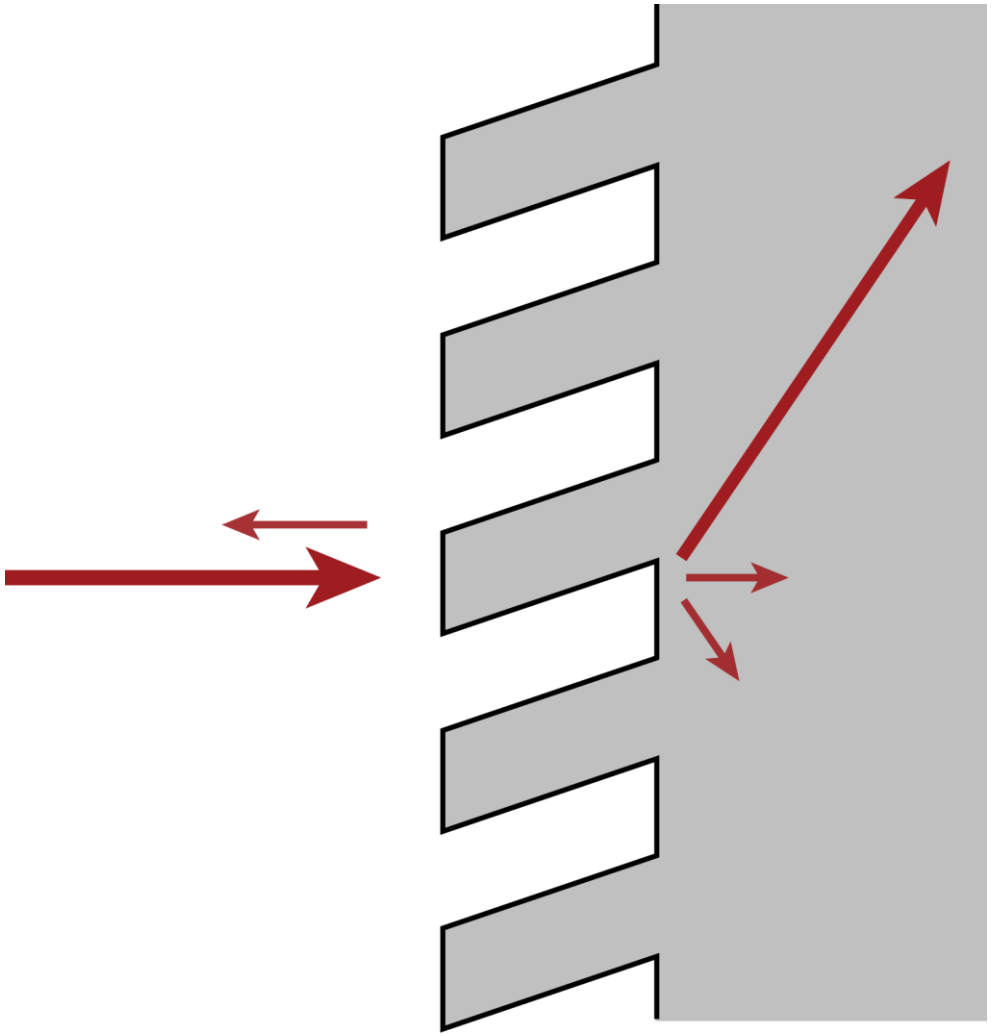
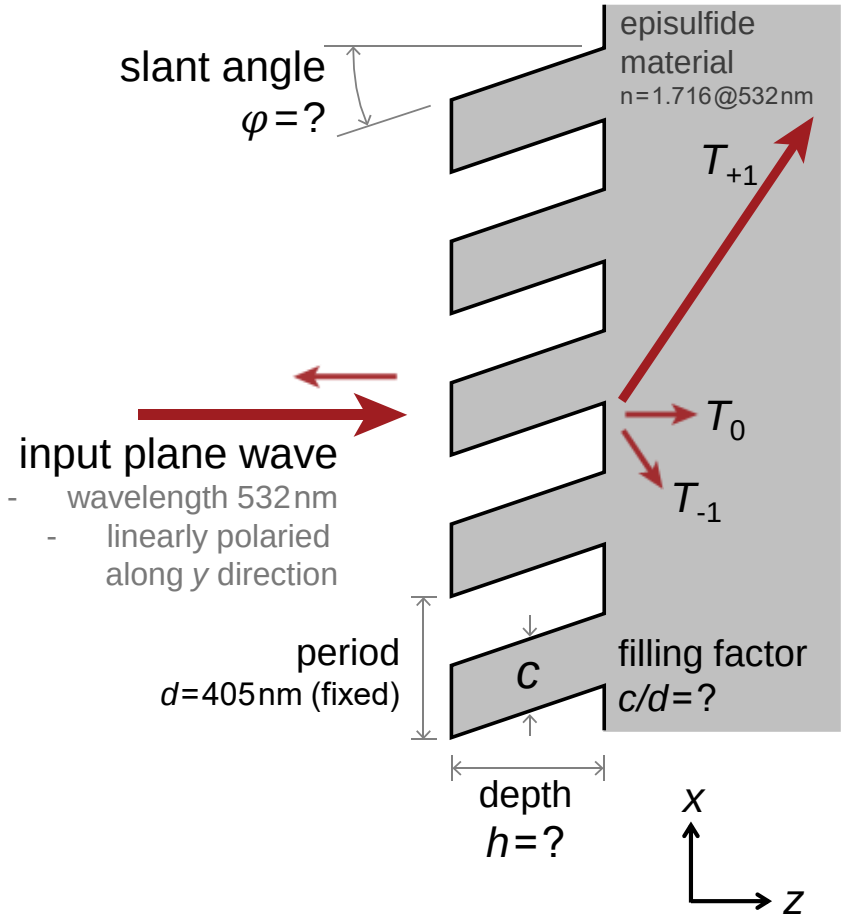
Parametric Optimization and Tolerance Analysis of Slanted Gratings

