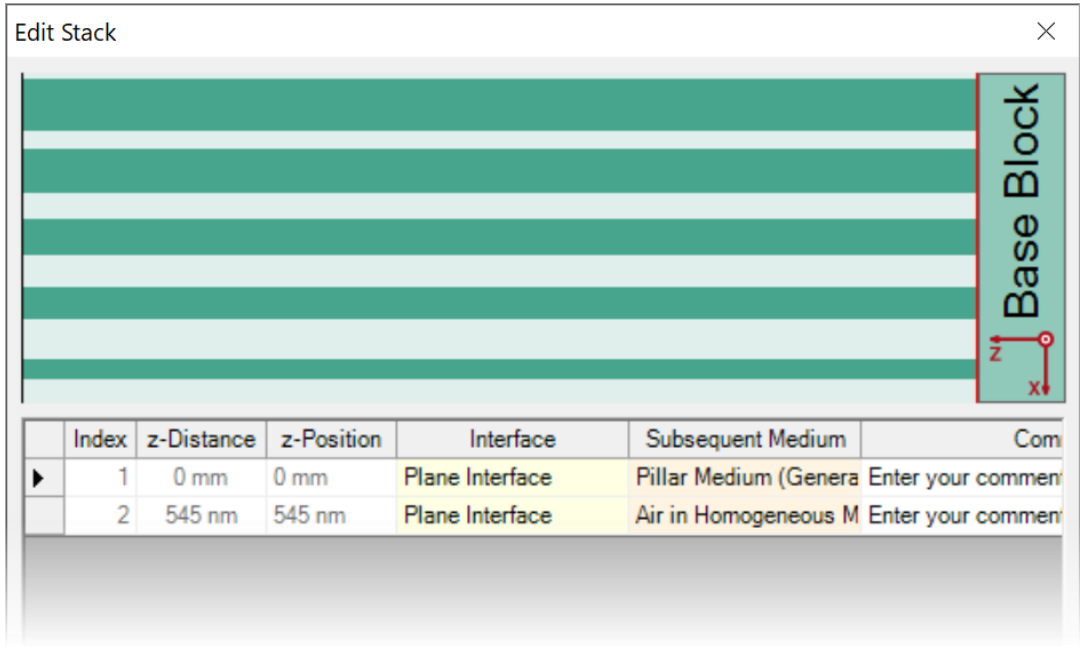
Metagrating Construction – Discussion at Examples

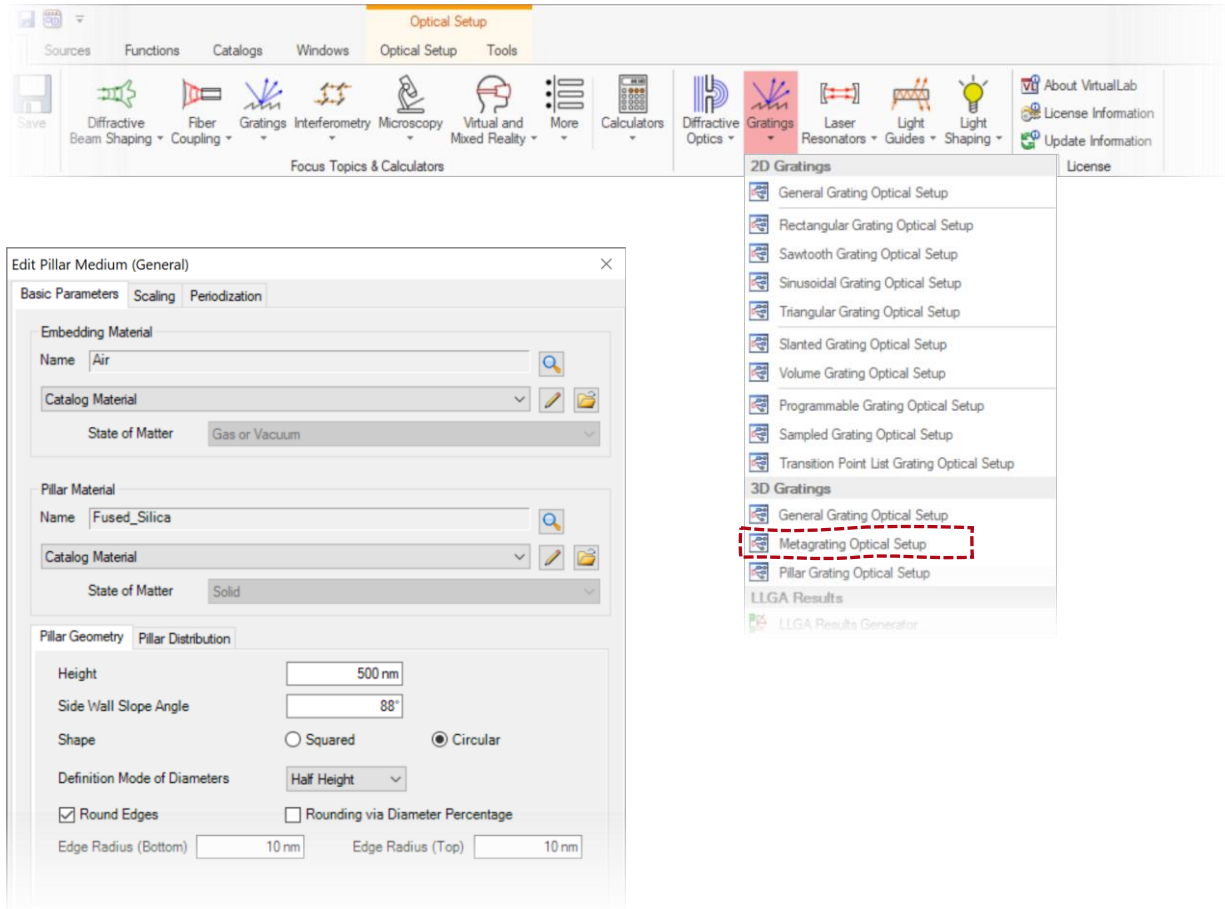
Abstract



Metagratings, which are usually composed of nanopillars with spatially varying parameters, are shown to have superior performance in comparison to traditional gratings. Such gratings can be set up in VirtualLab Fusion with the help of the pillar medium and, in this example, we show how to properly configure the metagrating setups. That includes the settings of media, materials, the pillar geometry, and the spatial distribution of the pillars. Additional hint is given on the setting of number of spatial frequencies is also given.

