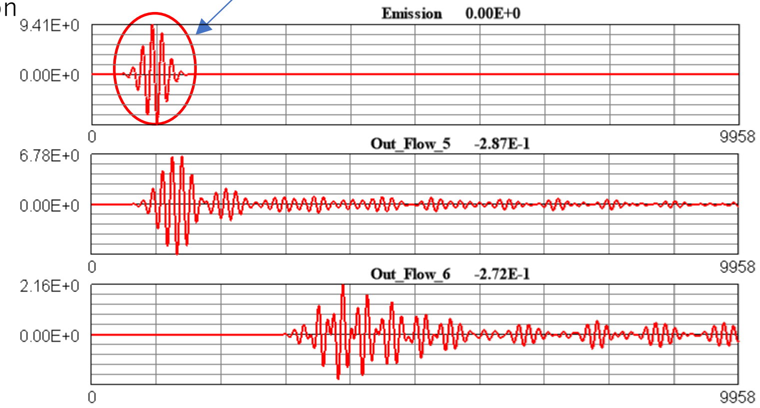
10nm bandpass filter structure centered at 940nm



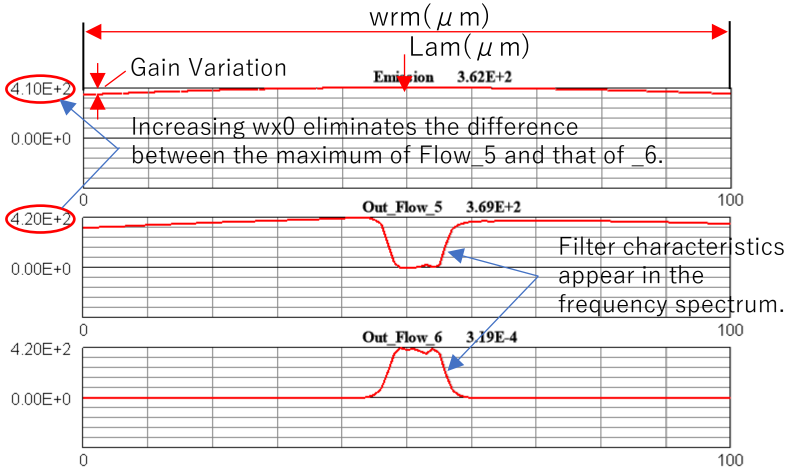
If "U/D_reverse" is checked in wscnt, B5/B6 is reversed as above.



i_xz_t.out



flow_t.out



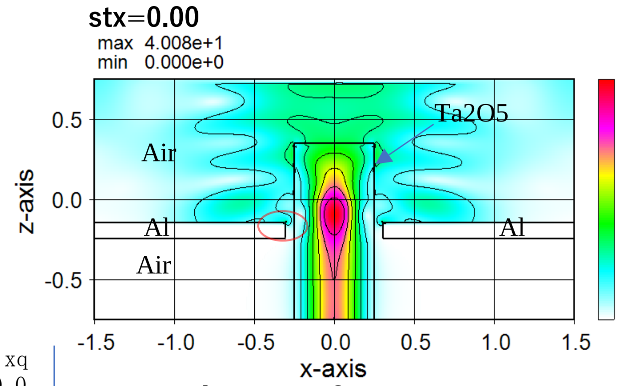
flow_f.out

14. Contents of wsf.dat (wsf08.dat), 24.9s

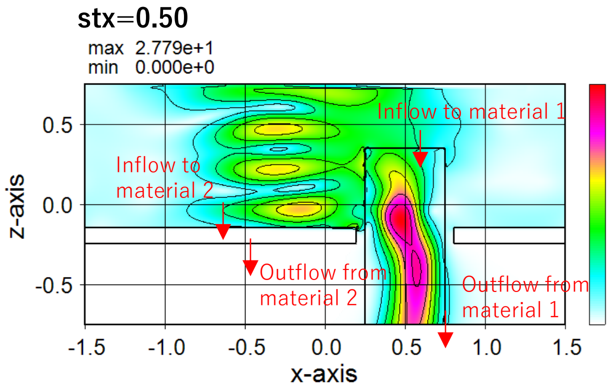
```
Digit 1     10         20         30         40         50         60
   ** wsf.dat
   *     kstp       kskp         lp       clp(0,1)  crn(<1.0)  kfl         kot         ity
            0         10         10         11       0.89          0           0           0
   *     kpls         tw(um)   kdip       kdr(0-2)  dnt(um)    nd1         nd2
            0        0.1          0          0          0       10.0          10          -3
   *     ksct         lx         ly         lz
            0         20         20         20
   *      kff        nff        thf(deg)  fif(deg)  krm        nrm         rm1(um)     rm2(um)
            0         90     -180.0        0.0          0        100        0.92        0.96
   *      wdx(um)    wdy(um)    dxy(um)    dz(um)
          3.0        0.0       0.01       0.01
   *      Lam(um)     th(deg)    fi(deg)    gm(deg)
         0.94        0.0        0.0        0.0
   *      wx0(um)    wy0(um)    xrm(rim)   yrm(rim)  sx0(um)    sy0(um)     kpx         kpy
          2.5        2.5        0.0        0.0        0.0        0.0           0           0
   *      stx(um)    sty(um)    csx(um)    csy(um)
          0.5        0.0        0.0        0.0
   * km     *   Name   ko        an         ab         ak
      1        Ta2O5    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
```

stx Shift length of overall structure center in x-direction (um). Not applicable for light source position.
sty Shift length of overall structure center in y-direction (um). Not applicable for light source position.
csx Cross sectional position of graphics in x-direction (um).
csy Cross sectional position of graphics in y-direction (um).

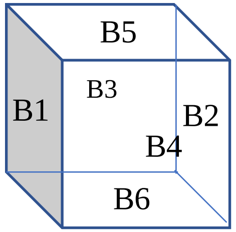
If "Al" is used, the material is treated as non-dispersed one. Always prefix the name with "-" to indicate a dispersed material. In most cases of dispersed materials, k is larger than n. FDTD algorithm runs out of control under the non-dispersed condition of k>n.



i_xz.out & m_xz.out



i_xz.out & m_xz.out



Wscntで上下反転している場合は上は-z側、下は+z側になる

15. Contents of wsf.dat (wsf09.dat), 1809s

```
Digit 1       10        20        30        40        50        60
** wsf.dat
*     kstp       kskp         lp      clp(0,1)  crn(<1.0) kfl        kot        ity
         0         10         10         11     0.89         0          0          0
*     kpls         tw(um)   kdip      kdr(0-2)  dnt(um)   nd1        nd2
         0        1.0          0          0        0     10.0         10         -3
*     ksct         lx         ly         lz
         0         20         20         20
*      kff        nff       thf(deg)  fif(deg)  krm        nrm        rm1(um)    rm2(um)
         0         90     -180.0       0.0        0        100       0.92       0.96
*      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
*      wx0(um)    wy0(um)    xrm(rim)   yrm(rim)  sx0(um)   sy0(um)    kpx        kpy
       3.0        3.0        1.0        1.0      0.0       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      Ta2O5   1     1.0000       0.00     0.0000
   2        -Al   1     2.0000       0.00     0.0000
                                                       桁数   70        80        90        100       110
* 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
```

Calculated as external data (nk.dat).

If unregistered, only up to two lines can be read.

Calculated as dispersion material

If extinction coefficient > refractive index, FDTD will runaway. Therefore, metallic materials should be always specified as dispersing materials and “-” is added to the beginning of the material name.

Corner R is expressed by setting elliptic exponent index xp.

km designation field (for optical materials)

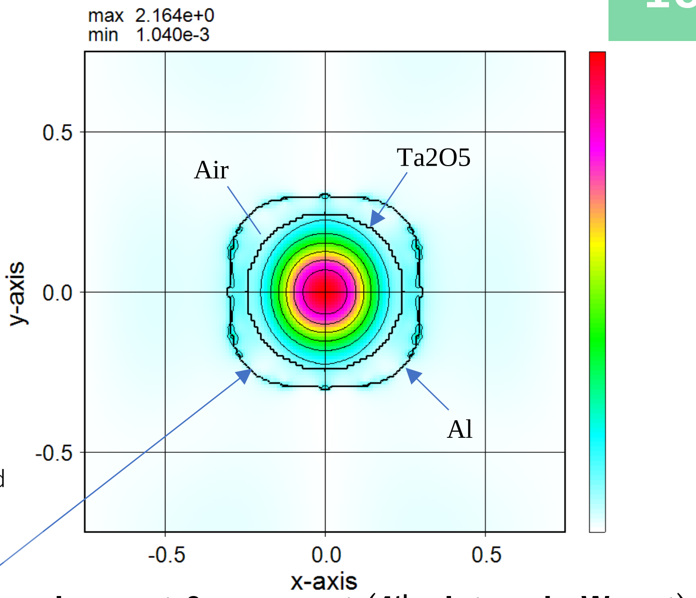
The first 4 digits are serial line numbers, up to 200 lines can be input. Name Material name (within 8 digits) SiO2,Ag,Al,Au,Be,Cr,Cu,Ni,Pd,Pt,Ti,W have internal data. For others, by entering the wavelength, refractive index, and extinction coefficient in the file of nk.dat as external data, the refractive index and extinction coefficient are automatically interpolated. If no data exists in nk.dat, the values defined by the right-side parameter of 'an' are given priority. nk.dat should be created by each user and stored in the same folder as wsf.exe.

ko Whether to output detected light amount to wsf1.out or not. =0 : not output, =1 : output.

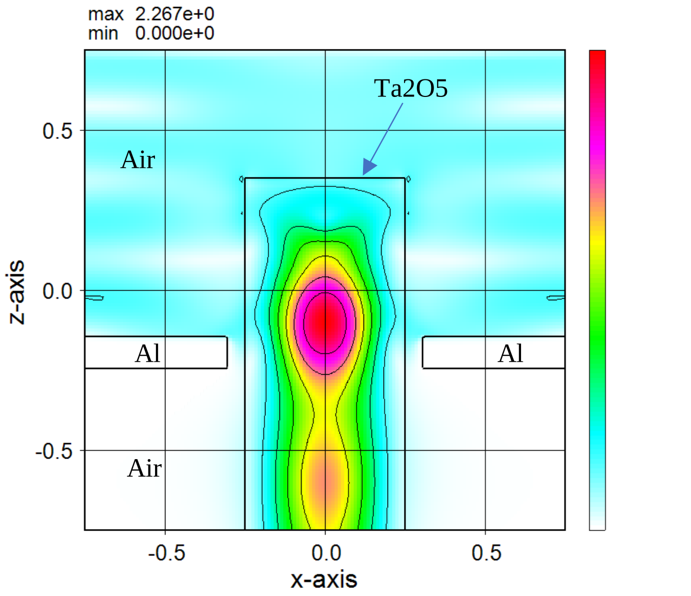
an Refractive index.

ab Abbe number, if =0, no dispersion (fixed to refractive index).

ak Extinction coefficient.

