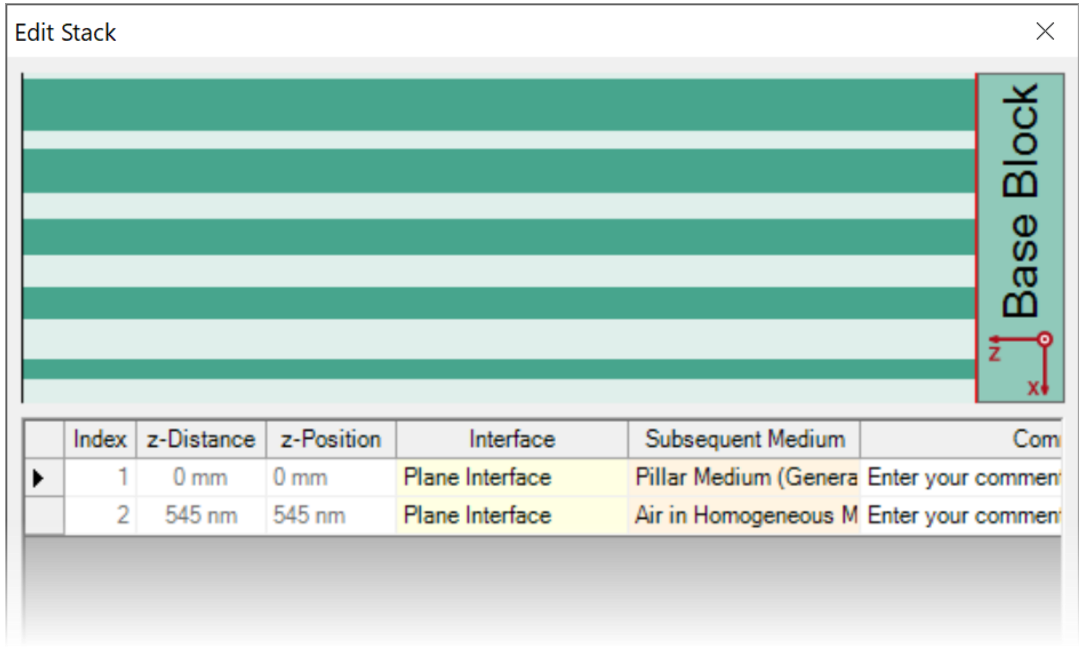
Metagrating Construction – Discussion at Examples

Abstract



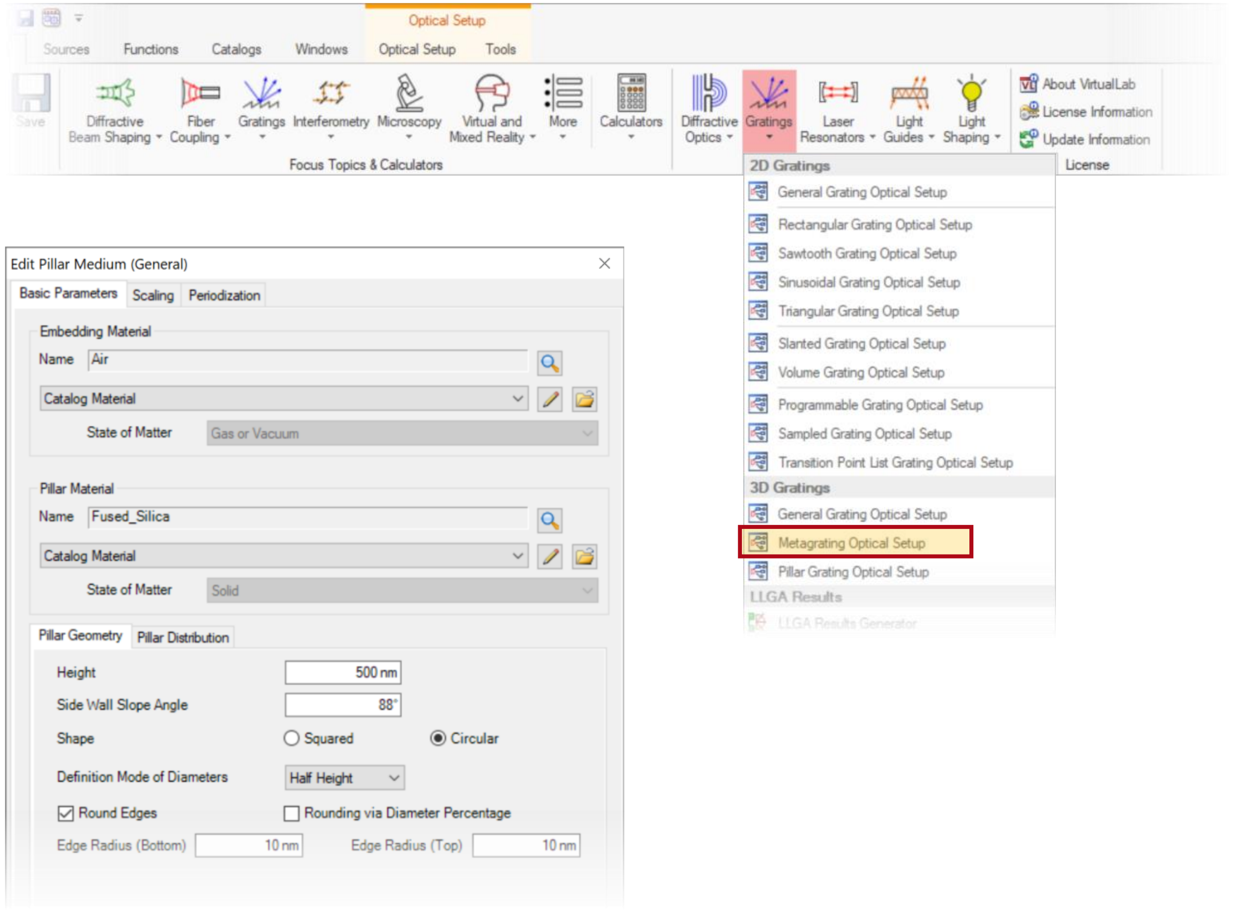
Metagratings, which are usually composed of nanopillars with spatially varying parameters, are shown to have superior performance in comparison to traditional gratings. Such gratings can be set up in VirtualLab Fusion with the help of the pillar medium and, in this example, we show how to properly configure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

Metagrating Construction and Modeling

VirtualLab Fusion provides:

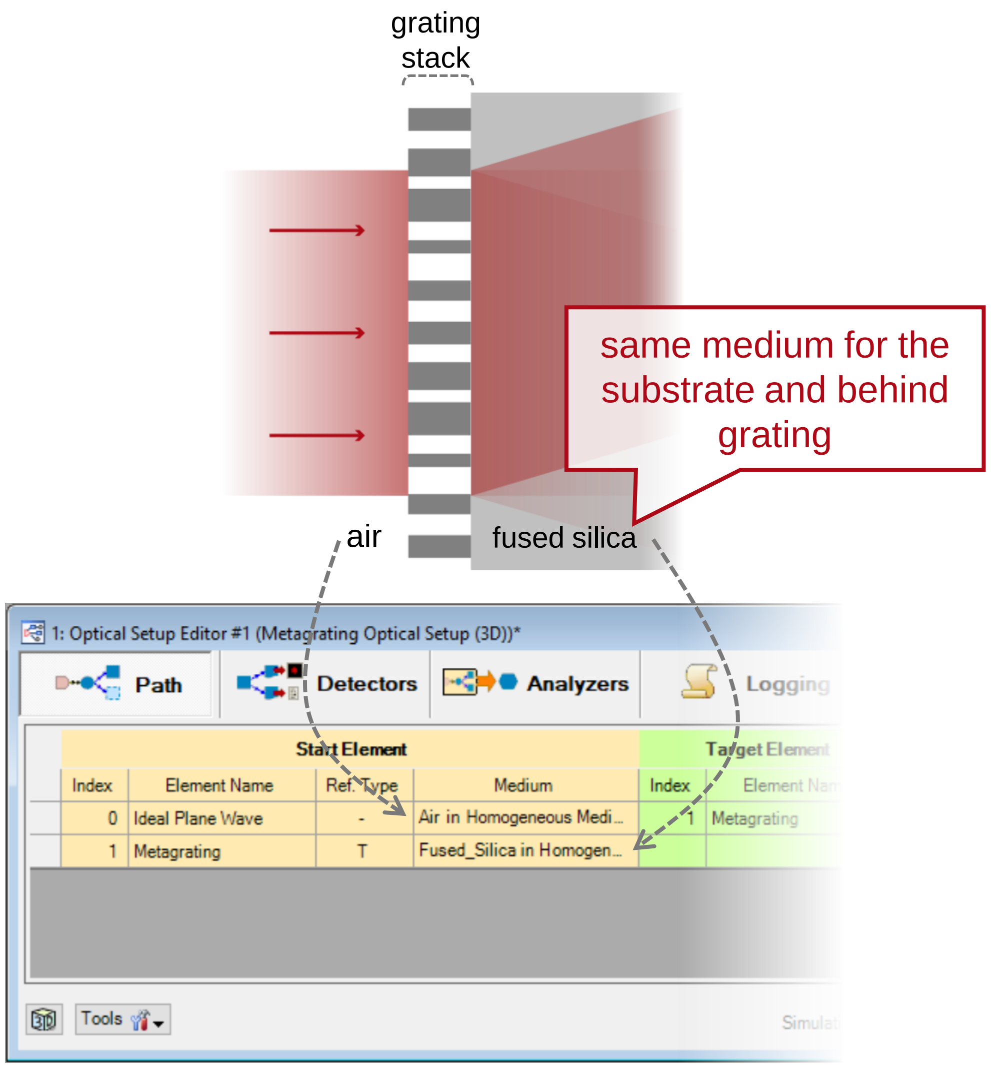
- **Pillar Medium (General)** for the construction of metagratings – and other similar structures – to arrange the distribution of circular/rectangular nanopillars;

- **Fourier modal method (FMM)** for the rigorous analysis of the performance of the metagratings thus configured, in terms of diffraction efficiency, polarization sensitivity, and so on.



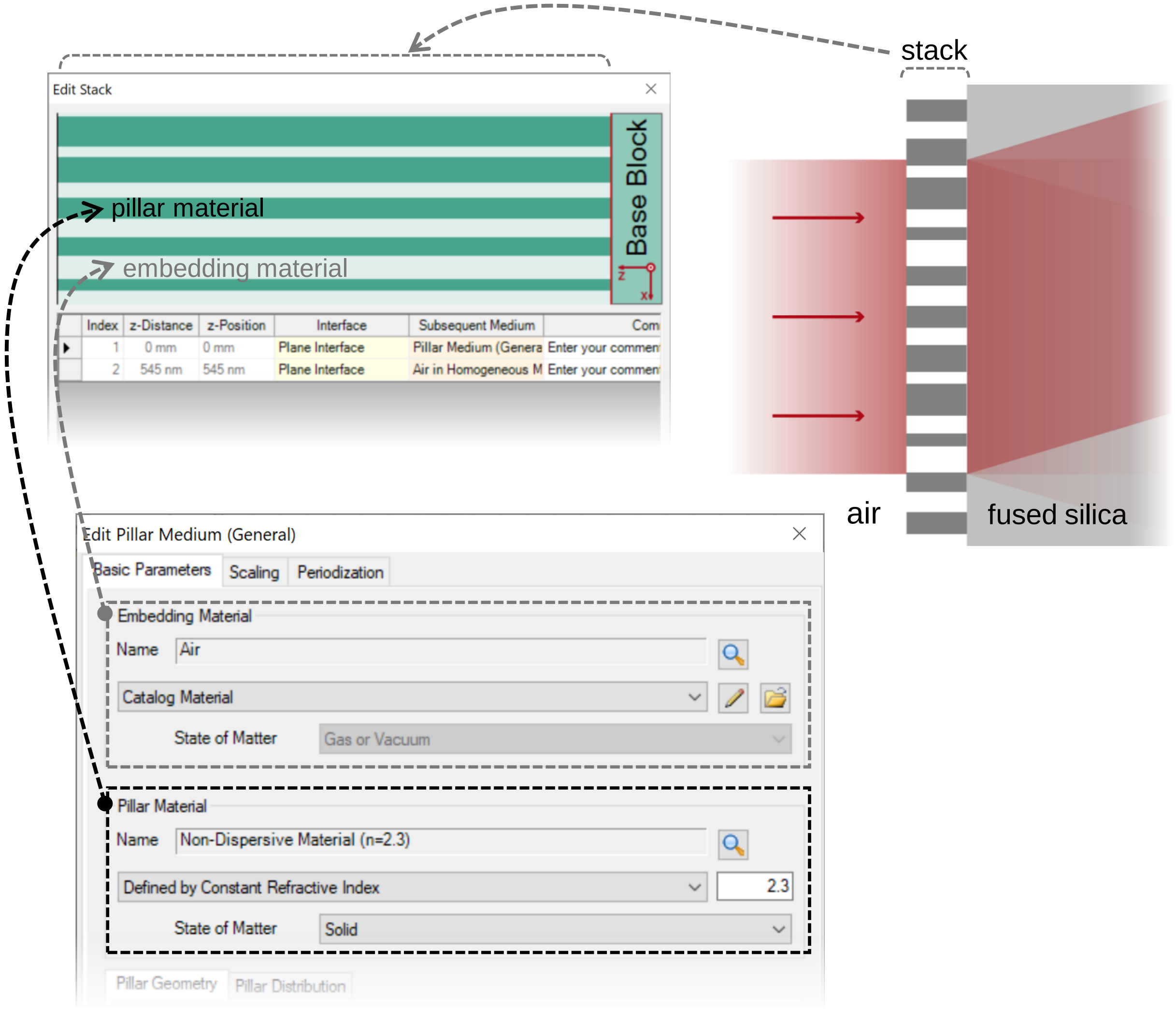
Media around Grating Component

- The media in front of and behind the grating are set in the optical setup editor.
- These media have to be configured according to 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 (meaning that the medium of the substrate of the structure and the medium behind it should be the same).

