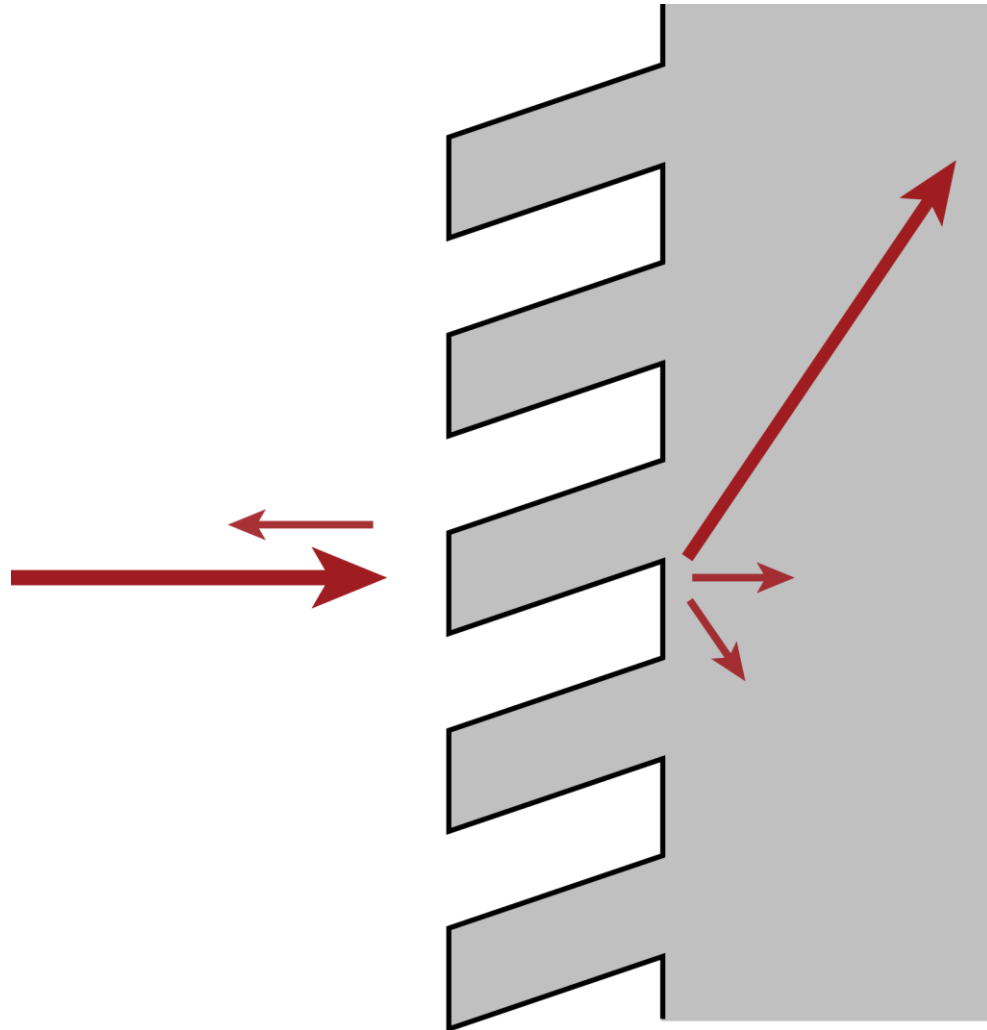


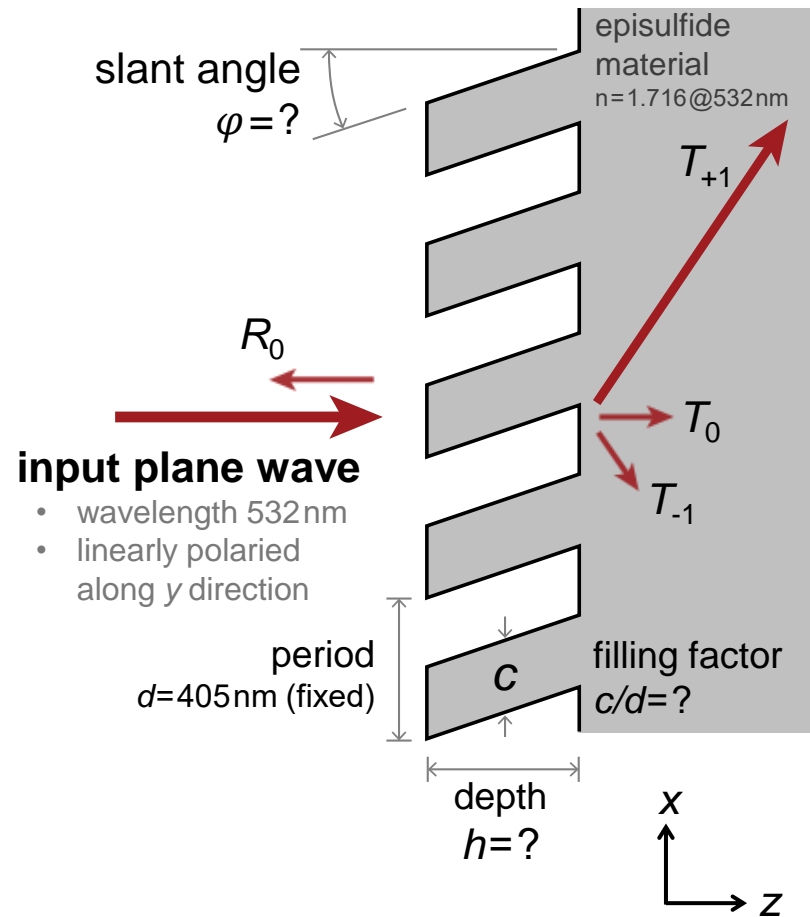
Parametric Optimization and Tolerance Analysis of Slanted Gratings

Abstract

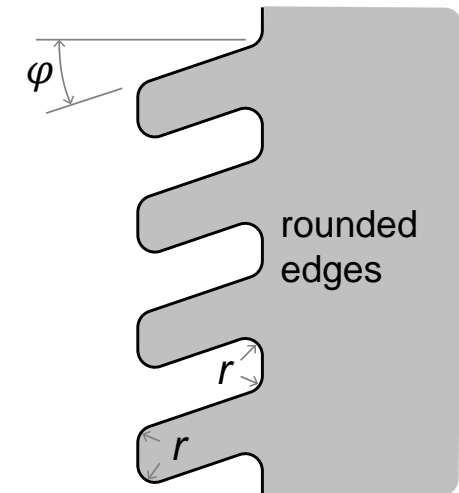
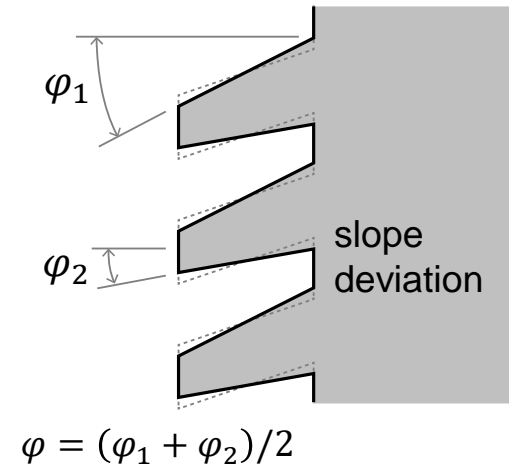


Coupling of light into guiding structures with high efficiency is an important issue for many applications, like backlight, optical interconnector, and near-to-eye displays. For such applications, slanted gratings are well-known for being capable to couple monochromatic light with high efficiency. In 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