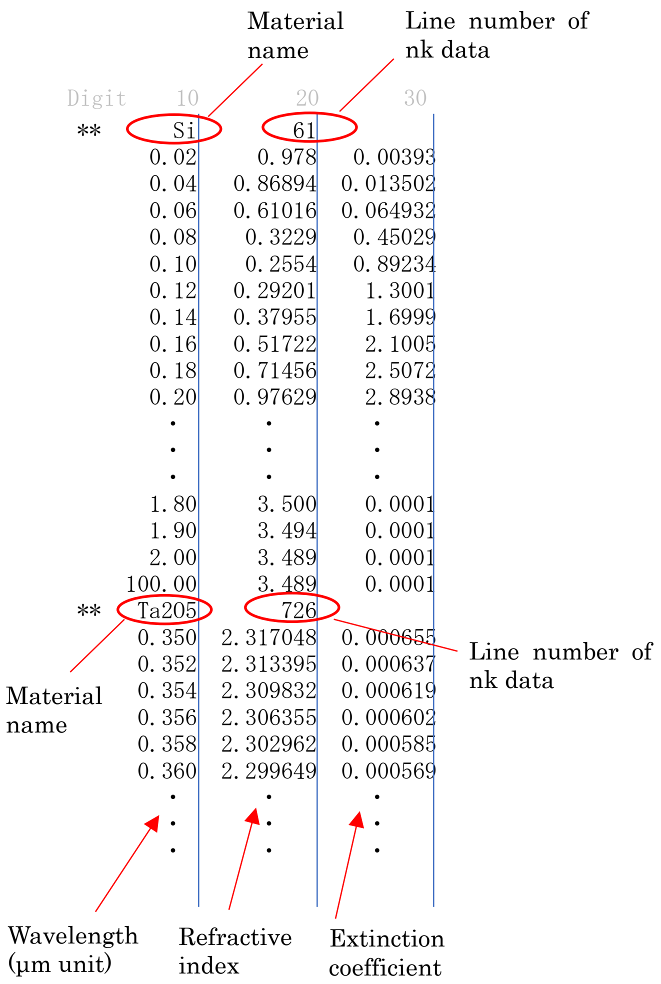


i_xy.out & m_xy.out (4th picture in Wscnt)



i_xz.out & m_xz.out

16. Contents of nk.dat



Excerpts from nk.dat

Numerical Data Input Rule

- After entering the delimiter mark (**) on the first line of the numerical data, write the material name (8 columns) and the number of lines of nk.dat (10 columns).
- Input numbers are half-width (Spaces should be half-width and Tab codes are not allowed).
- The right edge of the input digit must be aligned with a vertical line in 10-digit increments.
- Input numbers should be spaced by at least one half-width space.

The material data can be created by overlaying the actual measured values or literature values, etc. in the format shown above. The file name should be "nk.dat" and must be stored in the folder where wsf.exe is located. However, the material name must be other than -SiO2, -Ag, -Al, -Au, -Be, -Cr, -Cu, -Ni, -Pd, -Pt, -Ti, -W which are defined in internal materials. If there are duplicate material names, the first data takes priority.

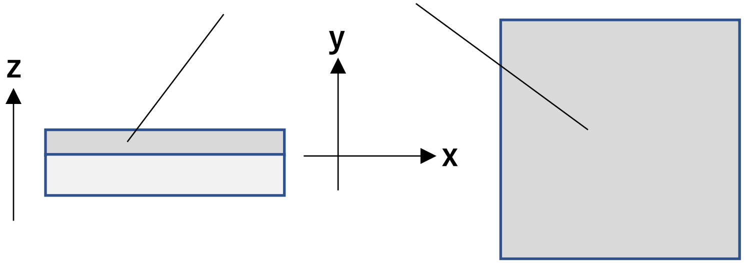
References

https://refractiveindex.info/?shelf=main&book=Ta2O5&page=Bright-amorphous

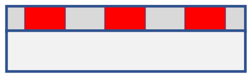
https://www.filmetricsinc.jp/refractive-index-database/Ta2O5

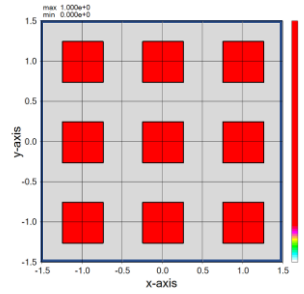
17. Procedure for defining optical structures

① Definition of a Base layer
1. setting km and tk
2. entering kf for reference

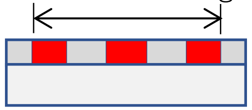


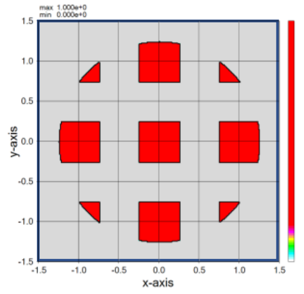
② Definition of periodic structures on a Base layer at Kf specification field
1. setting km, kd,and kt
2. definition of structures by setting parameters from ps to xq
3. entering kr for reference





③ Restriction of periodic structures at Kr specified field
1. setting kd and kt
2. definition of the restriction shape by setting parameters from ps to xp






```
** wsf.dat
*      kstp      kskp        lp      clp(0,1)  crn(<1.0)  kfl       kot       ity
          0        10        10        00      0.99         0         0         0
*      kpls        tw(um)   kdip     kdr(0-2)  dnt(um)    nd1       nd2
          0       1.0         0         0         0      0.01        10        -3
*      ksct        lx        ly        lz
          0        20        20        20
*       kff       nff    thf(deg)  fif(deg)  krm        nrm       rm1(um)   rm2(um)
          0        90    -180.0     0.0         0       100      0.92     0.96
*       wdx(um)   wdy(um)   dxy(um)   dz(um)
        3.0       3.0      0.01      0.01
*       Lam(um)    th(deg)   fi(deg)   gm(deg)
       0.94       0.0       0.0       0.0
*       wx0(um)   wy0(um)   xrm(rim)  yrm(rim)  sx0(um)   sy0(um)   kpx       kpy
        2.0       2.0       0.0       0.0       0.0       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        -SiO2   1    2.0000      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    2     0.0      0.00      0.00      2.50      2.50      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     1  0   1     0.0      1.00     1.000      0.50      0.50    -0.000      0.00      0.0       0.0
   2#    2     0  0   4     0.0      2.00      2.00      1.00      1.00     0.000      0.00      0.0       0.0
* kb  kl  km  kp       tk   kf    *    *    *    *    *    *    *    *    *    *    *    *    *    *    *    *
   1   0   0   0     0.60    1    0
```

Kr field ③ · Kf field ② · ① Base layer

18. Contents of wsf.dat (wsf10.dat), 9.9s

```
Digit 1        10        20        30        40        50        60
      ** wsf.dat
      *     kstp      kskp        lp   clp(0,1)  crn(<1.0) kfl       kot       ity
               0        10        10        00      0.99    0         0         0
      *     kpls        tw(um)  kdip   kdr(0-2)  dnt(um)  nd1       nd2
               0       1.0         0         0         0   0.01        10        -3
      *     ksct        lx        ly        lz
               0        20        20        20
      *      kff       nff   thf(deg)  fif(deg)  krm       nrm    rm1(um)   rm2(
               0        90    -180.0       0.0      0       100     0.92      0.96
      *      wdx(um)   wdy(um)   dxy(um)    dz(um)
             3.0       3.0      0.01      0.01
      *      Lam(um)    th(deg)   fi(deg)   gm(deg)
            0.94       0.0       0.0       0.0
      *      wx0(um)   wy0(um)   xrm(rim)  yrm(rim)  sx0(um)   sy0(um)   kpx       kpy
             2.0       2.0       0.0       0.0       0.0       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      -SiO2    1    2.0000      0.00    0.0000
         2#       -Al    1    2.0000      0.00    0.0000                   桁数   70        80
      * kr        * kd    kt        ps(deg)   px(um)    py(um)    wx(um)    wy(um)    sx(um)    sy(um)    xp
         1#          0     2        0.0       0.00      0.00      2.50      2.50      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       1.00      1.000     0.50      0.50    -0.000      0.00      0.0       0.0
         2#    2     0  0    4        0.0       2.00      2.00      1.00      1.00     0.000      0.00      0.0       0.0
      * kb  kl  km  kp      tk   kf    *    *    *    *    *    *    *    *    *    *    *    *    *    *    *    *
         1   0   0   0    0.60    1    0
```

Referred

See the pages that follow for relationship with figures.

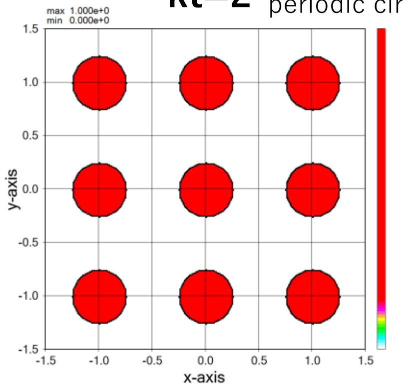
kf designation field (for foreground structures)

The first 4 digits are serial line numbers, up to 9999 lines can be input.

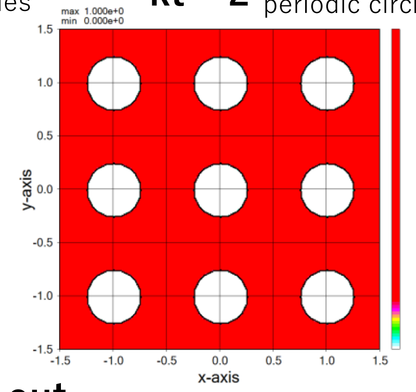
- km Construction material number referred in km designation field. km=0 means vacuum (n=1.0).
- kr Restriction shape number referred in kr designation field. kr=0 means restriction free.
- kd How to input shape data of structures.
  - =0: by internal definition. =1: by external data using sub.dat. Applied to all except for wx and wy, sub.dat can be input up to 400 types (up to 1000 lines for each type).
- kt Selection of shape type. (-kt shows an inverted shape for kt.)
  - When kd=1, kt=Pattern No. in sub.dat.
  - When kd=0,
    - kt=0 No area definition.
    - =1 Rectangular areas of width wx*wy centered on a square grid position of period px*py.
    - =2 Elliptic shape of width wx*wy and elliptic index xp centered on a square grid position of period px*py, where xp = -2.0 to -1.0 for star, = -1.0 for diamond, = 0.0 for ellipse, > 0.0 for square.
    - =3 Hexagons shape (top/bottom vertex angles) of width wx*wy centered on a square grid position of period px*py.
    - =4 Hexagon shape (left/right vertex angles) of width wx*wy centered on a square grid position of period px*py.
    - =5 Diamond shape of width wx*wy centered on a square grid position of period px*py.
    - =6 Right-angled triangular shape (diagonal 1st quadrant) of width wx*wy centered on a square grid position of period px*py.
    - =7 Right-angled triangular shape (diagonal 2nd quadrant) of width wx*wy centered on a square grid position of period px*py.
    - =8 Right-angled triangular shape (diagonal 3rd quadrant) of width wx*wy centered on a square grid position of period px*py.
    - =9 Right-angled triangular shape (diagonal 4th quadrant) of width wx*wy centered on a square grid position of period px*py.
    - =10 Linear lattice of period wx, angle wy, duty ratio xp, starting point xq included in each square grid of period px*py.
    - =11 Concentrically elliptic lattice of period wx, angle wy, duty ratio xp, starting point xq included in each square px*py of period px*py.
    - =12 Concentrically dodecagonal lattice of period wx, angle wy, duty ratio xp, starting point xq included in each square grid of period px*py.
    - =13 15-degrees-rotated lattice for kt=12.
    - =14 Concentrically 18-corner polygonal lattice of period wx, angle wy, duty ratio xp, starting point xq included in each square grid of period px*py.
    - =15 10-degrees-rotated lattice for kt=14.
    - =16 Concentrically hexagonal lattice of period wx, angle wy, duty ratio xp, starting point xq included in each square grid of period px*py.
    - =17 30-degrees-rotated lattice for kt=16.