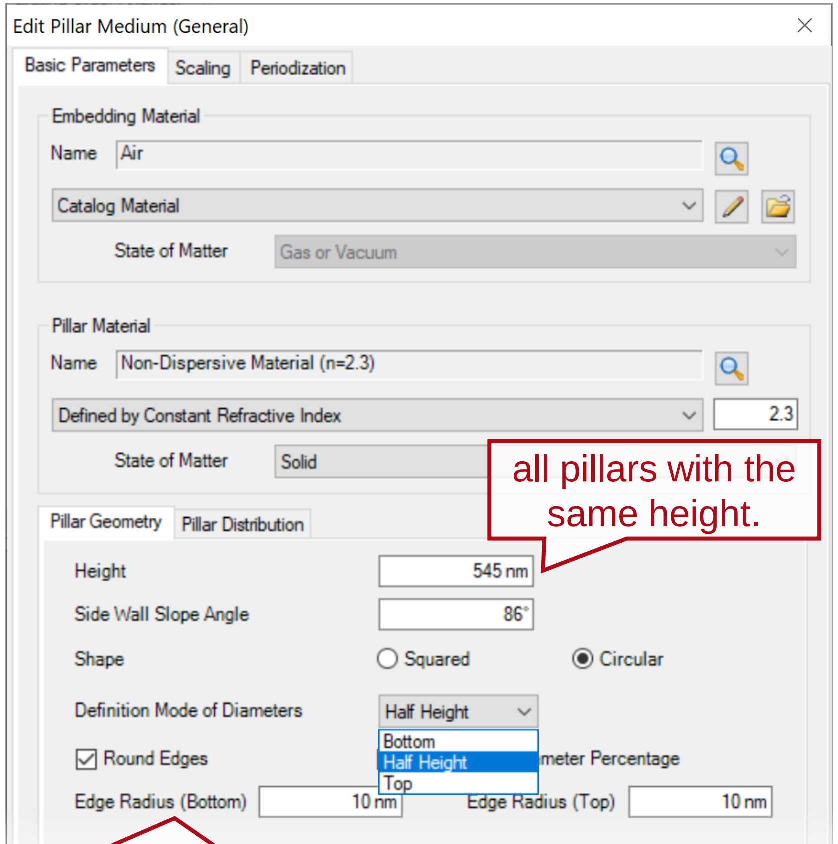


Materials inside Grating Stack

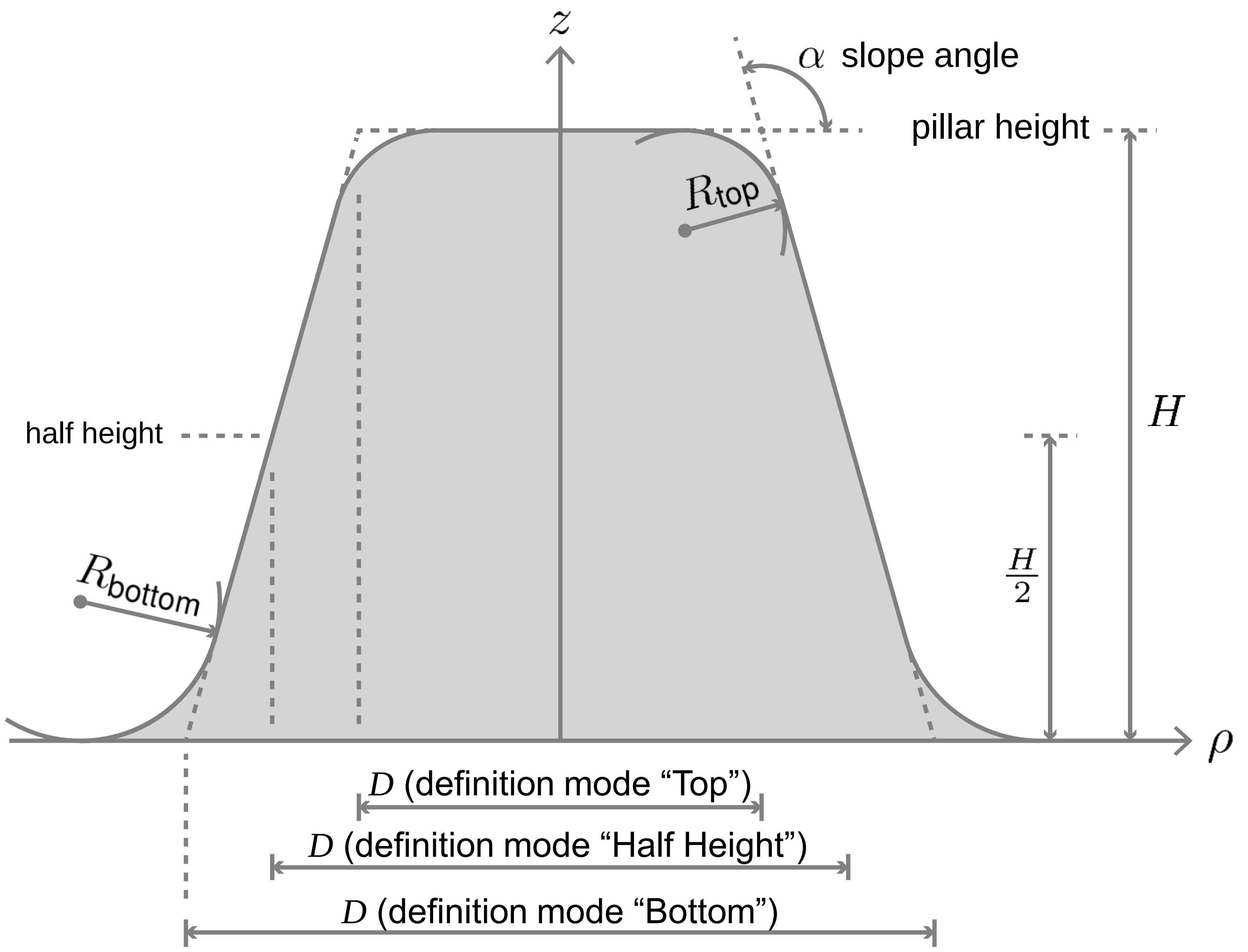
- The metagrating stack is constructed with the *Pillar Medium (General)* and two plane interfaces that sandwich the medium from both sides.
- In the configuration dialog of the *Pillar Medium (General)*, there are two materials to configure: the material for the pillars, and the material that will fill the space between them.
- Both of these materials are configured independently from any other materials in the system. This means that achieving a correct description of the physical reality (where the embedding medium coincides with the medium filling the space between the pillars) is the responsibility of the user.



