RpRs - Determination of optical constants in opaque solids

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(C) (1993,1994)

Using Fresnel's formula a straight-forward way of measuring the refractive index, n, and the absorption coefficient, k, of an opaque solid is to measure the reflection coefficients, Rp and Rs, for light polarized parallel and perpendicular to the plane of incidence at a given angle of incidence. However such measurements are very difficult to make, since absolute reflection coefficients must be measured.

In the approach used by the program RpRs not absolute reflection coefficients, but their ratio is determined for a number of angles of incidence. Any systematic error in the determination of reflection coefficients is thus avoided, and the larger number of data points reduces the error in the obtained optic constants.

The procedure yields very reliable results for materials with not too low absorption coefficients, a regime not as easily accessible by ellipsometry.

The program RpRs allows to input and edit data on Rp/Rs, to fit the data and to plot and print the results. A simulation routine allows to create data sets for experimenting with various (n,k)-parameter sets to get familiar with the method.

Experiment: Best results are obtained, if many data points are taken at angles of incidence in a range around the Brewster angle. Depending on the accuracy of each measurement a larger number or measurements decreases the error of the result.

Reading:
1. D.G. Avery, Proc. Phys. Soc. 65 B, 425 (1952)
2. S.P.F. Humphreys-Owen, Proc. Phys. Soc. 77, 949 (1960)
3. D.M. Kolb, J. Opt. Soc. Am. 26, 599 (1972)

Main menue:

The commands are activated by pressing the red numbers or letters.

- 1: Load input file
- 2: Direct input
- 3: Edit input data
- 4: Simulate exp. data values of Rp/Rs
- 5: Fit
- 6: Fit Result
- 7: Plot data
- 8: sAve data

During parameter entry the following edit keys are available:

RETURN	:	Accept line and exit					
ESCAPE	:	Exit					
^S	:	Cursor left					
^D	:	Cursor right					
^A	:	Goto begin of line					
^F	:	Goto end of line					
POS1, END	:	Begin/end of line					
^G	:	Delete character at cursor					

DEL	:	Delete	cha	aract	cer	to	the	left
^X	:	Delete	to	end	of	lir	ıe	
^Y	:	Delete	line					

1: Load input file

This menue entry allows to load previously measured data. The format is: "angle\_of\_incidence Rp/Rs weight" in free format with the data separated by blancs or commas. The parameter "weight" is optional; it allows to weight data points. If this parameter is not provided, or if its value is zero, a weight of 1 is used. A negative value indicates, that the data entry will not be used in the fit.

2: Direct input

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This mode is used to directly input experimental data. First the name of the file to store the data is asked. Then the data is typed as "angle\_of\_incidence Rp/Rs weight" in free format. The parameter "weight" is optional (see above). After typing the <return>-key the data entry line is formatted and displayed. To exit type F2 to save the data or F10 to quit without saving the data.

3: Edit input data

This function allows to edit the input data. Editing commands are:

F1	:	Help
F2	:	Save text
F3	:	New file
ESCAPE	:	Exit
^X	:	Cursor down
^E	:	Cursor up
^S	:	Cursor left
^D	:	Cursor right
^R	:	Scroll down
^C	:	Scroll up
^F	:	Word left
<b>^</b> A	:	Word right
POS1, END	:	Begin/end of line
^G	:	Delete character
^K,^T	:	Delete word
^Y	:	Delete line
^N	:	New line
^P	:	Redisplay
^Q,F8	:	Search string
^L,F9	:	Repeat search

4: Simulate exp. data values of Rp/Rs

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This is a simple routine to simulate experimental data including noise. Follow the instructions on the screen.

5: Fit

This command calls the fit routines and displays the experimental data, the fitted values for n and k and the fit. A fast converging multiregression fit routine is used.

6: Fit Result

After performing the fit this command lists the result and information about the fit. The following parameters are listed:

- refractive index n, its absolute and relative error,
- absorption index k, its absolute and relative error,
- number of iterations,
- standard deviation w/o fit,
- standard deviation with fit,
- correlation between n and k,
- statement about the fit convergence criterion.

The errors are calculated using the fit model functions. Therefore the obtained values are good estimates, if they are not too large, i.e., if the model function approximates the experimental data sufficiently good enough. The parameter "correlation between n and k" provides information about the correlation between n and k. If n is changed by a value, delta, and than fixed, the parameter k must be adjusted by the correlation parameter multiplied by delta for obtaining the best fit (or vice versa; the value smaller than 1 is used). The fit is not reliable, if n and k are correlated by more than 95% (absolute value).

7: Plot data

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This command allows to display graphically the data. In graphic mode (which is called also by the fit command) a hardcopy to a HP-laser printer or desk jet printer can be made by pressing the "H"-key.

8: sAve data -----This command stores the data in a file.

F1: Help
----This command displays help information (this file).

F10: Exit

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To leave the program.