- ps Rotation angle of all structures around the region center (deg).
- px Structure period in x-direction (um). When =0, it is an isolated pattern.
- py Structure period in y-direction (um). When =0, it is an isolated pattern.
- wx Structure width in y-direction (um).
- wy Structure width in y-direction (um).
- sx Shift length of the structure center in x-direction (um).
- sy Shift length of the structure center in y-direction (um).
- xp Elliptic exponent index for kt=2. Lattice duty ratio for kt=10 to 17.
- xq Starting point of lattice for kt=10 to 17.

kt=2 Defined inside periodic circles



kt=-2 Defined outside periodic circles



m_xy.out

19. Contents of wsf.dat (wsf11.dat), 11.0s

```
Digit 1      10        20        30        40        50        60
 ** wsf.dat
 *     kstp      kskp        lp       clp(0,1)  crn(<1.0) kfl        kot        ity
          0        10        10        00     0.99         0          0          0
 *     kpls        tw(um)  kdip       kdr(0-2)  dnt(um)    nd1        nd2
          0       1.0         0         0         0       0.01        10         -3
 *     ksct        lx        ly        lz
          0        20        20        20
 *      kff       nff       thf(deg)  fif(deg)  krm        nrm       rm1(um)    rm2(
          0        90    -180.0      0.0         0        100       0.92       0.96
 *      wdx(um)   wdy(um)   dxy(um)    dz(um)
        3.0       3.0      0.01      0.01
 *      Lam(um)    th(deg)   fi(deg)   gm(deg)
       0.94       0.0       0.0       0.0
 *      wx0(um)   wy0(um)   xrm(rim)  yrm(rim)  sx0(um)   sy0(um)   kpx        kpy
        2.0       2.0       0.0       0.0       0.0       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        -SiO2    1    2.0000      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     2      0.0      0.00      0.00      2.50      2.50      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     1  0      1      0.0      1.00     1.000      0.50      0.50    -0.000      0.00     0.0       0.0
   2#     2     0  0      4      0.0      2.00      2.00      1.00      1.00     0.000      0.00     0.0       0.0
 * kb   kl   km   kp          tk    kf    *    *    *    *    *    *    *    *    *    *    *    *    *    *    *    *
    1    0    0    0        0.60     1    0
```

Referred

kr designation field (for restricting shapes)

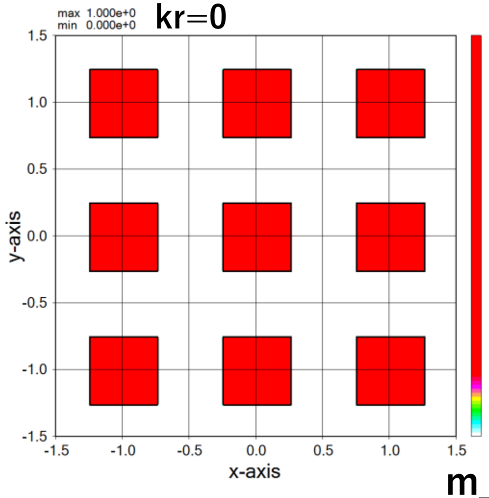
The first 4 digits are serial line numbers, up to 1000 lines can be input.

kd How to input shape data of structures.
- =0: by internal definition.
- =1: by external data using sub.dat. Applied to all except for wx and wy, sub.dat can be input up to 400 types (up to 1000 lines for each type).

kt Selection of shape type. (-kt shows an inverted shape for kt.)
- When kd=1, kt=Pattern No. in sub.dat.
- When kd=0,
- kt =0 No area restriction.
  - =1 Restricted by rectangular areas of width wx*wy centered on a square grid position of period px*py.
  - =2 Restricted by elliptic shape of width wx*wy and elliptic index xp centered on a square grid position of period px*py, where xp = -2.0 to -1.0 for star, = -1.0 for diamond, = 0.0 for ellipse, > 0.0 for square.
  - =3 Restricted by hexagons shape (top/bottom vertex angles) of width wx*wy centered on a square grid position of period px*py.
  - =4 Restricted by hexagon shape (left/right vertex angles) of width wx*wy centered on a square grid position of period px*py.
  - =5 Restricted by diamond shape of width wx*wy centered on a square grid position of period px*py.
  - =6 Restricted by a right-angled triangular shape (diagonal 1st quadrant) of width wx*wy centered on a square grid position of period px*py.
  - =7 Restricted by a right-angled triangular shape (diagonal 2nd quadrant) of width wx*wy centered on a square grid position of period px*py.
  - =8 Restricted by a right-angled triangular shape (diagonal 3rd quadrant) of width wx*wy centered on a square grid position of period px*py.
  - =9 Restricted by a right-angled triangular shape (diagonal 4th quadrant) of width wx*wy centered on a square grid position of period px*py.

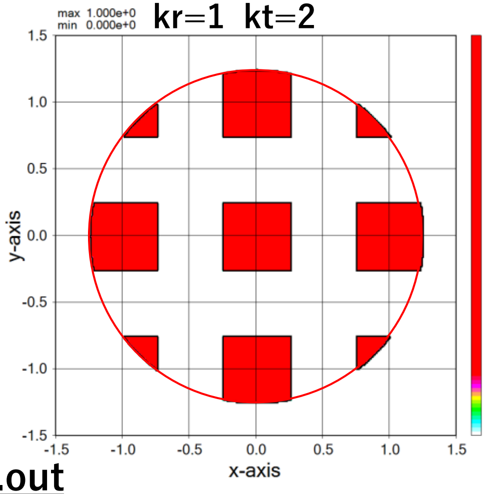
- ps Rotation angle of all structures around the region center (deg).
- px Structure period in x-direction (um). When =0, it is an isolated pattern.
- py Structure period in y-direction (um). When =0, it is an isolated pattern.
- wx Structure width in y-direction (μm).
- wy Structure width in y-direction (μm).
- sx Shift length of the structure center in x-direction (um).
- sy Shift length of the structure center in y-direction (um).
- xp Elliptic exponent index for kt=2. Lattice duty ratio for kt=10 to 17.

kr=0



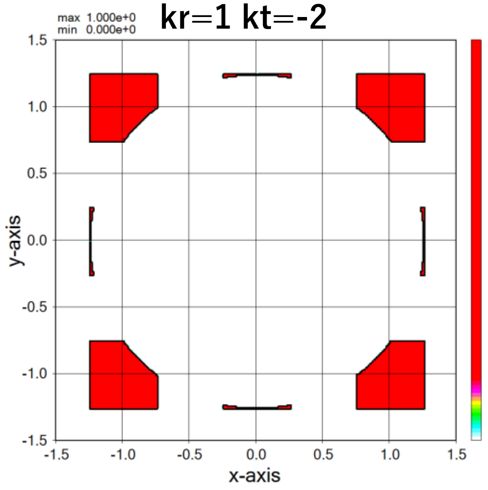
limited inside a circle by setting kr designation field

