SCOUT training

SCOUT training

First steps to successful spectrum simulation solutions

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Part I

1 Introduction

1.1 Overview

This training gives a careful introduction to spectrum simulation with the SCOUT software. It uses some program features introduced in version 2.27 which should be available for your work. See the section on program updates 7 for a description of program upgrades.

Training schedule
You should follow this sequence of exercises (if you like, you can print this section and enter the dates when you did the exercises in the right column):

- Check your SCOUT version 7
- Upgrade to the latest version from www.mtheiss.com 7

- Optical constants: Exercise 1 9
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1.2 Sources of help

In case you need help you can directly contact Wolfgang Theiss, the author of the SCOUT software. Send an e-mail to theiss@mtheiss.com and describe what you want to know.

SCOUT tutorial 1 gives an introduction into the basic handling of SCOUT. Developing a simple optical model and a first parameter fit, you are guided around and learn what to find where in the program.

The manipulation of SCOUT graphics including mouse actions and keyboard commands is explained in the 'Graphics course'.

SCOUT is an object oriented program. There are many lists managing various types of objects. General features of the implemented objects and lists are discussed in the technical manual (the main help file of SCOUT) in the section 'Technical notes'.

Details of the objects are given in the technical manual.

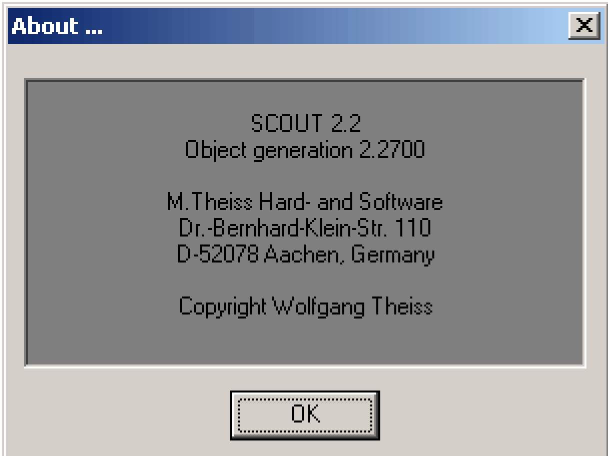
You may also visit our homepage www.mtheiss.com and look around. Especially the section 'Applications' might be of interest. In 'Support|Download' there is a section called 'Things to read' which could also give valuable hints.

Part II

2 Getting started

2.1 What SCOUT version do I have?

In some cases you need to know the version of your SCOUT program. Here is how you can find the version number of your SCOUT: Start the program and select the menu command ?|About SCOUT. You will see a small window like this:



The first line contains the major progam version.

In most cases the object generation given in the second line is important: When you try to load a SCOUT configuration, SCOUT checks if the file was created by a younger object generation (i.e. with a higher version number). If so, the configuration is not loaded. Please update to a more recent version in this case.

2.2 Update to the latest version

You can download the latest versions of our SCOUT and CODE software from our homepage www.mtheiss.com. Go to the 'Support' section and from there to 'Download'. Each program has its own section with a short description of the items you can download.

You will be asked for a username and a password. If you don't have any yet, please ask us for a download account (e-mail to theiss@mtheiss.com).

There are two types of program downloads:

1. The full setup comes in a large zip-file. It contains a setup routine that will install the current version of the software like it is distributed on our setup CDs. You will have to de-install any previous version before you execute the new setup. The full setup is not updated as frequently as the small download file described below.

2. The small download file is a zip-file as well. It contains the latest program executable and sometimes a few additional files which belong to the latest version of the software. No de-installation is necessary for this download version: Just copy the files to the right destination folders, overwriting existing files of the same name.

Part III

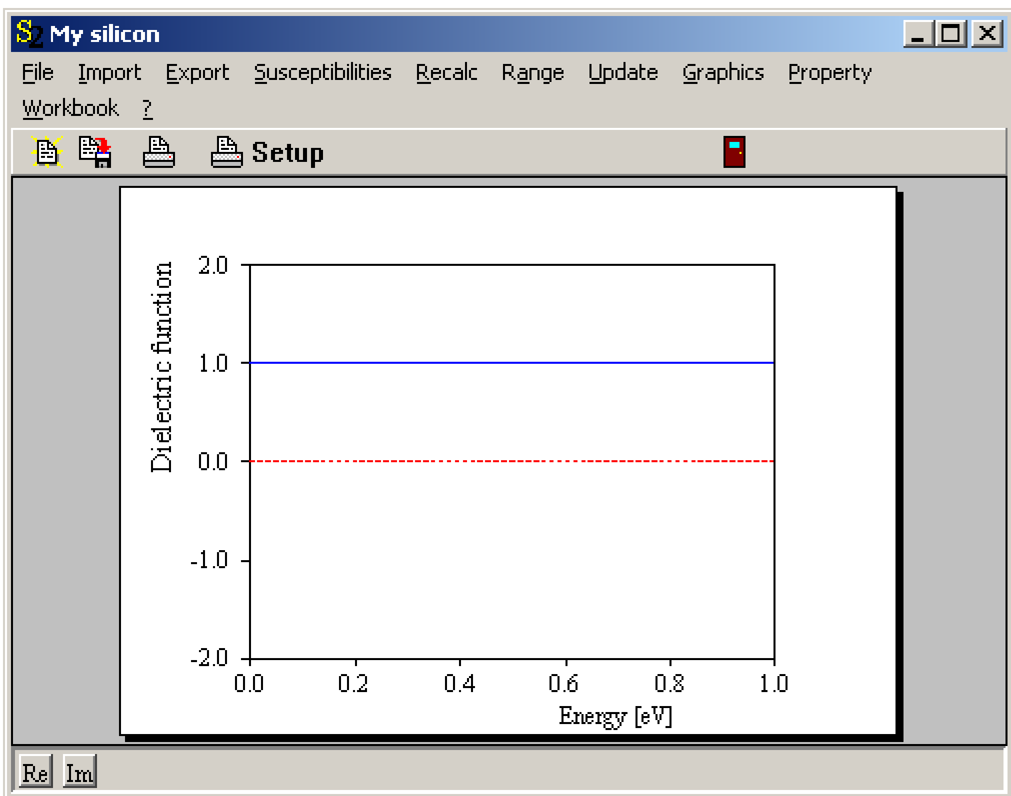
3 Optical constants

3.1 Exercise 1: Defining a constant refractive index

This is a simple exercise to train basic actions for the definition of optical constant models. You will define a new material with a constant refractive index and save it to the database.

Please follow these instructions:

- Start SCOUT.
- Execute the menu command **File|New** to start with an empty configuration.
- Open the list of materials with the menu command '**Objects|Materials**'.
- Press in this list the '**+**' button which will create an object of type 'Dielectric function model'. The name of the object is 'Dummy name'.
- Click on the name 'Dummy name' and type in the new name 'My silicon'. Press the **Return** key to make the new name permanent.
- Double click the name which opens a color dialog. Select yellow and leave the dialog. The material 'My silicon' is now shown in the list with a yellow background.
- Use the **Edit** menu command to open the window that shows the optical constant data of 'My silicon' graphically:



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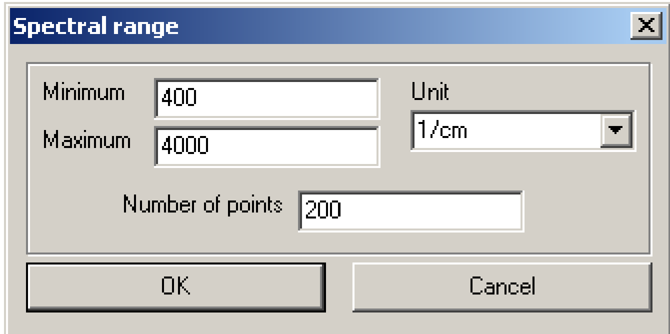
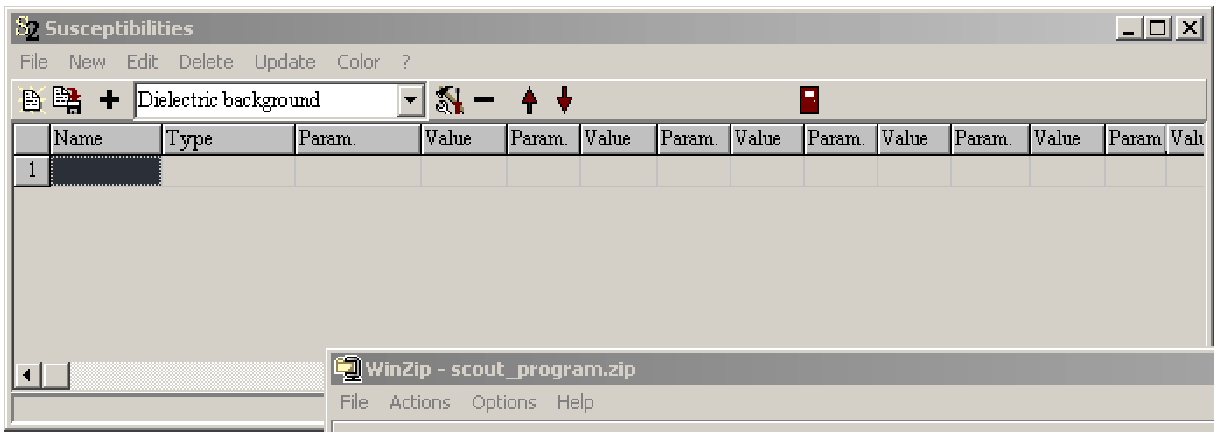
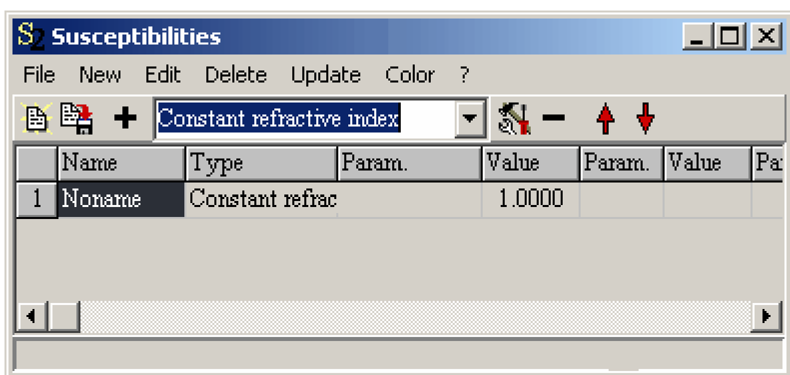
- 8. In this window, use the **Range** command to set a spectral range from 400 to 4000 1/cm with 200 points:



- Use the menu command **Susceptibilities** to open a list with contributions to the optical constant model of 'My silicon':

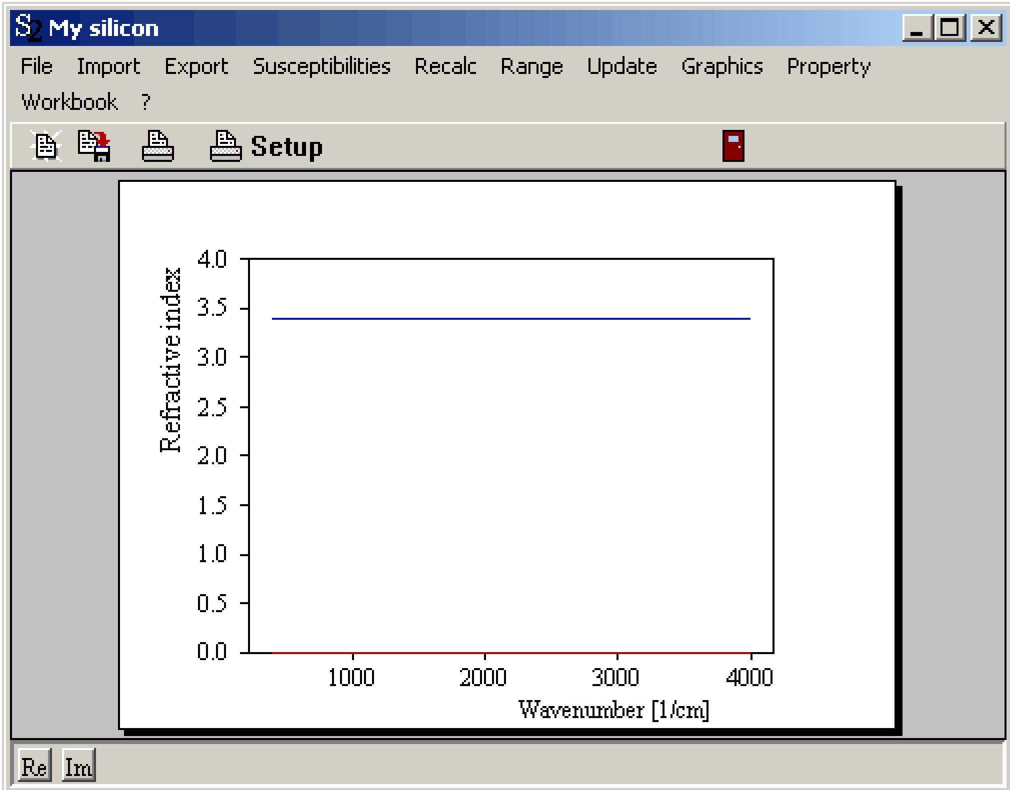


- Select in the dropdown box between the '+' and the '-' buttons the object type 'Constant refractive index' and press the '+' button to create such an object. The list should look like this now:

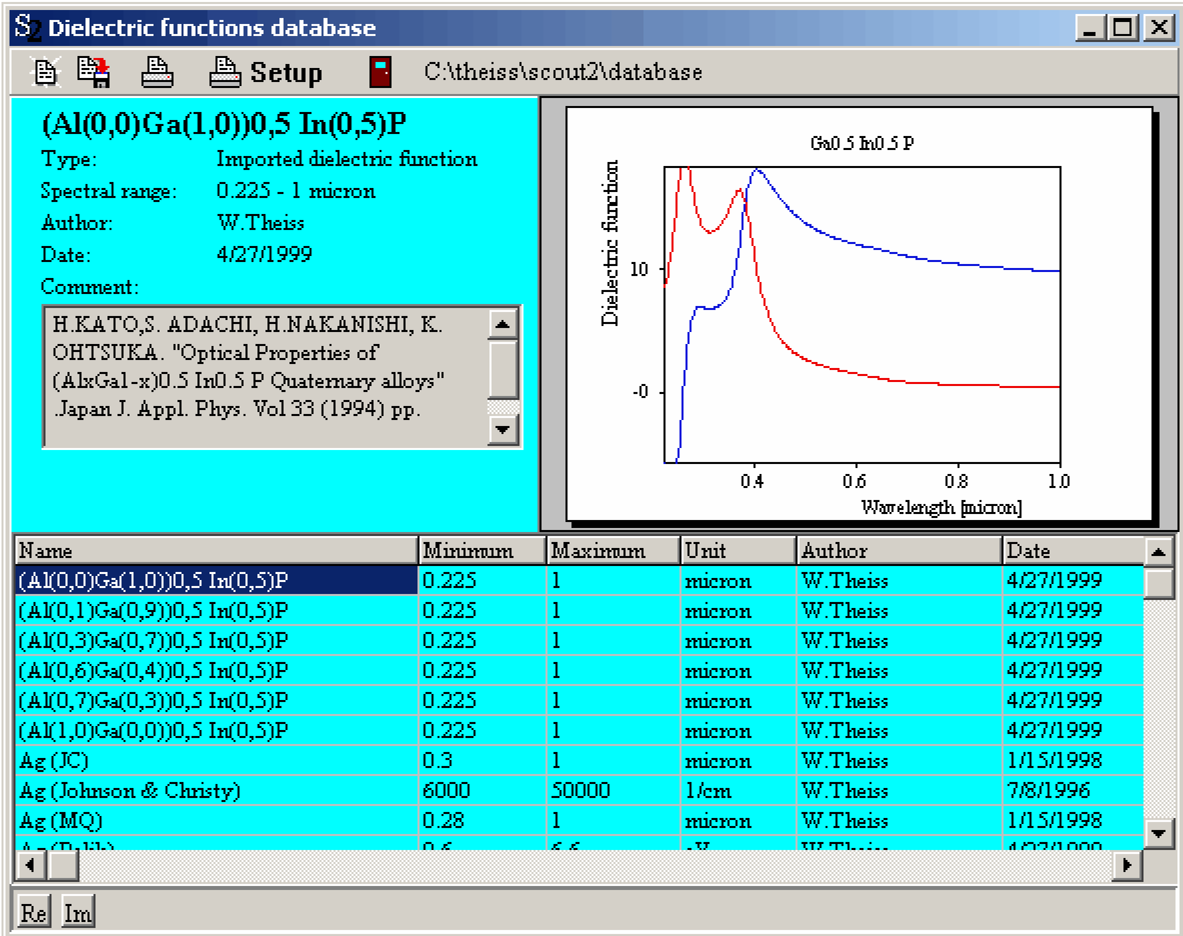


- Click on 'Noname' and overwrite the name by 'n'.
- Move the cursor to '1.0000' and overwrite it by '3.4'.
- Close the susceptibilities dialog and return to the window with the graphical representation of the optical constants of 'My silicon'.
- Press **Recalc** and use the menu command **Property|Refractive index** to show the refractive index of 'My silicon'.
- Click on the text 'Refractive index' inside the window. This opens the dialog to set the parameters for the graphical appearance. For the y-axis, set a minimum of 0.0, a maximum of 4.0, a tick spacing of 0.5 and the number of decimals to 1. Then leave the dialog.

- You should now have this:



- Close this window and return to the list of materials. You will now store the new material to the database. Use the **Database** command to open the database of materials:



- Select 'My silicon' in the list of materials and drag it to the database window. Drop it to the list of materials. You will be asked for your name and a description of the material. The description will be shown later when you scroll through the database.
- Scroll down the database list and verify that the new material is entered properly.