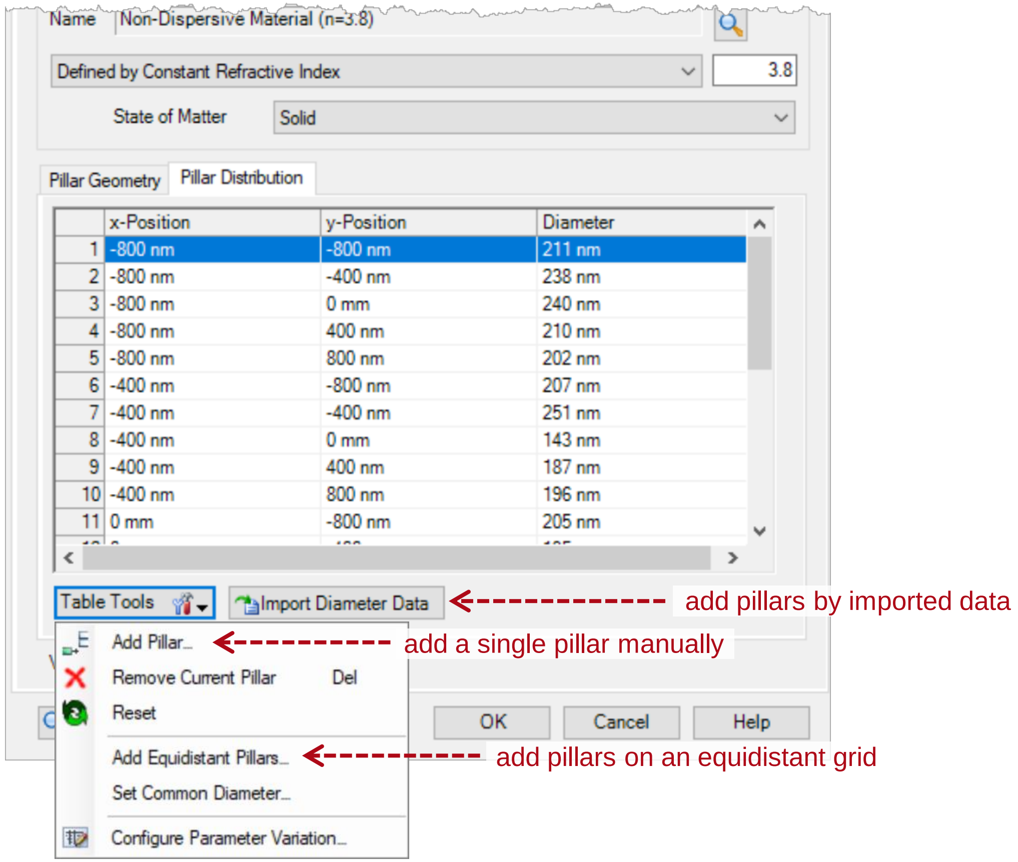
Single Pillar Geometry Configuration



round edges for e.g. tolerance considerations



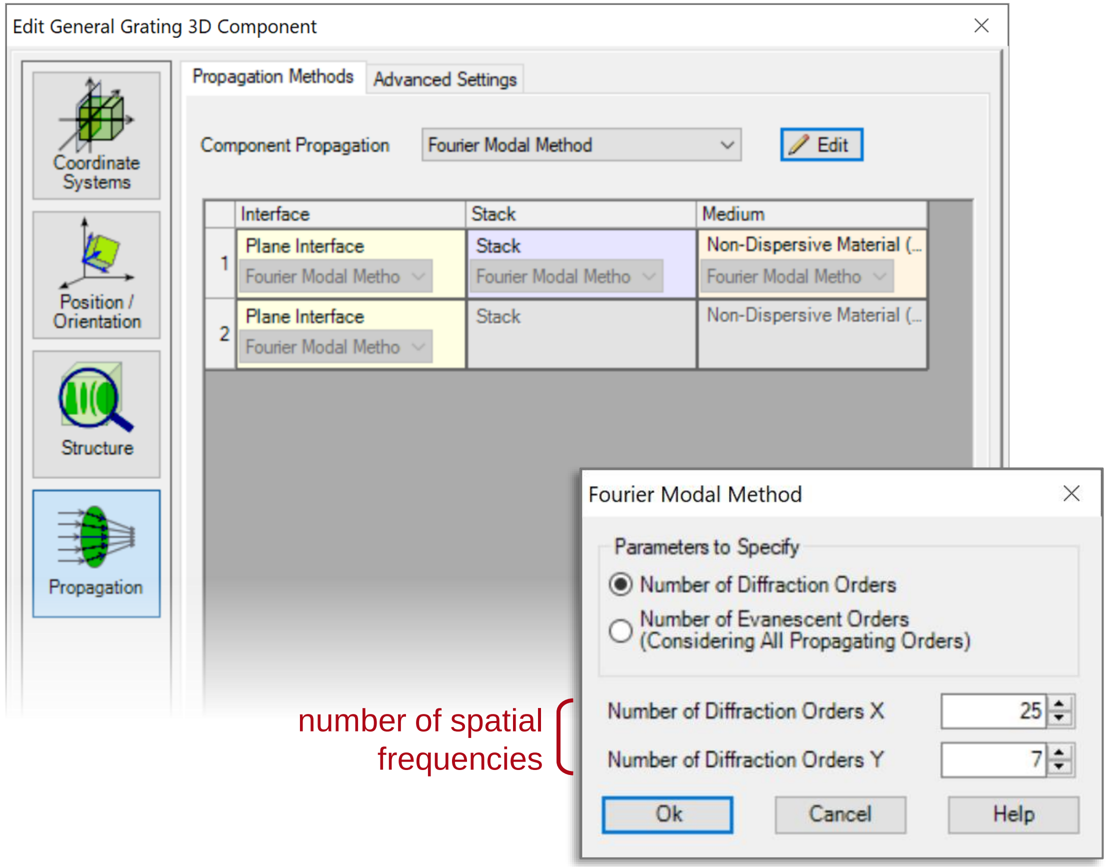
Distribution of Pillars



- The lateral position (x, y) and diameter of each pillar in the distribution (in the period of the metastructure) can be freely configured.
- There are several ways to do this:
  - pillar by pillar, manually;
  - on an equidistant grid all at once;
  - using an imported array containing the data 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.