Abstract

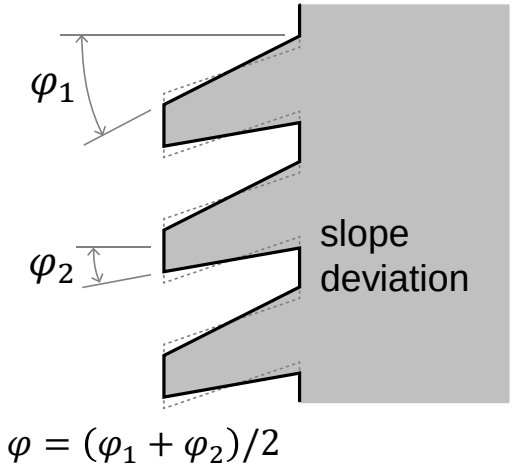


Coupling of light into guiding structures with high efficiency is an important issue for many applications, like backlight, optical interconnector, and near-to-eye displays. For such applications, slanted gratings are well-known for being capable to couple monochromatic light with high efficiency. In this example, the optimization of a slanted grating with the rigorous Fourier modal method (FMM, also known as RCWA) is presented. The optimized grating shows a diffraction efficiency of over 90% for a predefined direction order. In addition, the influence from the slope deviation and the rounded edges of the grating are investigated.

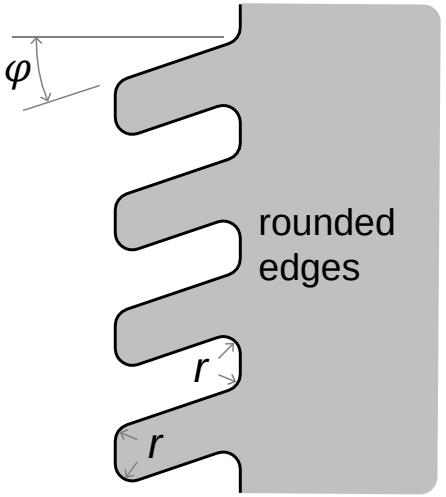
Modeling Task



How to optimize the T_{+1} order diffraction efficiency, by adjusting the slant angle φ, grating depth *h*, and filling factor *c/d*?