kr=1 kt=2



limited outside a circle by setting kr designation field

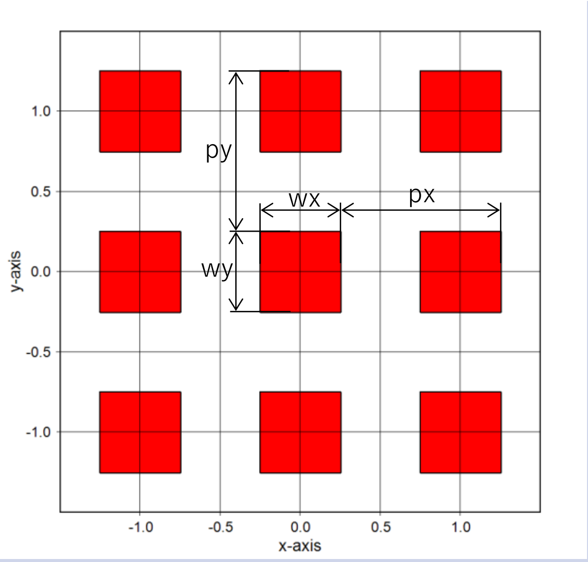
kr=1 kt=-2



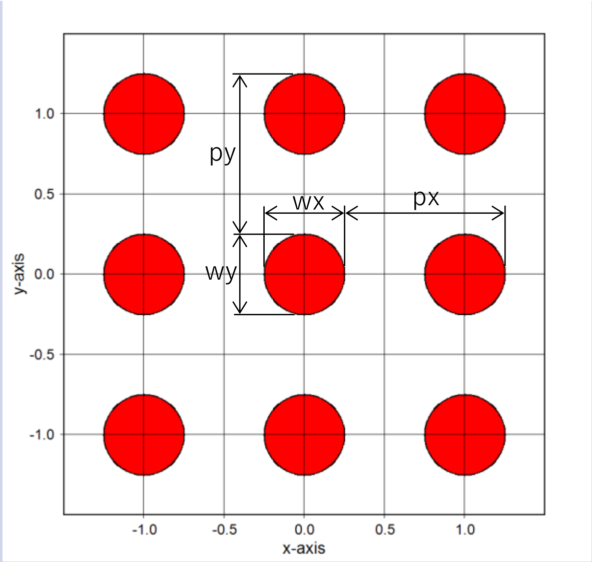
m_xy.out

20. Relationships (1) between kt and structures for kd=0

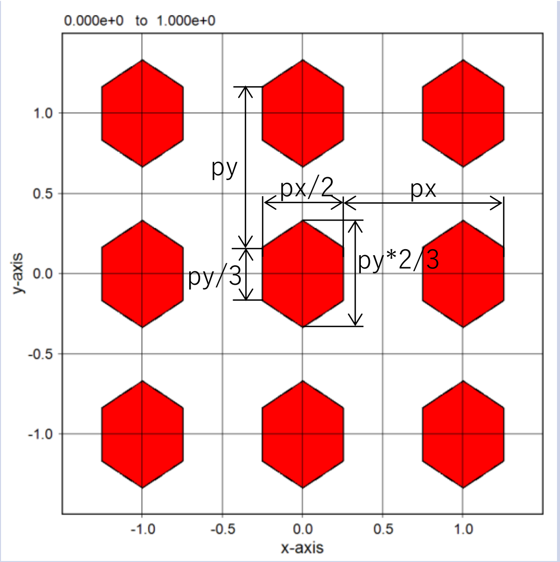
kt=1



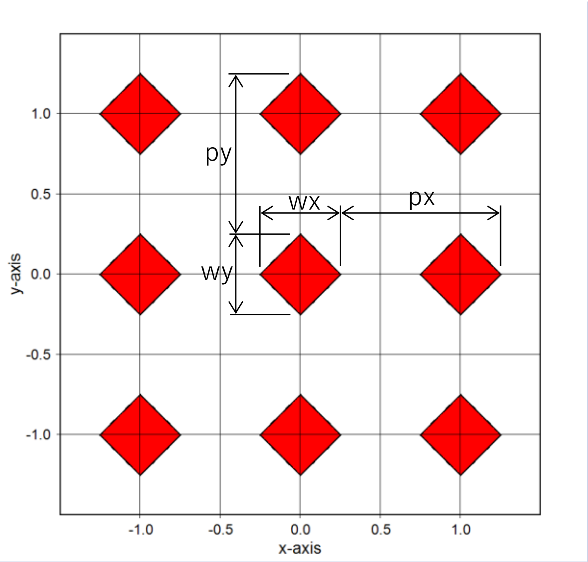
kt=2



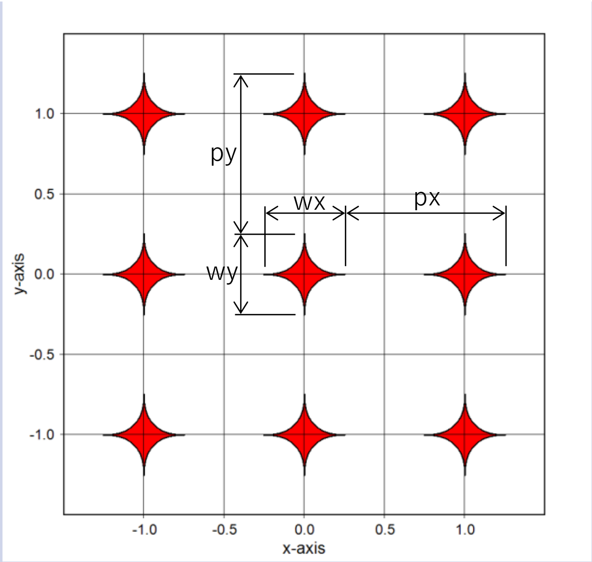
kt=3



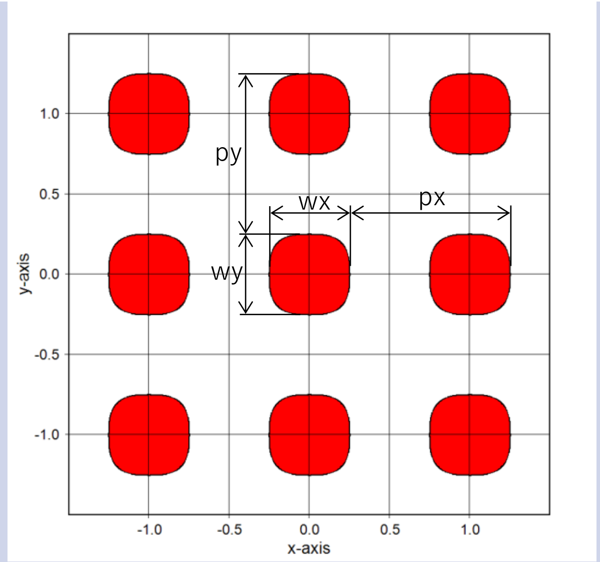
kt=2,xp=-1.0



kt=2,xp=-1.5

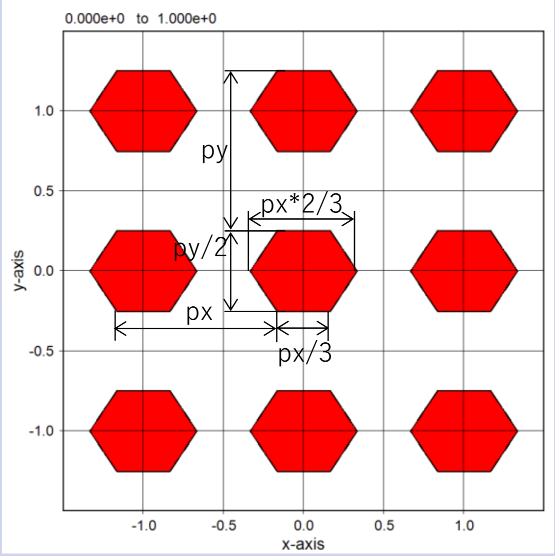


kt=2,xp=1.0

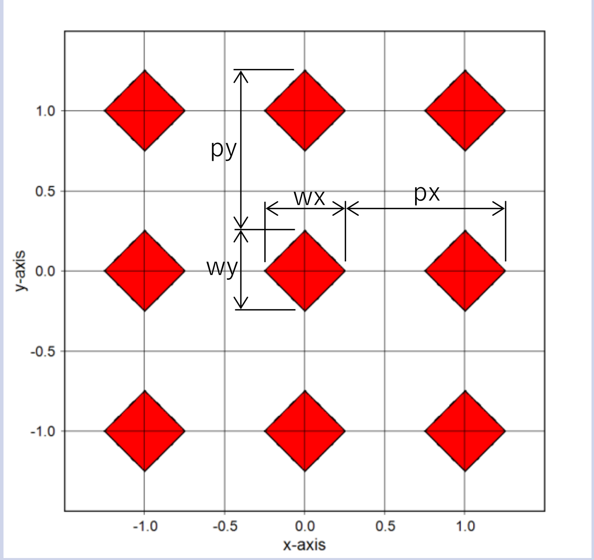


21. Relationships (2) between kt and structures for kd=0

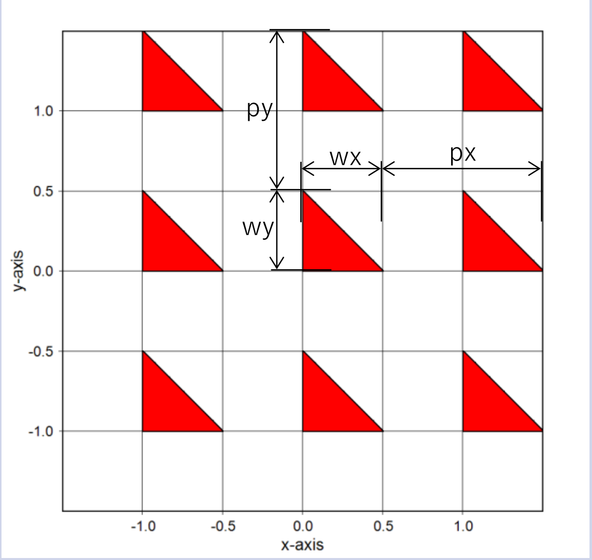
kt=4



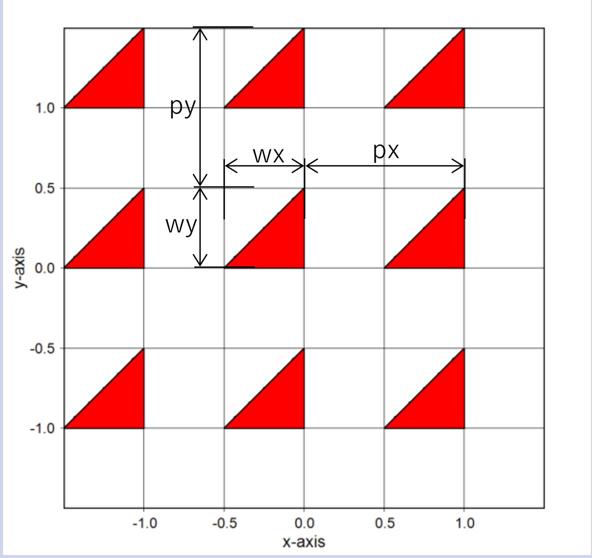
kt=5



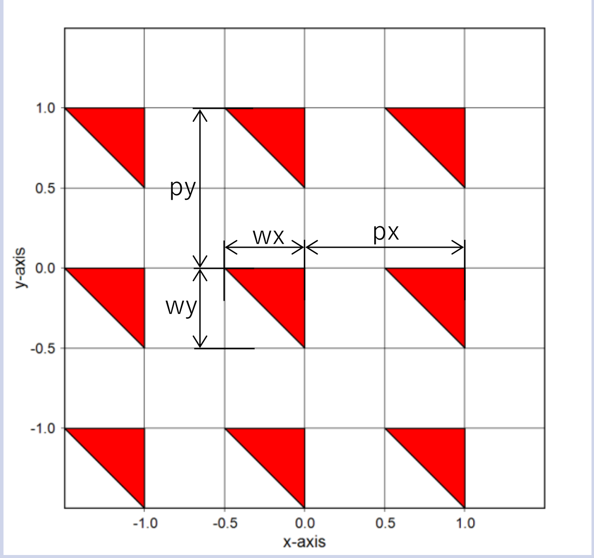