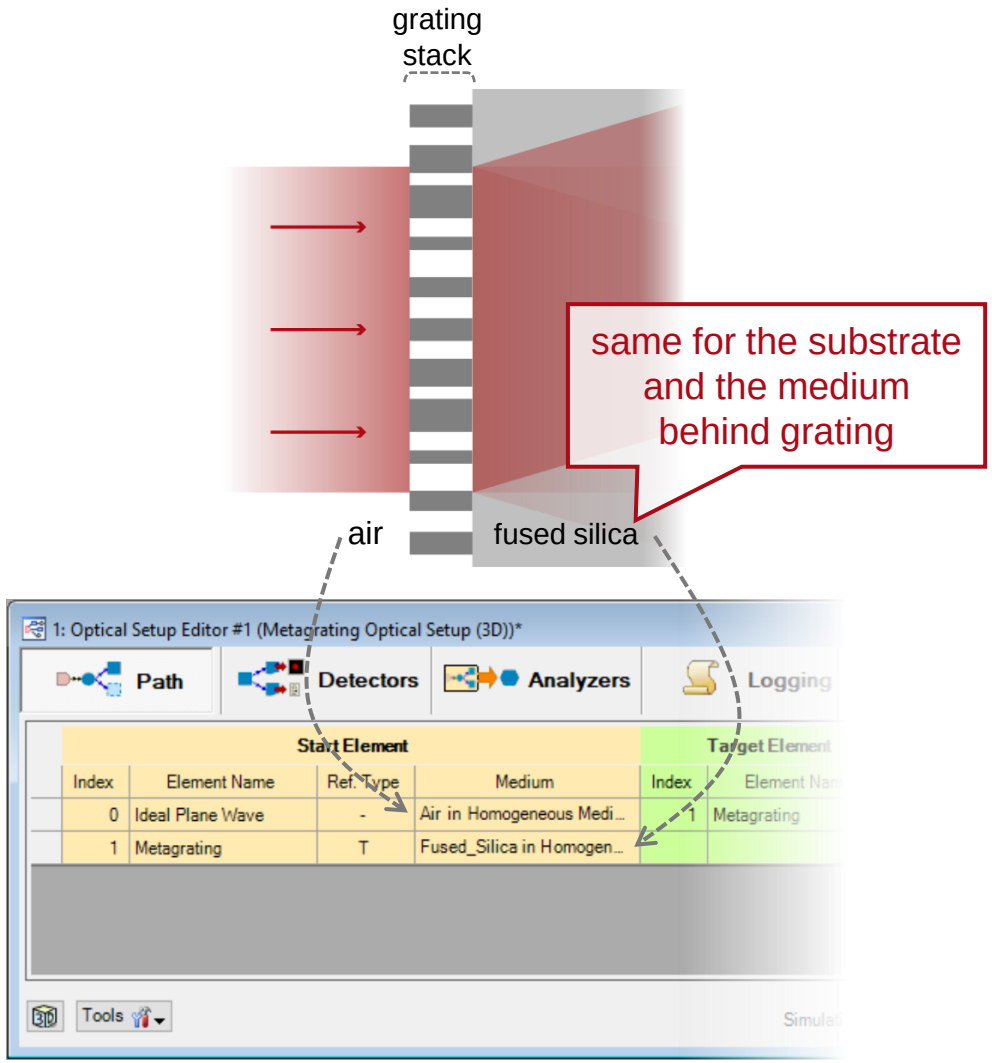
Metagrating Construction and Modeling

- VirtualLab Fusion provides
  - **Pillar Medium (General)** for the construction of metagrating – and other proper structures – by the composition of circular / rectangular nanopillars;
  - **Fourier modal method (FMM)** for the rigorous analysis of the performance of the composed metagratings, in terms of diffraction efficiency, polarization sensitivity, and so on.



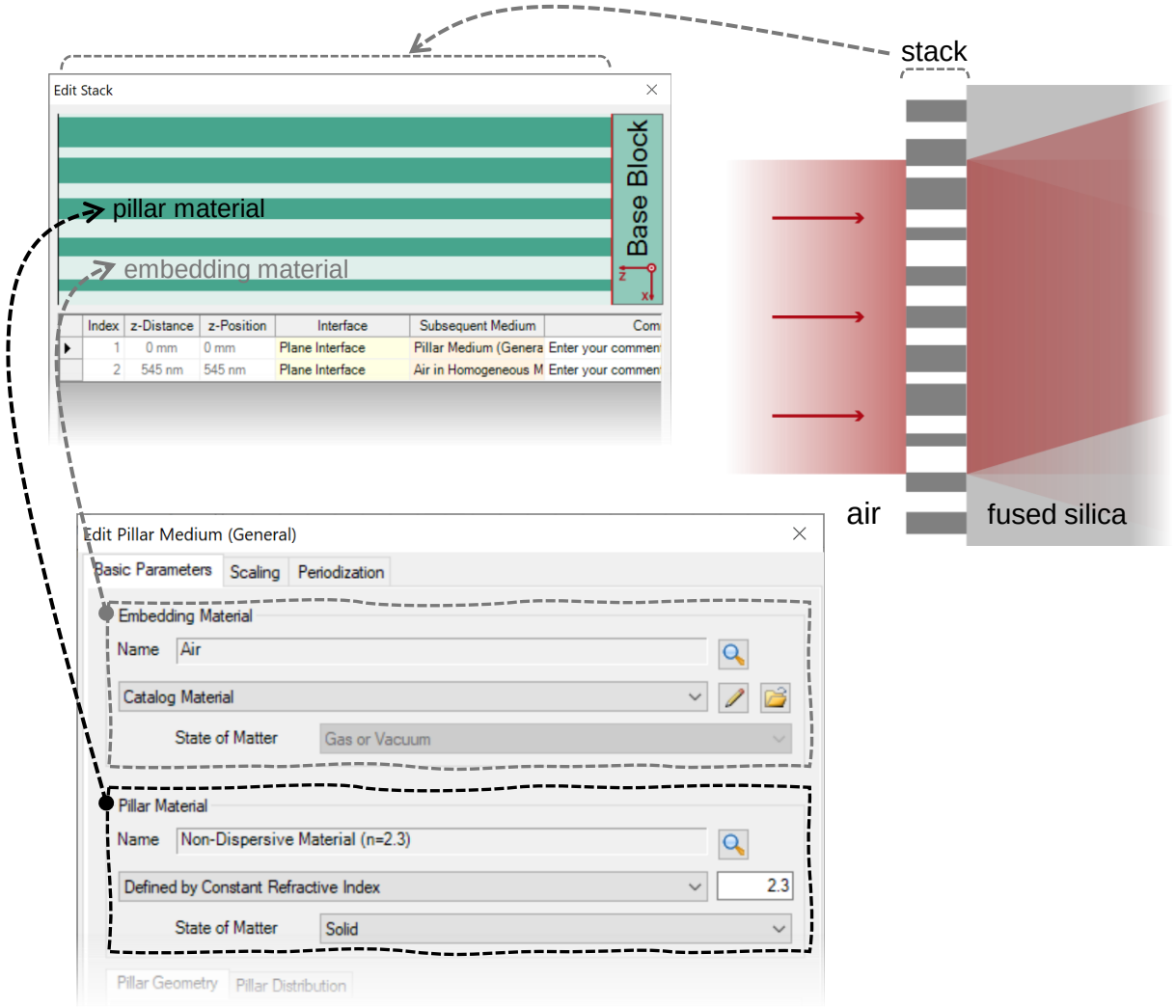
Media around Grating Component

- Media in front and behind grating
  - The medium in front and that behind the grating shall be set in the optical setup editor.
  - The media shall be configured according the actual situation under investigation.
  - As a convention for grating efficiency analysis, the Fresnel loss between the substrate and the surrounding medium is usually neglected.