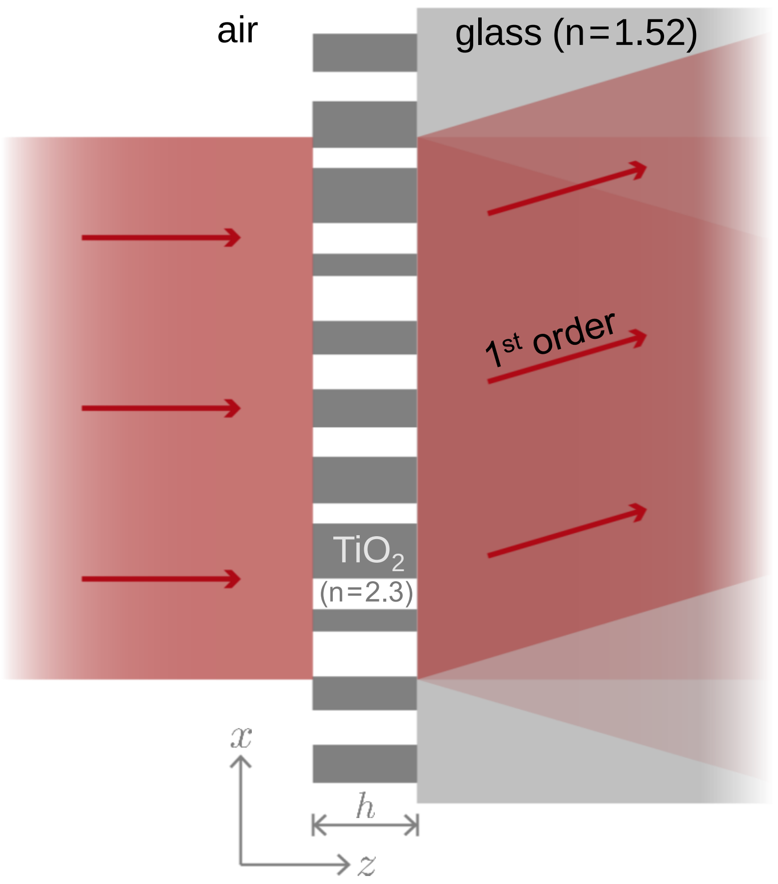
Numerical Parameter Setting

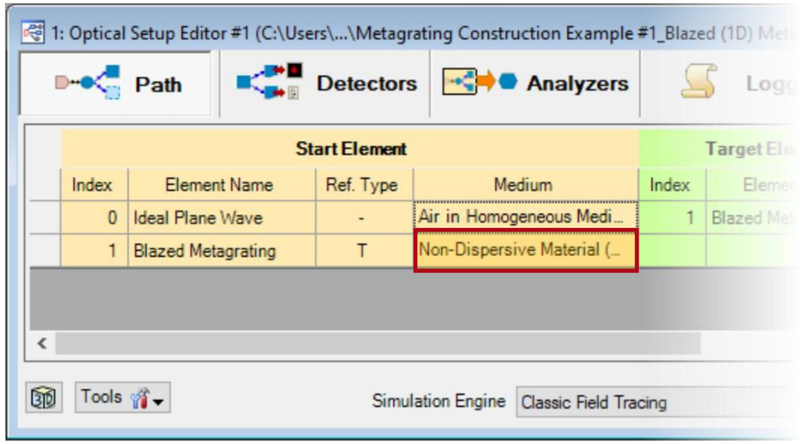
- To obtain a convergent result from the FMM/RCWA simulation, a high enough number of spatial frequencies must be used.
- For metagratings (which are usually composed of an array, 1D or 2D, of pillars) we recommend performing a convergence test to ensure numerical convergence of the algorithm.
- For 1D metagratings (e.g. blazed meta-grating), the required number of spatial frequencies should be checked separately for the x and y directions.



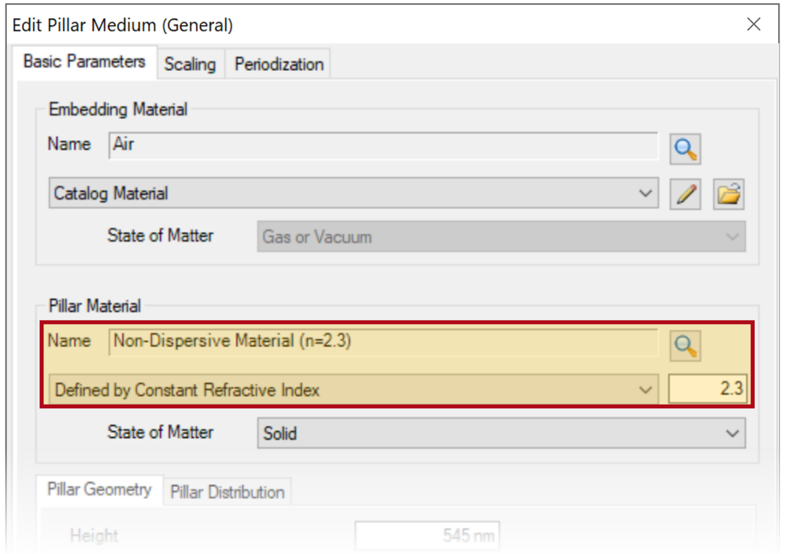
Example #1: One-Dimensional Blazed Metagrating

Configuration of Materials and Media





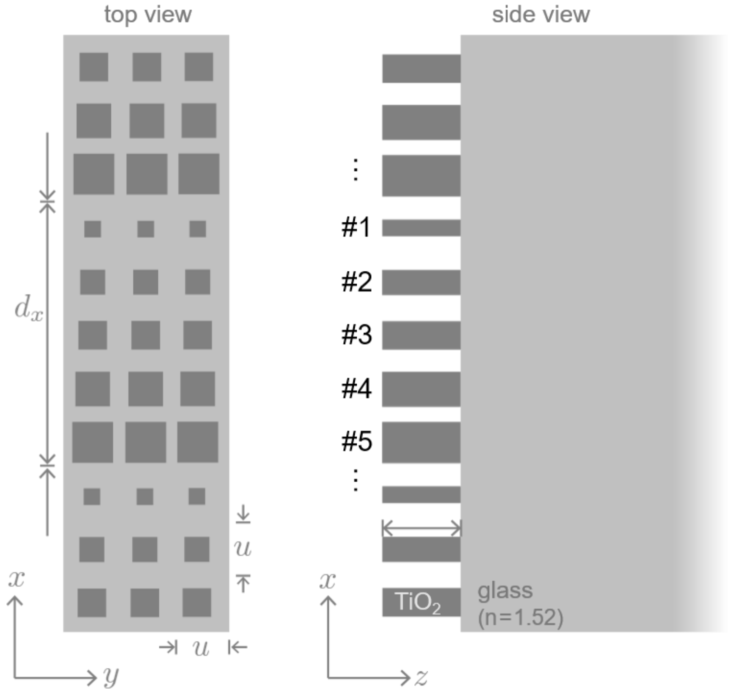
The medium behind grating is set the same as the glass substrate, with n=1.52.

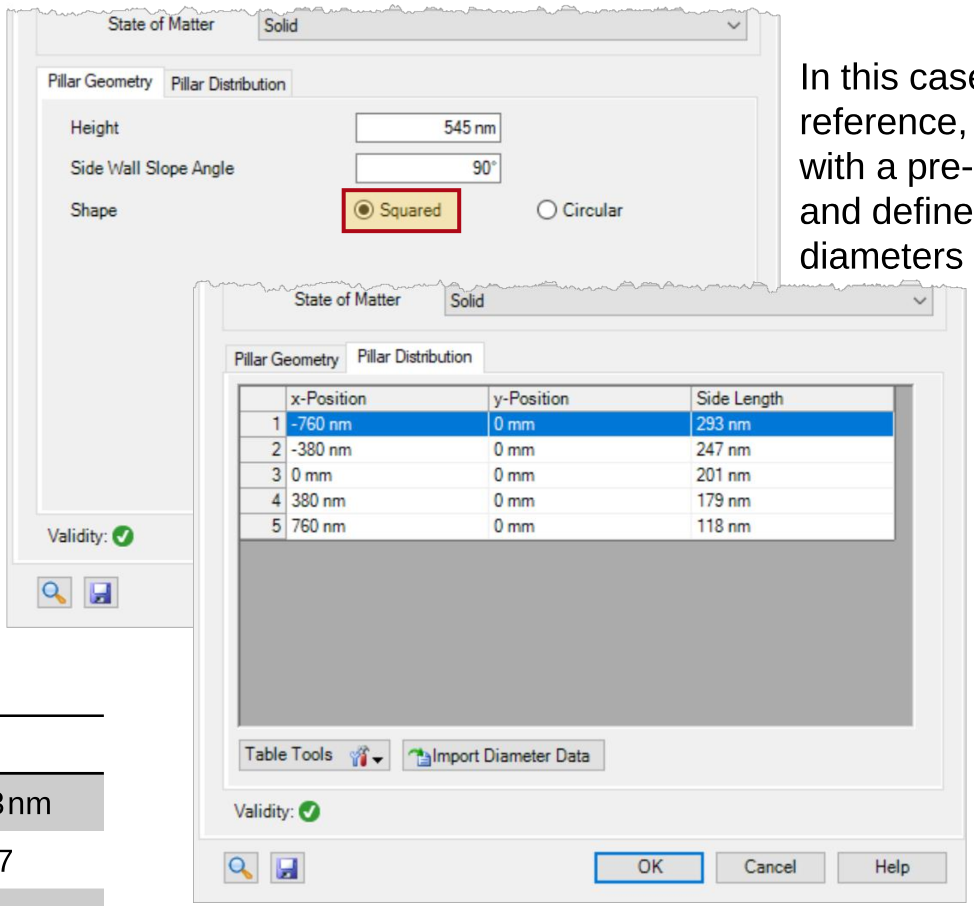


The pillar material is set with n=2.3 for TiO_2 at the given wavelength.