Exercise 1
Define a material named 'My glass' with a constant refractive index of 1.5 in the visible spectral range (400 ... 700 nm). Make it appear light green in the list of materials and store it to the database.

Check your solution reading the section Solutions/Optical constants/Exercise 1 46

3.2 Exercise 2: Retrieving materials from the database

Compared to exercise 1, this will be simple. You will learn how to import optical constant data from the database into the list of materials.

- Start SCOUT and switch to an empty configuration using the **File|New** command.
- Open the list of materials with **Objects|Materials**.
- Use the **Database** command in this list to open the database window.
- In the database window, scroll to the item 'My glass' and drag it to the list of materials.
- Drop it there and verify that it is entered in addition to the 'Vacuum' object.

Exercise 2
Load the material 'My silicon' from the database into the list of materials.

Check your solution reading the section Solutions/Optical constants/Exercise 2 47

Part IV

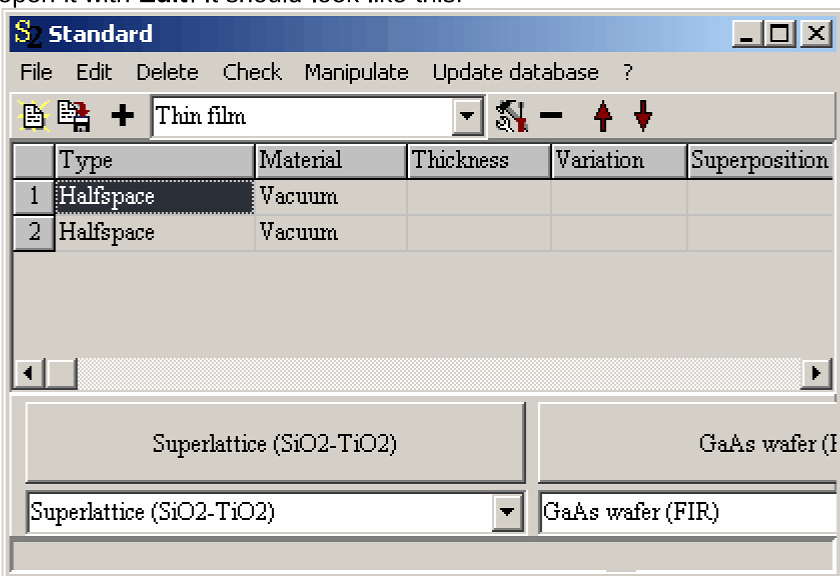
4 Layer stacks

4.1 Exercise 1: Simple layer stacks

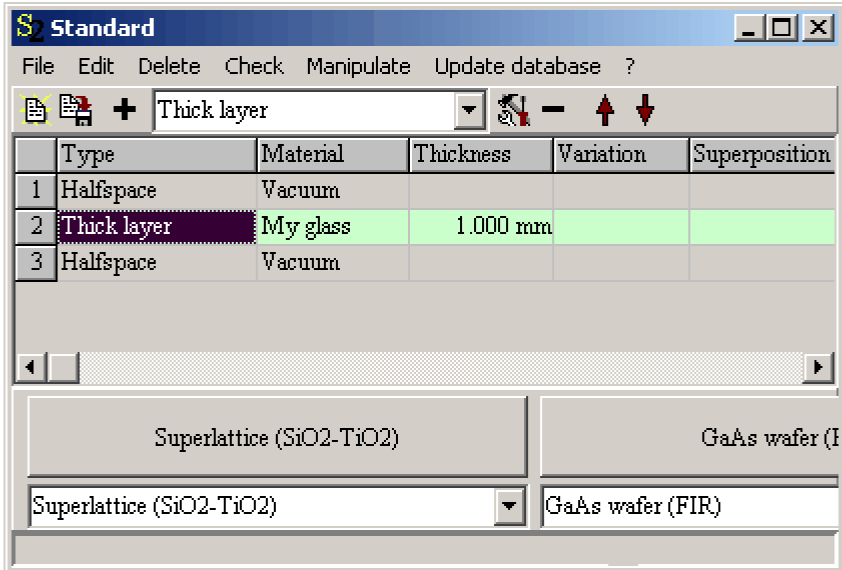
Here is the first example of building a (very simple) layer stack.

Instructions to follow:

- Start SCOUT and use the **File|New** command to start with an empty configuration.
- Go to the list of materials and open the database window (see Optical constants/Exercise 2 12). Keep the list of materials open and visible on your screen.
- In the main window of SCOUT, apply the **Objects|Layer stacks** menu command to open the list of layer stacks (In SCOUT you can use more than one layer stack, and the list of layer stacks is used to manage the stacks).
- Even an empty SCOUT configuration has already a default layer stack which is called 'Standard'. Select it and open it with **Edit**. It should look like this:



- Select line 2 in the list, i.e. the bottom halfspace (filled with 'Vacuum').
- Between the '**+**' and the '**-**' button there is a dropdown box (labeled 'Thin film' at present). Select the new object type 'Thick layer' in the dropdown box and press the '**+**' button. A new layer of type 'Thick layer' is created (above the layer which is selected at present). Use this layer type for thick substrates such as glass plates or silicon wafers.
- Now we have to fill in a material. You can do that by a drag&drop action from the database. Arrange the layer stack window and the database window on your screen in a way that you have mouse access to both of them. Then drag the material 'My glass' from the database window to the thick layer that you just created and drop it there:



- Note that the material 'My glass' has been entered into SCOUT's list of materials. SCOUT does not work with database items directly but copies objects at request. This way, if you save a SCOUT configuration, it is complete and independent of the database.
- Manual thickness change: Place the cursor to the cell which displays the thickness of the layer. Type in '**4**' and press **Return**. This changes the thickness of the layer.
- Change of material assignment: There are several ways to change the material assignment of a layer. You can drag another material from the database to the layer, as we just did. Try that for 'My silicon'. Alternatively, you can drag a material from the list of materials to the layer. Try that for 'My glass'.
- The fastest way to change the material assignment is this: In the layer stack window, place the cursor in cell that displays the assigned material of the layer (it should be 'My glass' at present). Now press the F4 key several times and watch the changes of the assignment. Pressing the F4 key you cycle through the list of materials in the forward direction, and you can stop at the material of your choice. Using the F5 key cycles through the list in the backward direction. Try both directions and stop at 'My glass'.
- In the main window of SCOUT, use the command File|SaveAs and save the present configuration using the name 'Layer_stack_exercise_0'. The extension *.sc2 will be added automatically to the filename. If you are asked if you want to save the content of the workbook and the batch control window, answer with 'Yes'.

Exercise 1
Start with an empty SCOUT configuration and create a layer stack of the following structure: A thick layer of silicon (thickness 0.3 mm) is surrounded by two glass layers (use the layer type "Thin film") of 4 nm thickness each. This 3-layer stack is placed in between the two vacuum halfspaces.
If necessary, use the red arrows in the toolbar of the layer stack definition window to move the selected layer up or down in the list.
Save the SCOUT configuration using the name 'Layer_stack_exercise_1'.

Check your solution reading the section Solutions/Layer stacks/Exercise 1 47

4.2 Exercise 2: Defining several layer stacks

Exercise 2
Start with an empty SCOUT configuration and create two layer stacks.

The first one should be a 10 nm silver layer (object type: Thin film, optical constants: Take the object

'Ag model' from the database) on a 1 mm thick layer of 'My glass'.
The second one should be a 15 nm silver layer on a 0.5 mm thick layer of 'My silicon' .

In the layer stack list, call the first layer stack 'Ag on glass' and the second one 'Ag on Si wafer'. Assign different colors to the two layer stacks.

In the material list, assign a color of light blue to silver.

Save the configuration using the name 'Layer_stack_exercise_2.sc2' .

Check your solution reading the section Solutions/Layer stacks/Exercise 2 47

Part V

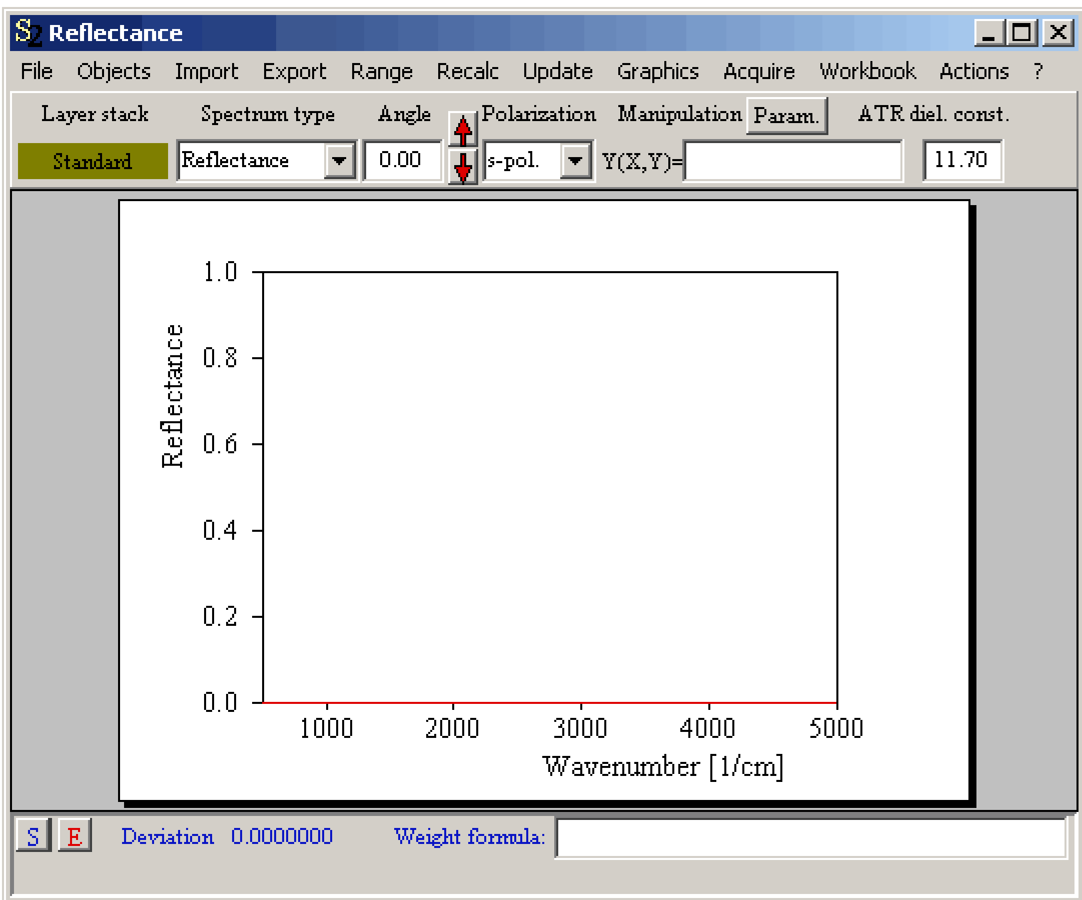
5 Spectra

5.1 Exercise 1: Infrared spectrum of silicon

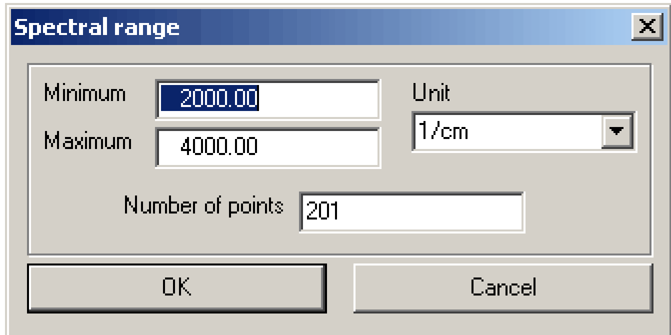
Having defined optical constants and layer stacks, we are now in the position to compute our first spectrum. The instructions below show you how to compute the reflectance of silicon (a simplified version of silicon for the moment) in the infrared.

Instructions:

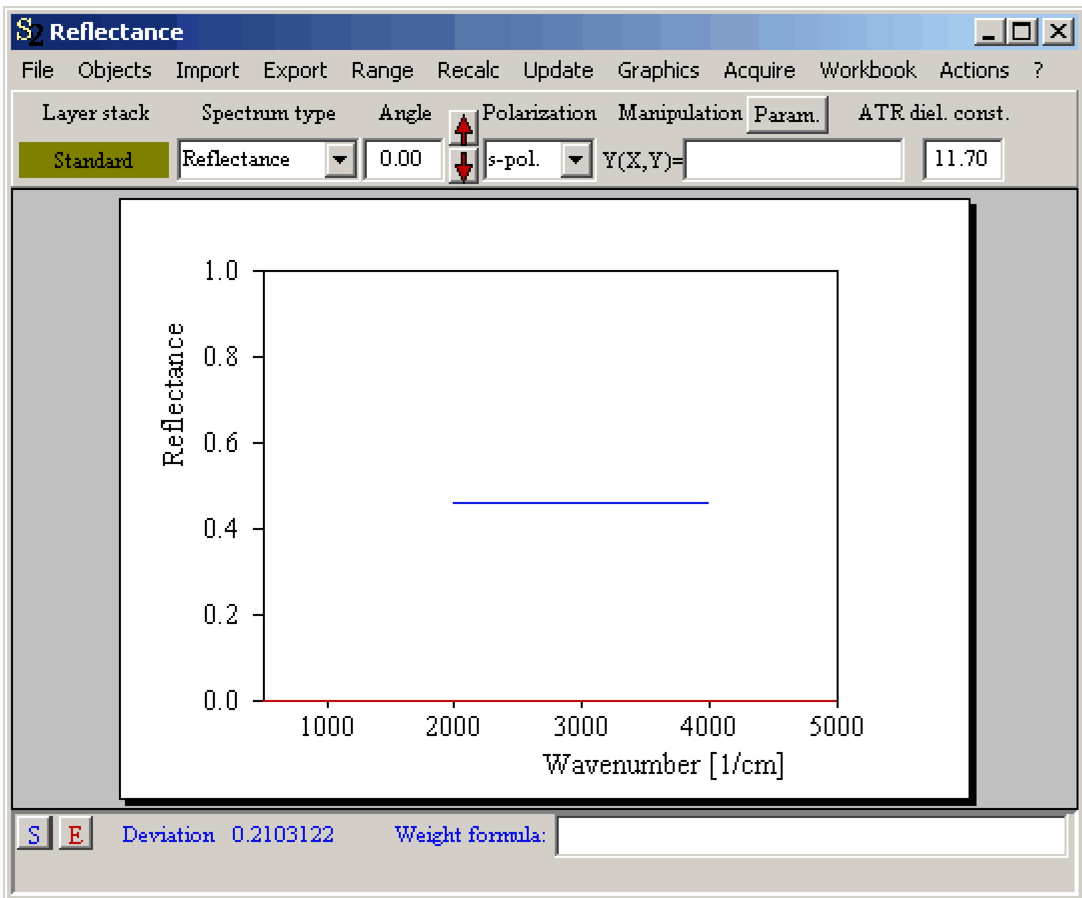
- Start SCOUT and use the **File|New** command to start with an empty configuration.
- Create a simple layer stack with a thick layer of 'My silicon' in between two vacuum halfspaces. The silicon layer should have a thickness of 0.5 mm. See the section 'Layer stacks|Exercise1: Simple layer stacks 15' for help if necessary. Call the layer stack 'Si wafer'.
- In the main window of SCOUT, use the command **Objects|Spectra** to open the list of spectra. Even in a new configuration, there is a spectrum called 'Spectrum simulation' already in the list.
- Select the spectrum and change its name to 'Reflectance'.
- Use the **Edit** command to open the window of the spectrum:



- Apply the **Range** command and set a spectral range of 2000 ... 4000 1/cm with 201 data points (this leads to steps of 10 1/cm between the points) in the following dialog:



- You should now see the computed reflectance spectrum in the specified range as the blue curve in the graph below:



- Click on the red arrows to the right of the label **Angle**. This way you can change the angle of incidence in steps of 5 degrees. Alternatively, you can type in a value for the angle of incidence in the edit box directly below the **Angle** label. Having entered a new value, you have to use the **Recalc** command to compute the new spectrum.
- Use the dropdown box below the label **Polarization** to change from s-polarization (s-pol) to p-polarization (p-pol). Ignore the possible 'Mixed' polarization for the moment. Use the **Recalc** command to compute the new spectrum after polarization changes.

Exercise 1

Save the configuration we developed up to now using the name 'Spectra_silicon_infrared.sc2'.

Compute the reflectance of silicon in the infrared for
45 degrees angle of incidence and s-polarization
45 degrees angle of incidence and p-polarization
10 degrees angle of incidence and s-polarization
10 degrees angle of incidence and p-polarization
75 degrees angle of incidence and s-polarization
75 degrees angle of incidence and p-polarization
63.23 degrees angle of incidence and s-polarization
32.12 degrees angle of incidence and p-polarization
and write down the approximate values in a table. Rough values taken from the graph are sufficient at the moment.