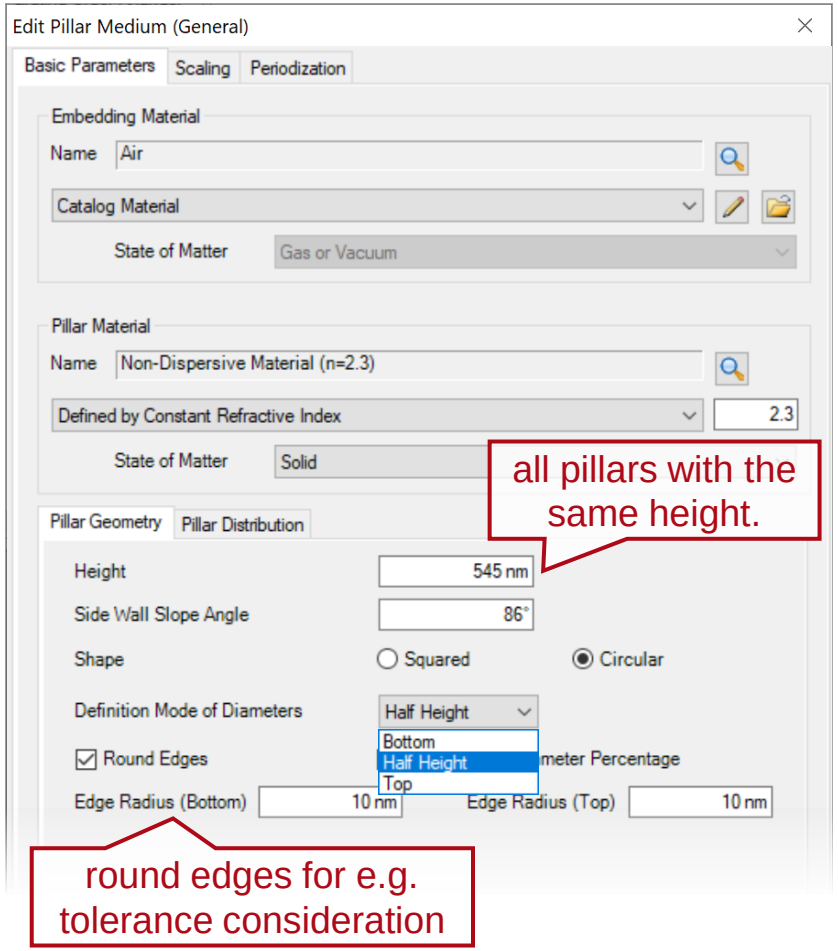


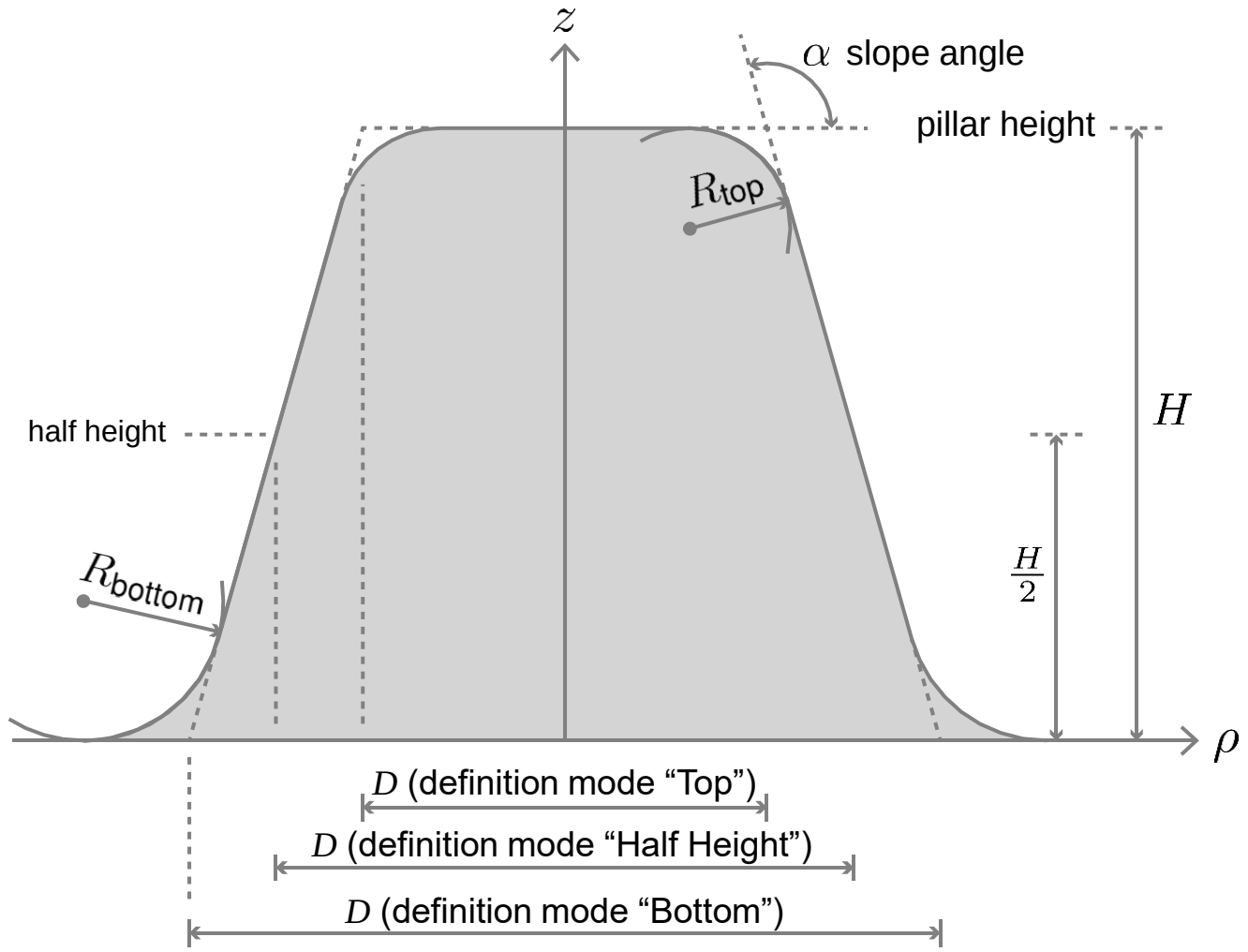
Materials inside Grating Stack

- Grating stack
  - The metagrating stack is constructed by the Pillar Medium (General) and two plane interfaces that press it from both sides.
  - The pillar regions are filled by the specified pillar material, while the rest filled by the embedding material.
  - Both the pillar and embedding materials can be defined independently from the media in front or behind the grating.

