

Subwavelength Grating Structure

Products: DiffractMOD RCWA, MOST

Applications: PICs

Introduction

MOST provides powerful scanning and optimization tools to explore a device's parameter space and help designers create optimal designs. In this application note, we will explore the powerful features of MOST.

As an example, here we use a subwavelength grating (SWG) to demonstrate the usage of user measurements. SWGs have emerged recently as a promising alternative to Bragg reflection stacks for broadband, high reflectivity filtering applications. SWGs offer high reflectivity for a broad spectral region with significant phase changes; this property can be used to engineer the beam.

User Measurements

Each RSoft device simulator supports a considerable number of standard measurements which should suffice for most problems. However, it is still possible that no standard measurement is suitable for a specific request. User-defined measurements allow you to create a custom measurement for any situation based on any output data file, and extend the analysis capabilities for the simulated properties.

Users can refer to section 3.D.2 of the MOST manual for the conventions used to create user measurements. As an example, here we use a subwavelength grating (SWG) to demonstrate the usage of user measurements.

As shown in Fig. 1, the SWG grating is a set of silicon grooves with period=0.76 μ m on a quartz substrate. It is illuminated at normal incident with a TM-polarized plane wave. For this application, we will use **DiffractMOD RCWA**, RSoft's RCWA tool to measure the complex ER and ET coefficients of the 0th order of this grating.

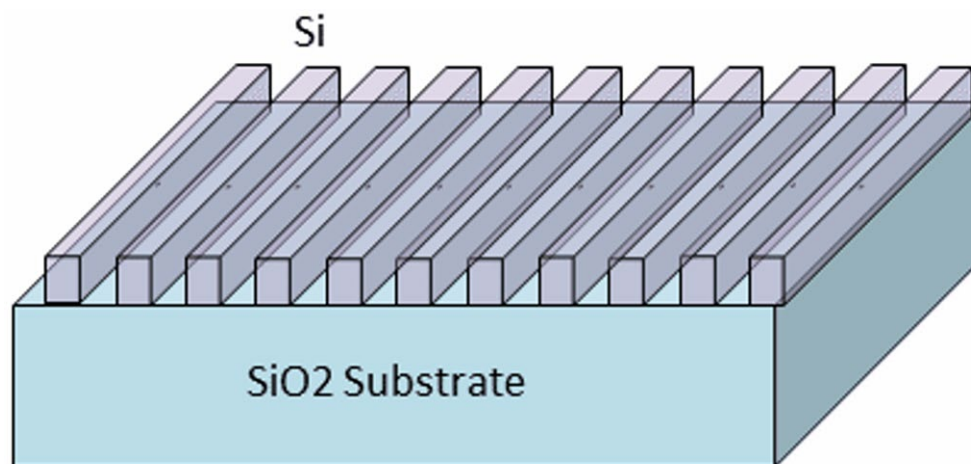


Figure 1. SWG structure

In Fig. 2, we show the SWG structure as it is set up in the **RSoft CAD**. Only one period of the structure needs to be drawn to represent the entire structure, since periodic boundary conditions are used. To obtain complex ER and ET coefficients, the "Output Complex ER, ET Coefficients (P-S plane)" option has been enabled in the Output > More dialog box. By default, the data file is recorded in the real/imag format. To get the desired amp/phase output, we define a variable "rcwa_output_e_coef_format = 4" in the symbol table.