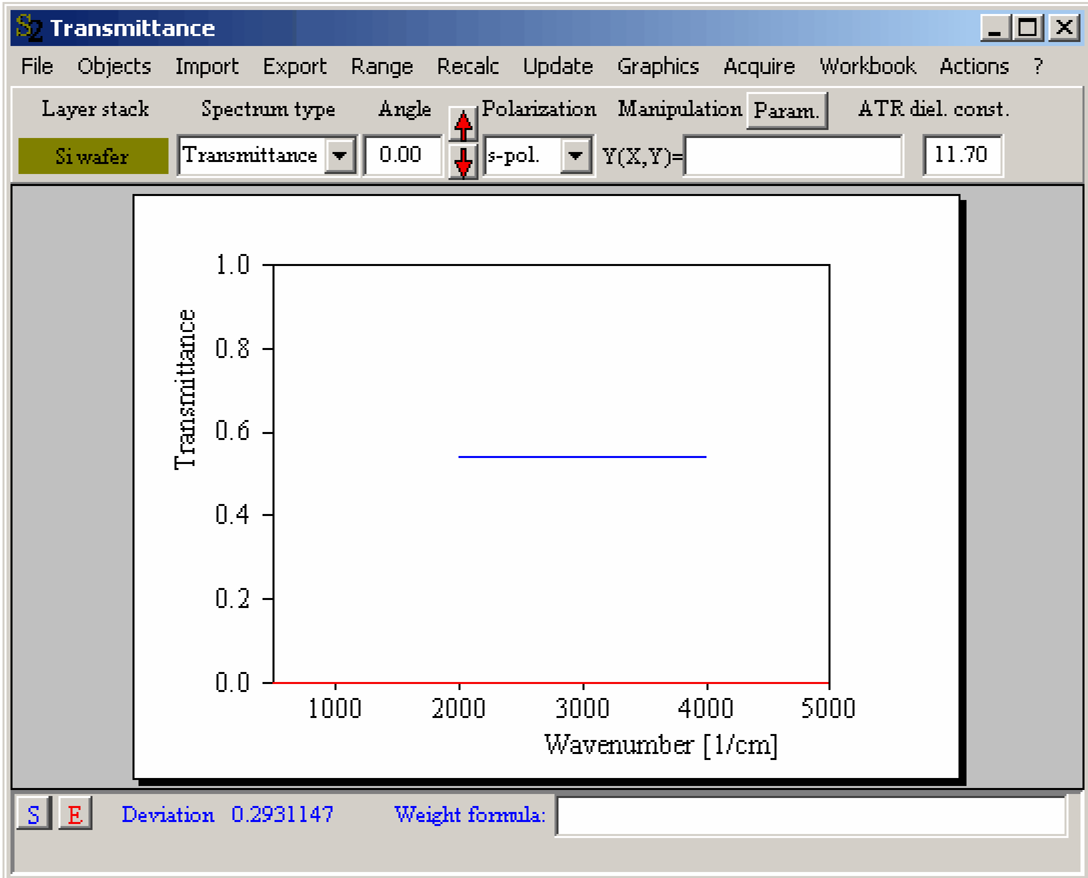
Check your solution reading the section Solutions/Spectra/Exercise 1 48

5.2 Exercise 2: Simultaneous computation of R and T

We will now compute two spectra at the same time. For the simple silicon example, the reflectance and the transmittance in the infrared will be calculated.

Instructions:

- Open the configuration 'Spectra_silicon_infrared.sc2' that you saved in exercise 1 using the command **File|Open**.
- Go to the list of spectra.
- Pressing the '+' button, create a new object of type 'R, T, ATR' and name it 'Transmittance'.
- Open the new object's window and set its **Range** to 2000 ... 4000 1/cm (201 points).
- Select the type 'Transmittance' in the dropdown box under the label '**Spectrum type**' and use the **Recalc** command to compute the spectrum:



- Save this configuration using the name 'Spectra_silicon_infrared_rt.sc2'.

Exercise 2

Start with an empty configuration.
Load the optical constants of 'My glass' from the database.
Define a layer stack with a thick layer (1 mm) of 'My glass' between vacuum halfspaces.

a) Compute a reflectance and a transmittance spectrum in the visible (400 ... 700 nm, 1 nm wavelength steps) for 10 degrees angle of incidence and p-polarized light. Read the Graphics course (helpfile delivered with SCOUT) and try to set reasonable graphics parameters for the spectra.

b) Change the angle of incidence to 60 degree and compute the spectra again.

Set the angles of incidence to 0 degree and save the configuration using the name 'Spectra_glass_visible_rt.sc2'.

Check your solutions reading the section Solutions/Spectra/Exercise 2 49

Part VI

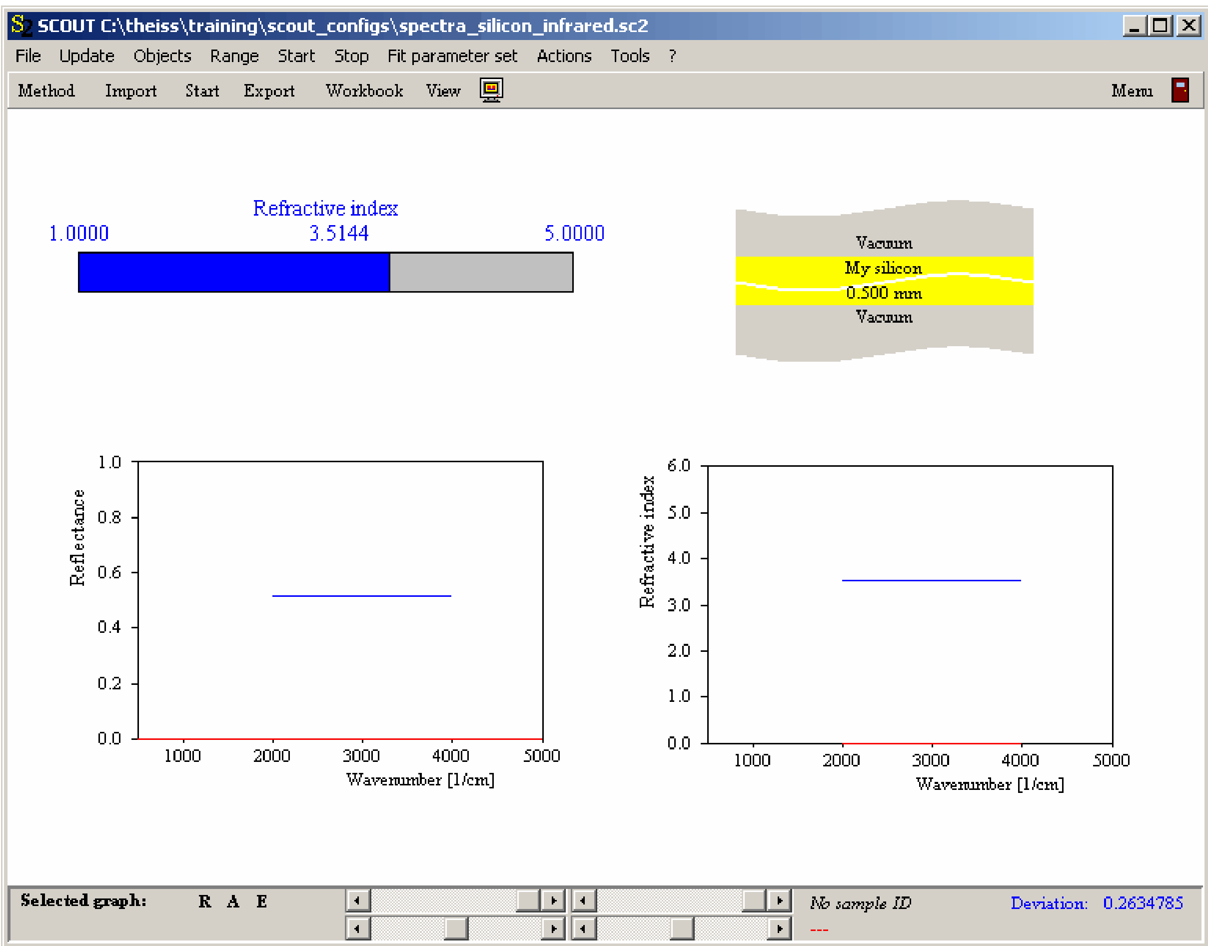
6 Parameter fits

6.1 Exercise 1: Refractive index of Si in the infrared

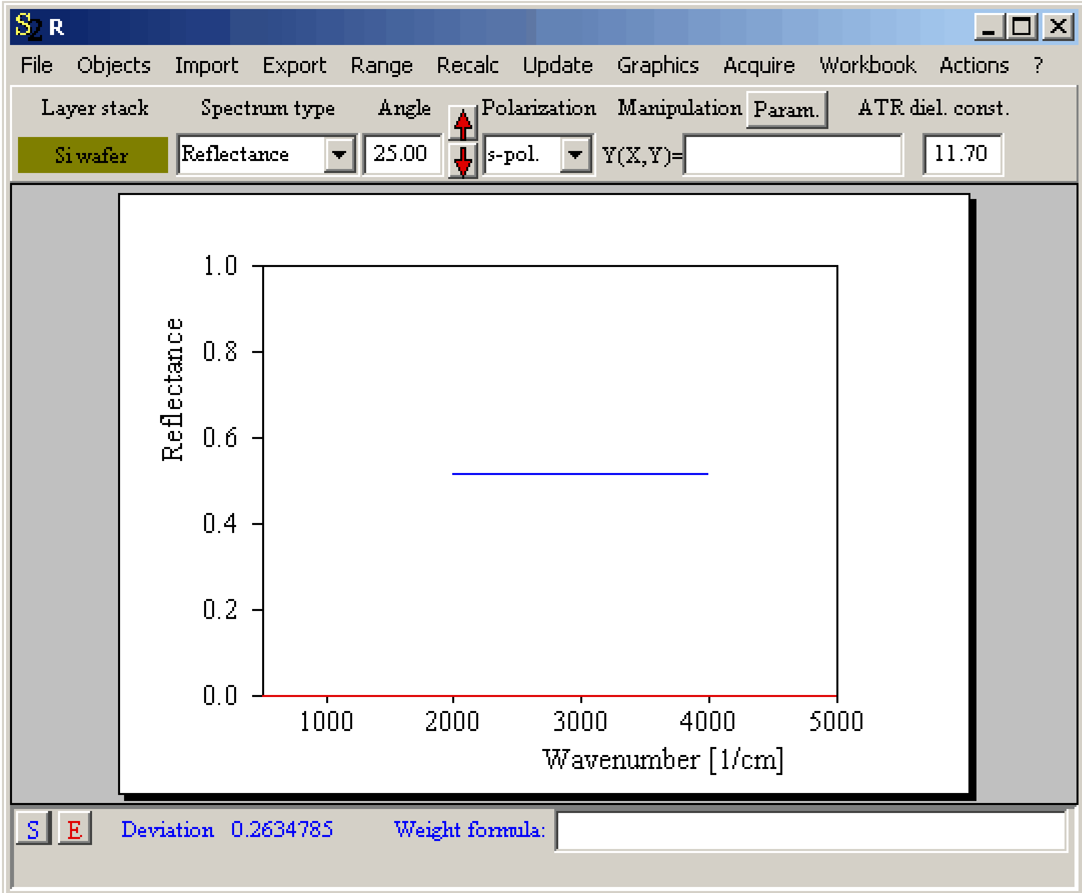
In this section you are going to determine the refractive index of silicon in the infrared, analyzing a measured reflectance spectrum.

Instructions:

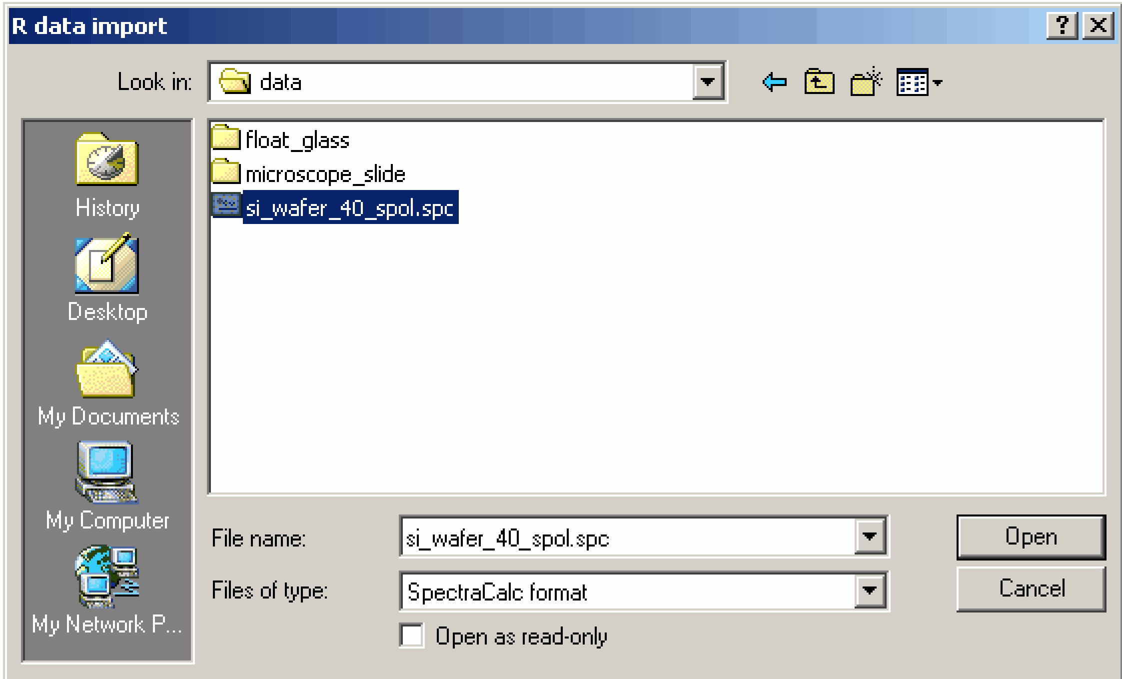
- Open the configuration 'Spectra_silicon_infrared.sc2' that you saved in 'Spectra | Exercise 1' using the command **File|Open**.
- Generate a view with the following items: The reflectance spectrum, the optical constants of 'My silicon', the layer stack and a horizontal slider varying the refractive index of 'My silicon' in the range 1 ... 5. It should look like this:



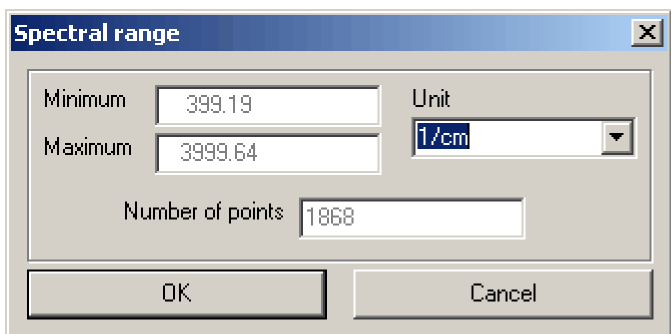
- Press the **Ctrl**-key and click with the left mouse button on the reflectance spectrum. The following window pops up:



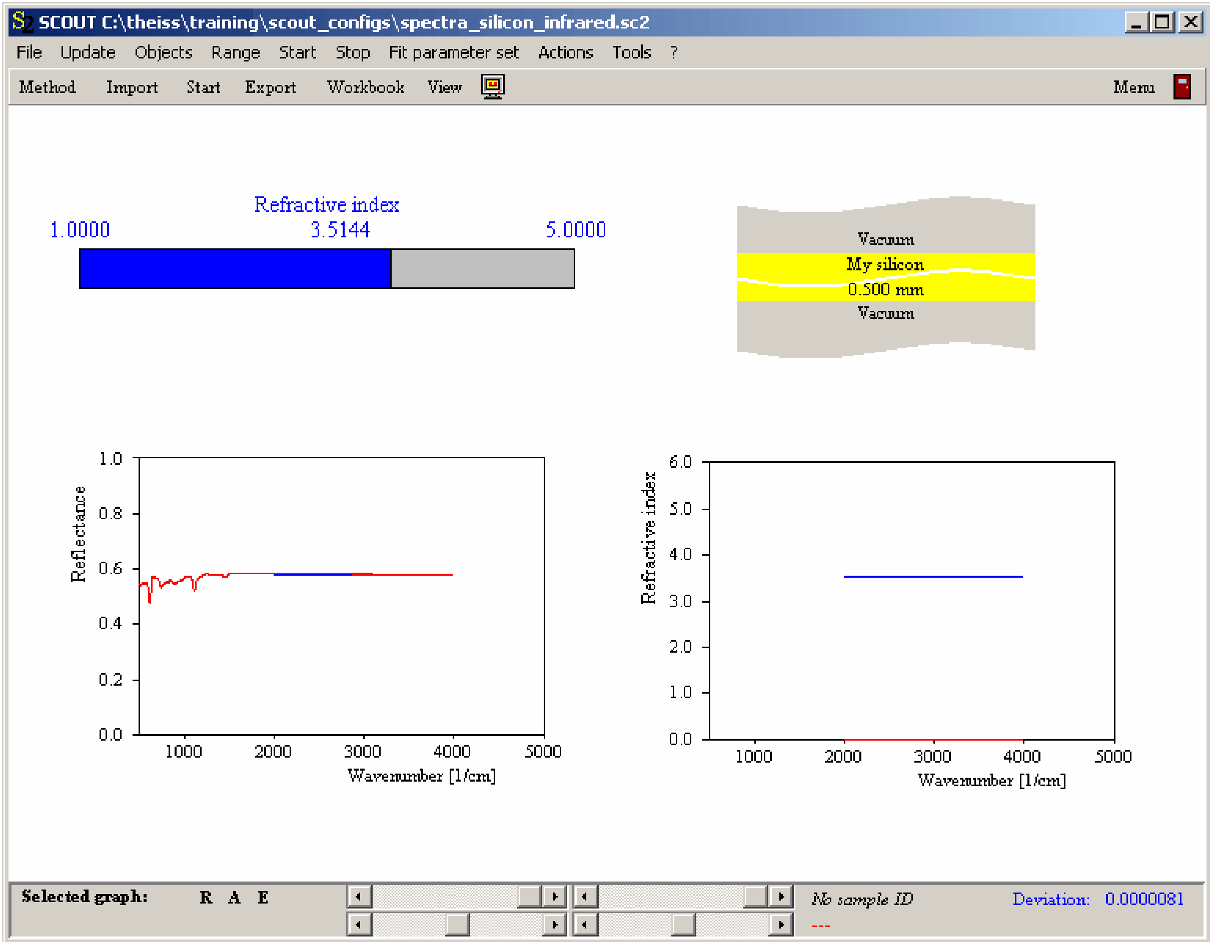
- Set the **Angle** of incidence to 40 (degrees).
- Use the **Import** command which opens the following dialog:



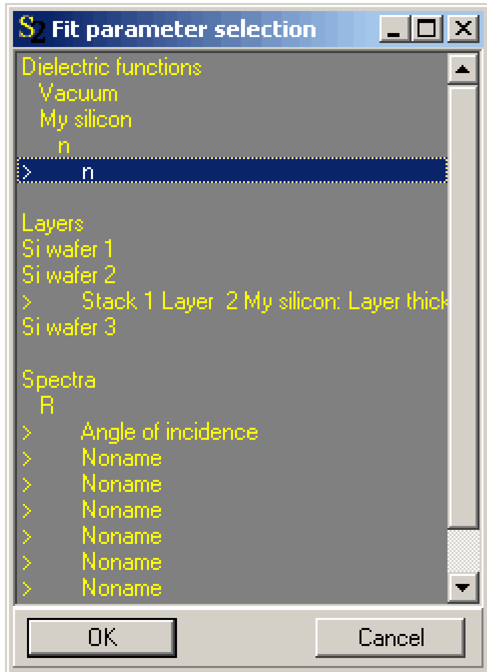
- Select the file type 'SpectraCalc format' and search for the file 'si_wafer_40_spol.spc' in the Data subfolder of the training folder. In the next dialog, select the spectral unit '1/cm':



- Close the spectrum window and observe the measured spectrum (drawn red) in the main window:



- Using the slider, set the refractive index to a value of 2.0 (which is certainly wrong).
- In the main window, use the **Range** command and select the spectral range 2000 ... 2500 1/cm with 20 points.
- Open the list of fit parameters (command: **Objects|Fit parameters**) and use the '**+**' button. This opens a list of all possible fit parameters of the current model. Select the 'refractive index parameter' of the material 'My silicon' (like indicated in the following picture). Then press **OK**:



- The configuration is now ready for your first automatic parameter fit. Save the configuration using the name 'Si_wafer_fit1.sc2'.