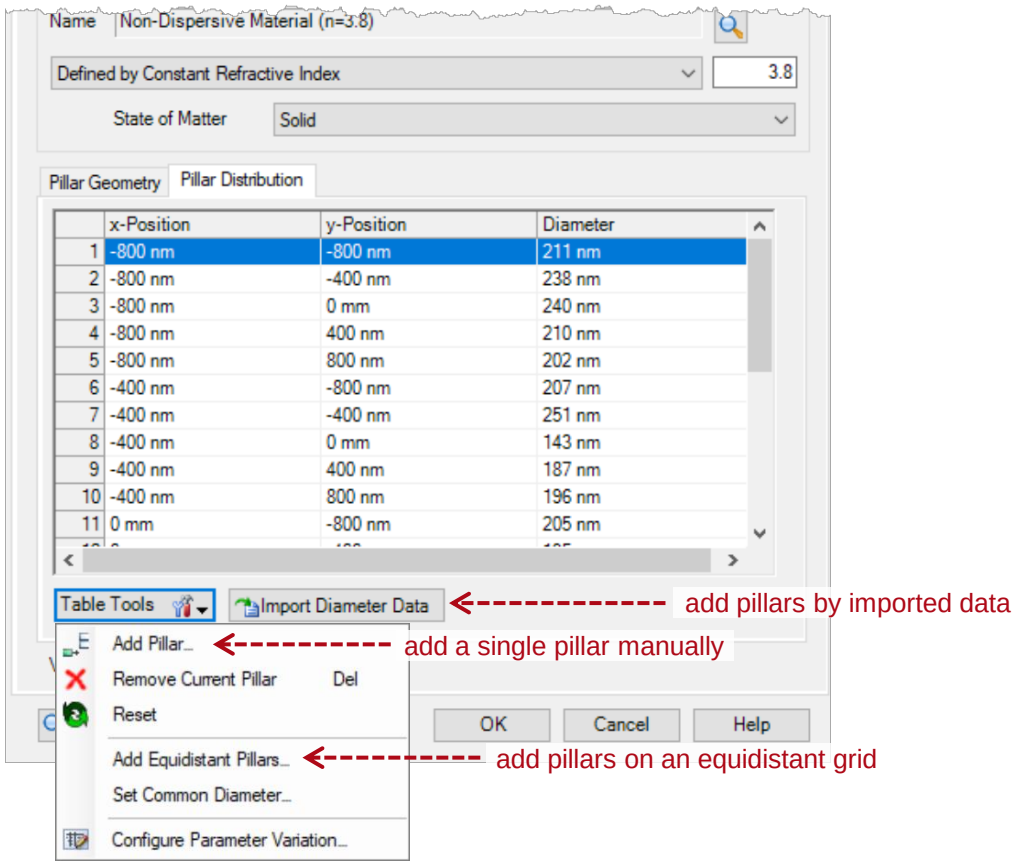


Single Pillar Geometry Configuration





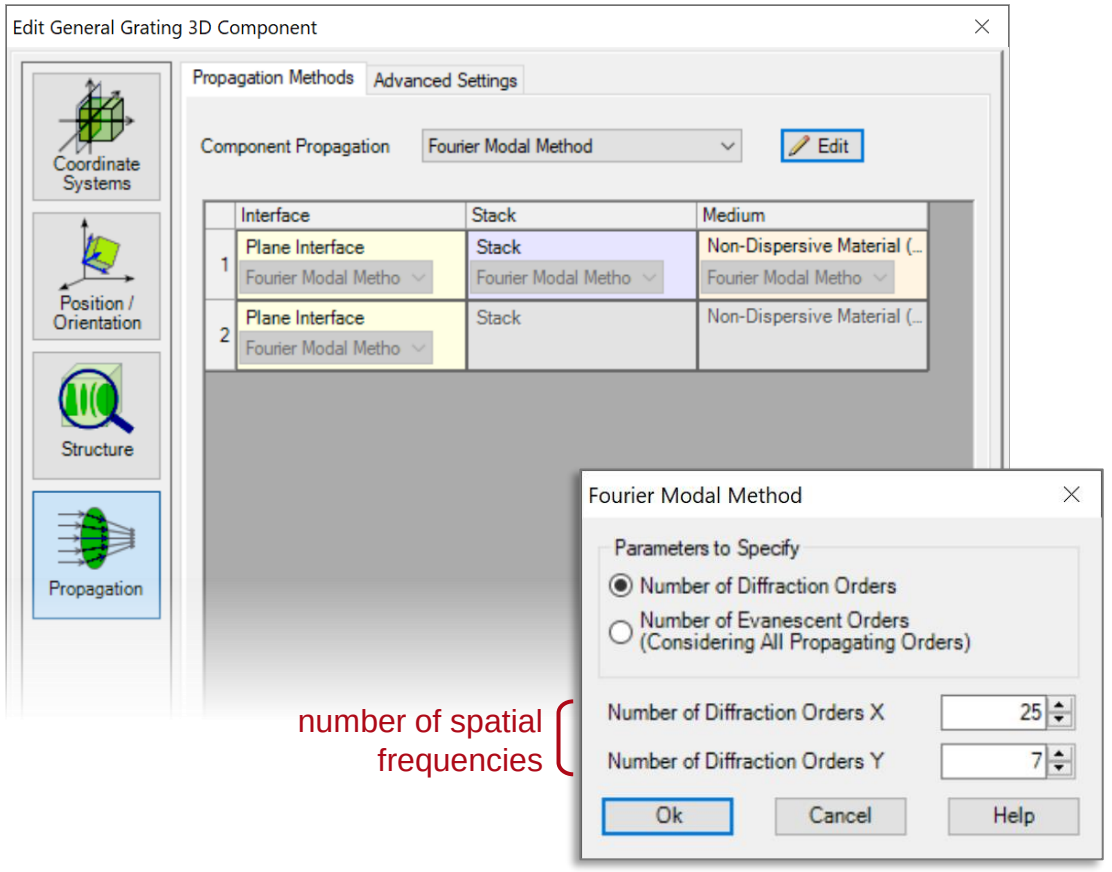
Distribution of Pillars



- Pillar Distribution
  - One can specify the pillar diameter at an arbitrary lateral position (x, y).
  - Pillars can be added
    - one by one manually;
    - on an equidistant grid at once;
    - According to an imported array that defines the lateral position and diameter of each pillar.
  - Pillar positions can be arbitrarily varied either directly, or as deviations from their original positions.