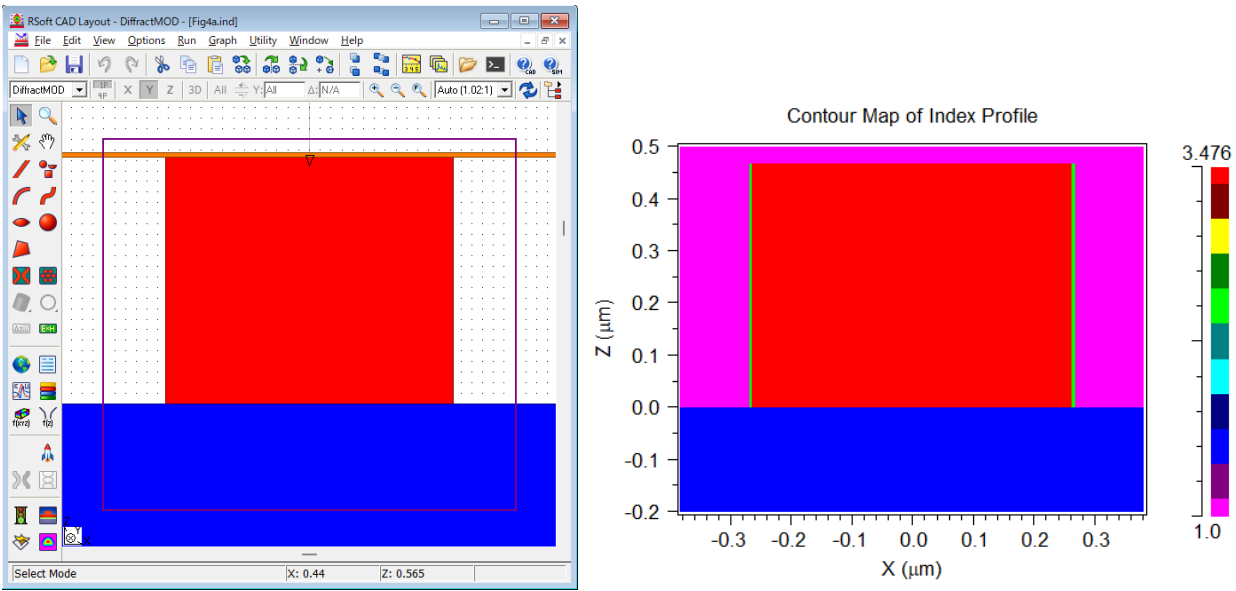


Figure 2. SWG structure as drawn in the RSoft CAD (left) with corresponding index profile (right)

An example of the coefficient output data file for this SWG structure, for a two harmonic simulation, is shown in Table 1. The data file lists the amp/phase of one field component for each diffraction order. To pick out the results we need from this data file, we have to create a user measurement.

dftmp_ep_ref_coef.dat - Notepad										
File Edit Format View Help										
# reflected ep (amp phase)										
# none -2 -1 0 1 2										
1	0	0	0	0	0	0.999925	-19.5464	0	0	0

Table 1. Two-harmonic coefficient output data file for the SWG structure

First, we will create a user measurement for the amplitude term. Open the MOST dialog box, click the Measurements tab, and click New meas. Next, define "Amp" as the name for the user measurement and set File to <prefix>_ep_ref_coef.dat. The <prefix> keyword will automatically be replaced by the MOST prefix for each simulation. Since we want to measure a single number from the data file, choose Scalar in the User measure/Type field.

For the amplitude measurement, a value of [-1,-6] can be used for Indices because the amplitude of the 0th order is the last row (there is only one row in this data file), 6thcolumn number as counted

from the right. Alternatively, instead of [-1,-6], the indices could be selected as [1, 7]. Once completed, click the Accept button to finalize the user measurement.

Following the same procedure, a user measurement can be defined for the phase term. For the phase user measurement, the indices should be [-1, -5].

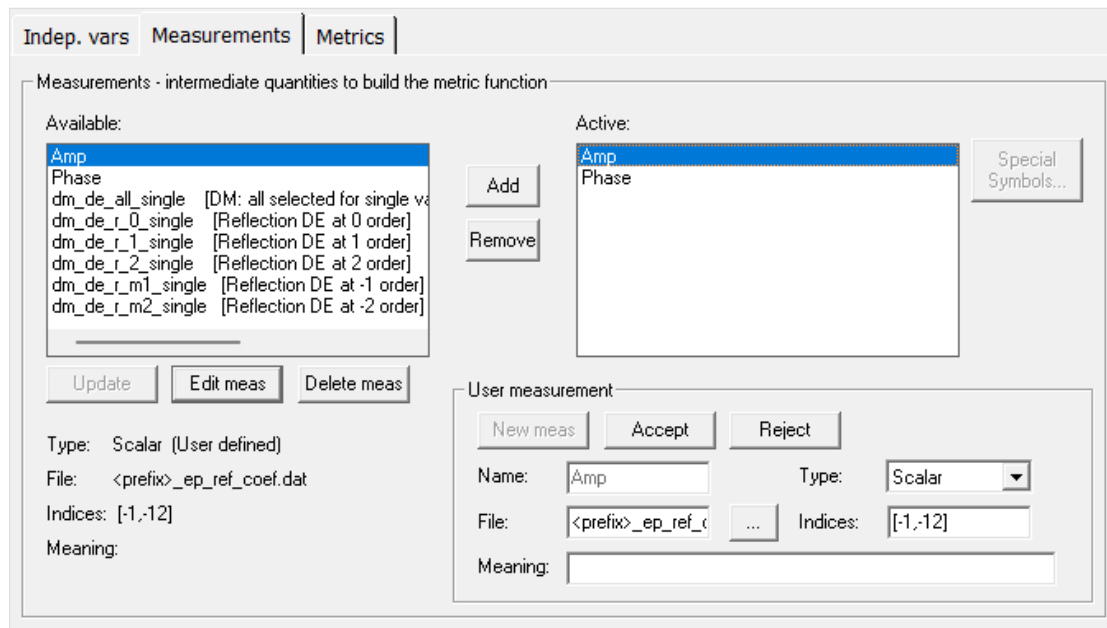


Figure 3. The MOST dialog with the user-measurements Amp and Phase defined.