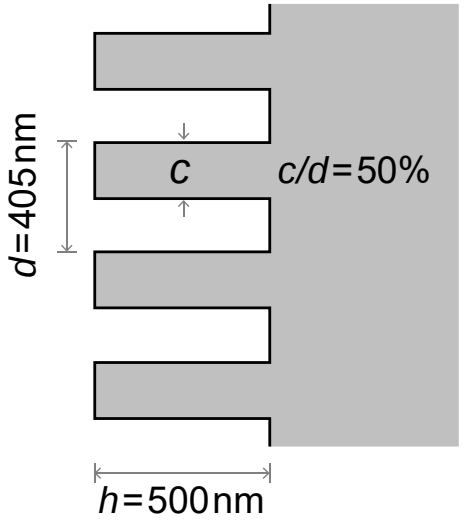
$\varphi = (\varphi_1 + \varphi_2)/2$



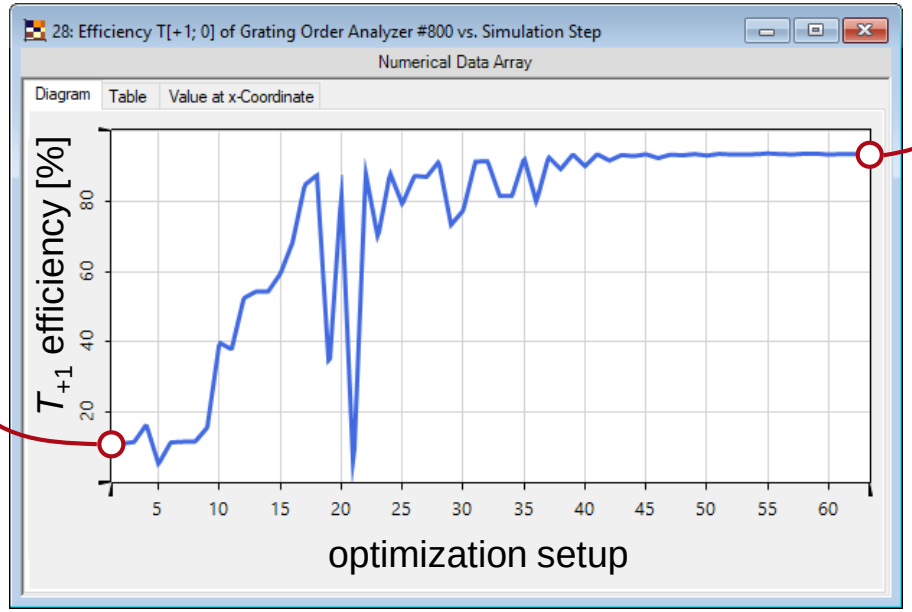
In addition, how to evaluate the grating performance with the slope deviation and the rounded edges due to the fabrication technique taken into account?

Parametric Optimization for 1st Order

initial structure

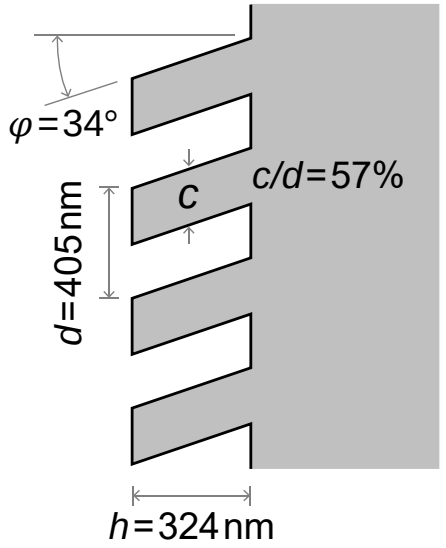


Order	Efficiency
-1	11.551%
0	72.795%
+1	11.551%



parametric optimization – downhill simplex method – with rigorous Fourier modal method (FMM) used for grating efficiency calculation