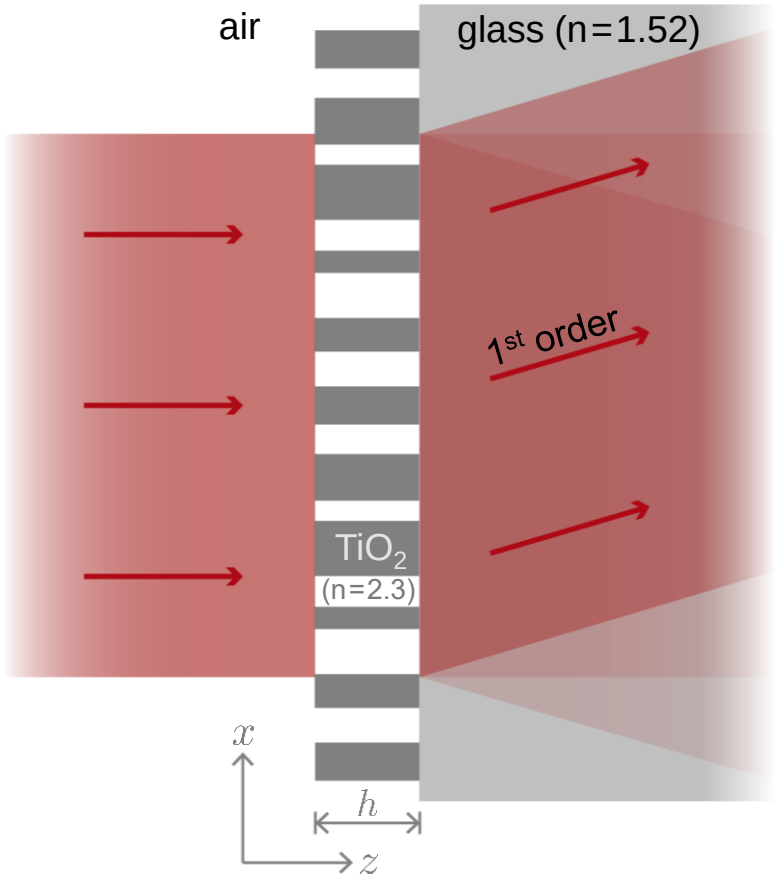
Numerical Parameter Setting

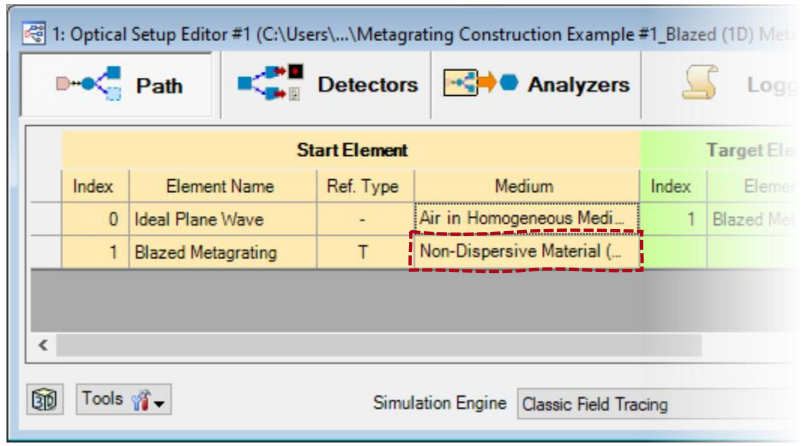
- Number of spatial frequencies
  - To obtain converged result from FMM / RCWA simulation, enough number of spatial frequencies should be used.
  - For metagratings, which is usually composed by an array (1D or 2D) of pillars, we recommend to perform convergence test to ensure the numerical convergence.
  - For 1D metagratings (e.g. blazed metagrating), the required number of spatial frequencies should be check separated for x and y directions.



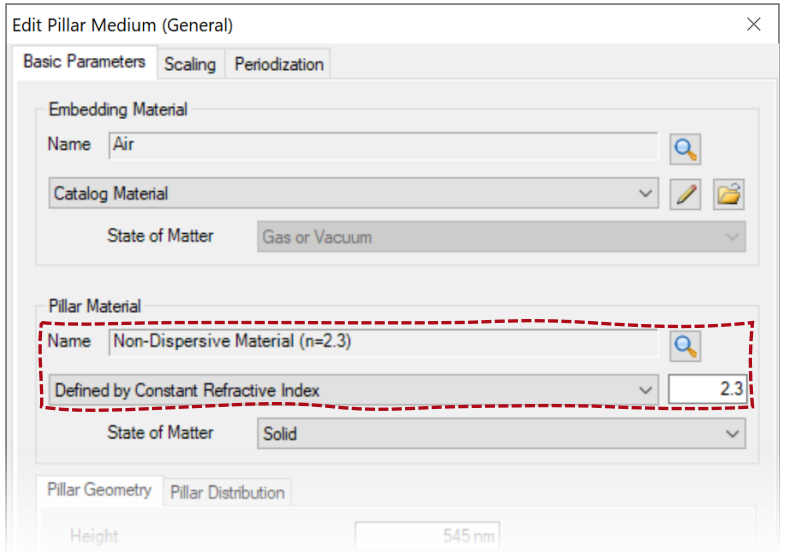
Example #1: One-Dimensional Blazed Metagrating

Media and Materials Configuration





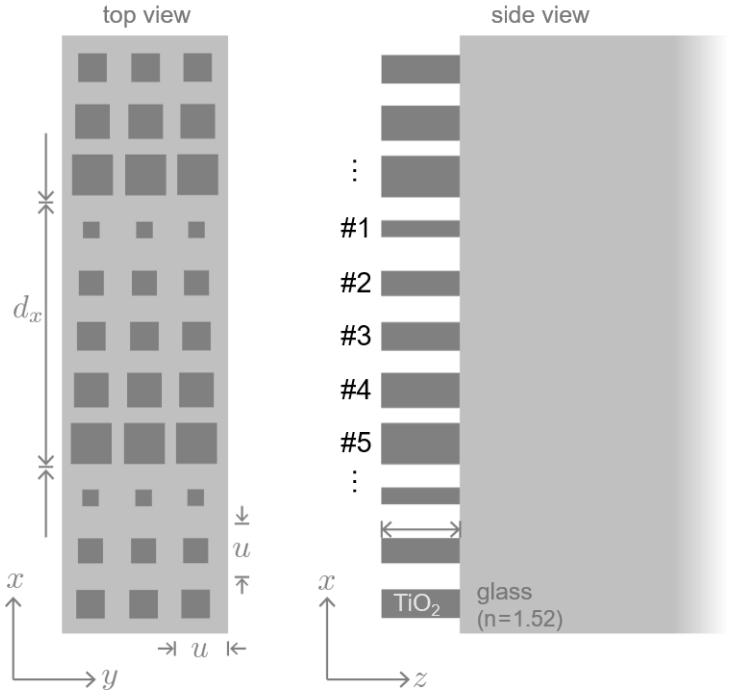
The medium behind grating is set the same as the glass substrate, with n=1.52.



The pillar material is set with n=2.3 for TiO_2 at the given wavelength.

