Comments on EXCEL worksheet for characterizing optical thin film materials.

This EXCEL spreadsheet is an example of one method of extracting optical thin film constants from measured spectral data. The example uses data from an article titled "Characterizing Optical Thin Films (II)". The reader is authorized to download the spreadsheet and to use it as they see fit. The author of the spreadsheet and Denton Vacuum, LLC take no responsibility for the materials in the spreadsheet and the results obtained in using the spreadsheet as it is and/or any future modifications by the user.

The spreadsheet consists of three sheets.

Sheet number 1 shows the manipulation of spectral transmission data. The first column in the data block is the number of the interference order for the film (ranging from 1 to 11). The blocks highlighted with a yellow background contain data extracted from the spectral transmission of the example film and data for the substrate on which the film is deposited. The column headed λ contains the wavelength of each interference order. The column headed T_{micro} contains the transmission from air into the uncoated substrate. These values were entered form a table, however, they could be calculated from a dispersion formula. The column headed Ts_m is the transmission of a clear microscope slide coated one side. Subsequent columns show the calculations to ultimately end up with the refractive index of the film in the column headed n_{scaled}.

- Tf_m – the calculated transmission from air through the film into the microscope slide.
- Rf_m – the calculated reflectance of the film back into the air ($1-Tf_m$).
- n_s – the refractive index (calculated from T_{micro}) of the substrate at the wavelength of the order (could also be calculated from a dispersion formula and the wavelength).
- n_m – the refractive index of the film calculated from Rf_m and n_s (valid at odd quarter wavelengths).
- d_m – thickness of the film calculated from the order number, wavelength and refractive index (valid at odd quarter wavelengths).
- n_{scaled} – scaled refractive index calculated from the selected odd quarter wavelength order (x=3, can be changed), the wavelength of the selected order, the refractive index of the selected order and the wavelength of each of the other orders.

The column to the far right is a mechanism to select the thickness of the order defined in the first row (x=3) to use in calculating the scaled refractive index. If x=5 were selected instead of 3, then the thickness used in the calculation would be 283.17 and all of the scaled refractive index would be changed scaled down by the ratio 280.0588/283.17. The choice of the order to use in this scaling is up to the user. The scaling is only as accurate as the measured data. Furthermore, it is assumed that the film is non-absorbing. Perfect non-absorbing data would result in all of the thicknesses calculated by this method being very close to each other. From this example, the thicknesses calculated from the 3rd, 5th and 7th order are reasonable since the film in these regions is reasonably non-absorbing

(280.059, 283.17 and 277.04 respectively). Note: there is a little bit of absorption present in the 7th order, but not much. The greater the absorption in the film, the more reduction there will be in the calculated thickness.

The lower half of the page just brings down the order of the wavelength and the scaled refractive index for plotting. At either end of the plot range is a line that goes to the origin of the plot (0,0) since I have not yet figured out how to leave room for additional data without the use of unfilled cells containing 0.

Sheet number 2 shows the manipulation of spectral reflection data. The first column in the data block is the number of the interference order for the film (ranging from 1 to 11). The blocks highlighted with a yellow background contain data to be filled in by the user. The column headed λ contains the wavelength of each interference order. The third column (headed R_{ref}) contains the reflectance of the uncoated frosted back substrate and the column headed Rf_m contains the spectral reflection of the example film deposited of a microscope slide with a frosted back. The reflectance of the substrate was entered from a table, however it could also be generated by the appropriate dispersion formula. Subsequent columns show the calculations to ultimately end up with the refractive index of the film in the column headed n_{scaled}.

- n_s – the refractive index of the substrate calculated from R_{ref} (but it could also be calculated from a dispersion formula and λ.
- n_m – the refractive index of the film calculated from Rf_m and n_s (valid at odd quarter wavelengths).
- d_m – thickness of the film calculated from the order number, wavelength and refractive index (valid at odd quarter wavelengths).
- n_{scaled} – scaled refractive index calculated from the selected odd quarter wavelength order (x=3, can be changed), the wavelength of the selected order, the refractive index of the selected order and the wavelength of each of the other orders.

The column to the right has the same function as on the first sheet. Also, the comments relative to the index scaling from the first sheet are appropriate on this sheet. The extinction coefficient (k) has been transferred from the third sheet of the spreadsheet.

Sheet number 3 shows the calculation of the extinction coefficient at the even order wavelengths. Other than the columns headed k_p (preliminary extinction coefficient) and k (the extinction coefficient), all data in the various columns have been transferred from the 1st and 2nd sheet. The k_p column can have a negative value if $Tf_m + Rf_m > 1$. The last column uses an EXCEL "IF" function to assure that the extinction coefficient is positive (negative values are replaced with a zero.