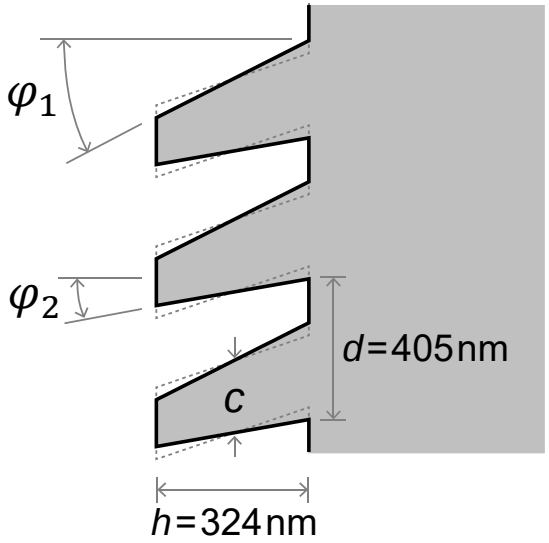
optimized structure



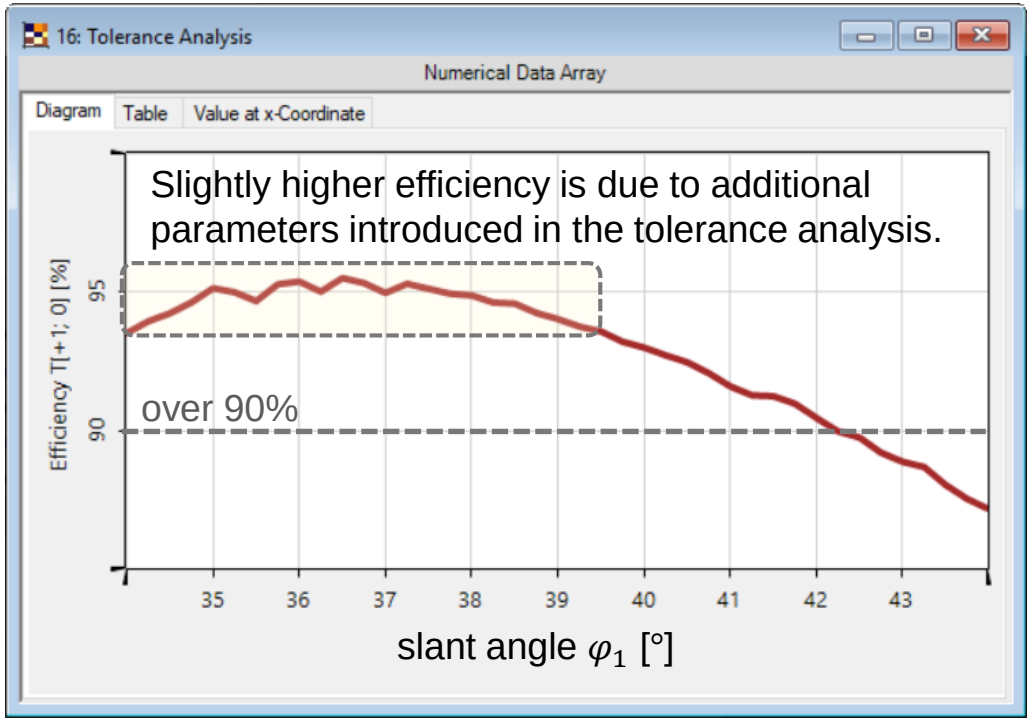
Order	Efficiency
-1	3.257%
0	0.365%
+1	**93.659%**

Results – Tolerance Analysis

The fabricated slanted gratings often shows a deviation from the perfect parallel grating lines. Such slope deviations should be taken into account for the tolerance analysis.



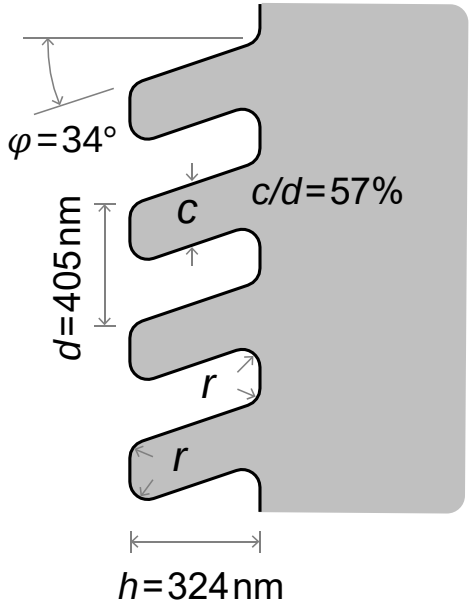
- fixed average slant angle $\varphi = (\varphi_1 + \varphi_2)/2 = 34°$
- fixed filling factor (average) c/d=57%
- varying φ_1 from 34 to 44°