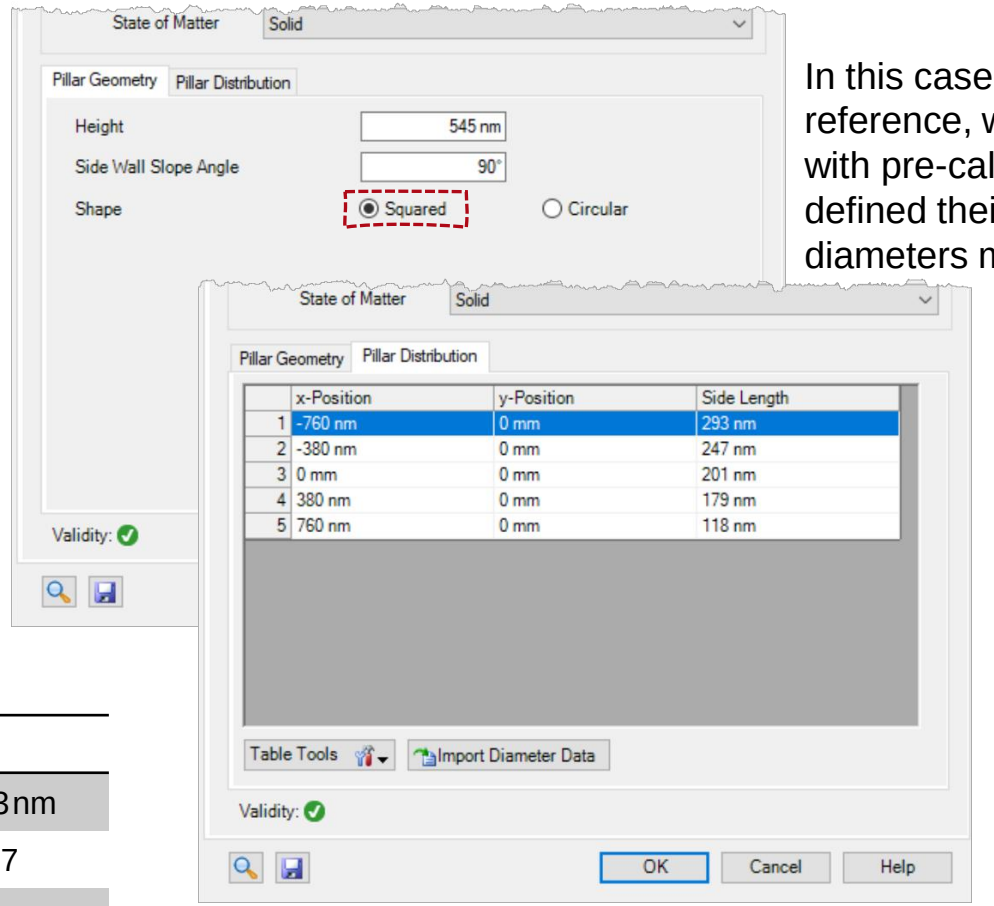
see the full Application Use Case

Pillar Geometry and Distribution



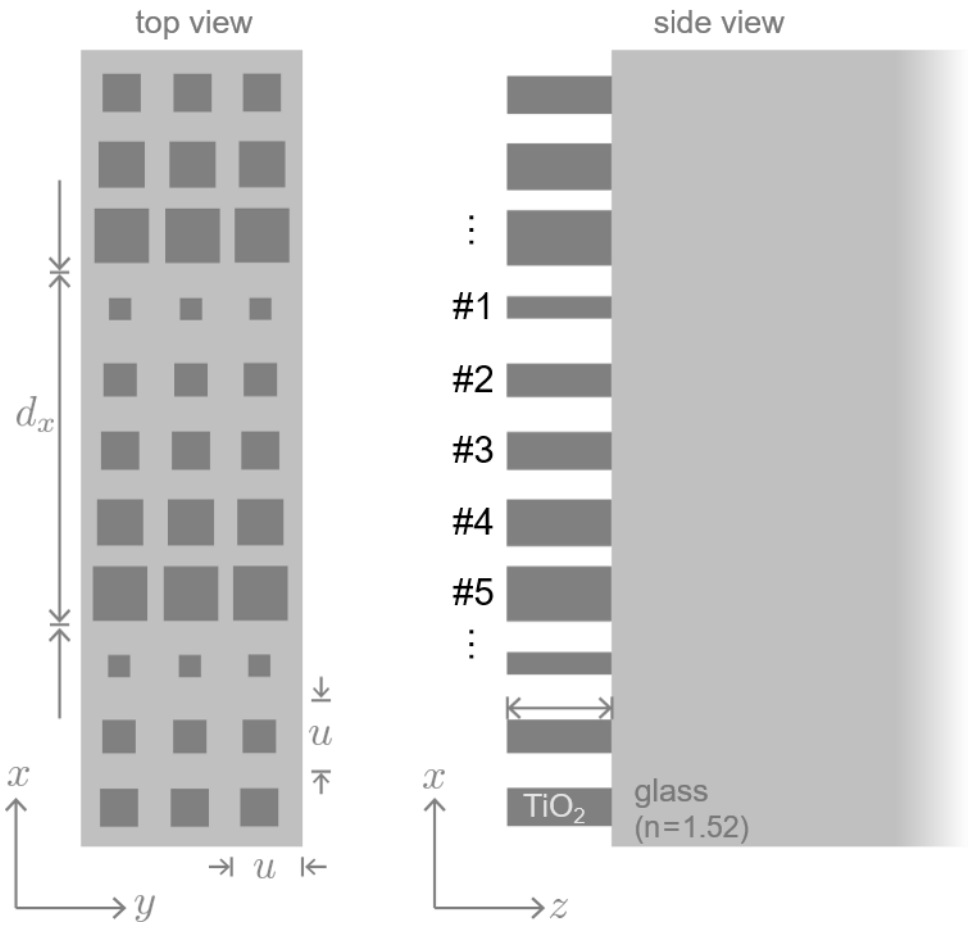
	#1	#2	#3	#4	#5
D	118 nm	179 nm	201 nm	247 nm	293 nm
f=D/u	0.31	0.47	0.53	0.65	0.77
$\Delta\psi$	0.20π	0.69π	0.98π	1.40π	1.73π