After creating the user measurements, we can scan over any symbol and automatically produce plots of the user measurements just as we would with a built-in measurement. Figure 4 shows the results of separate scans over the (a) free space wavelength and (b) the grating period, to investigate the amplitude and phase changes of the reflected light. The two graphs obtained are shown in Fig. 4; these results agree well with the graphs shown in Fig. 1 of [1].

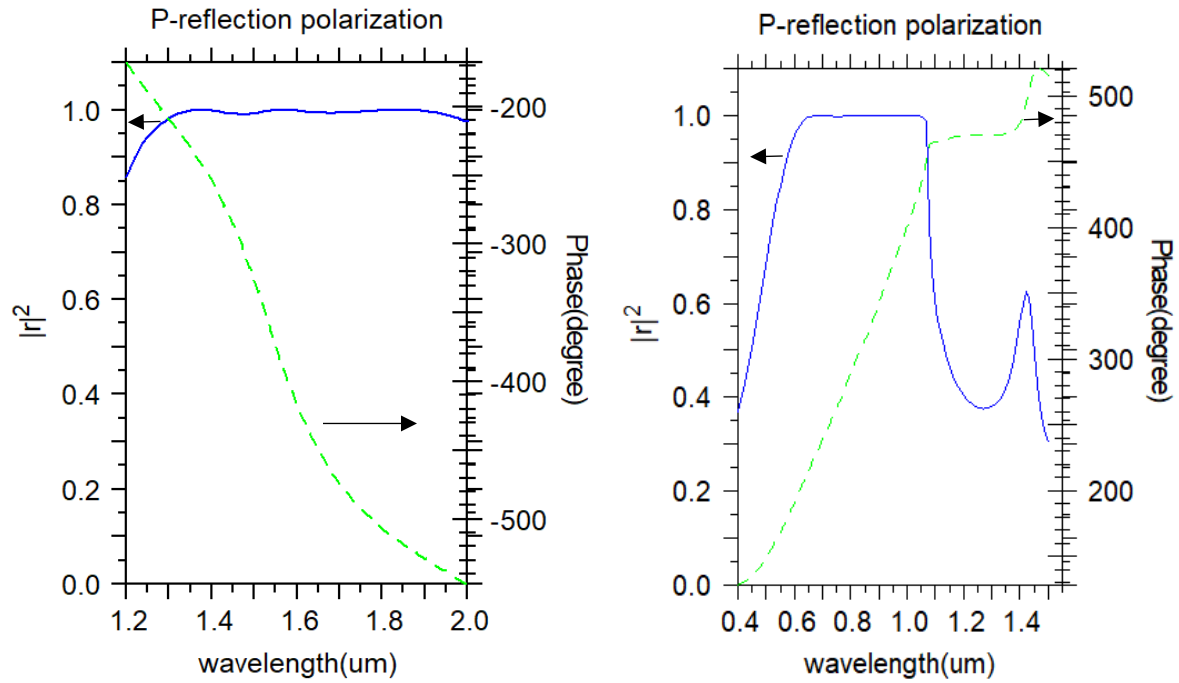


Figure 4. Amp/Phase changes of SWG vs (a) wavelength and (b) period

We can see that the reflection from the SWG is very high for a broad period and spectral range, while the phase shows a significant change. This property was used in [1] to form a self- focusing mirror using a nonperiodic SWG.

Conclusion

This application note demonstrated how MOST enhances photonic device design through user-defined measurements and parameter scanning. Using a subwavelength grating (SWG), amplitude and phase responses were extracted to evaluate broadband reflectivity and phase control. The results highlight efficient analysis and optimization capabilities for advanced photonic structures.

Example Files

Supporting Files for Application Note "Subwavelength Grating Structure"

References

[1]: D. Fattal, J. Li et al. "Flat dielectric grating reflectors with focusing abilities" Nature Photonics 4, 466 – 470, 2010

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