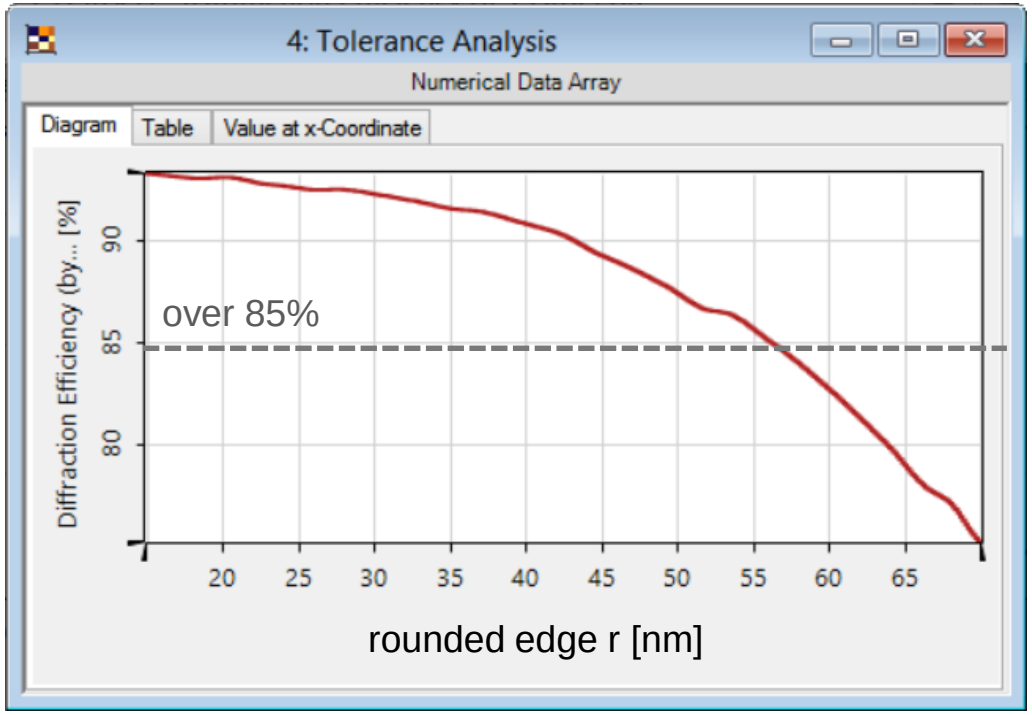
Rigorous simulation with Fourier modal method (FMM), for tolerance analysis over 50 steps, takes 30 seconds.

Results – Tolerance Analysis

The fabricated slanted gratings often shows a deviation from the perfect parallel grating lines. The rounded edges should be taken into account for the tolerance analysis.