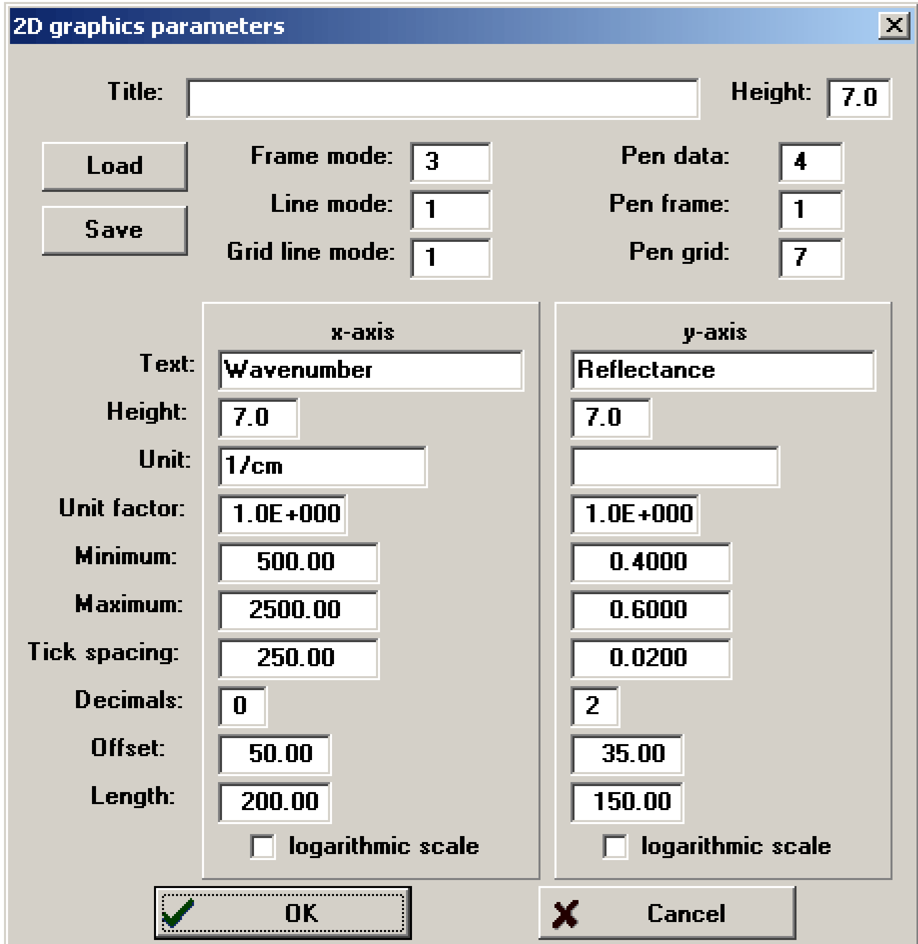
Exercise 1
Press the **Start** button in the main window. A short sequence of graphics updates indicates SCOUT's fit activity.

Compare the result of the fit with Solutions/Parameter fits/Exercise 1 51

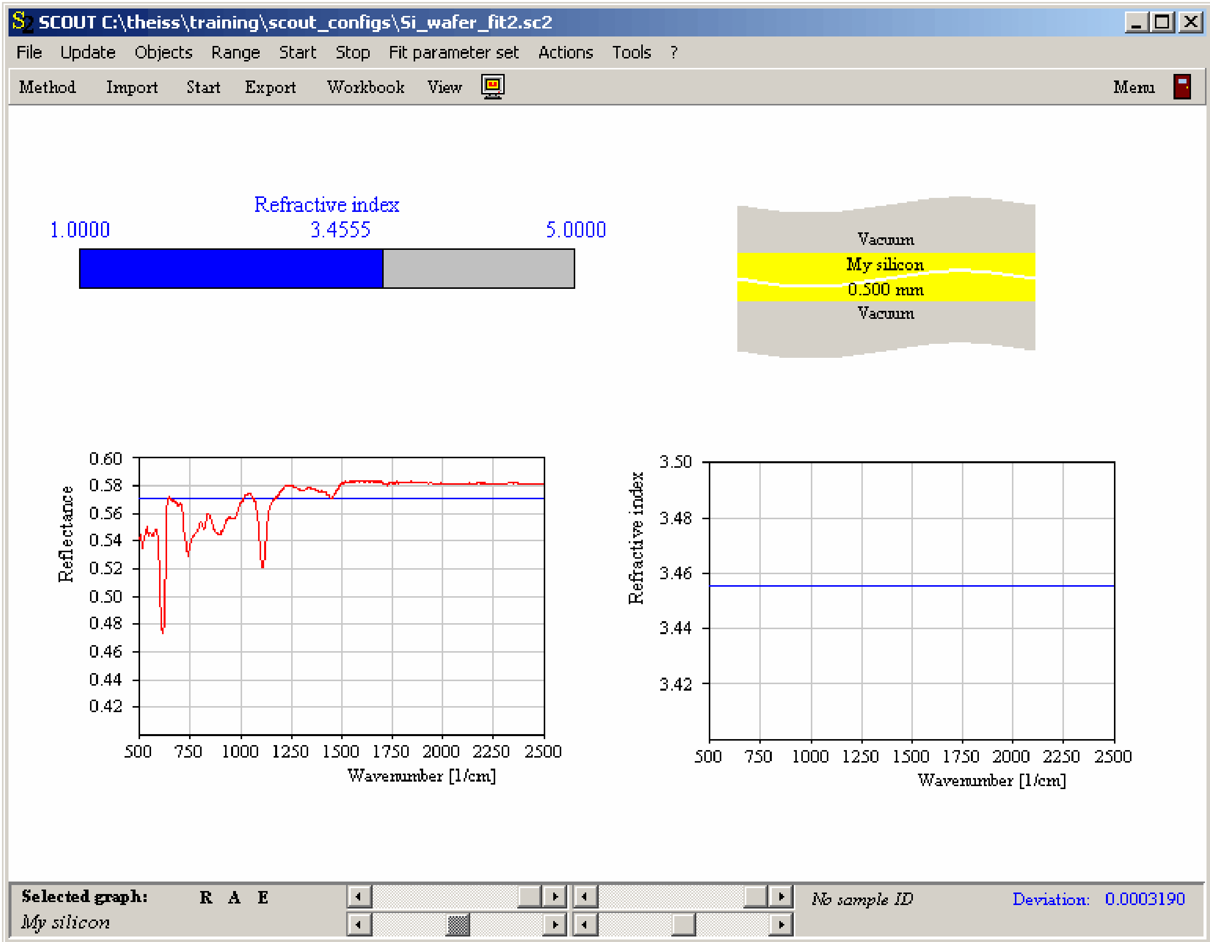
6.2 Exercise 2: Improving the optical constant model for Si

In this section the simple model for the optical constants of Si will be refined. Additional oscillators representing impurities and multiphonon absorption will be added.

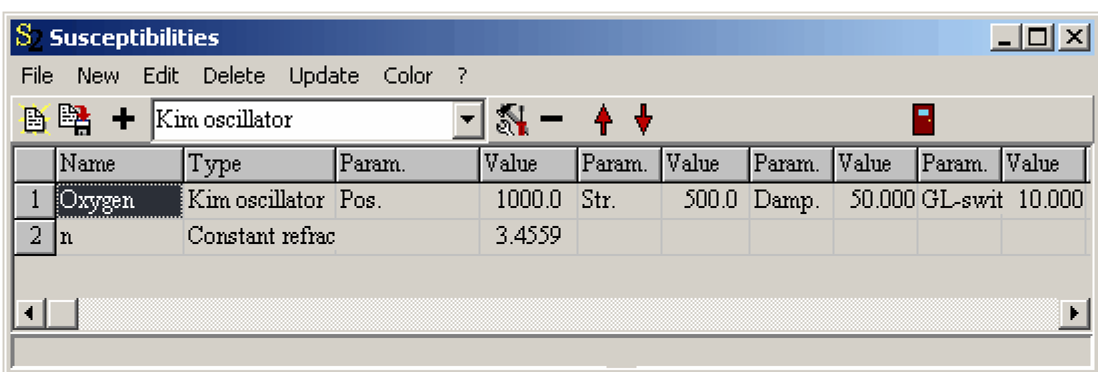
Instructions:
- Load the configuration 'Si_wafer_fit1.sc2' from the last section.
- In the main window, use the **Range** command to extend the spectral range to 500 ... 2500 1/cm (500 points).
- Press the **Start** button and watch the fit activity.
- Select the reflectance spectrum by a mouse click, and then click on the '**E**' button in the lower right corner. Set the graphics parameters to the values shown below:



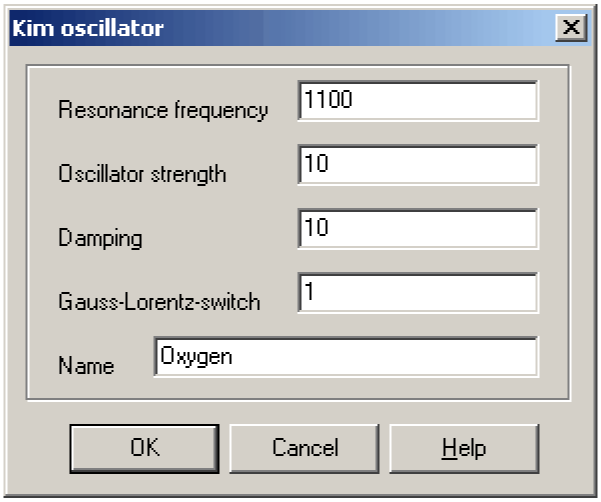
- Similarly, select the refractive index graph by a mouse click and press the '**E**' button to modifiy the graphics parameters appropriately:



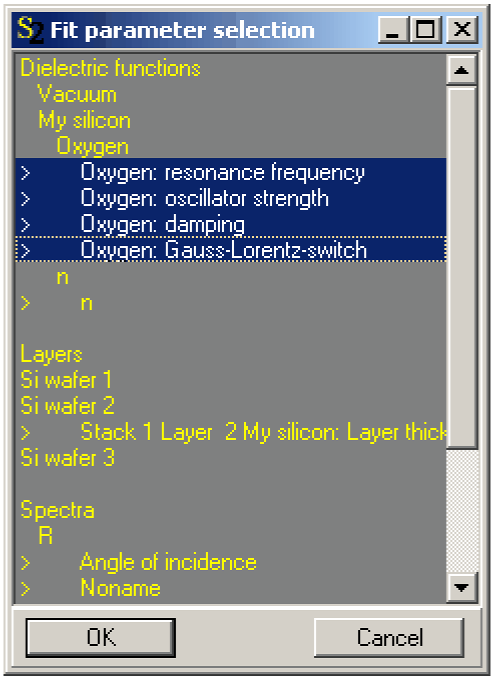
- Press the **Ctrl**-key and click on the optical constant object. The corresponding window opens and you can open the list of susceptibilies with the Susceptibilities command. In this list, select the new type 'Kim oscillator' and create a new item of this type. Call it 'Oxygen' like in the following example:



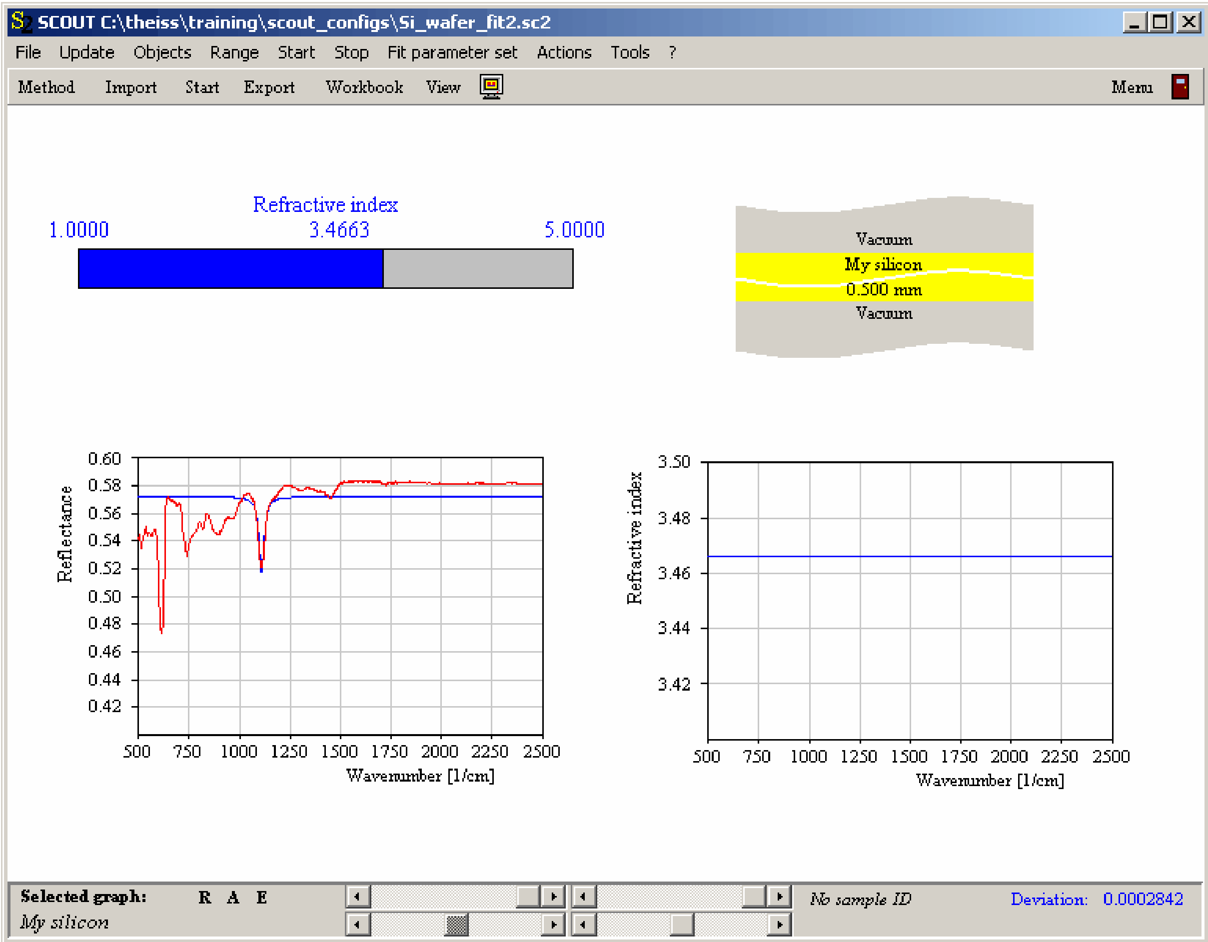
- Select the new item and use the **Edit** command to open the object's dialog. Set the following parameter values and leave the dialog. Then **Update** the main window. The new oscillator leads to absorption of infrared radiation around 1100 1/cm.



- Now we have to add the additional parameters to the list of fit parameters in order to adjust them automatically. Open the list of fit parameters and use the '+' button to open the selection list of all possible fit parameters. Keeping the Ctrl-key pressed down, you can select and de-select several items in the list. Like in the following example, select all 4 parameters of the 'Carbon' oscillator:



- Now press **Start** again in the main window. When the fit has finished the new oscillator parameters are adjusted:



Exercise 2
Similar to the 'Oxygen' oscillator, add a new Kim oscillator to the model for the optical constants of Si. Call it 'Carbon'. Use the starting values 610, 10, 10 and 1 for the 4 parameters and select them as new fit parameters (in addition to the old ones).
Important: In the list of fit parameters, set a high limit of 50 for the damping constant of the 'Carbon' oscillator. Then press the Start button for a new parameter fit.
Save the new configuration using the name 'Si_wafer_fit2.sc2'.