see the full Application Use Case

Pillar Geometry and Distribution



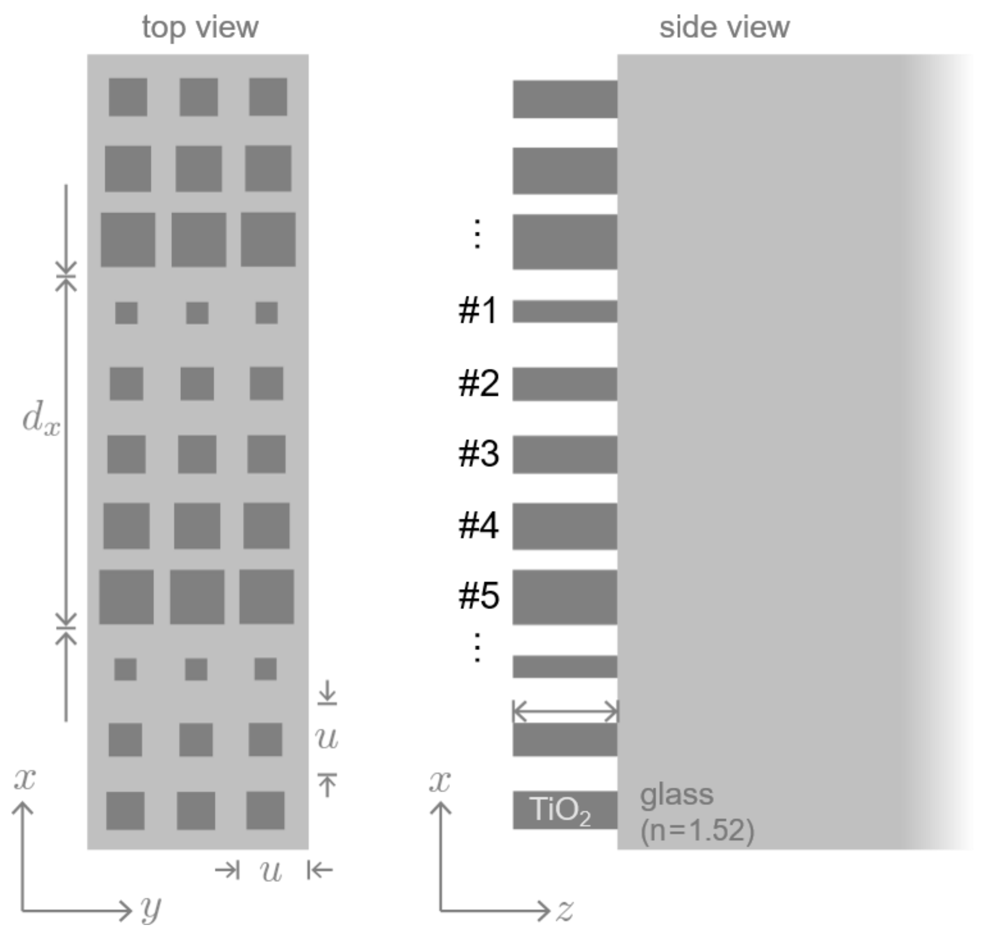


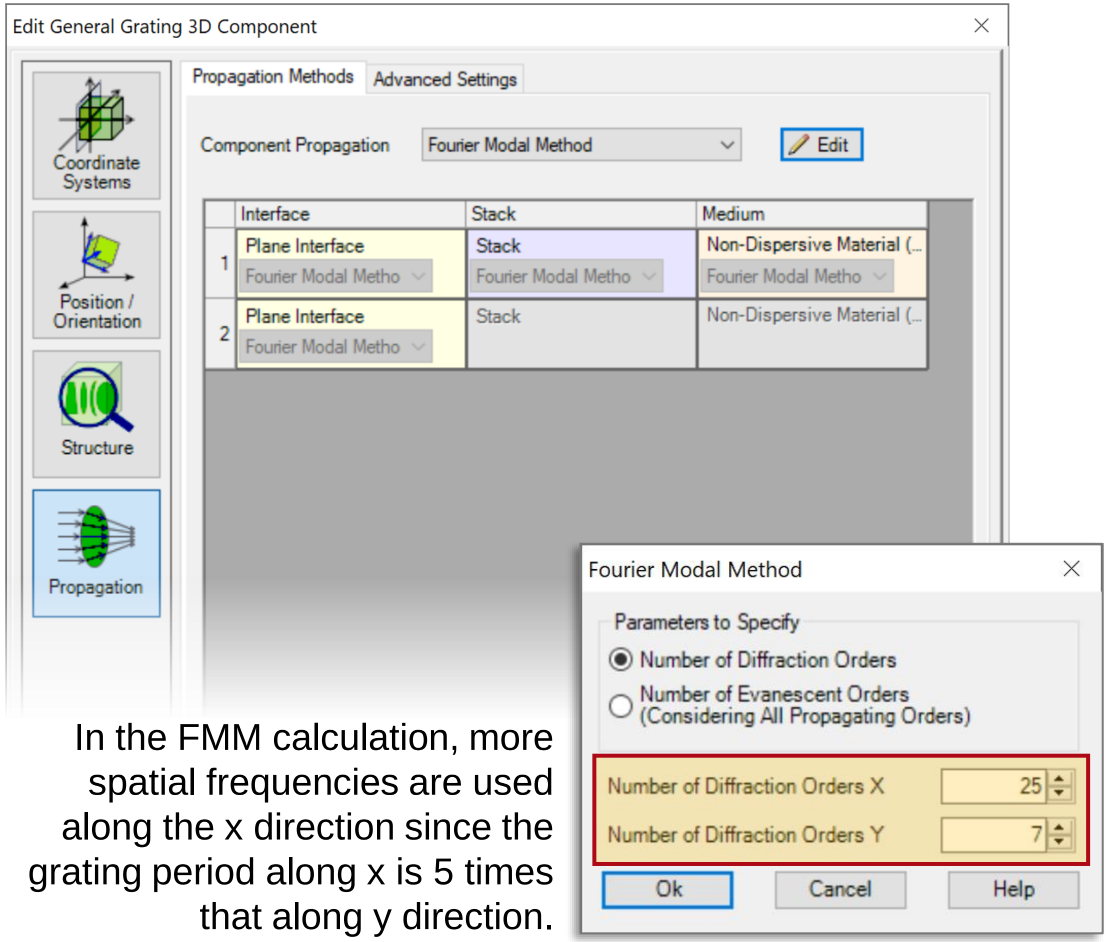
In this case, following the reference, we use square pillars with a pre-calculated height, and define their positions and diameters manually.