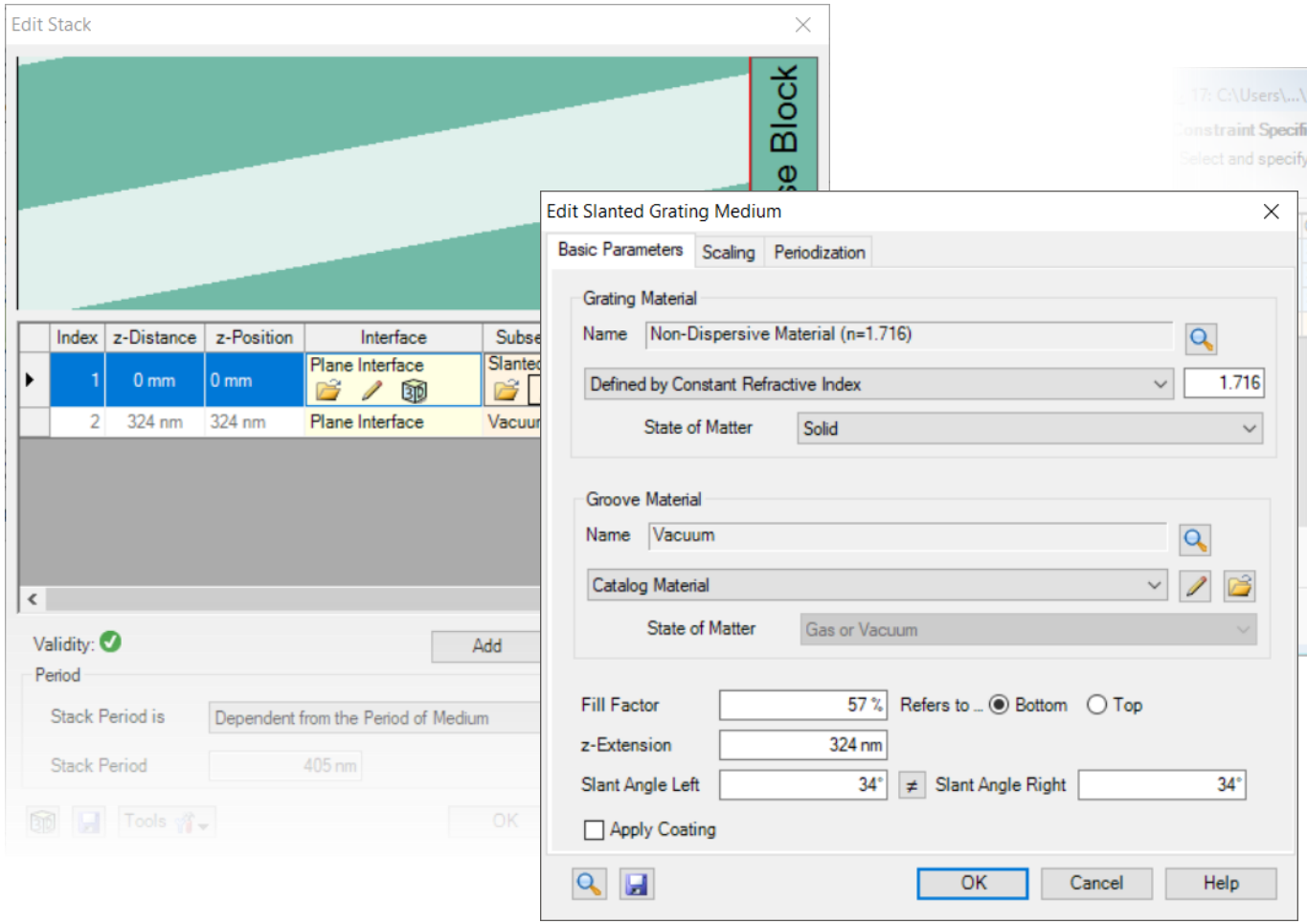
- fixed average slant angle $\varphi = 34°$
- fixed filling factor c/d=57%
- varying *r* from 15nm 70nm



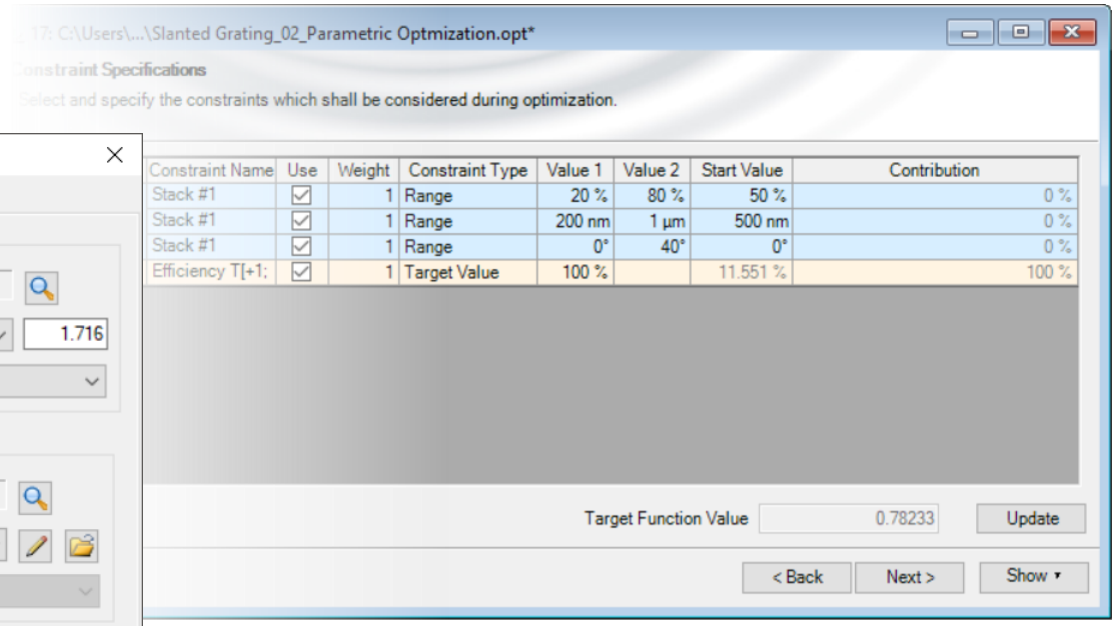
Rigorous simulation with Integral Method (IM), for tolerance analysis over 30 steps, takes 9 seconds.