Compare the result of the fit with Solutions/Parameter fits/Exercise 2 52

6.3 Exercise 3: Finishing the optical constant model for Si

Exercise 3 (advanced level!)
Following the instructions given in the previous section 28, add more oscillators to the optical constant model of Si. Make use of low and high limits in the list of fit parameters to avoid 'floating away'. Decide yourself when the fit is good enough. For a 'high quality fit' you may have to add many oscillators. In the end it is useful to display the absorption coefficient of the 'My silicon' material.

Compare your result with the suggestion given in Solutions/Parameter fits/Exercise 3 53.

Part VII

7 Defining views

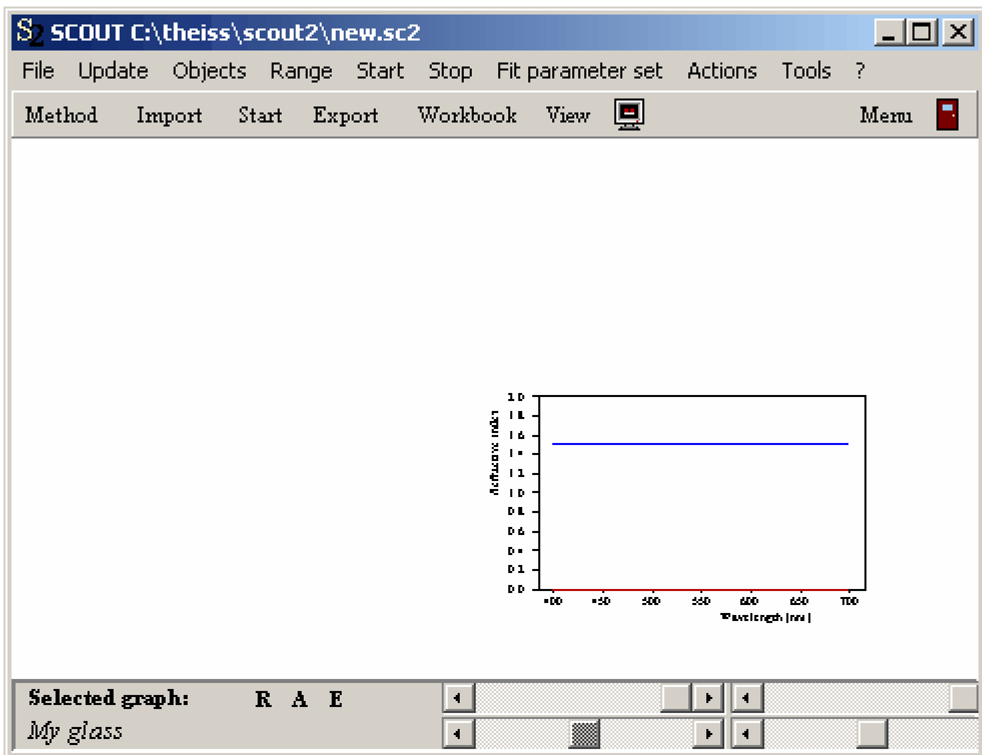
7.1 Exercise 1: Display optical constants

This first exercise will show you how you can graphically display optical constants in views. You will learn how to move and re-size the graph, and how to delete it from the view.

- Start SCOUT.
- Execute the menu command **File|New** to start with an empty configuration.

Adding an optical constant graph to a view

- Load the material 'My glass' into the list of materials.
- Drag the material 'My glass' from the list of materials to the center of the main window of SCOUT and drop it there. Verify that you get the following picture:



Moving a graph within a view

- Press the **Shift** button on your keyboard and keep it down.
- Place the mouse cursor in the middle of the optical constant graph, press the **left mouse button down** and move it around while you still keep the **Shift** key down. This moves the whole graph in the view. Try to move the graph to the upper left quarter of the main window. All view items can be moved this way.

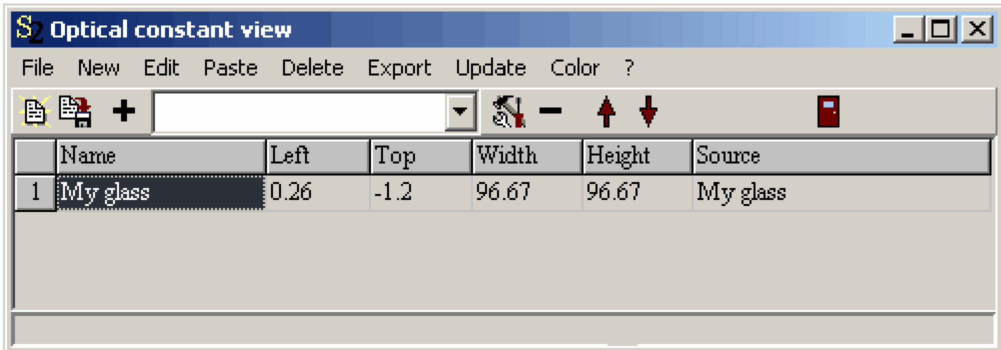
Re-sizing a graph in a view with the mouse

- Place the mouse cursor in the middle of the optical constant graph, press the **right mouse button down** and move it slowly towards the lower right corner of the graph. This increases the size of the graph in the view.
- Moving the mouse cursor towards the upper left corner of an object (with the right mouse button down) decreases its size.

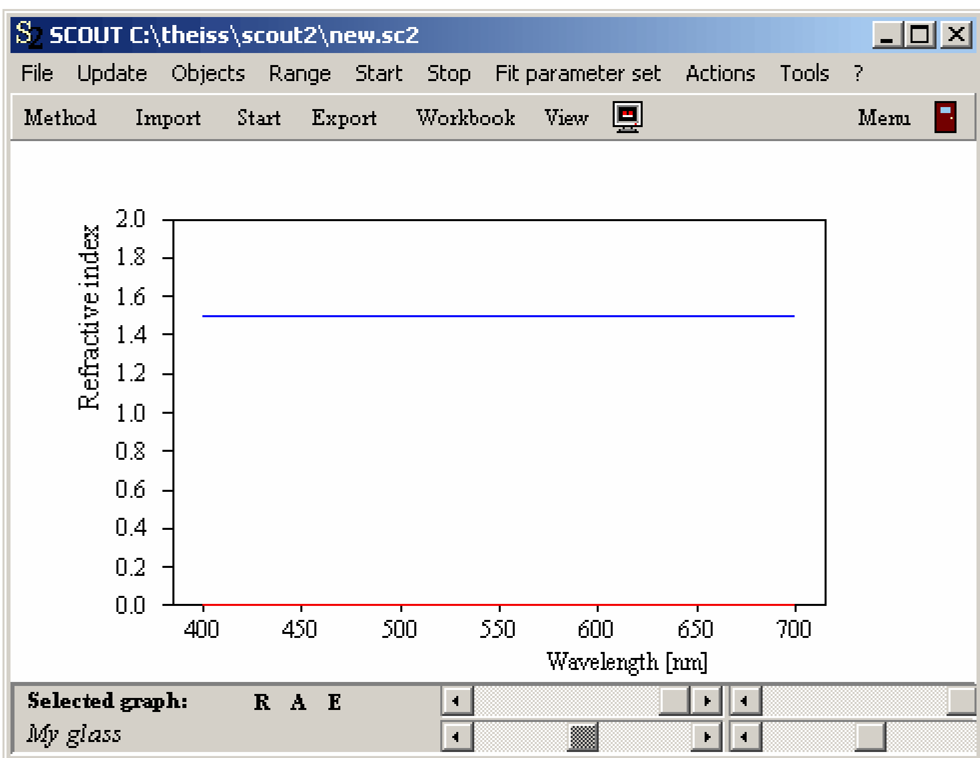
- Try to set the size of the graph in such a way that it fills the entire main window of SCOUT.

Well-defined object position and size by typing in coordinates

- Open the list of views with the menu command **Objects|Views**. There is only one view in the list of views.
- Change the name of the view to 'Optical constant view'.
- Open the view object with the 'Edit' command. It should look like this:



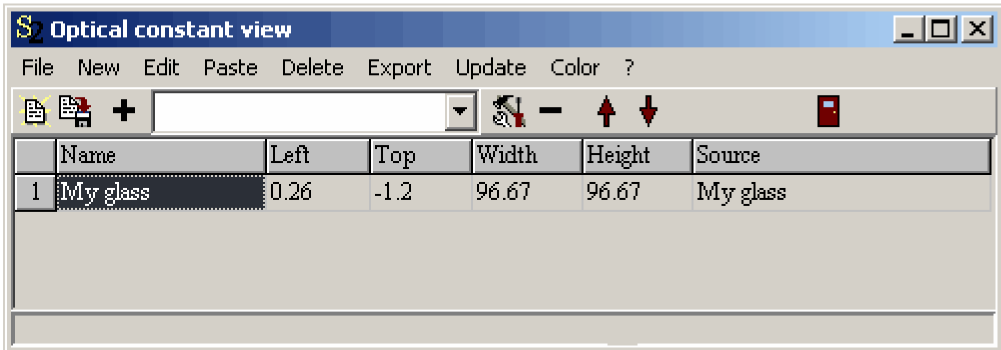
- The numbers called **Left**, **Top**, **Width** and **Height** specify the position (Left and Top) of the graph and its size (Width, Height). All values are percentages with respect to the full width or height of the main windows drawing area. The upper left corner of the view has the coordinates (0.0,0.0), the lower right corner is given by (100.0,100.0).
- Set values of 0.0, 0.0, 100.0 and 100.0 for the parameters Left, Top, Width and Height. Press **Update** in the main window and it should look like this now:



Deletion of view objects from a view

To delete objects from a view you have to go to the list of view objects and delete the corresponding item there.

- Open the list of views with the menu command **Objects|Views**. In the list of views, select the view you want to modify and use the **Edit** command to open its list.
- In the list of view items, select the one you want to delete and press the '**-**' button (e.g. the one called 'My glass' in the following example).



- Press Update in the main window in order to update the view. Verify that your changes are done properly.

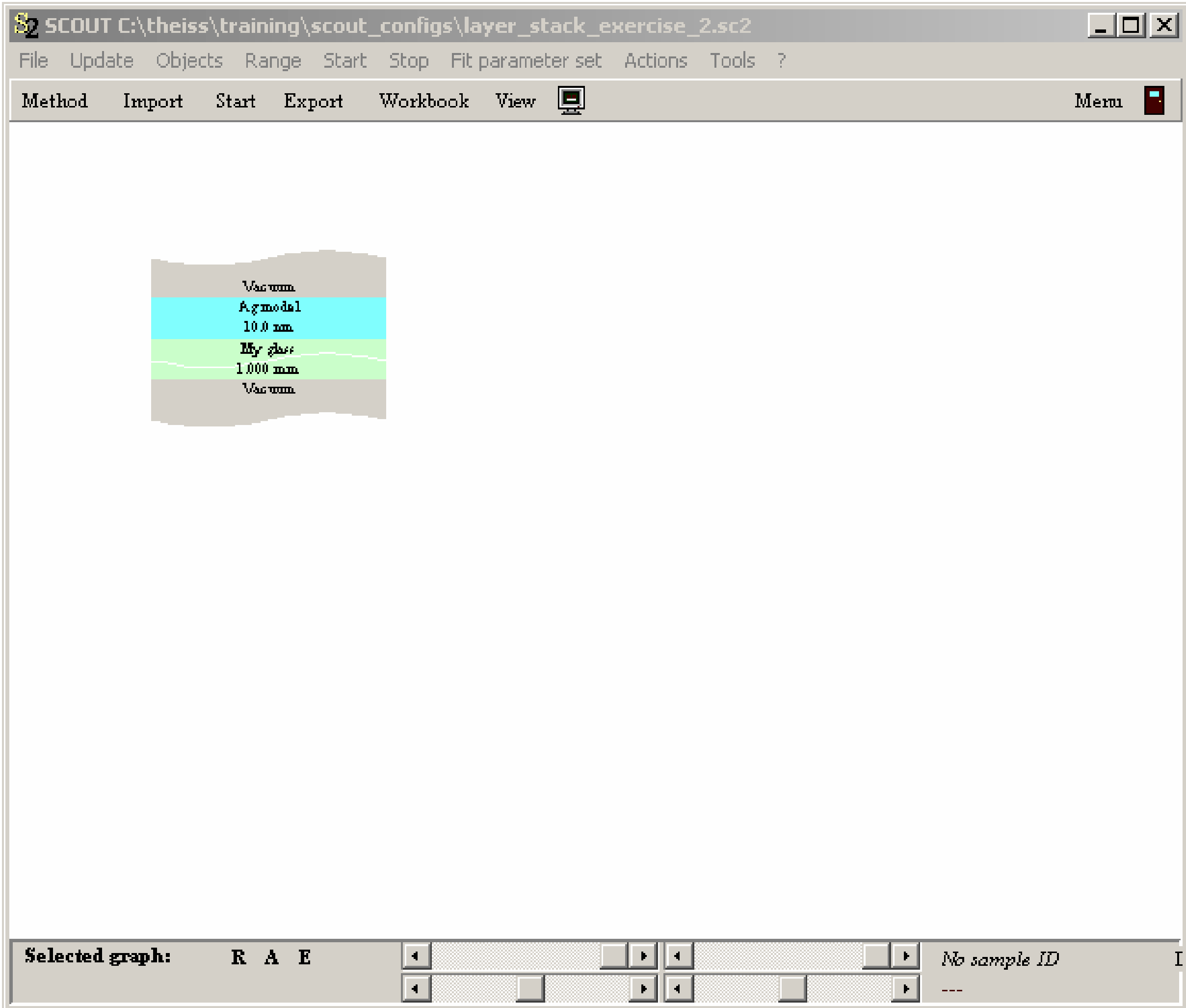
Exercise 1
Start with an empty SCOUT configuration. Load the materials 'My glass' and 'My silicon' from the database. Display all materials in the main window of SCOUT: 'Vacuum' in the upper left corner, 'My glass' in the lower left corner, and 'My silicon' in the lower right corner.

Check your solution reading the section Solutions/Defining views/Exercise 1 54

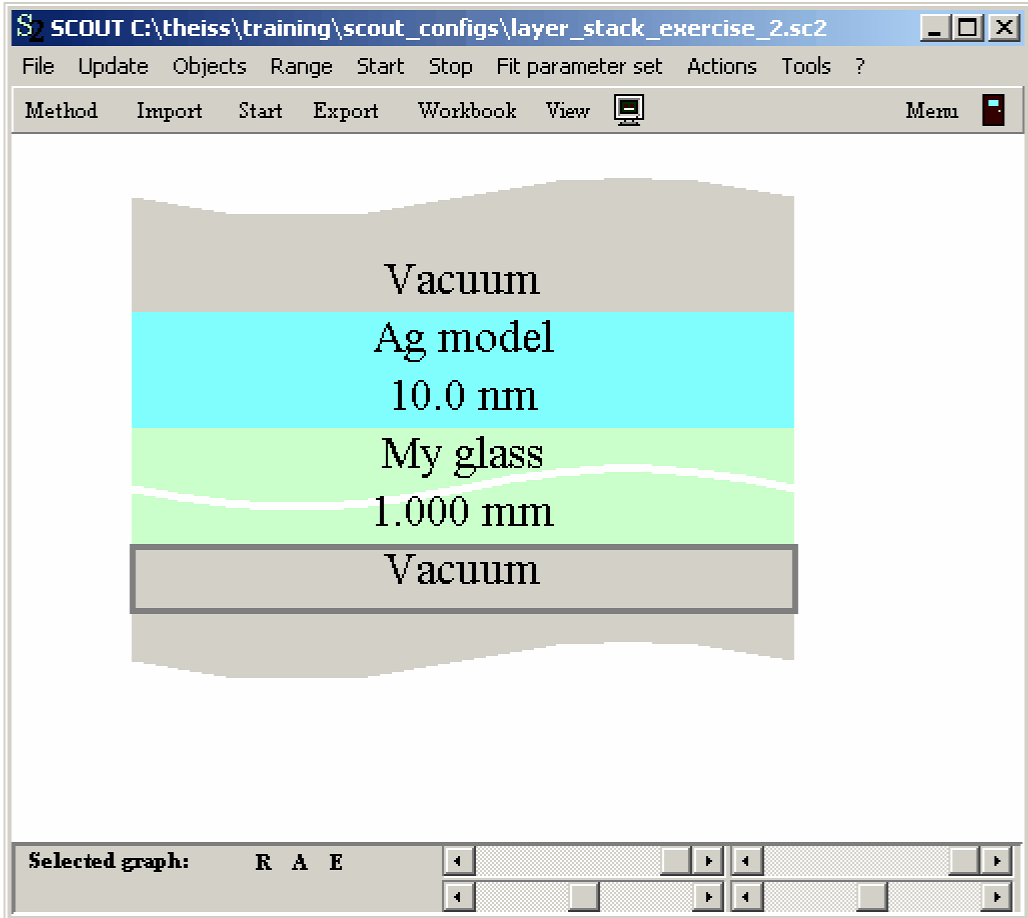
7.2 Exercise 2: Display a layer stack in a view

Now you will learn how layer stacks can be displayed in a view. It's quite simple if you follow these instructions:

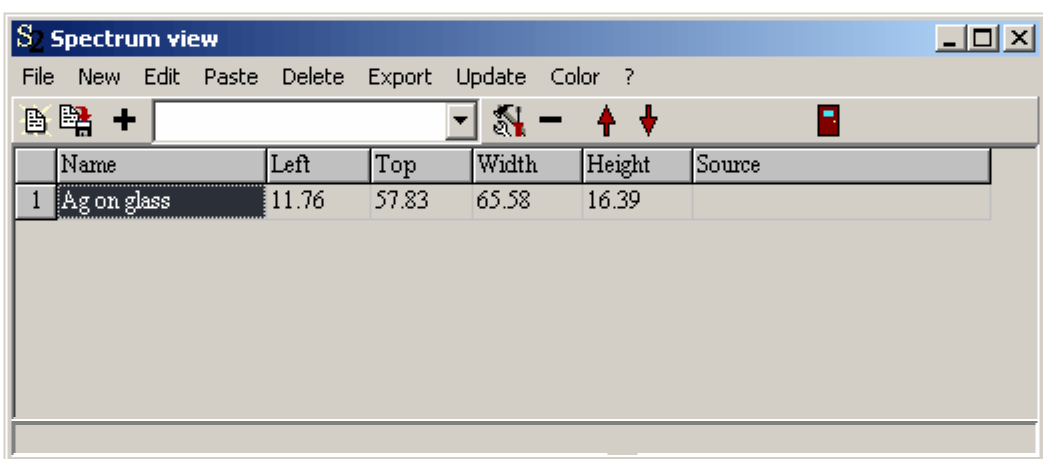
- Start SCOUT and open the configuration 'Layer_stack_exercise_2.sc2' that you created in a previous session 16.
- Open the list of layer stacks and drag the object called 'Ag on glass' to the main window of SCOUT. It should look like this now:



- Like optical constant graphs in views, layer stacks can be moved and re-sized in a view by appropriate mouse actions. However, there is the following difference: Whereas the optical constant graph is sensitive to the mouse cursor in a rectangle surrounding the whole graph, layer stacks in views have a rather small rectangle of 'mouse sensitivity' in the bottom halfspace. This is sketched in the following graph by the gray rectangle:



- Play with shift and re-size operations in order to get a feeling for the special layer stack behaviour in views.
- Inspect the coordinates of layer stack view objects in the view object list: These numbers refer to the dimensions of the gray sensitivity rectangle shown above:



Exercise 2

Start with the SCOUT configuration 'Layer_stack_exercise_2.sc2' that you created in a previous exercise 16. Create a view that displays

- the optical constants of silver in the upper left quarter of the main window
- the optical constants of 'My glass' in the lower left quarter
- the optical constants of 'My silicon' in the lower right quarter
- the two layer stacks ''Ag on glass' and 'Ag on Si wafer' in the upper right corner

Save the configuration using the name ''View_exercise_2.sc2'.