kt=6



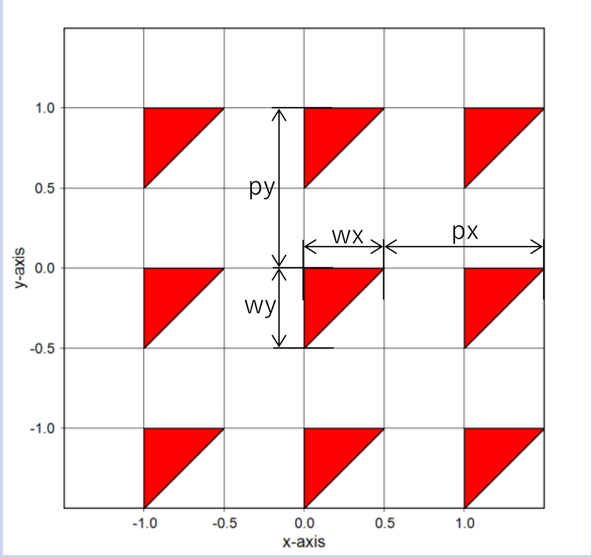
kt=7



kt=8

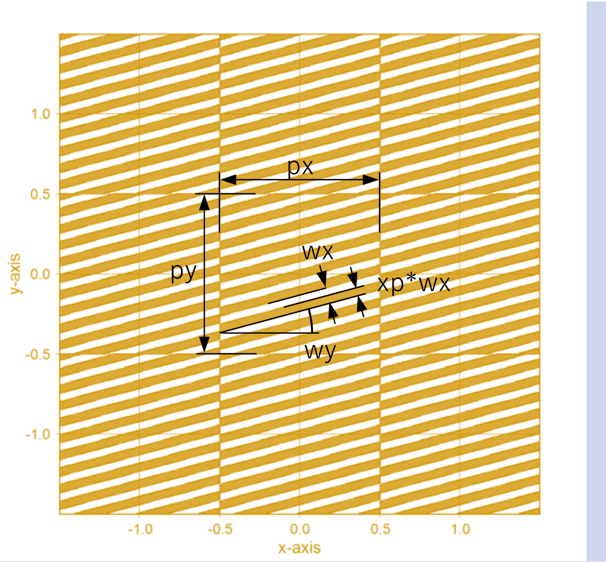


kt=9

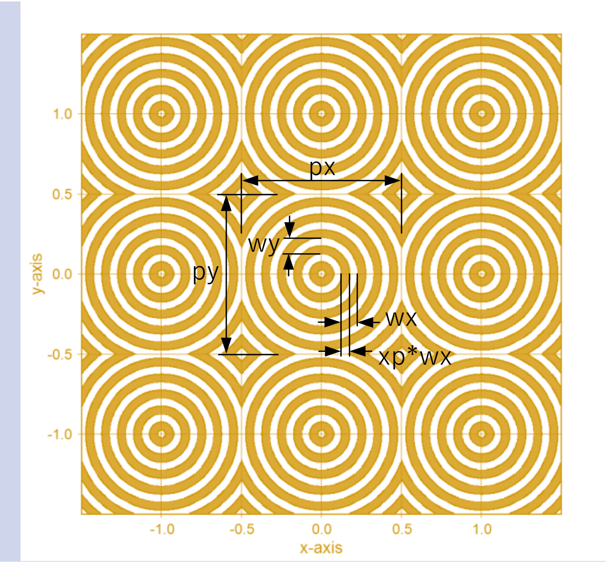


22. Relationships (3) between kt and structures for kd=0

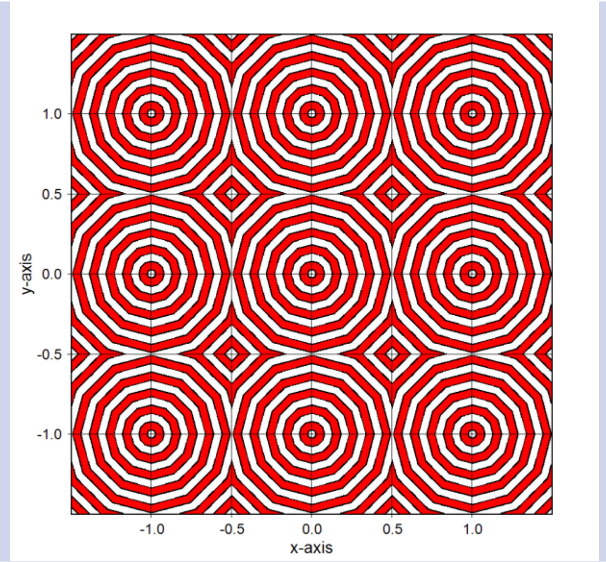
kt=10



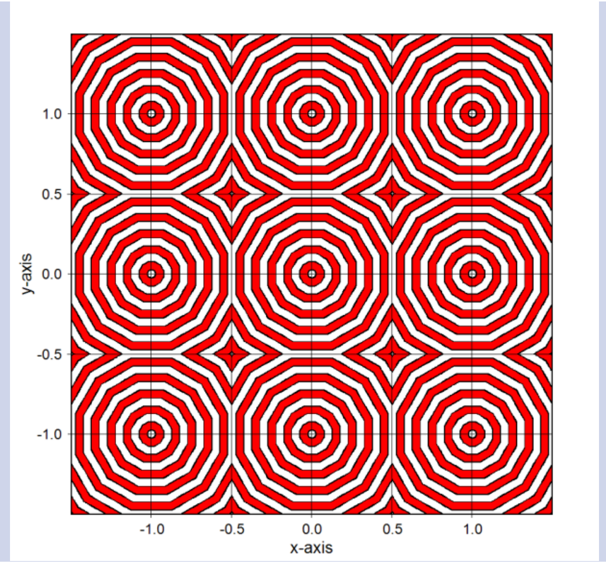
kt=11



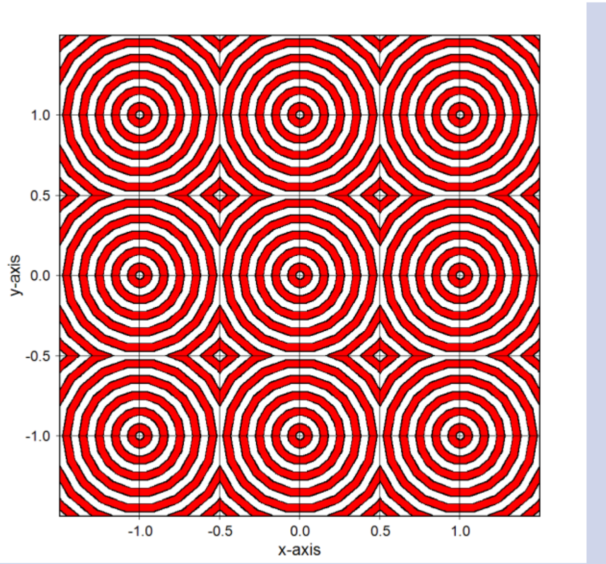
kt=12



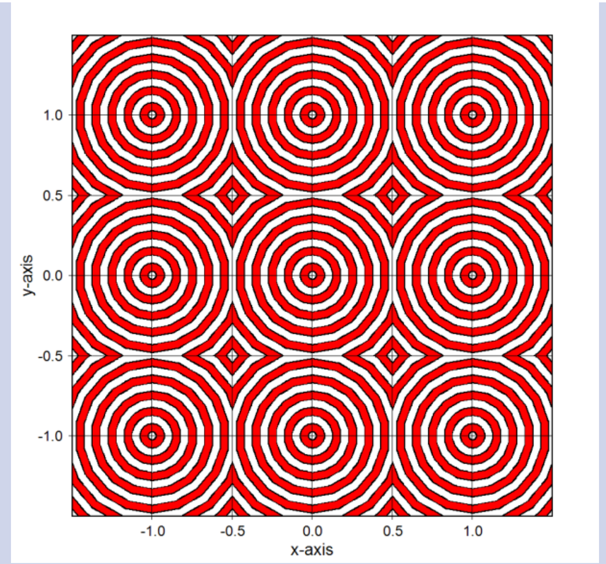
kt=13



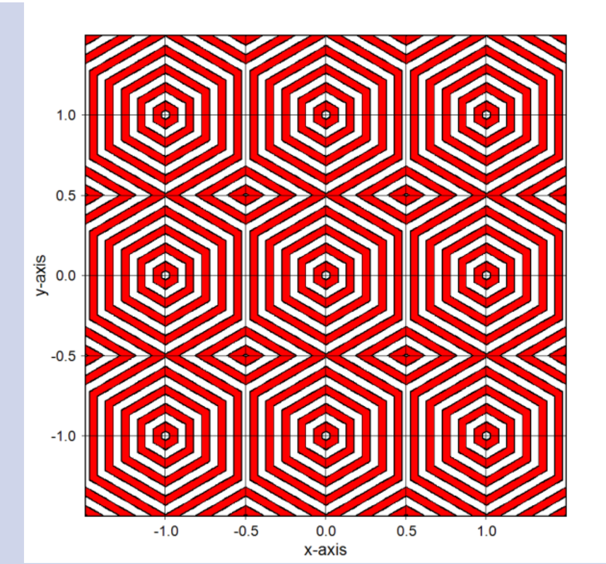
kt=14



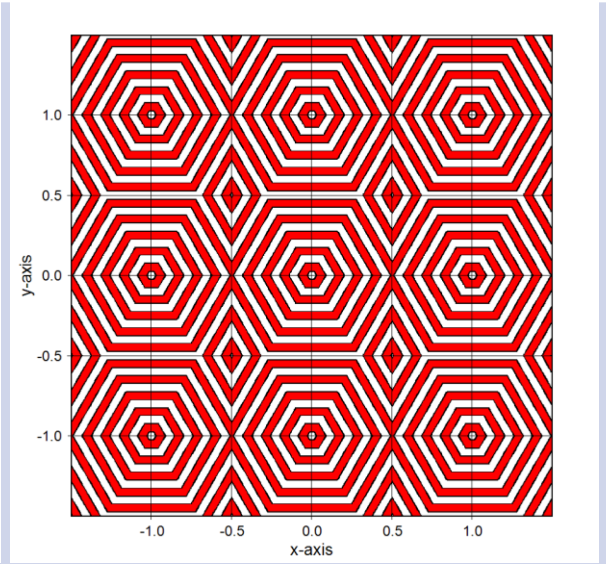
kt=15



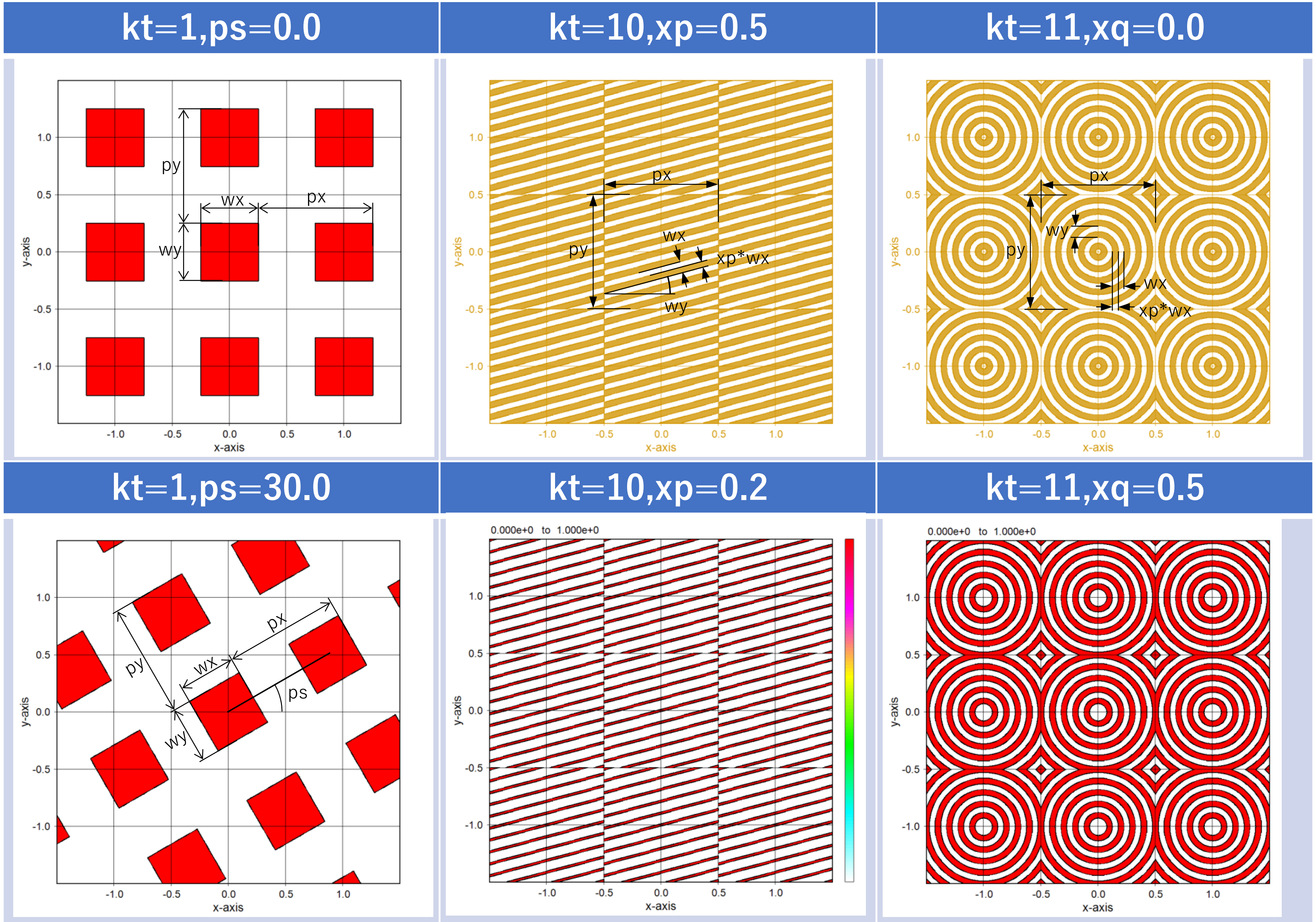
kt=16



kt=17



23. Relationships (4) between kt and structures for kd=0



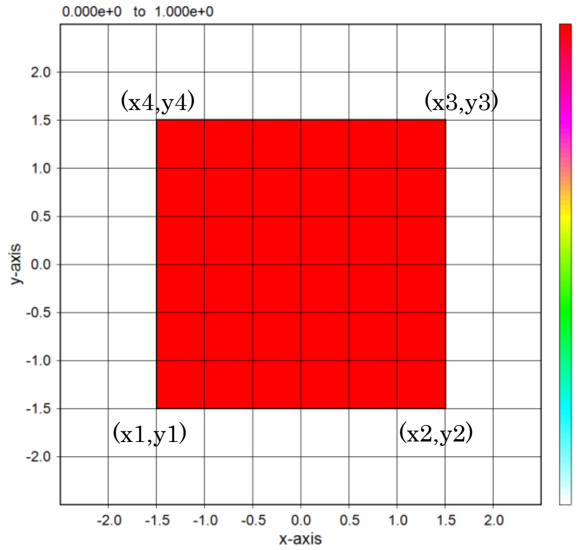
24. Reference to sub.dat for kd=1 (sub.dat)