	#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)

Number of Spatial Frequencies

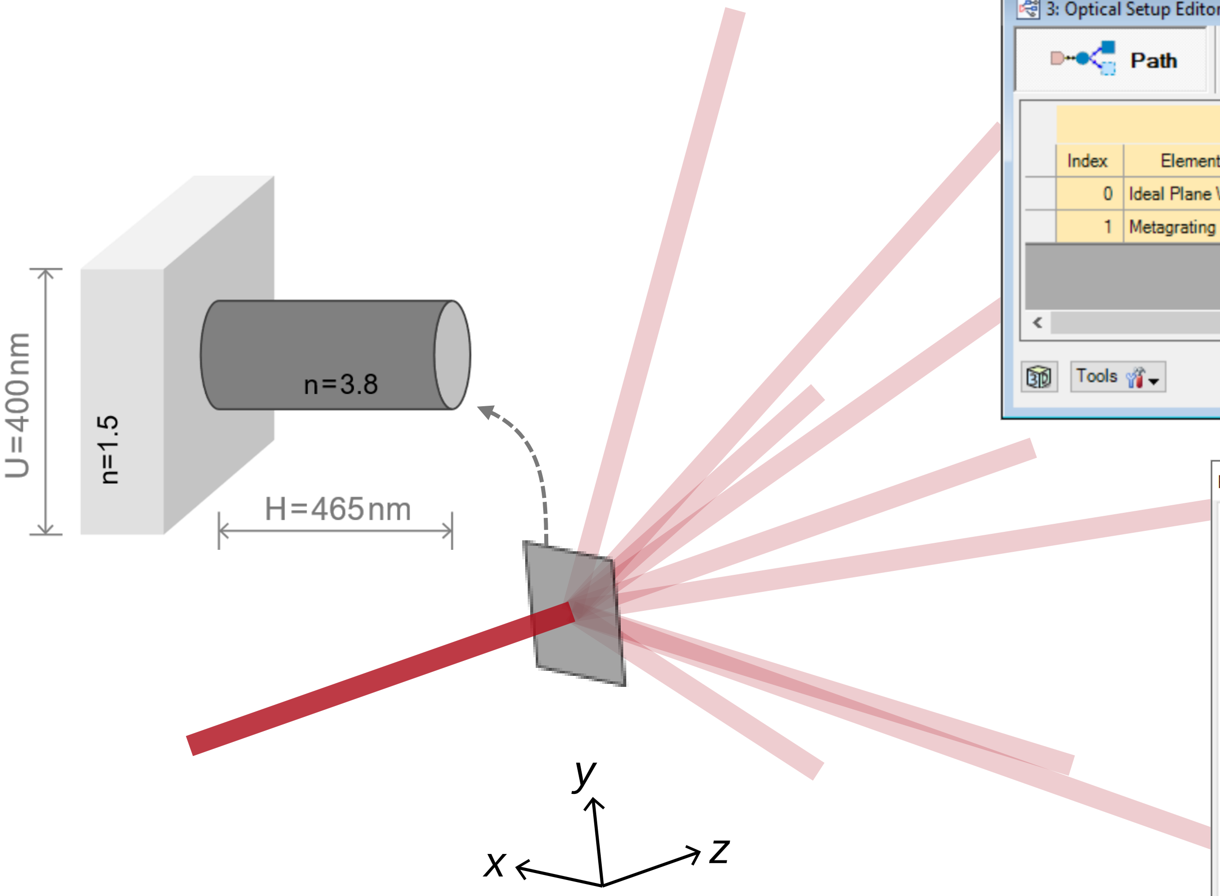


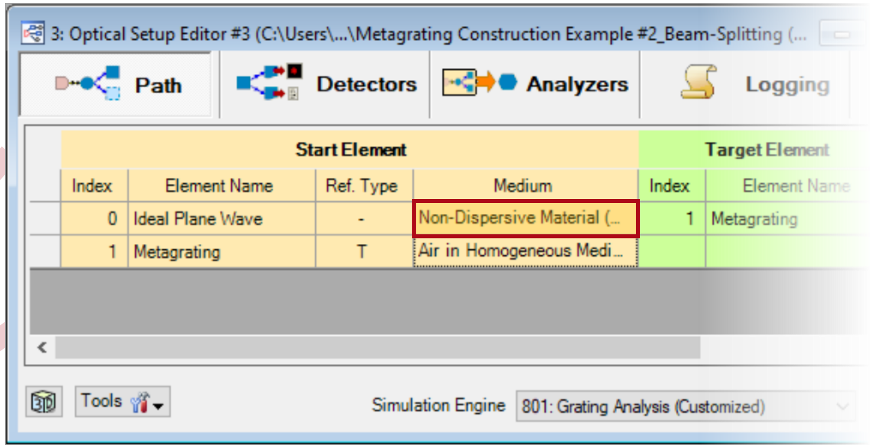


In the FMM calculation, more spatial frequencies are used along the x direction since the grating period along x is 5 times that along y direction.

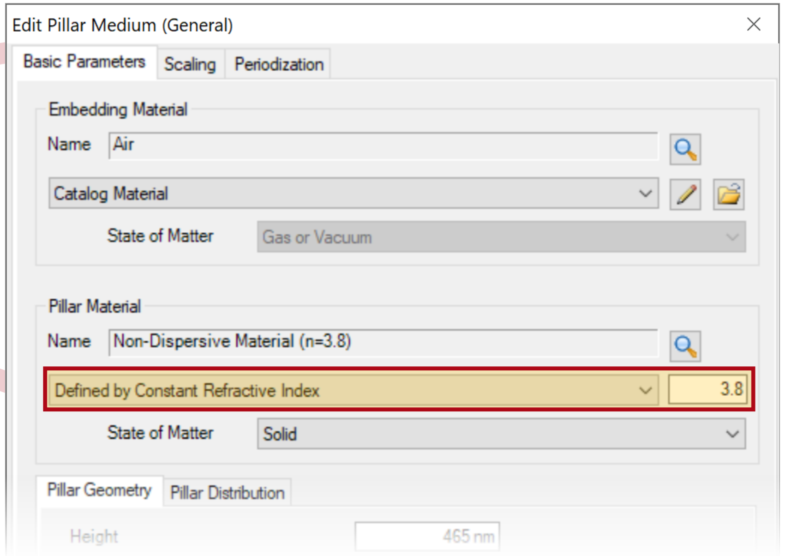
Example #2: Two-Dimensional Beam-Splitting Metagrating