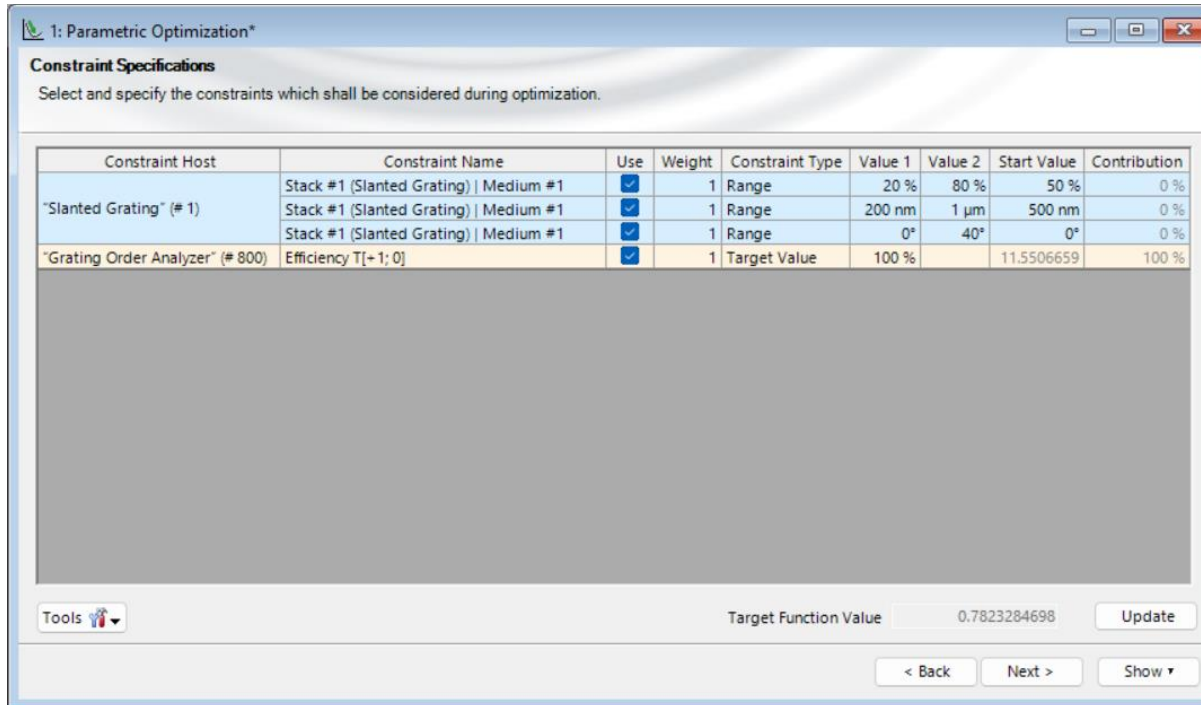


How to optimize the diffraction efficiency of the T_{+1} order, by adjusting the slant angle φ , grating depth h , and filling factor c/d ?



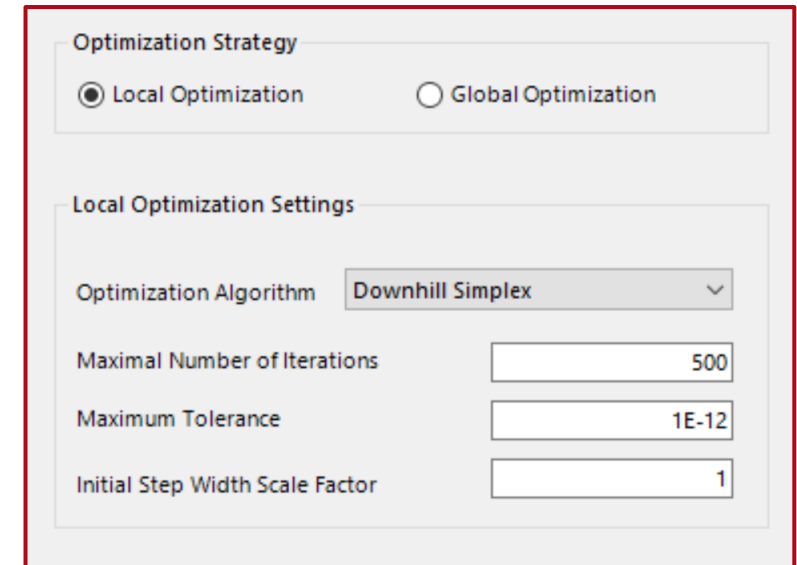
In addition, how to evaluate the grating performance with the slope deviation and the rounded edges due to fabrication processes taken into account?

Optimization



The screenshot shows a software window titled "1: Parametric Optimization*" with a "Constraint Specifications" section. Below the title bar, there is a text instruction: "Select and specify the constraints which shall be considered during optimization." A table lists the constraints with columns for Constraint Host, Constraint Name, Use, Weight, Constraint Type, Value 1, Value 2, Start Value, and Contribution. The table contains four rows of constraints. At the bottom of the window, there is a "Tools" dropdown, a "Target Function Value" field showing "0.7823284698", an "Update" button, and navigation buttons for "< Back", "Next >", and "Show ▾".