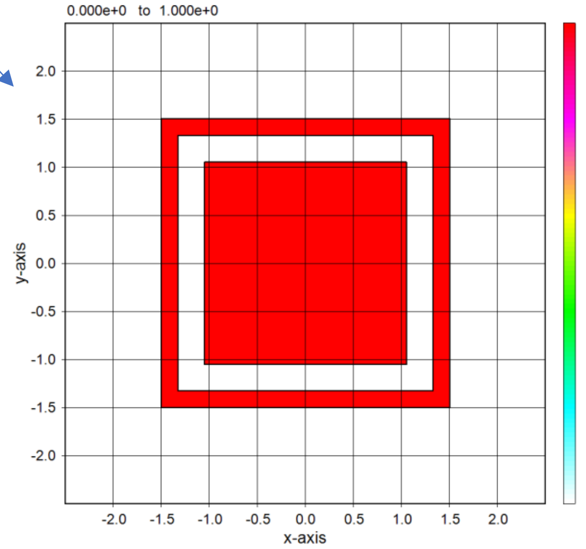
Contents of sub.dat

Digit1	5	15	25	35	45	55	65	75	85
		x1	y1	x2	y2	x3	y3	x4	y4
	1	-1.5000	-1.5000	1.5000	-1.5000	1.5000	1.5000	-1.5000	1.5000
	2	-1.0500	-1.0500	1.0500	-1.0500	1.0500	1.0500	-1.0500	1.0500
		-1.5000	-1.5000	1.5000	-1.5000	1.5000	-1.3250	-1.5000	-1.3250
		1.3250	-1.3250	1.5000	-1.3250	1.5000	1.3250	1.3250	1.3250
		1.5000	1.3250	1.5000	1.5000	-1.5000	1.5000	-1.5000	1.3250
		-1.5000	-1.3250	-1.3250	-1.3250	-1.3250	1.3250	-1.5000	1.3250

Corresponding to the values kt of wsf.dat. Duplication is prohibited.

Excerpt of sub.dat





The enclosing figures of four points (in μm) of (x1,y1), (x2,y2), (x3,y3), and (x4,y4) or their aggregate figures are lined up at a pitch of px, py and a shift amount of sx, sy.

Numeric data input rules

- Input numerals must be one-byte ones (full-width spaces are not allowed, nor are tab codes).
- The right end of the input numerals for each must be aligned with 10-digits increments after first 5-digits.
- Input numbers should be separated by at least one space.

25. Method of forming a lens shape (wsf12.dat), 251s

```
** wsf.dat
*     kstp      kskp       lp        clp(0,1)  crn(<1.0) kfl       kot       ity
         0        10       10        00        0.99        0         0         0
*     kpls      tw(um)   kdip       kdr(0-2)  dnt(um)   nd1       nd2
         0       1.0        0         0         0       5.0        10        -3
*     ksct        lx       ly        lz
         0        20       20        20
*      kff       nff      thf(deg)   fif(deg)  krm       nrm       rm1(um)   rm2(um)
         0        90    -180.0       0.0        0       100       0.92      0.96
*      wdx(um)   wdy(um)   dxy(um)   dz(um)
       2.0       2.0      0.02      0.02
*     Lam(um)    th(deg)   fi(deg)   gm(deg)
      0.75       0.0       0.0       0.0
*      wx0(um)   wy0(um)   xrm(rim)  yrm(rim)  sx0(um)   sy0(um)   kpx       kpy
       1.5       1.5       0.0       0.0       0.0       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        -Si02   1    1.4500      0.00     0.0000
* kr        * kd    kt      ps(deg)   px(um)    py(um)    wx(um)    wy(um)    sx(um)    sy(um)    xp
  1#          0     2        0.0      0.00      0.00      2.50      2.50      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    2    0  0    2        0.0     1.000     1.000     0.244     0.244     0.000     0.00      0.0       0.0
   2    2    0  0    2        0.0     1.000     1.000     0.420     0.420     0.000     0.00      0.0       0.0
   3    2    0  0    2        0.0     1.000     1.000     0.539     0.539     0.000     0.00      0.0       0.0
   4    2    0  0    2        0.0     1.000     1.000     0.633     0.633     0.000     0.00      0.0       0.0
   5    2    0  0    2        0.0     1.000     1.000     0.712     0.712     0.000     0.00      0.0       0.0
   6    2    0  0    2        0.0     1.000     1.000     0.782     0.782     0.000     0.00      0.0       0.0
   7    2    0  0    2        0.0     1.000     1.000     0.844     0.844     0.000     0.00      0.0       0.0
   8    2    0  0    2        0.0     1.000     1.000     0.900     0.900     0.000     0.00      0.0       0.0
   9    2    0  0    2        0.0     1.000     1.000     0.951     0.951     0.000     0.00      0.0       0.0
  10    2    0  0    2        0.0     1.000     1.000     0.998     0.998     0.000     0.00      0.0       0.0
  11    2    0  0    2        0.0     1.000     1.000     1.041     1.041     0.000     0.00      0.0       0.0
  12    2    0  0    2        0.0     1.000     1.000     1.081     1.081     0.000     0.00      0.0       0.0
  13    2    0  0    2        0.0     1.000     1.000     1.118     1.118     0.000     0.00      0.0       0.0
  14    2    0  0    2        0.0     1.000     1.000     1.153     1.153     0.000     0.00      0.0       0.0
  15    2    0  0    2        0.0     1.000     1.000     1.185     1.185     0.000     0.00      0.0       0.0
  16    2    0  0    2        0.0     1.000     1.000     1.215     1.215     0.000     0.00      0.0       0.0
  17    2    0  0    2        0.0     1.000     1.000     1.243     1.243     0.000     0.00      0.0       0.0
  18    2    0  0    2        0.0     1.000     1.000     1.269     1.269     0.000     0.00      0.0       0.0
  19    2    0  0    2        0.0     1.000     1.000     1.293     1.293     0.000     0.00      0.0       0.0
  20    2    0  0    2        0.0     1.000     1.000     1.316     1.316     0.000     0.00      0.0       0.0
  21    2    0  0    2        0.0     1.000     1.000     1.337     1.337     0.000     0.00      0.0       0.0
  22    2    0  0    2        0.0     1.000     1.000     1.357     1.357     0.000     0.00      0.0       0.0
  23    2    0  0    2        0.0     1.000     1.000     1.375     1.375     0.000     0.00      0.0       0.0
  24    2    0  0    2        0.0     1.000     1.000     1.392     1.392     0.000     0.00      0.0       0.0
  25    2    0  0    2        0.0     1.000     1.000     1.407     1.407     0.000     0.00      0.0       0.0
* kb   kl   km   kp         tk     kf     *    *    *    *    *    *    *    *    *    *    *    *    *    *    *    *
   1    0    0    0      0.500    000     0
```

続き

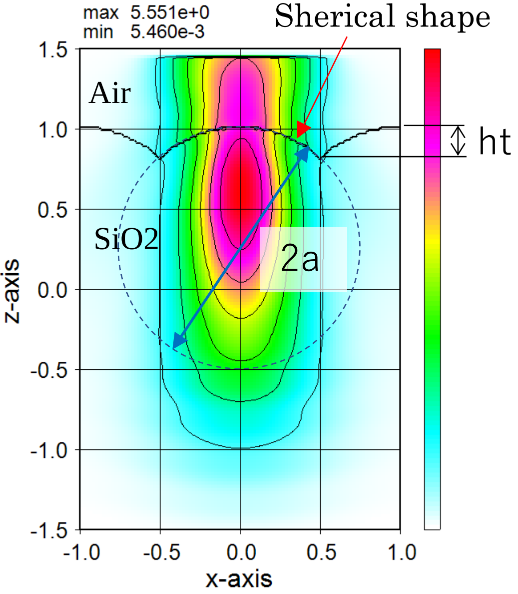
```
  2    0    0    0    0.020    001    0
  3    0    0    0    0.020    002    0
  4    0    0    0    0.020    003    0
  5    0    0    0    0.020    004    0
  6    0    0    0    0.020    005    0
  7    0    0    0    0.020    006    0
  8    0    0    0    0.020    007    0
  9    0    0    0    0.020    008    0
 10    0    0    0    0.020    009    0
 11    0    0    0    0.020    010    0
 12    0    0    0    0.020    011    0
 13    0    0    0    0.020    012    0
 14    0    0    0    0.020    013    0
 15    0    0    0    0.020    014    0
 16    0    0    0    0.020    015    0
 17    0    0    0    0.020    016    0
 18    0    0    0    0.020    017    0
 19    0    0    0    0.020    018    0
 20    0    0    0    0.020    019    0
 21    0    0    0    0.020    020    0
 22    0    0    0    0.020    021    0
 23    0    0    0    0.020    022    0
 24    0    0    0    0.020    023    0
 25    0    0    0    0.020    024    0
 26    0    0    0    0.020    025    0
 27    0    2    0    2.000    000    0
```

Rewritten — As it is — Rewritten — As it is — Rewritten

	A	B	C	D	E
1					
2	a=radius	n=Layer No	y=a-n*dz	x=sqrt(a^2-y^2)	2x=Intercept width
3	0.75	1	0.740	0.122	0.244
4	dz=Grid interval	2	0.720	0.210	0.420
5	0.02	3	0.700	0.269	0.539
6	ht=height	4	0.680	0.316	0.633
7	0.5	5	0.660	0.356	0.712
8		6	0.640	0.391	0.782
9		7	0.620	0.422	0.844
10		8	0.600	0.450	0.900
11		9	0.580	0.475	0.951
12		10	0.560	0.499	0.998
13		11	0.540	0.520	1.041
14		12	0.520	0.540	1.081

wsems_data.xlsx

ht Structure height (μm)
a Radius for circular cross-section (μm)



i_xz.out & m_xz.out

26. Method of converting AFM data by afm.exe (afm01.dat)

nx	x-axis measurement point
ny	y-axis measurement point
dx	x-axis measurement increment (μm)
dy	y-axis measurement increment (μm)
amp	z-axis measurement amplification ratio
theta	Azimuth angle of the plane normal with the z-axis (deg)
phi	Angular angle of the plane normal around the z-axis (deg)
psi	Rotation angle of the measured image around the plane normal (deg)