Configuration of Materials and Media





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



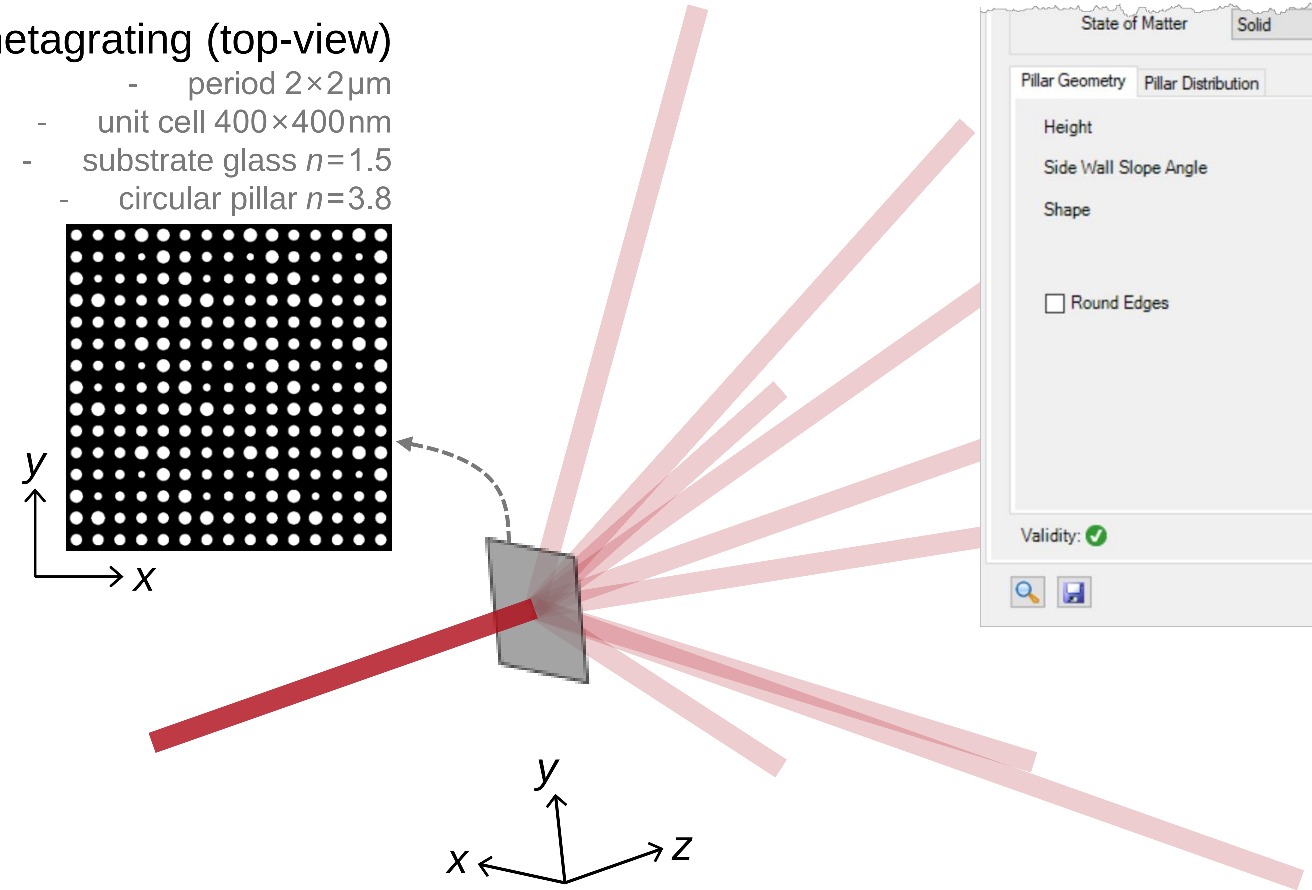
The pillar material is set with n=3.8 for the given wavelength.

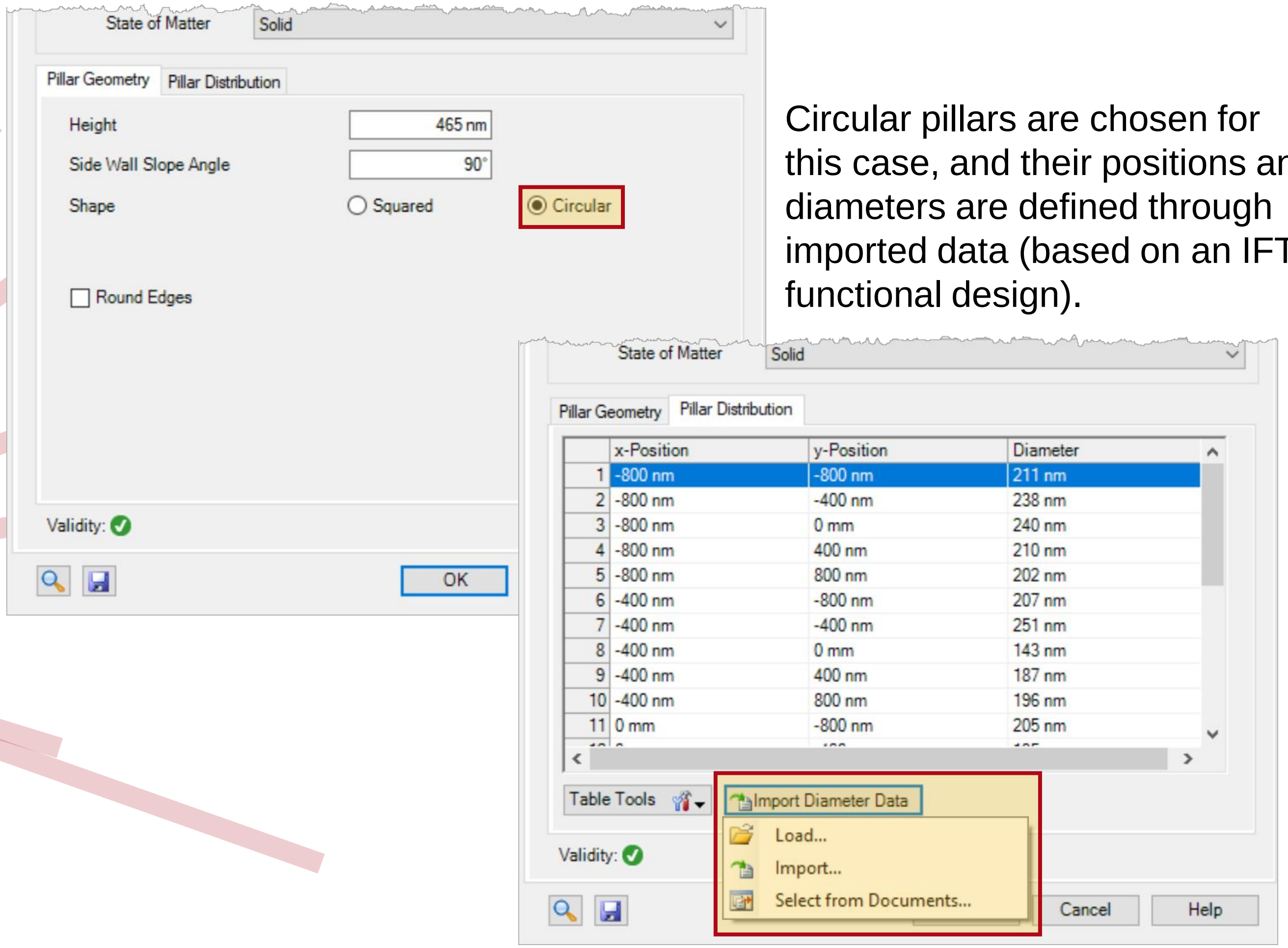
see the full Application Use Case

Pillar Geometry and Distribution

metagrating (top-view)

- period 2×2µm
- unit cell 400×400nm
- substrate glass n=1.5
- circular pillar n=3.8





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

Document Information

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