Constraint Host	Constraint Name	Use	Weight	Constraint Type	Value 1	Value 2	Start Value	Contribution
"Slanted Grating" (# 1)	Stack #1 (Slanted Grating) Medium #1	<input checked="" type="checkbox"/>	1	Range	20 %	80 %	50 %	0 %
	Stack #1 (Slanted Grating) Medium #1	<input checked="" type="checkbox"/>	1	Range	200 nm	1 μ m	500 nm	0 %
	Stack #1 (Slanted Grating) Medium #1	<input checked="" type="checkbox"/>	1	Range	0°	40°	0°	0 %
"Grating Order Analyzer" (# 800)	Efficiency T[+1; 0]	<input checked="" type="checkbox"/>	1	Target Value	100 %		11.5506659	100 %

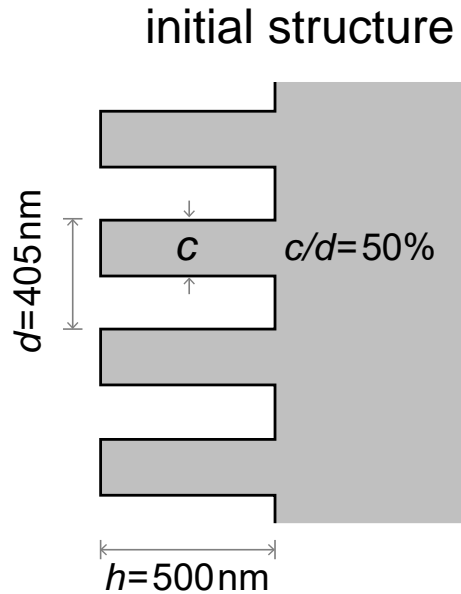


The screenshot shows a configuration panel for optimization. It has two main sections: "Optimization Strategy" and "Local Optimization Settings". In the "Optimization Strategy" section, there are two radio buttons: "Local Optimization" (which is selected) and "Global Optimization". The "Local Optimization Settings" section includes a dropdown menu for "Optimization Algorithm" set to "Downhill Simplex", a text input for "Maximal Number of Iterations" set to "500", a text input for "Maximum Tolerance" set to "1E-12", and a text input for "Initial Step Width Scale Factor" set to "1".

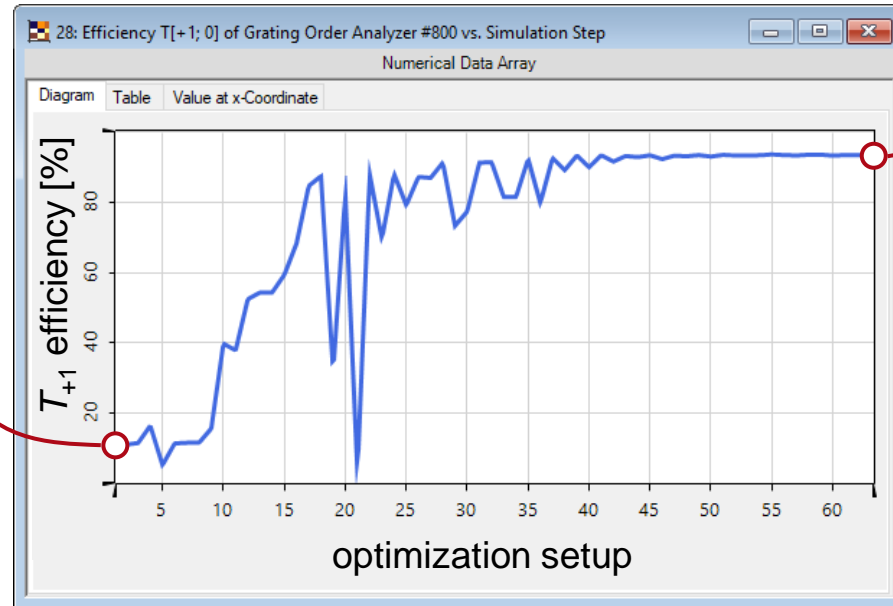
In order to find an optimized set of parameters for the slanted grating, the *Optimization* document enables the definition of parameter constraints and weights for the target values. Find more information under:

[!\[\]\(e78f798d4ea5c530c9db49e7d26e6b95_img.jpg\) Introduction to the Parametric Optimization Document](#)

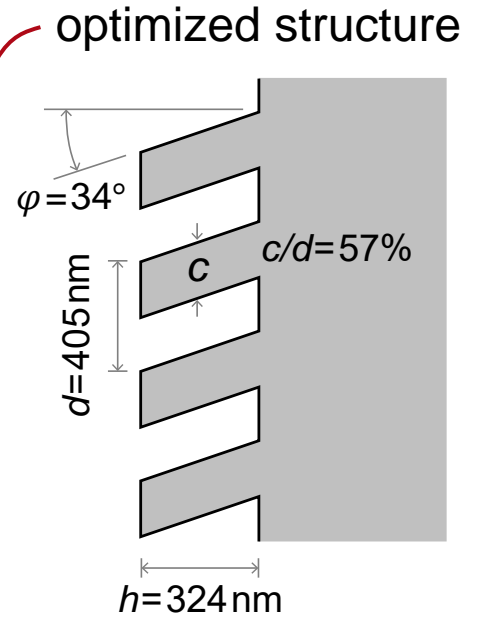
Parametric Optimization for 1st Order



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



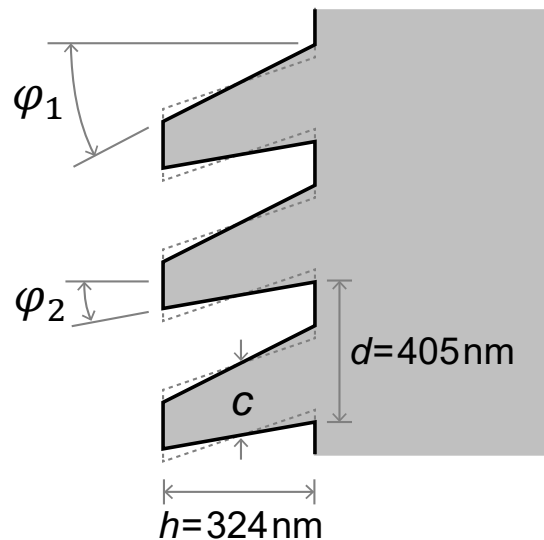
parametric optimization – downhill simplex method – with rigorous Fourier modal method (FMM) used for grating efficiency calculation



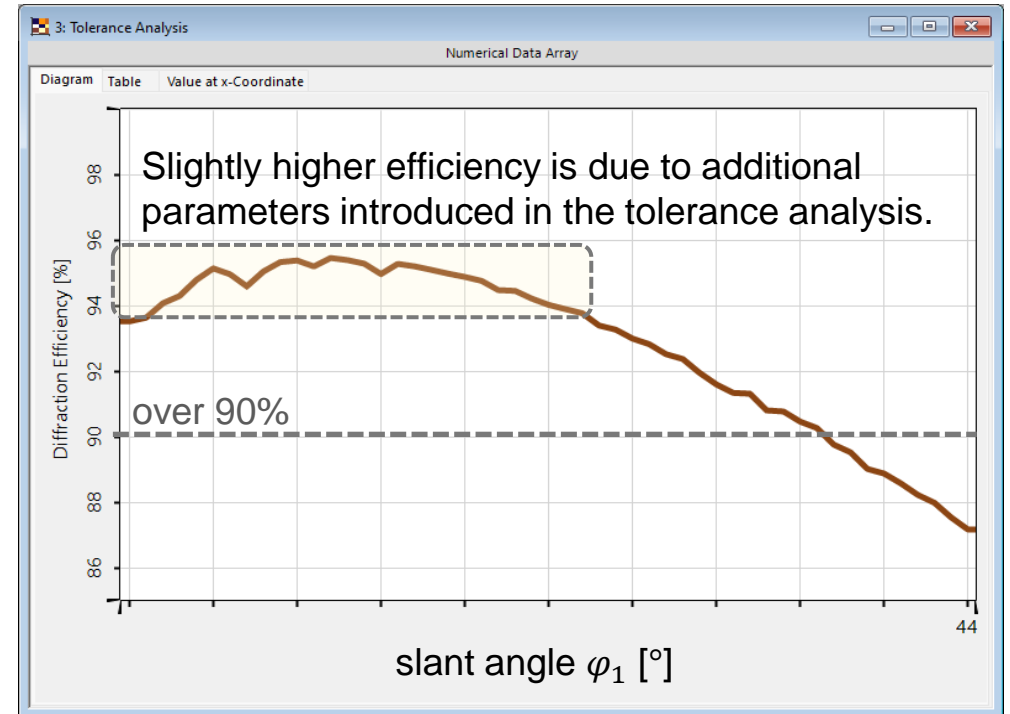
Order	Efficiency
-1	3.257%
0	0.365%
+1	93.659%