AFM measurement data of nx ·ny (for x and y-axis) points, each value in μm, displayed in 10 digits

Input file afm.dat

```
** AFM data
nx        ny        dx(um)    dy(um)    amp       theta(deg)  phi(deg)  psi(deg)
15        15        0.07      0.07      1.000     0.000       0.0000    0.0000
0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.007605 0.011817 0.007605 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000 0.032162 0.064350 0.086619 0.094445 0.086619 0.064350 0.032162 0.000000 0.000000 0.000000 0.000000
0.000000 0.000000 0.007605 0.057395 0.110630 0.153556 0.180427 0.189501 0.180427 0.153556 0.110630 0.057395 0.007605 0.000000 0.000000
0.000000 0.000000 0.057395 0.127439 0.189501 0.235001 0.261937 0.270777 0.261937 0.235001 0.189501 0.127439 0.057395 0.000000 0.000000
0.000000 0.032162 0.110630 0.189501 0.253019 0.296660 0.321334 0.329225 0.321334 0.296660 0.253019 0.189501 0.110630 0.032162 0.000000
0.000000 0.064350 0.153556 0.235001 0.296660 0.336921 0.358735 0.365534 0.358735 0.336921 0.296660 0.235001 0.153556 0.064350 0.000000
0.007605 0.086619 0.180427 0.261937 0.321334 0.358735 0.378339 0.384319 0.378339 0.358735 0.321334 0.261937 0.180427 0.086619 0.007605
0.011817 0.094445 0.189501 0.270777 0.329225 0.365534 0.384319 0.390000 0.384319 0.365534 0.329225 0.270777 0.189501 0.094445 0.011817
0.007605 0.086619 0.180427 0.261937 0.321334 0.358735 0.378339 0.384319 0.378339 0.358735 0.321334 0.261937 0.180427 0.086619 0.007605
0.000000 0.064350 0.153556 0.235001 0.296660 0.336921 0.358735 0.365534 0.358735 0.336921 0.296660 0.235001 0.153556 0.064350 0.000000
0.000000 0.032162 0.110630 0.189501 0.253019 0.296660 0.321334 0.329225 0.321334 0.296660 0.253019 0.189501 0.110630 0.032162 0.000000
0.000000 0.000000 0.057395 0.127439 0.189501 0.235001 0.261937 0.270777 0.261937 0.235001 0.189501 0.127439 0.057395 0.000000 0.000000
0.000000 0.000000 0.007605 0.057395 0.110630 0.153556 0.180427 0.189501 0.180427 0.153556 0.110630 0.057395 0.007605 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000 0.032162 0.064350 0.086619 0.094445 0.086619 0.064350 0.032162 0.000000 0.000000 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.007605 0.011817 0.007605 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
```

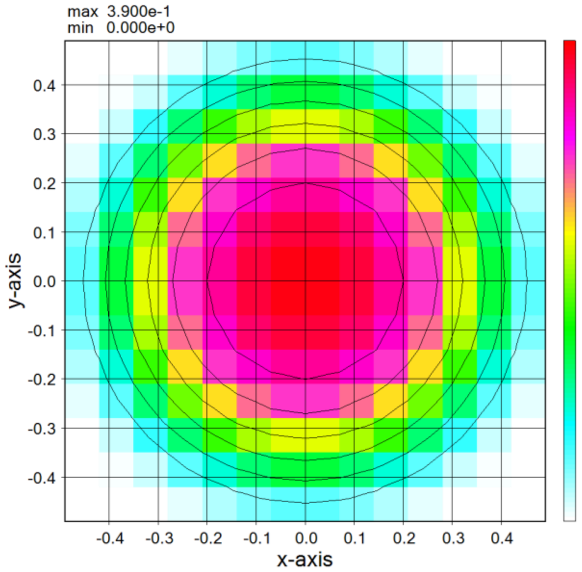
Execution file afm.exe

Click to generate (overwrite) the output file in a folder

Output file

afm.out	For being pasted into sub.dat.
afm_xy.out	AFM data before and after correction which Wscnt visualizes as 1st and 2nd picture.

In case of theta=phi=psi=0, AFM data is the same before and after correction and one is selected.



afm_xy.out 2nd picture visualized by Wscnt

27. Pasting converted data of AFM (wsf13.dat), 225s

```
** wsf.dat
*       kstp       kskp         lp        clp(0,1)  crn(<1.0) kfl        kot        ity
           0         10         10         00       0.99        0          0          0
*       kpls         tw(um)   kdip        kdr(0-2)  dnt(um)   nd1        nd2
           0        1.0          0          0          0      5.0         10         -3
*       ksct         lx         ly         lz
           0         20         20         20
*        kff        nff        thf(deg)   fif(deg)  krm        nrm        rm1(um)    rm2(um)
           0         90     -180.0       0.0          0        100       0.92       0.96
*        wdx(um)    wdy(um)    dxy(um)    dz(um)
         2.0        2.0       0.02       0.02
*        Lam(um)    th(deg)    fi(deg)    gm(deg)
        0.75        0.0        0.0        0.0
*        wx0(um)    wy0(um)    xrm(rim)   yrm(rim)  sx0(um)   sy0(um)    kpx        kpy
         1.8        1.8        0.1        0.1       0.0       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#           Si    1     1.0000       0.00      0.0000
   2         -SiO2    1     1.4500       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    2    0   1   11       0.0       1.00       1.00       0.00       0.00      0.000       0.00       0.0        0.0
   2    2    0   1   12       0.0       1.00       1.00       0.00       0.00      0.000       0.00       0.0        0.0
   3    2    0   1   13       0.0       1.00       1.00       0.00       0.00      0.000       0.00       0.0        0.0
   4    2    0   1   14       0.0       1.00       1.00       0.00       0.00      0.000       0.00       0.0        0.0
   5    2    0   1   15       0.0       1.00       1.00       0.00       0.00      0.000       0.00       0.0        0.0
   6    2    0   1   16       0.0       1.00       1.00       0.00       0.00      0.000       0.00       0.0        0.0
   7    2    0   1   17       0.0       1.00       1.00       0.00       0.00      0.000       0.00       0.0        0.0
   8    2    0   1   18       0.0       1.00       1.00       0.00       0.00      0.000       0.00       0.0        0.0
   9    2    0   1   19       0.0       1.00       1.00       0.00       0.00      0.000       0.00       0.0        0.0
  10    2    0   1   20       0.0       1.00       1.00       0.00       0.00      0.000       0.00       0.0        0.0
  11    2    0   1   21       0.0       1.00       1.00       0.00       0.00      0.000       0.00       0.0        0.0
  12    2    0   1   22       0.0       1.00       1.00       0.00       0.00      0.000       0.00       0.0        0.0
  13    2    0   1   23       0.0       1.00       1.00       0.00       0.00      0.000       0.00       0.0        0.0
  14    2    0   1   24       0.0       1.00       1.00       0.00       0.00      0.000       0.00       0.0        0.0
  15    2    0   1   25       0.0       1.00       1.00       0.00       0.00      0.000       0.00       0.0        0.0
  16    2    0   1   26       0.0       1.00       1.00       0.00       0.00      0.000       0.00       0.0        0.0
  17    2    0   1   27       0.0       1.00       1.00       0.00       0.00      0.000       0.00       0.0        0.0
  18    2    0   1   28       0.0       1.00       1.00       0.00       0.00      0.000       0.00       0.0        0.0
  19    2    0   1   29       0.0       1.00       1.00       0.00       0.00      0.000       0.00       0.0        0.0
* kb   kl   km   kp        tk     kf    *    *    *    *    *    *    *    *    *    *    *    *    *    *    *    *
   1    0    0    0     0.200      0    0
```

Rewritten

As it is

Input file

afm.dat

afm.out

Output file

paste

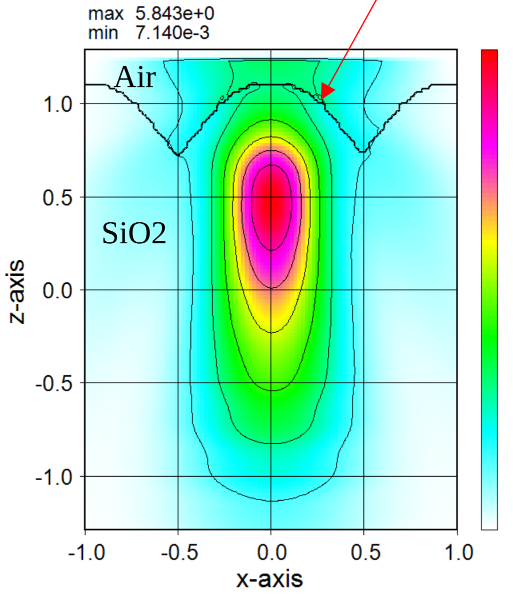
sub.dat

Continued

```
 2   0   0   0   0.0200    1   0
 3   0   0   0   0.0200    2   0
 4   0   0   0   0.0200    3   0
 5   0   0   0   0.0200    4   0
 6   0   0   0   0.0200    5   0
 7   0   0   0   0.0200    6   0
 8   0   0   0   0.0200    7   0
 9   0   0   0   0.0200    8   0
10   0   0   0   0.0200    9   0
11   0   0   0   0.0200   10   0
12   0   0   0   0.0200   11   0
13   0   0   0   0.0200   12   0
14   0   0   0   0.0200   13   0
15   0   0   0   0.0200   14   0
16   0   0   0   0.0200   15   0
17   0   0   0   0.0200   16   0
18   0   0   0   0.0200   17   0
19   0   0   0   0.0200   18   0
20   0   0   0   0.0200   19   0
21   0   2   0    2.000    0   0
```

Rewritten

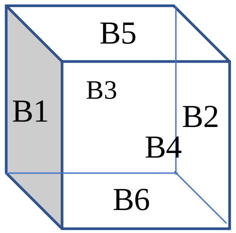
Measurement shape of AFM expressed by sub.dat