Peek into VirtualLab Fusion

flexible and easy settings of slanted gratings

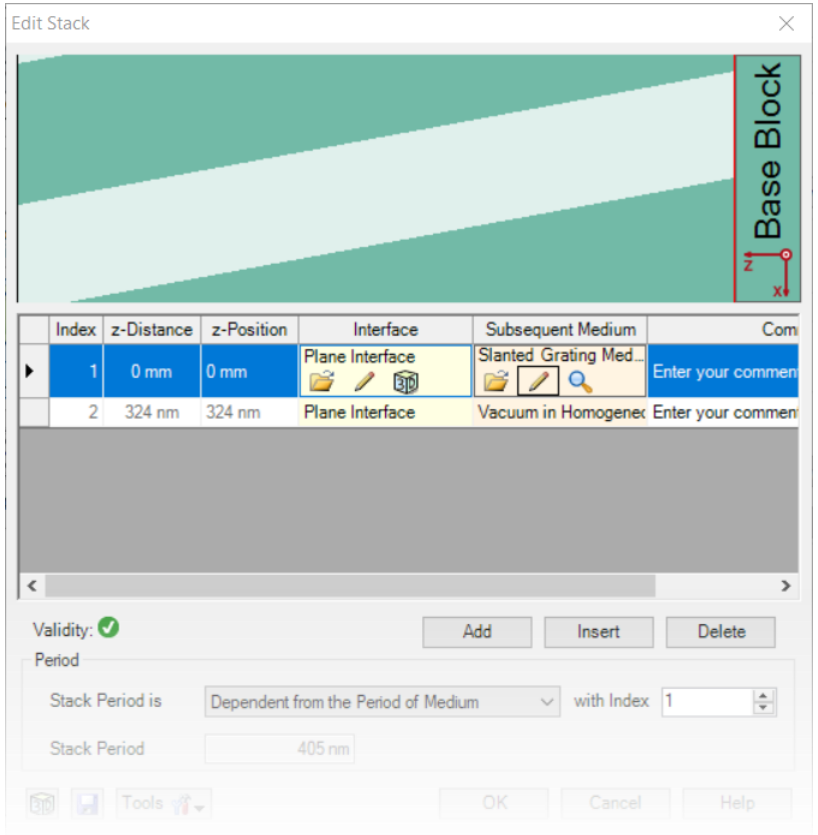


parametric optimization of grating parameters

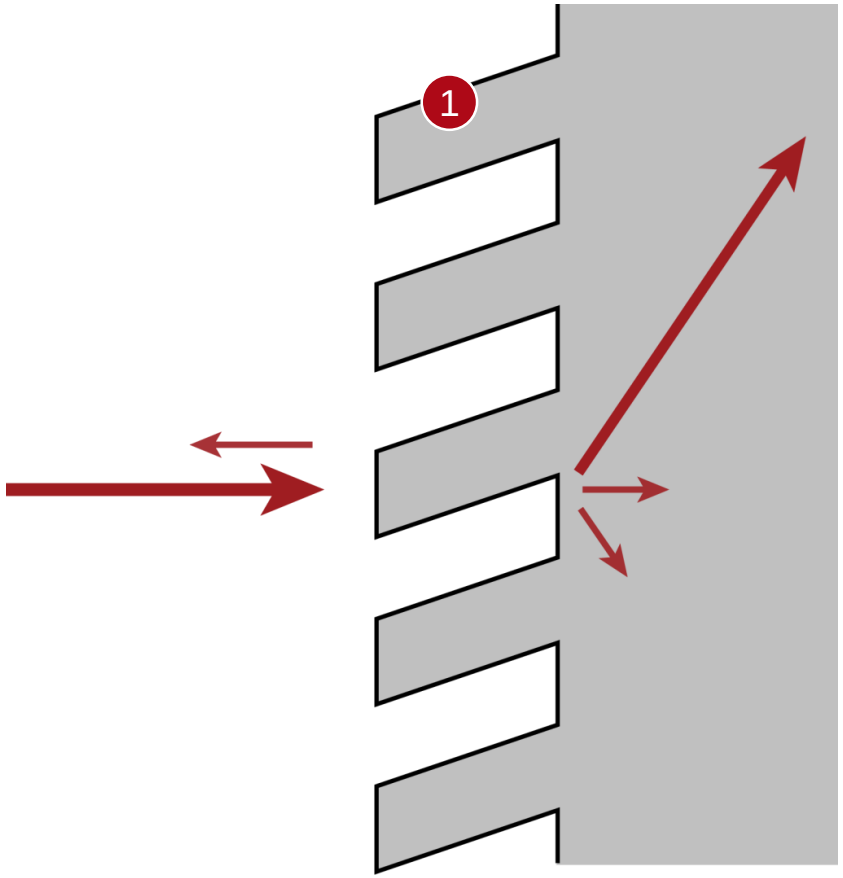


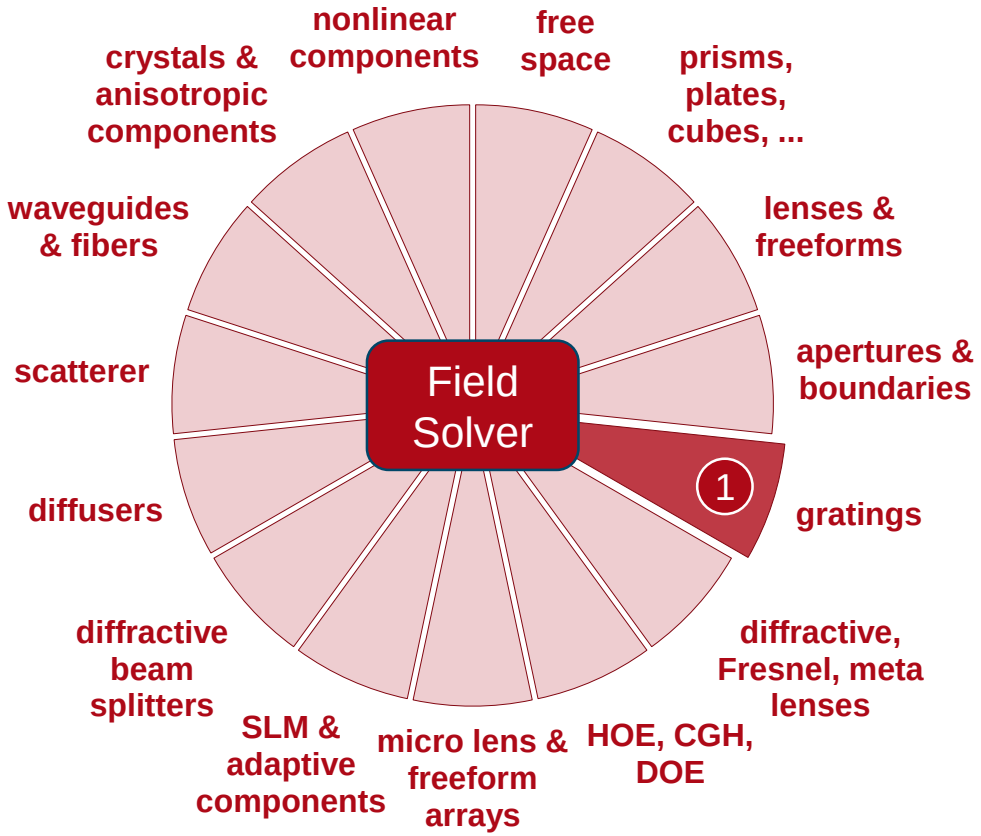
Workflow in VirtualLab Fusion

- Construct grating structure
  - Configuration of Grating Structures by Using Special Media [Use Case]
  - Advanced Configuration of Slanted Gratings [Use Case]
- Analyze grating diffraction efficiency
  - Grating Order Analyzer [Use Case]
- Optimize grating parameters with Parametric Optimization
- Tolerance analysis with Parameter Run
  - Usage of the Parameter Run Document [Use Case]



VirtualLab Fusion Technologies





Document Information

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VL version used for simulations	7.6.0.78
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