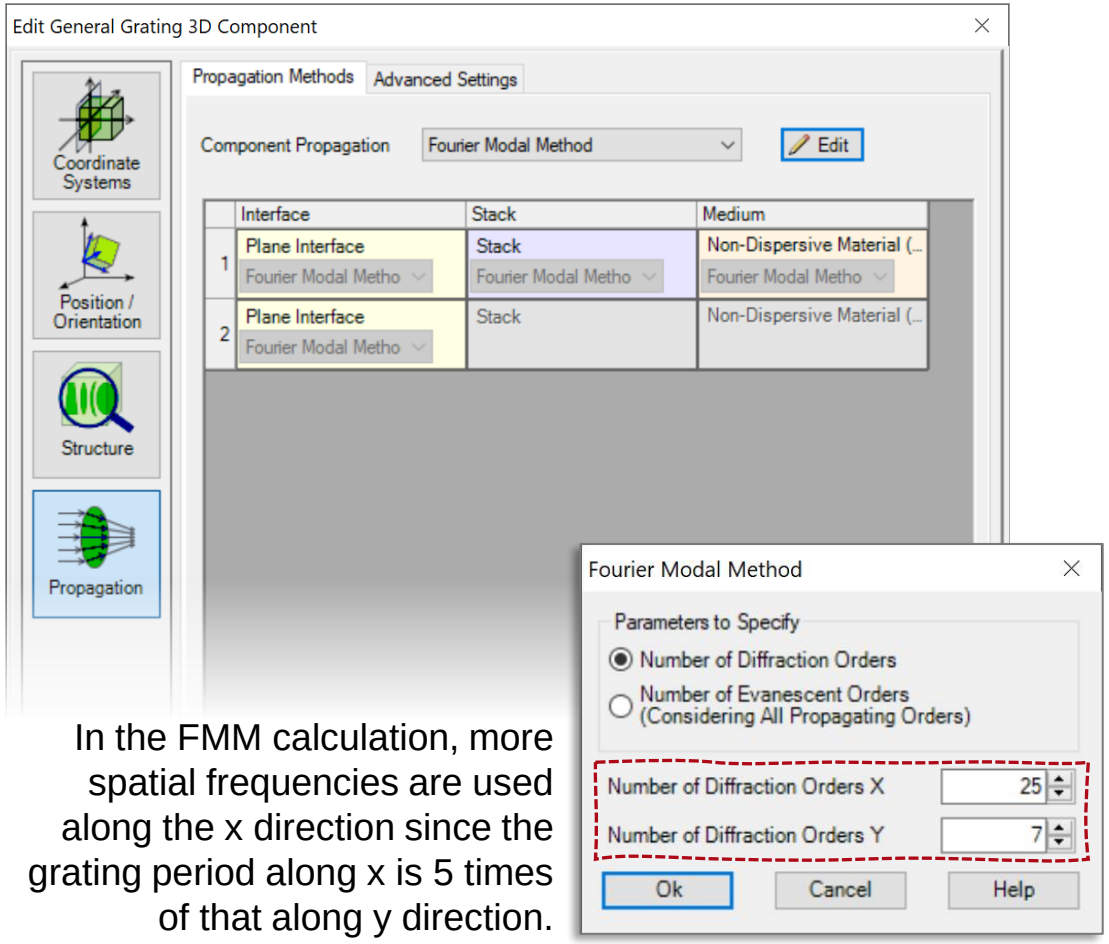
Selection of pillar diameters follows from P. Lalanne, *et al*., Opt. Lett. 23, 1081-1083 (1998)



In this case, following the reference, we use square pillars with pre-calculated height, and defined their positions and diameters manually.