Check your solution reading the section Solutions/Defining views/Exercise 2 55

7.3 Exercise 3: Computed spectra in views

Computed spectra can be displayed in views quite simply: Open the list of spectra (**Objects|Spectra**) and drag the spectrum you want to see to the desired position in the view. For a fine-tuning of the position and the size of view objects, open the list of view objects and type in the wanted coordinates of the individual objects.

Exercise 3
Start with the configuration 'Spectra_glass_visible_rt.sc2' that was the result of exercise 2 21 in the section 'Spectra'.
Display
- the computed reflectance spectrum in the lower left quarter of the main window
- the transmittance spectrum in the lower right quarter
- the optical constants of 'My glass' in the upper right quarter
- and the layer stack in the upper left quarter

of the main window.

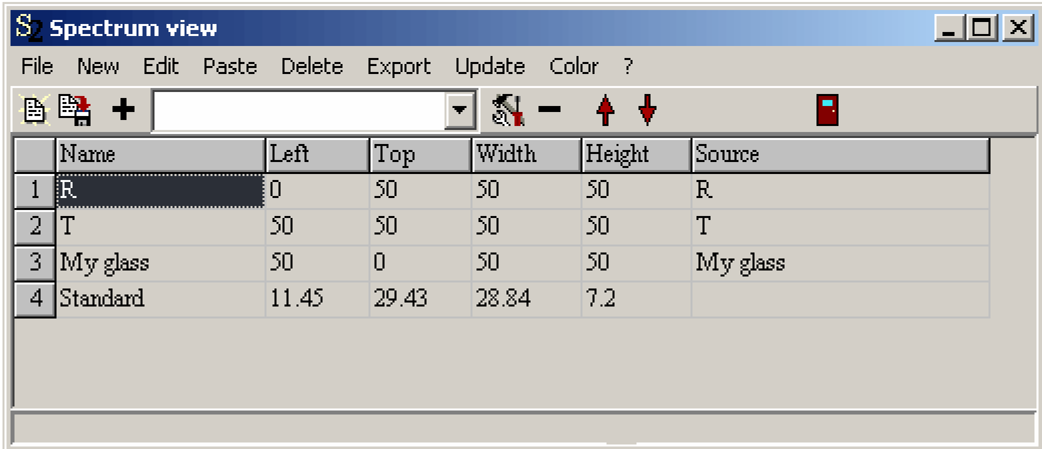
Use the File|Save command to store these modifications of the configuration.

Check your solutions reading the section Solutions/Defining views/Exercise 3 56

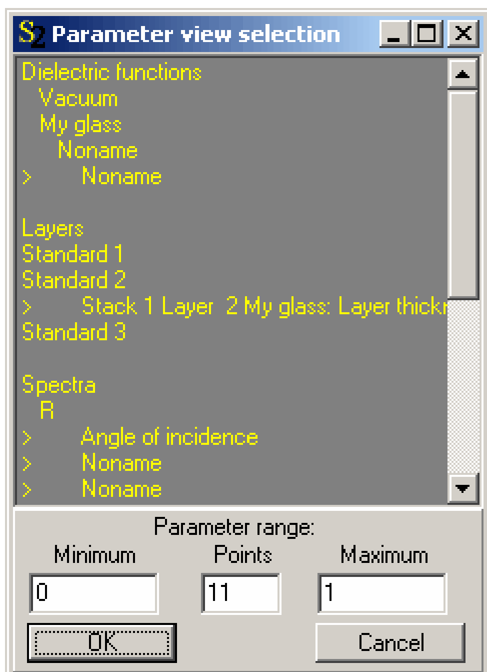
7.4 Exercise 4: Modifying the model using sliders

This section tells you how parameters of the optical model can be changed graphically in a view. This feature of SCOUT is very important to develop an intuitive feeling for the influence of individual parameters on the final spectra.

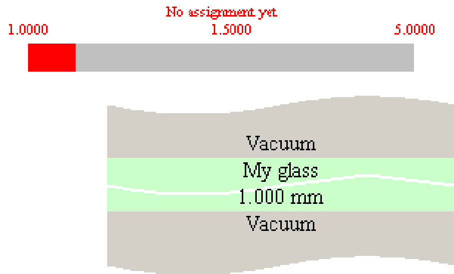
Instructions:
- Load the configuration 'Spectra_glass_visible_rt.sc2' that was created and re-fined in previous exercises 39. Use the command **Objects|Views** to open the list of views. Select the view that is defined there (I called it 'Spectrum view') and open it with **Edit**. The list should look like this:

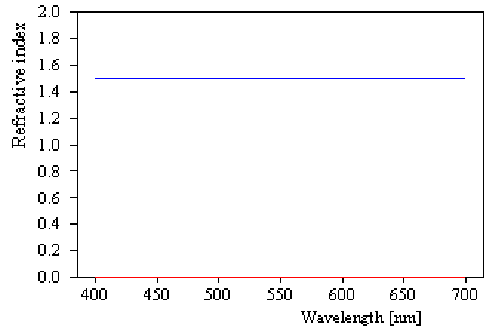


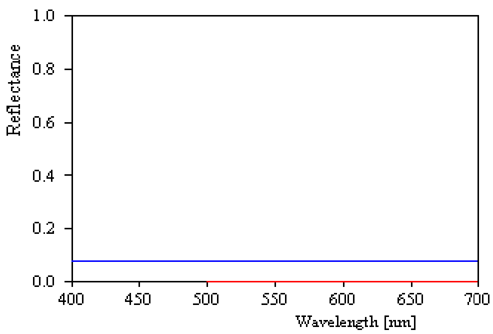
- To create a slider object, select in the dropdown box located to the right of the '+' button the object type 'Horizontal bar' and press the '+' button. The following dialog lists all parameters of the current optical model:

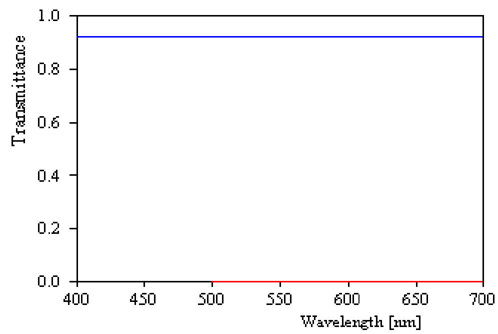


- The selectable parameters are marked with a preceeding '>'. Click on the parameter 'Noname' of the object 'My glass' and press **OK**.
- Select a color for the slider in the next dialog, e.g. red.
- You are now asked for the range of the parameter variation. Type in a minimum of 1.0 and a maximum of 5.0.
- Press update in the main window:

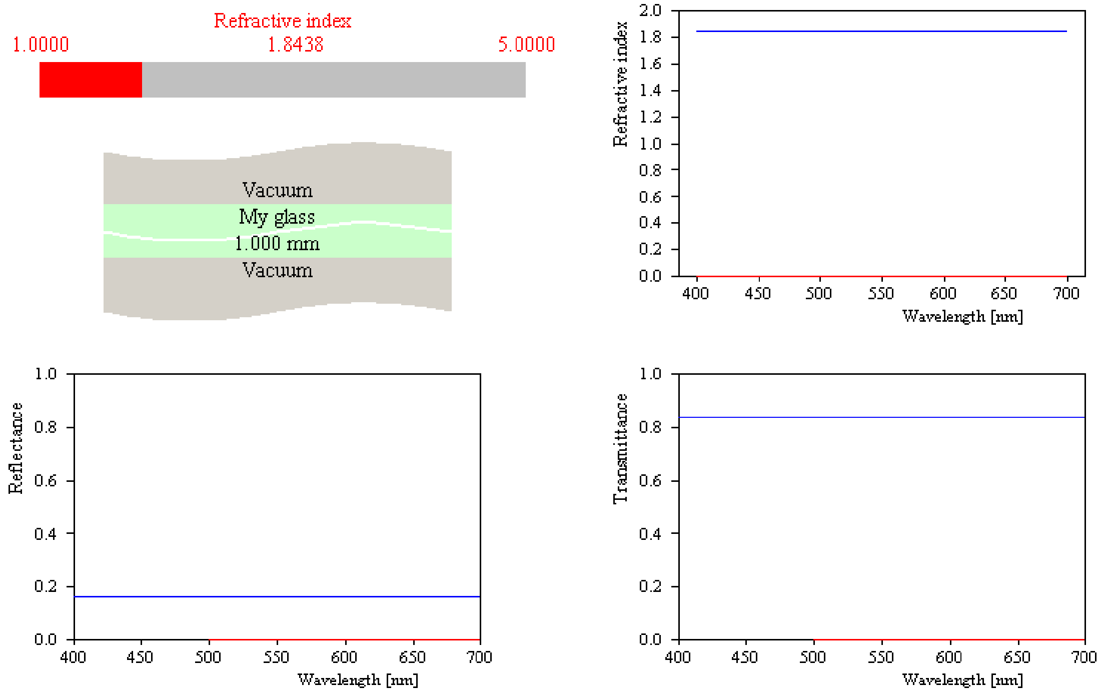








- Notice that a horizontal bar graph has been created which is named 'No assignment yet' at present. Go to the list of the view objects and type in the new name 'Refractive index'.
- If you like you can re-arrange the layer stack display and the bar graph a little (see below).
- Now place the mouse cursor on the bar graph, press the left mouse button down and drag the bar position to a different position. Note that the optical constants and the spectra are instantly re-computed:



Exercise 4

After these modifications, save the configuration using the File|Save command.
Using the configuration above, answer the following questions:

1. What refractive index leads to vanishing reflectance?
2. What refractive index leads to a perfect beam splitter with 50% transmittance and 50% reflectance?
3. Diamond has a refractive index of about 2.4 in the visible. How large is the transmittance of a diamond window?

Solutions in Solutions|Defining views|Exercise 4 57.

Part VIII

8 Using SCOUT tools

8.1 Exercise 1: DirectDF

SCOUT comes with several small tools that are added for specific tasks. The program DirectDF computes the optical constants of transparent substrate materials such as glass directly from measured R and T spectra.
In this exercise you will learn how to use DirectDF in order to determine the optical constants of float glass. The obtained data are added to the database for future use.

Instructions:

- Start SCOUT
- Use the menu command Tools|DirectDF to start the DirectDF program
- The DirectDF help contains a step-by-step example that you should follow (Ignore the error message that R+T is greater than 1 at some spectral points).

Exercise 1
Use the DirectDF tool to determine the optical constants of float glass in the spectral range 320 ... 2500 nm wavelength. Measured transmittance and reflectance spectra are given in the subfolder /data/float_glass delivered with this training instruction. The thickness of the glass is 4 mm.
Store the optical constants in the SCOUT database using the name 'Float glass (training)'.
Load the new material into SCOUT's material list, open its window and select the property 'Absorption coefficient". Generate a graph using logarithmic scaling for the y-axis.

Check your solution reading the section Solutions/Using SCOUT tools/Exercise 1 57

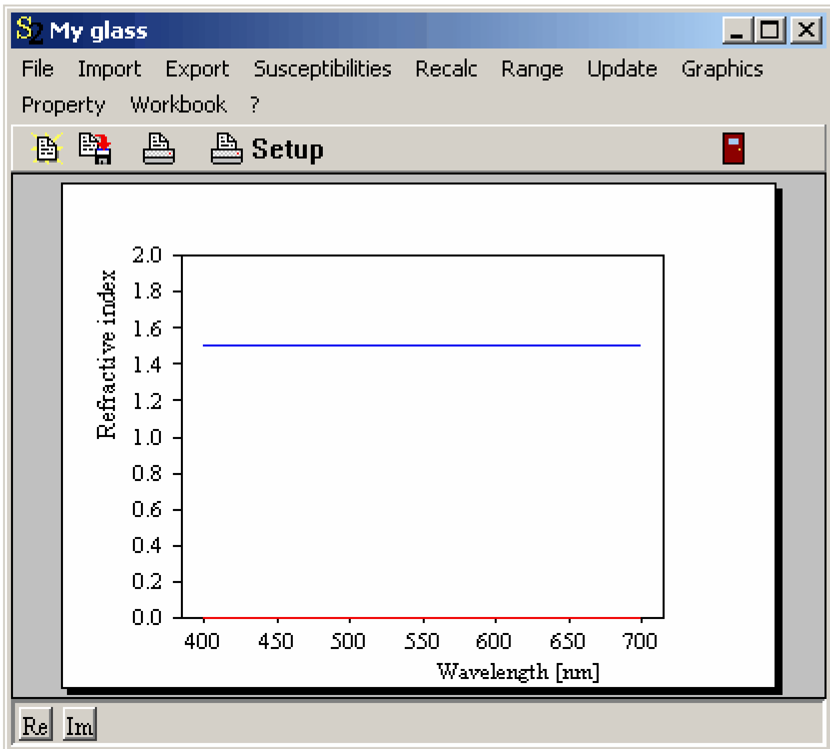
Part IX

9 Solutions

9.1 Optical constants

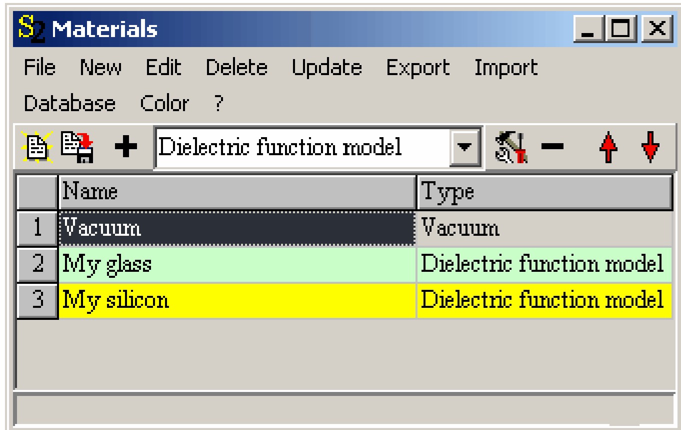
9.1.1 Exercise 1

After exercise 1, the database should contain the new materials called 'My silicon' and 'My glass'. 'My glass' should have the following optical constants:



9.1.2 Exercise 2

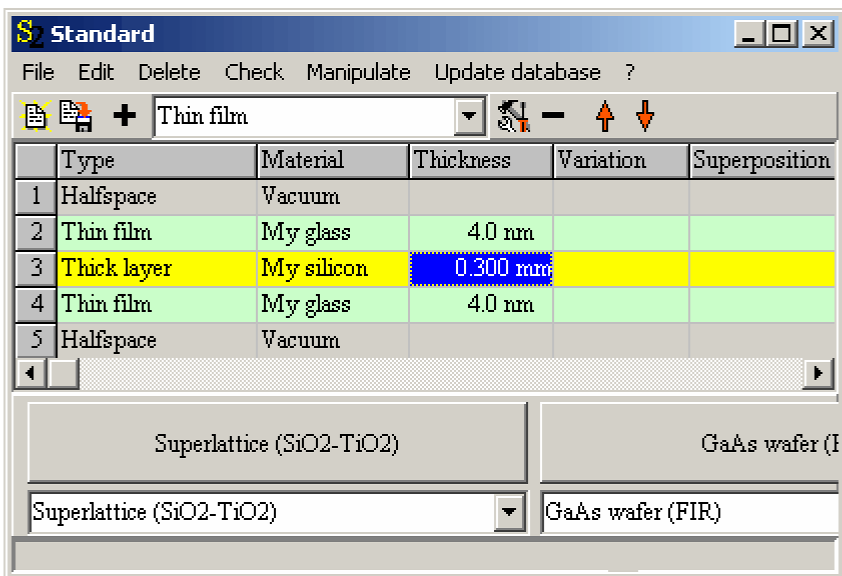
After exercise 2, the list of materials should look like this:



9.2 Layer stacks

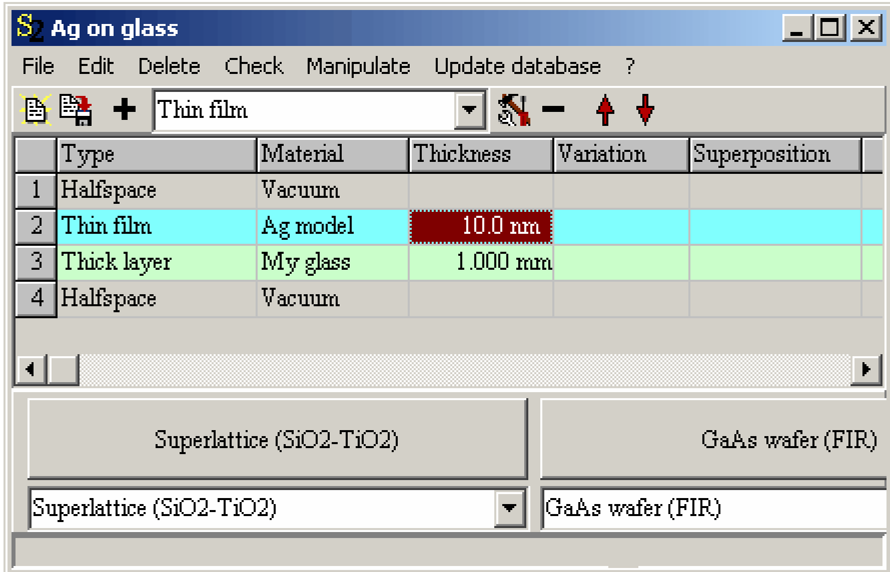
9.2.1 Exercise 1

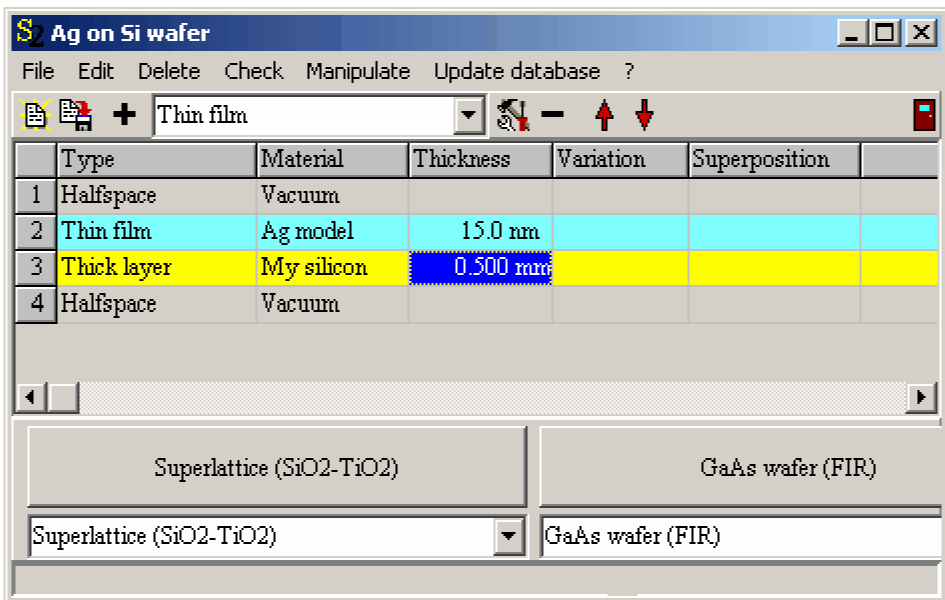
The layer stack definition window should look like this after exercise 1:



9.2.2 Exercise 2

These are the two layer stacks that you should have obtained:





9.3 Spectra

9.3.1 Exercise 1

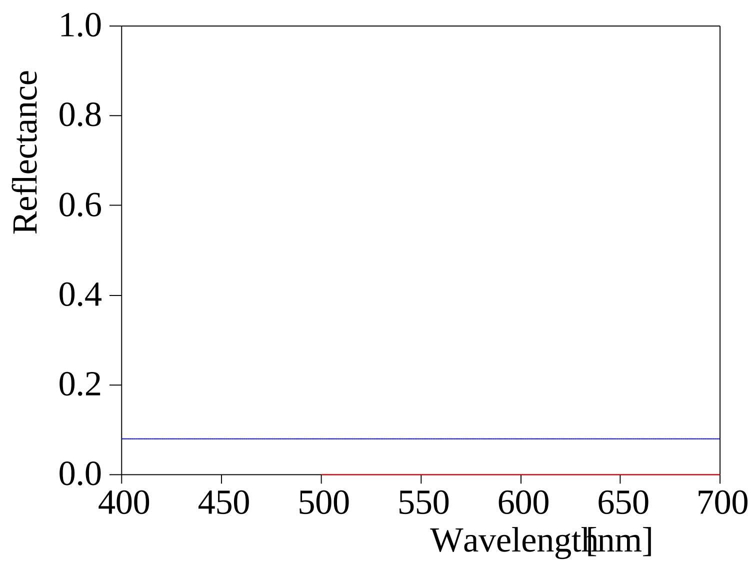
You should have obtained the following reflectance values in this exercise:

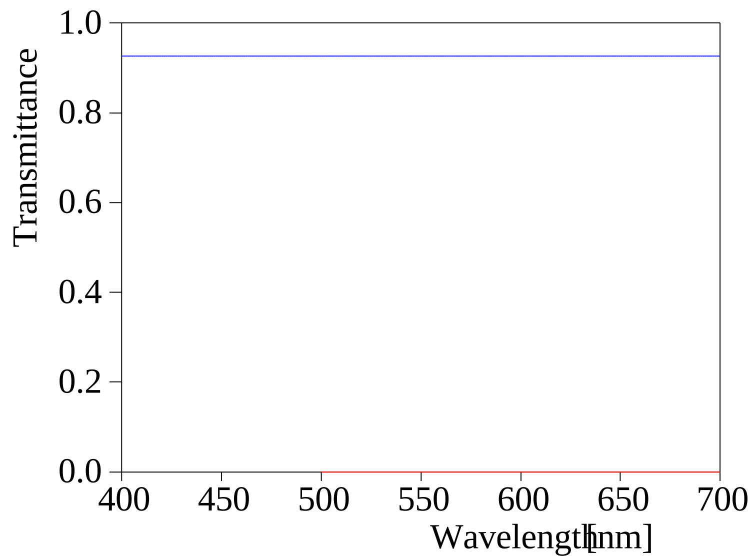
Angle	Polarization	Reflectance
45	s-pol	0.593
45	p-pol	0.302
10	s-pol	0.465
10	p-pol	0.452
75	s-pol	0.842
75	p-pol	0.004
63.23	s-pol	0.730
32.12	p-pol	0.386

9.3.2 Exercise 2

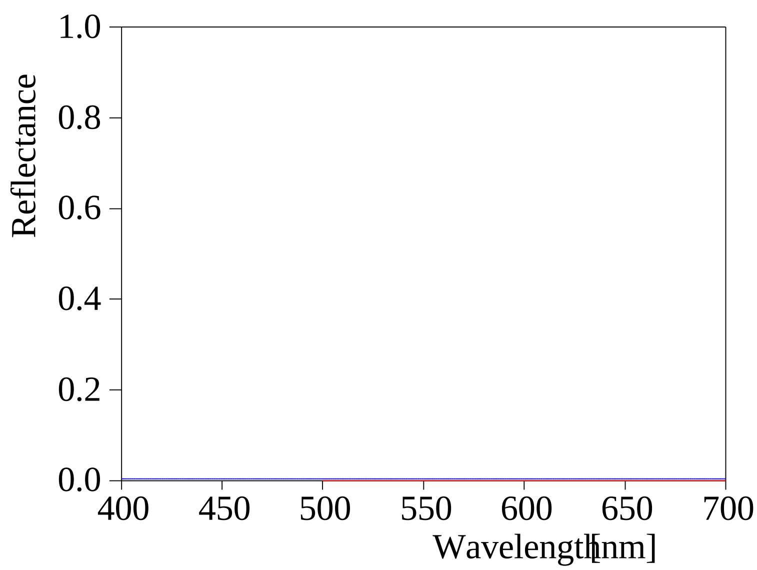
Here are the spectra that you should have obtained:

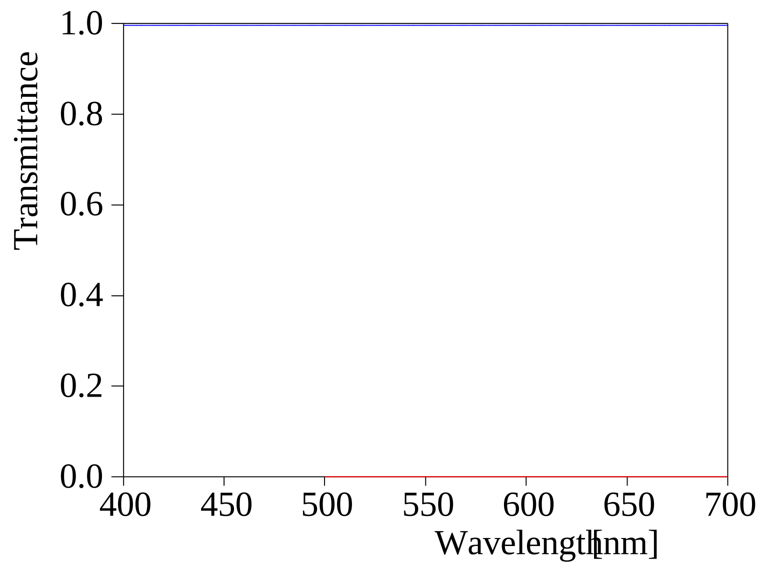
a) 10 degree angle of incidence





b) Angle of incidence: 60 degree

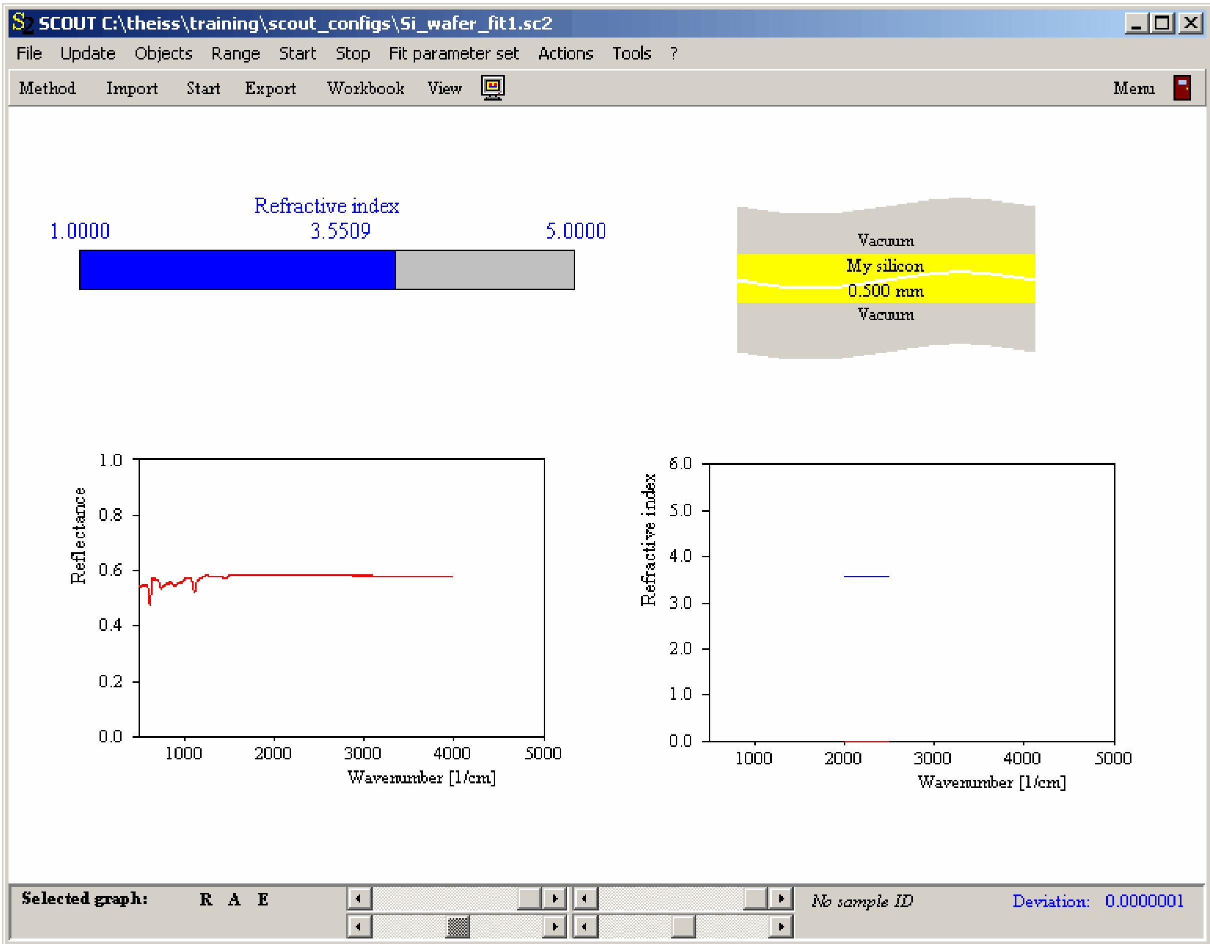




9.4 Parameter fits

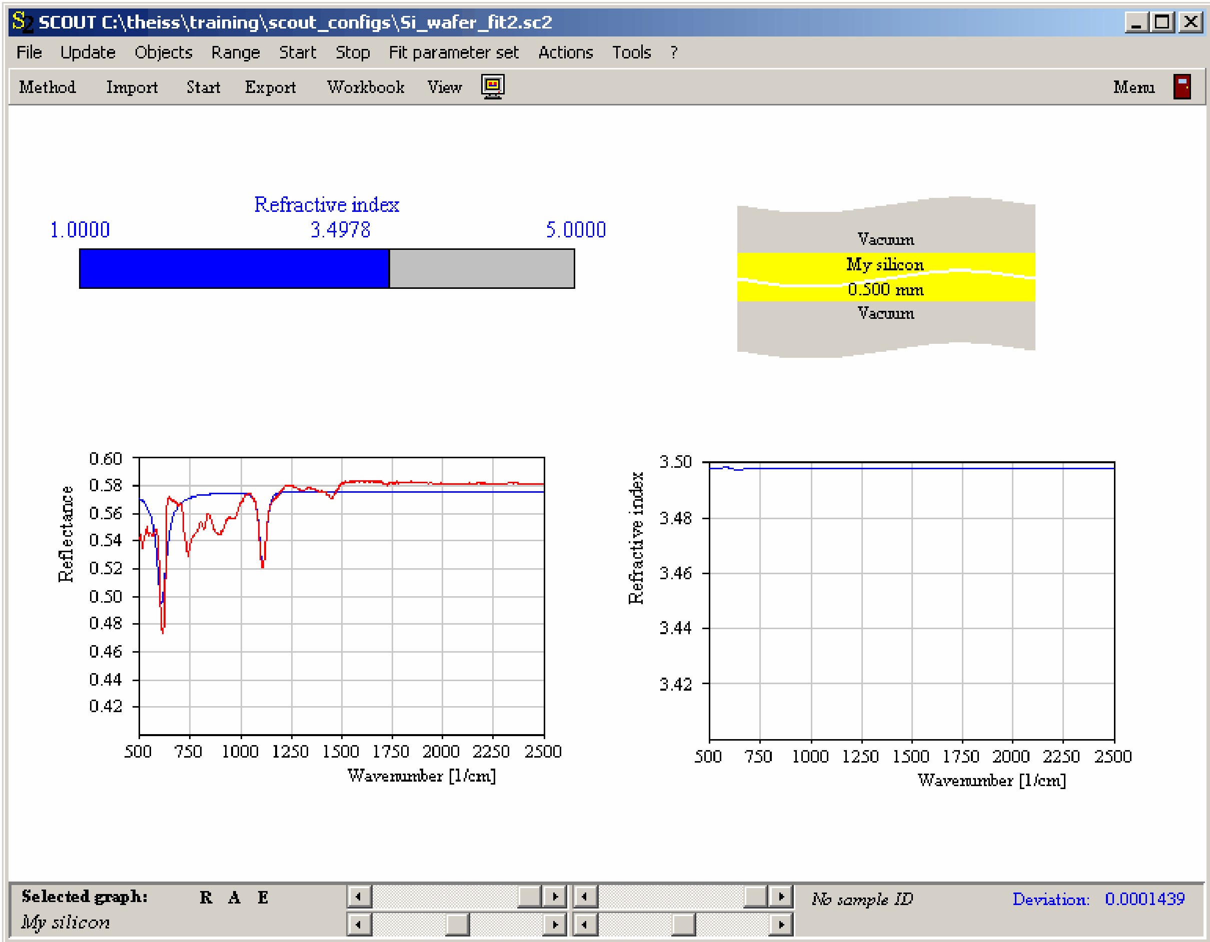
9.4.1 Exercise 1

The value of the refractive index should be 3.55 and the main window should look like this:



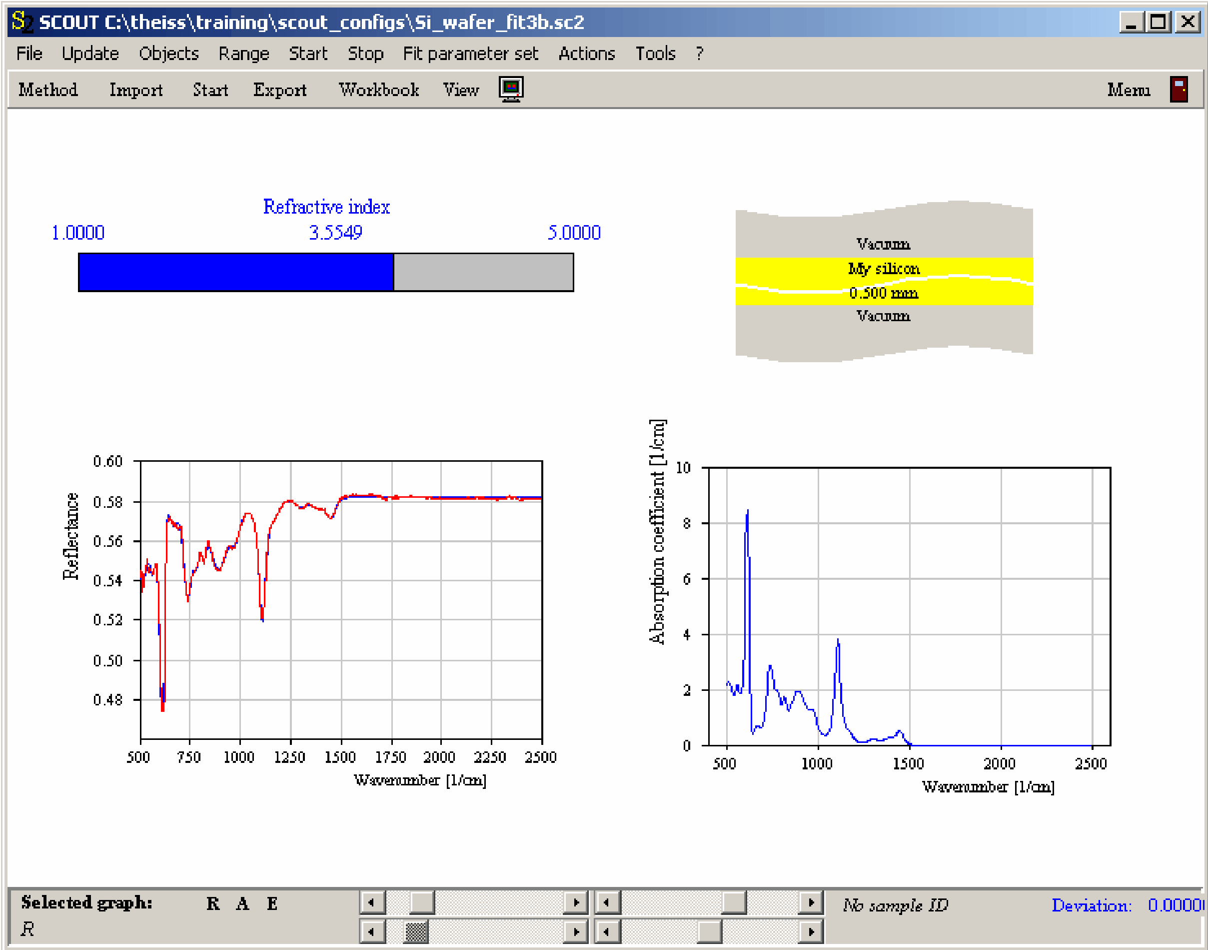
9.4.2 Exercise 2

The new fit result should be something like this:



9.4.3 Exercise 3

A satisfying (I hope you agree) result is shown below:

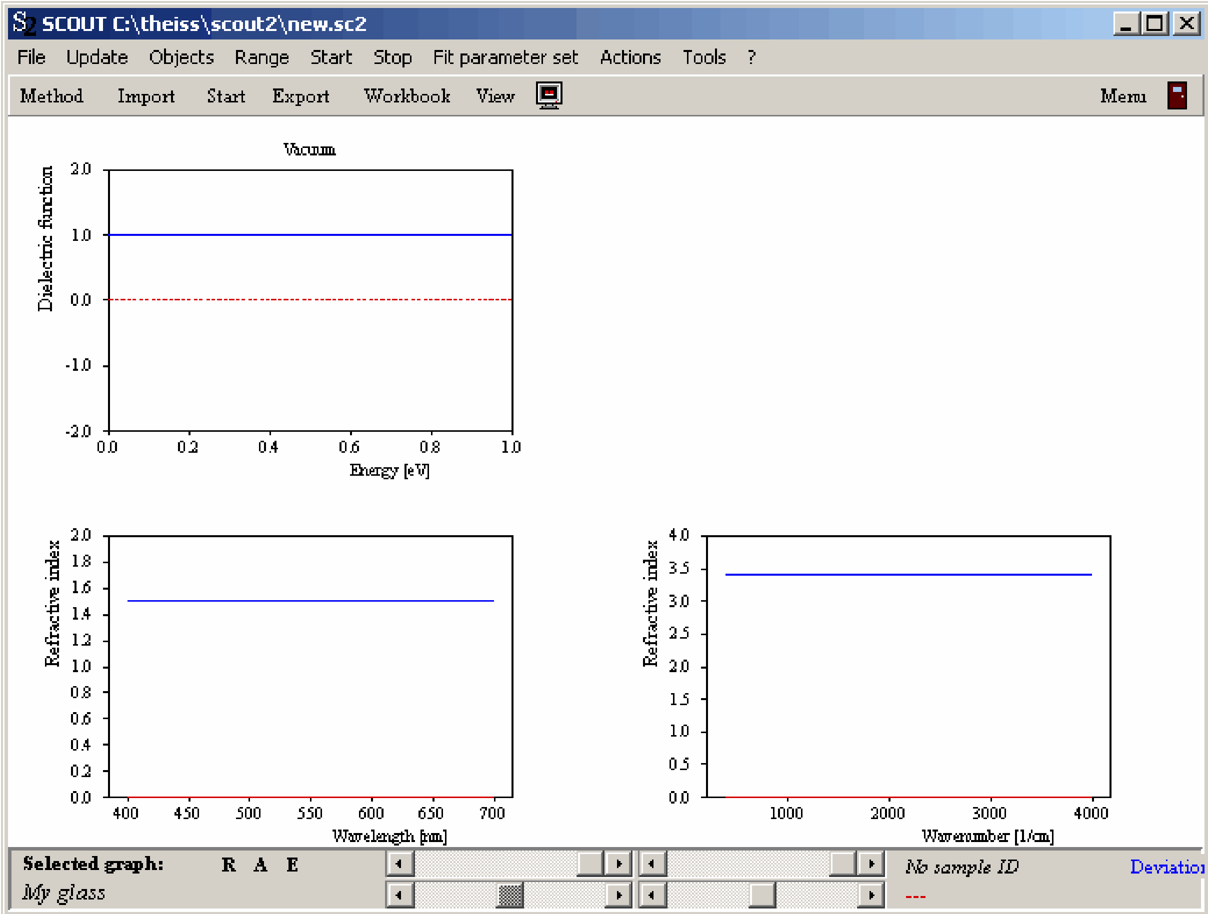


This configuration is stored under the name 'Si_wafer_fit3.sc2'.

9.5 Defining views

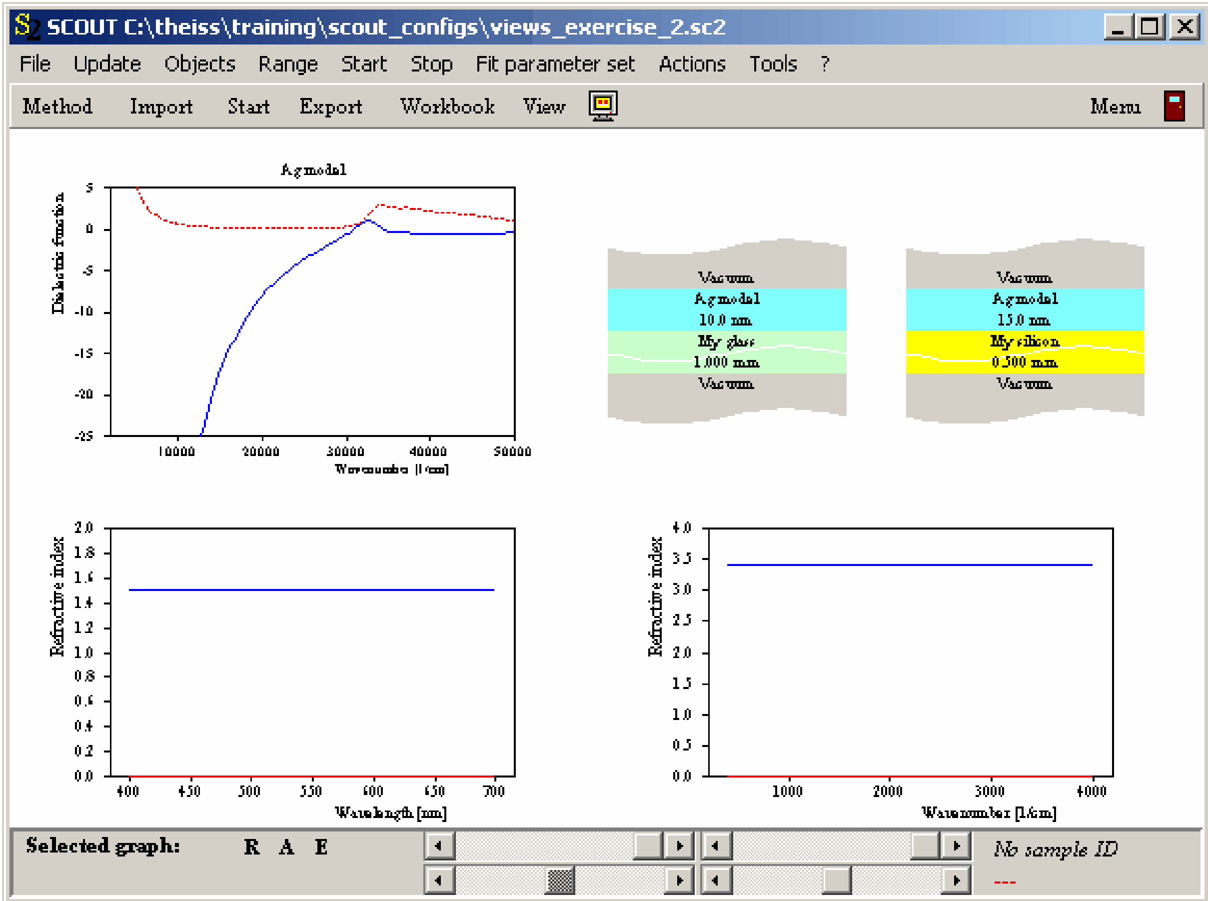
9.5.1 Exercise 1

The view should look like this:

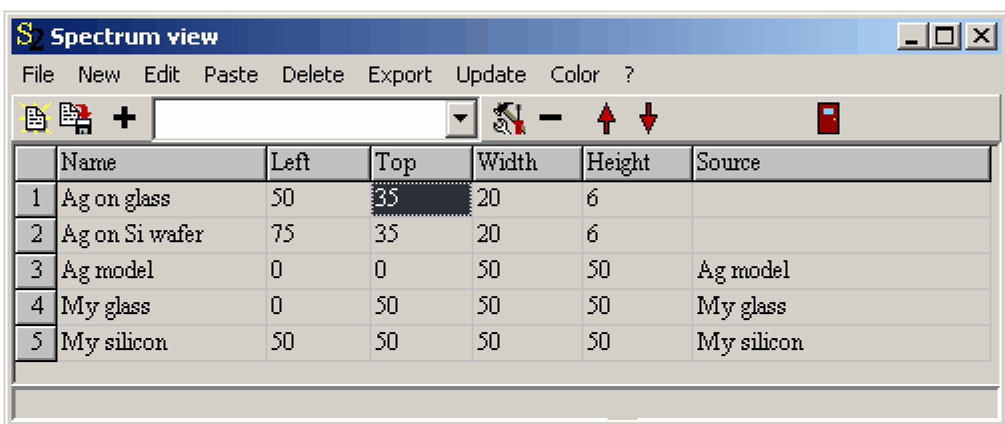


9.5.2 Exercise 2

Your main window should look like this:



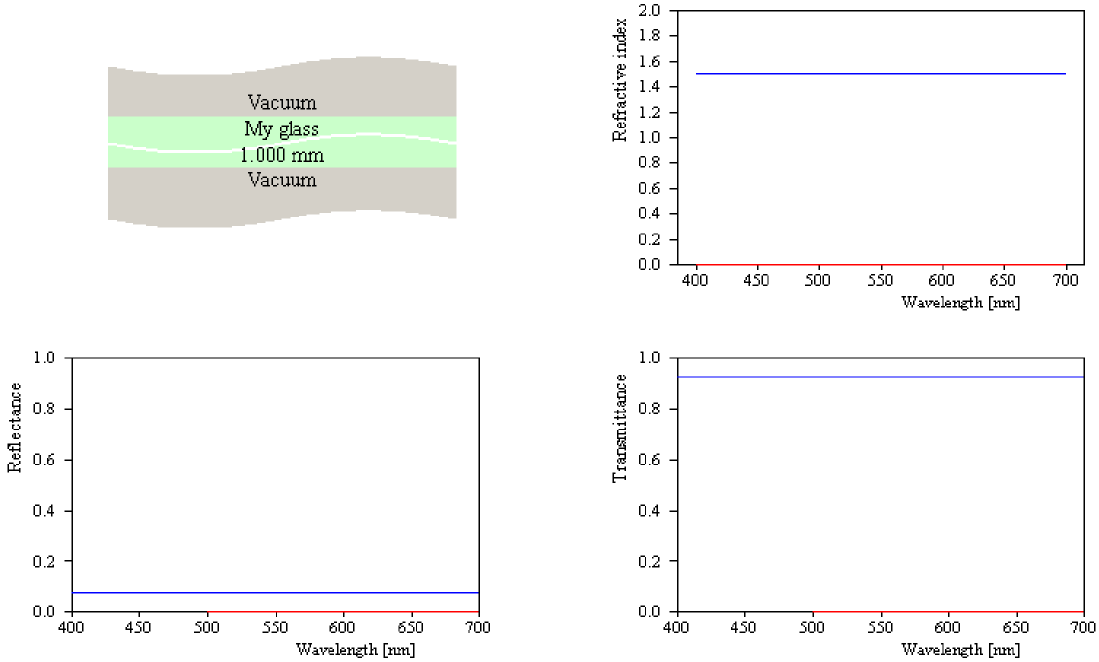
This is the content of the view object list:



	Name	Left	Top	Width	Height	Source
1	Ag on glass	50	35	20	6	
2	Ag on Si wafer	75	35	20	6	
3	Ag model	0	0	50	50	Ag model
4	My glass	0	50	50	50	My glass
5	My silicon	50	50	50	50	My silicon

9.5.3 Exercise 3

Here is what your main window should display:



9.5.4 Exercise 4

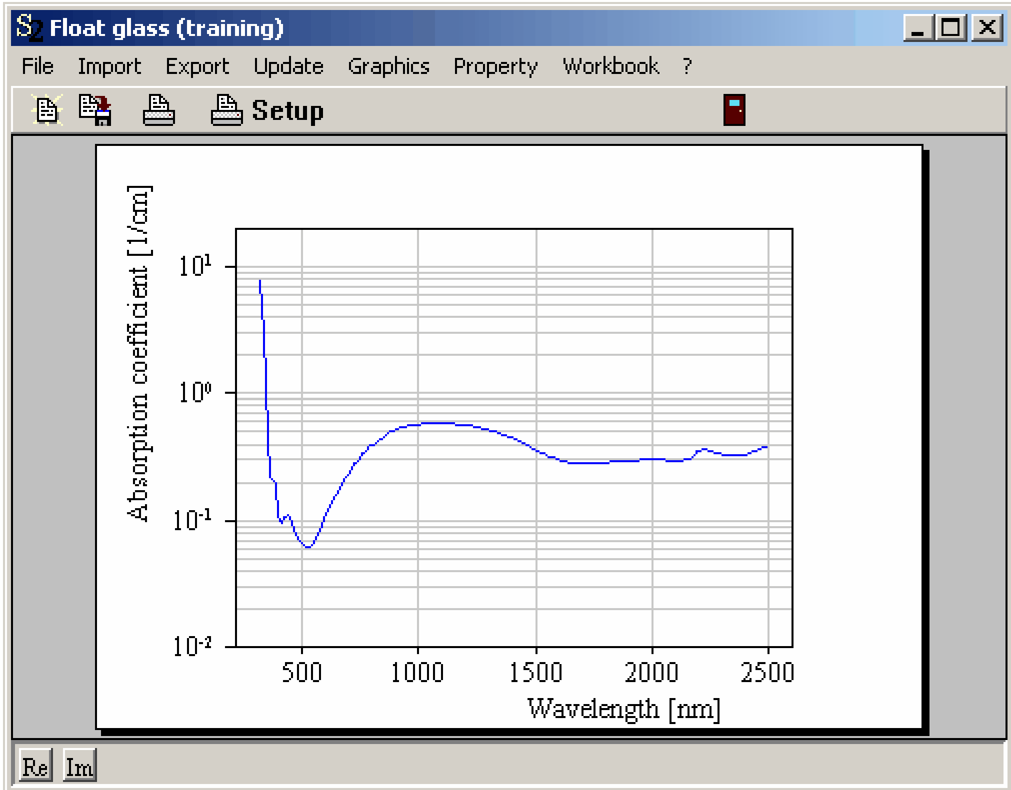
These are the answers to the questions of this exercise:

1. What refractive index leads to vanishing reflectance? (1.0)
2. What refractive index leads to a perfect beam splitter with 50% transmittance and 50% reflectance? (3.68)
3. Diamond has a refractive index of about 2.4 in the visible. How large is the transmittance of a diamond window? (71%)

9.6 Using SCOUT tools

9.6.1 Exercise 1

After this exercise you should have a graph similar to the following:



Float glass (training)
File Import Export Update Graphics Property Workbook ?
Setup
Absorption coefficient [1/cm]
10^1
10^0
10^{-1}
10^{-2}
500 1000 1500 2000 2500
Wavelength [nm]
Re Im

Index