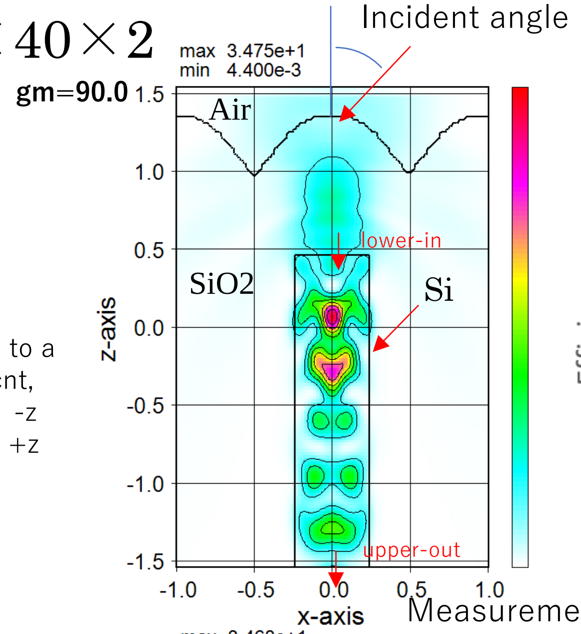
i_xz.out & m_xz.out

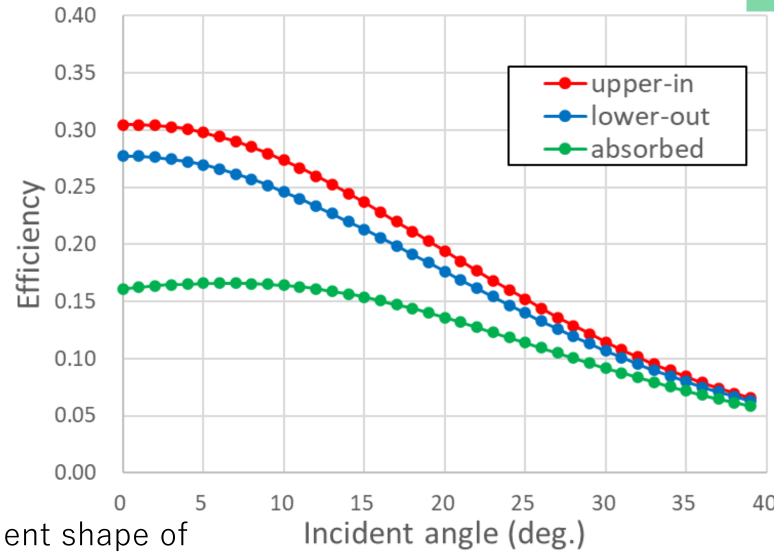
28. Calculation example (wsf14.dat), 523s×40×2

```
** wsf.dat
*     kstp      kskp        lp        clp(0,1)  crn(<1.0)  kfl      kot       ity
         0        10        10        00         0.99        0        0         0
*     kpls        tw(um)  kdip        kdr(0-2)  dnt(um)    nd1      nd2
         0       1.0         0         0          0      15.0       10        -3
*     ksct        lx        ly        lz
         0        20        20        20
*      kff       nff      thf(deg)   fif(deg)   krm       nrm       rm1(um)   rm2(um)
         0        90    -180.0       0.0         0       100       0.92      0.96
*      wdx(um)   wdy(um)   dxy(um)    dz(um)
       2.0       2.0       0.02       0.02
*      Lam(um)   th(deg)   fi(deg)    gm(deg)
      0.75       0.0       0.0        0.0
*      wx0(um)   wy0(um)   xrm(rim)   yrm(rim)  sx0(um)   sy0(um)   kpx       kpy
       1.8       1.8       0.0        0.0       0.0       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           Si   1      1.0000     0.00      0.0000
   2        -SiO2   1      1.4500     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    2    0  1    11    0.0       1.00      1.00      0.00      0.00      0.000     0.00      0.0       0.0
   2    2    0  1    12    0.0       1.00      1.00      0.00      0.00      0.000     0.00      0.0       0.0
   3    2    0  1    13    0.0       1.00      1.00      0.00      0.00      0.000     0.00      0.0       0.0
   4    2    0  1    14    0.0       1.00      1.00      0.00      0.00      0.000     0.00      0.0       0.0
   5    2    0  1    15    0.0       1.00      1.00      0.00      0.00      0.000     0.00      0.0       0.0
   6    2    0  1    16    0.0       1.00      1.00      0.00      0.00      0.000     0.00      0.0       0.0
   7    2    0  1    17    0.0       1.00      1.00      0.00      0.00      0.000     0.00      0.0       0.0
   8    2    0  1    18    0.0       1.00      1.00      0.00      0.00      0.000     0.00      0.0       0.0
   9    2    0  1    19    0.0       1.00      1.00      0.00      0.00      0.000     0.00      0.0       0.0
  10    2    0  1    20    0.0       1.00      1.00      0.00      0.00      0.000     0.00      0.0       0.0
  11    2    0  1    21    0.0       1.00      1.00      0.00      0.00      0.000     0.00      0.0       0.0
  12    2    0  1    22    0.0       1.00      1.00      0.00      0.00      0.000     0.00      0.0       0.0
  13    2    0  1    23    0.0       1.00      1.00      0.00      0.00      0.000     0.00      0.0       0.0
  14    2    0  1    24    0.0       1.00      1.00      0.00      0.00      0.000     0.00      0.0       0.0
  15    2    0  1    25    0.0       1.00      1.00      0.00      0.00      0.000     0.00      0.0       0.0
  16    2    0  1    26    0.0       1.00      1.00      0.00      0.00      0.000     0.00      0.0       0.0
  17    2    0  1    27    0.0       1.00      1.00      0.00      0.00      0.000     0.00      0.0       0.0
  18    2    0  1    28    0.0       1.00      1.00      0.00      0.00      0.000     0.00      0.0       0.0
  19    2    0  1    29    0.0       1.00      1.00      0.00      0.00      0.000     0.00      0.0       0.0
  20    1    0  0     1    0.0       0.0       0.0       0.50      0.50      0.000     0.00      0.0       0.0
* kb   kl   km   kp       tk    kf    *    *    *    *    *    *    *    *    *    *    *    *    *    *    *    *
   1    0    0    0    0.200     0    0
   2    0    0    0    0.0200    1    0
   3    0    0    0    0.0200    2    0
   4    0    0    0    0.0200    3    0
   5    0    0    0    0.0200    4    0
   6    0    0    0    0.0200    5    0
   7    0    0    0    0.0200    6    0
   8    0    0    0    0.0200    7    0
   9    0    0    0    0.0200    8    0
  10    0    0    0    0.0200    9    0
  11    0    0    0    0.0200   10    0
  12    0    0    0    0.0200   11    0
  13    0    0    0    0.0200   12    0
  14    0    0    0    0.0200   13    0
  15    0    0    0    0.0200   14    0
  16    0    0    0    0.0200   15    0
  17    0    0    0    0.0200   16    0
  18    0    0    0    0.0200   17    0
  19    0    0    0    0.0200   18    0
  20    0    0    0    0.0200   19    0
  21    0    2    0    0.500     0    0
  22    0    2    0    2.000    20    0
```

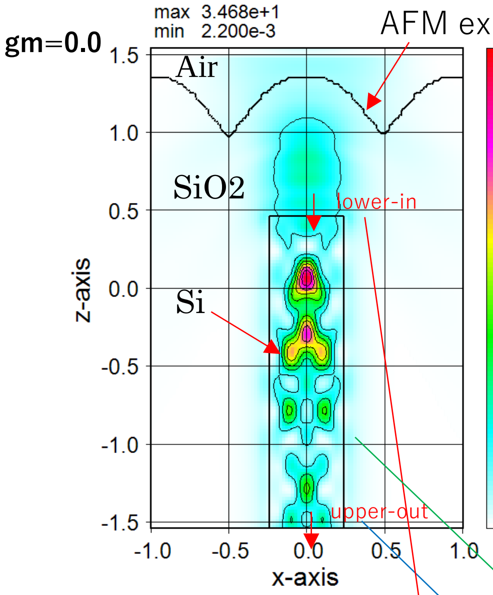


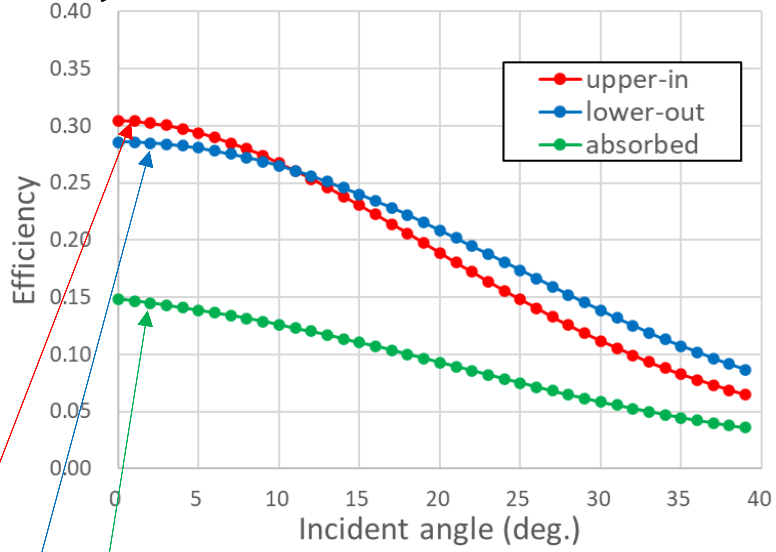
When up/down is set to a reversal mode in Wscnt, "up" is correspond to -z side and "down" is to +z side.





Measurement shape of AFM expressed by sub.dat





i_xz.out & m_xz.out

wsf1.outの出力結果（検出光量）

Transmitted	Reflected	Absorbed	Total	01/lower-in	upper-out	absorbed	02/lower-in	upper-out	absorbed
3.9601E-01	1.0659E-01	2.5324E-01	7.5584E-01	3.0458E-01	2.8560E-01	1.4853E-01	7.1858E-01	4.2959E-01	1.0471E-01

wsf1.out

29. Notes

1. Metallic materials (e.g., Ag, Al, Au, Be, Cr, Cu, Ni, Pd, Pt, Ti, W) whose k (extinction coefficient) is larger than n (refractive index) will cause a runaway (spatial energy divergence) in the FDTD algorithm. To prevent this, it is necessary to treat these materials as dispersed materials. In Wsf, these materials (including SiO2) are defined as internal materials and are prefixed with -, like -Ag. This is done to distinguish from externally definitions.
2. When defining the dispersed material by nk.dat as an external definition, be aware that the condition of $k > n$ causes a runaway.
3. To prevent calculation runaway, crn (Courant index) is set less than 1.0. Especially in the case of dispersive materials, crn must be set to 0.9 or less for a stable calculation.
4. The larger the grid width, the more inaccurate and the more prone to runaway. Normally, it should be set to 1/10 or less of the wavelength.
5. To obtain significant results, dnt (propagation distance) should be set at a large value so that oscillation becomes stably constant in the case of CW oscillation, or so that the amount of light remaining in the analysis region is sufficiently attenuated in the case of pulsed oscillation. The calculation stability can be judged by whether the stability coefficient value converges at 0.001 or less. The output results are evaluated for the last step of one cycle in the CW oscillation, and for all steps from the start of oscillation in the pulsed oscillation.
6. The light source is not completely transparent and interferes to some extent with reflected light. To prevent this effect, the light source can be placed far away, or a scattering field (ksct=1) can be used, or pulsed oscillation (kpls≠0) can be used, etc.
7. If an execution error occurs, please check the following items.
   a. Do input numbers contain half-width ones?
   b. Is the right edge of an input number aligned with the right edge of the variable label (or the * mark) above?
   c. Is the type of input digits (integer type or real number type) correct? An integer type is without a decimal point, and a real number type with a decimal point.
   d. Are there any numbers not specified in km, kb, or kf specification fields?