Number of Spatial Frequencies

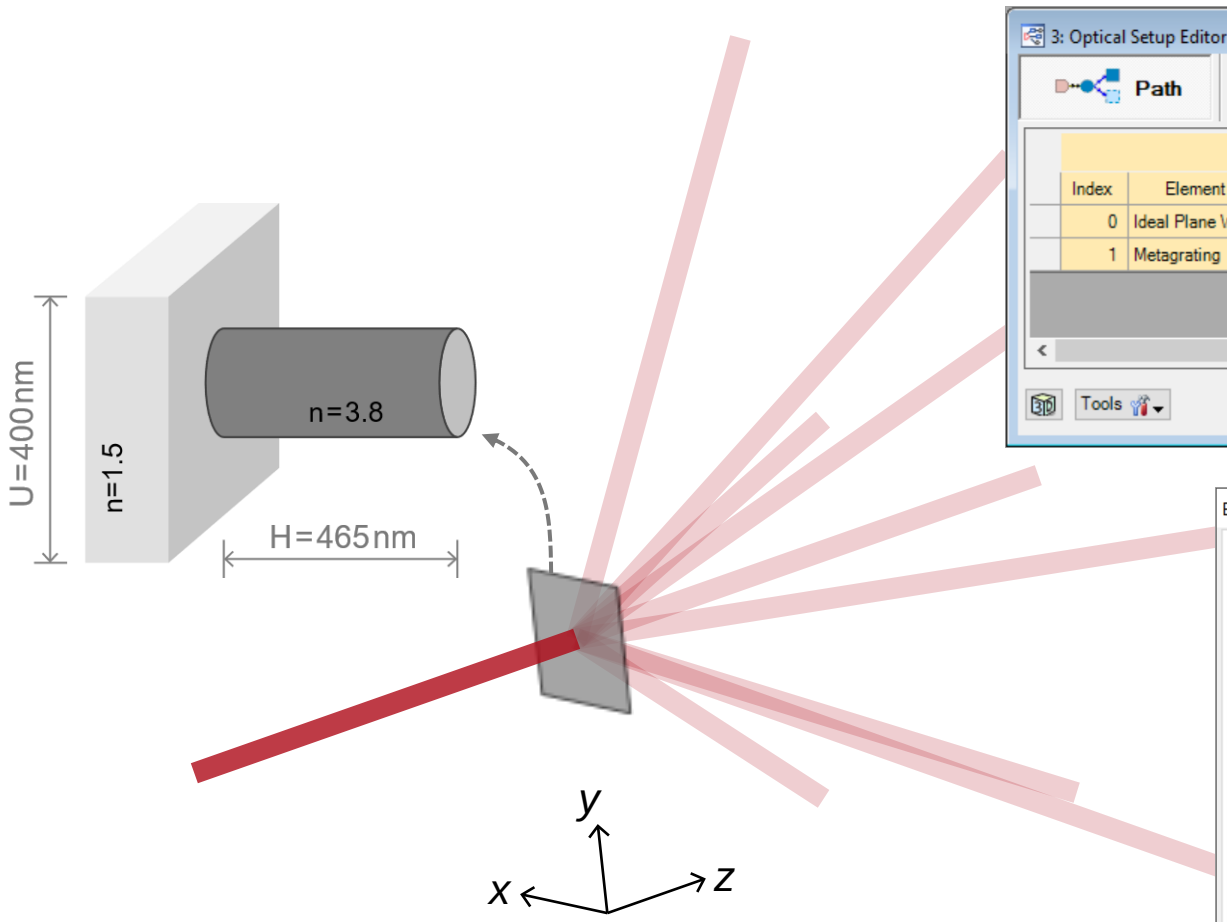


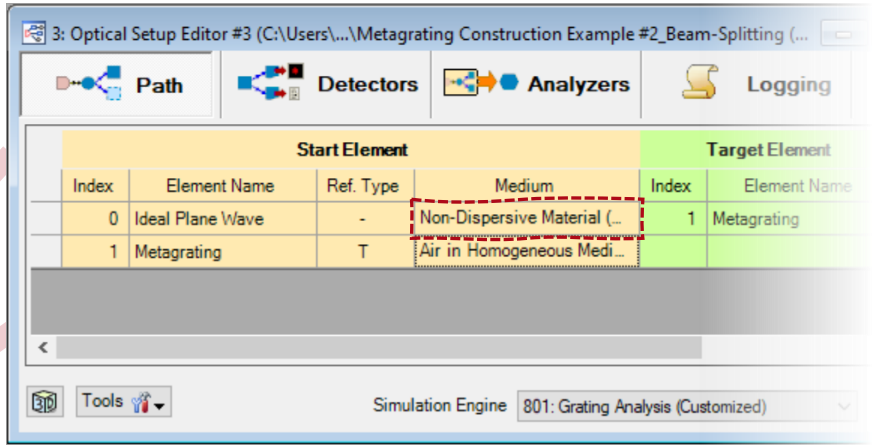


In the FMM calculation, more spatial frequencies are used along the x direction since the grating period along x is 5 times of that along y direction.

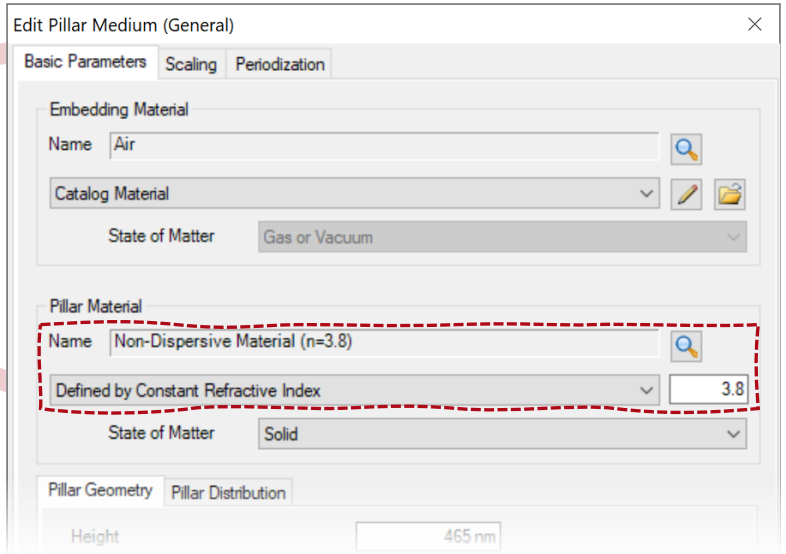
Example #2: Two-Dimensional Beam-Splitting Metagrating

Media and Materials Configuration





The medium in front of the grating is set the same as the substrate, with n=1.5, and, in this way, the incident light is assumed from inside the substrate.

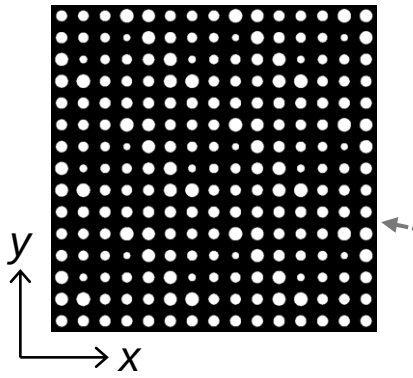


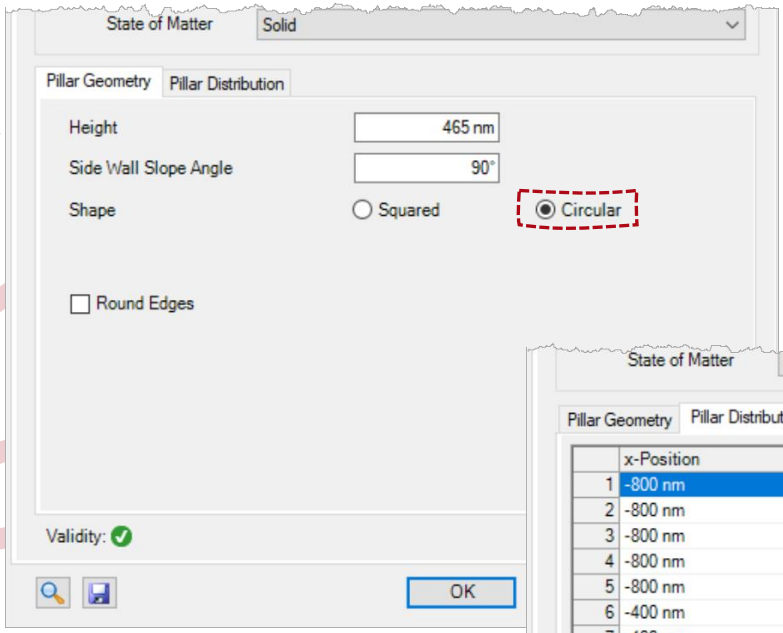
The pillar material is set with n=3.8 for the given wavelength.

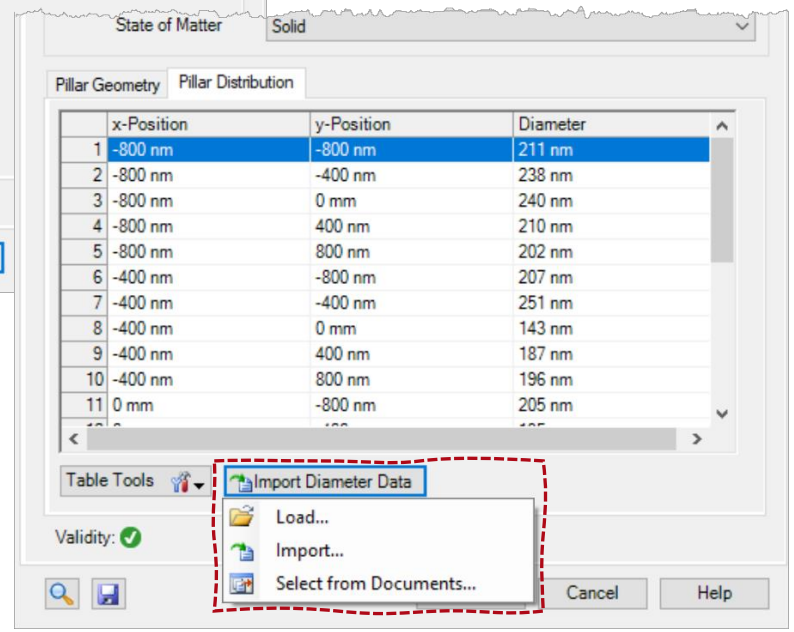
see the full Application Use Case

Pillar Geometry and Distribution

metagrating (top-view)
- period 2×2 μm
- unit cell 400×400 nm
- substrate glass $n=1.5$
- circular pillar $n=3.8$







Circular pillars are chosen for this case, and their positions and diameters are defined by imported data (calculated based on IFTA design).

Document Information

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