Results – Tolerance Analysis

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



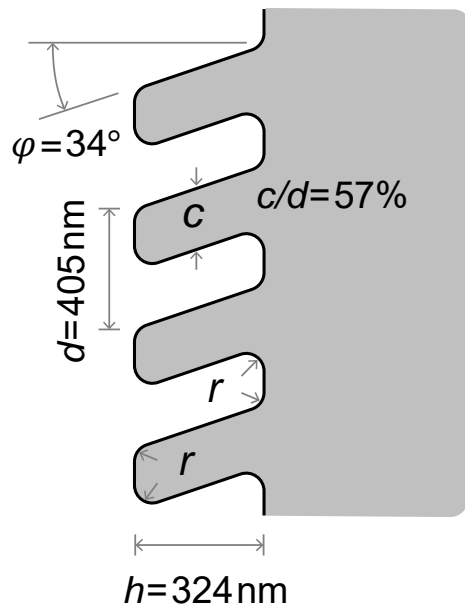
- fixed average slant angle $\varphi = (\varphi_1 + \varphi_2)/2 = 34^\circ$
- fixed filling factor (average) $c/d = 57\%$
- varying φ_1 from 34 to 44°



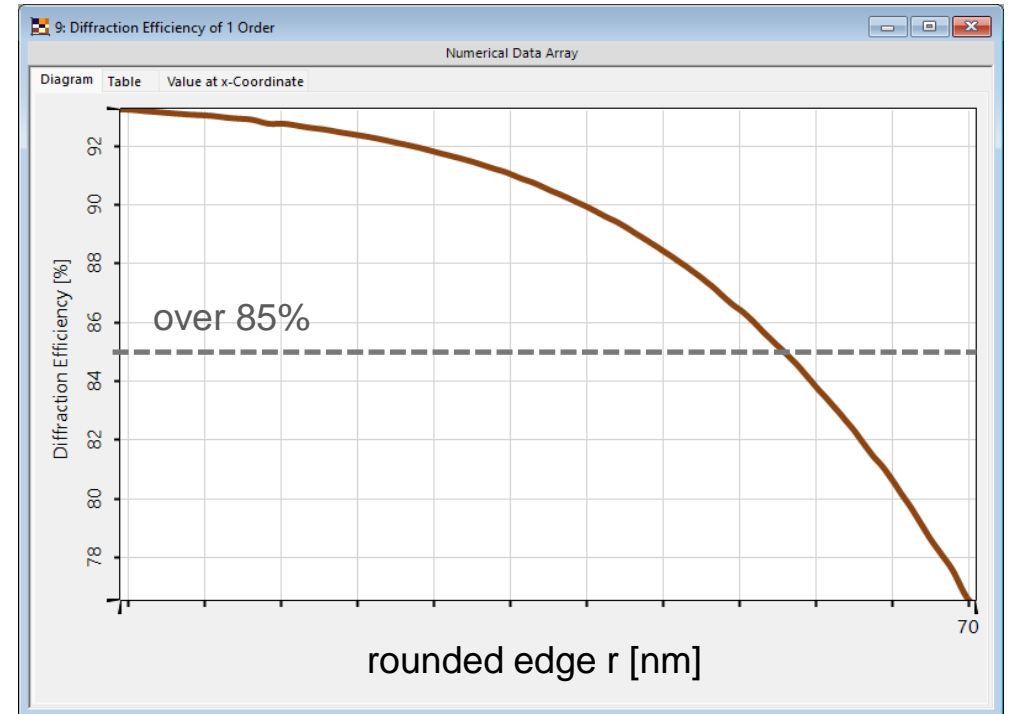
Rigorous simulation with Fourier modal method (FMM).

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.

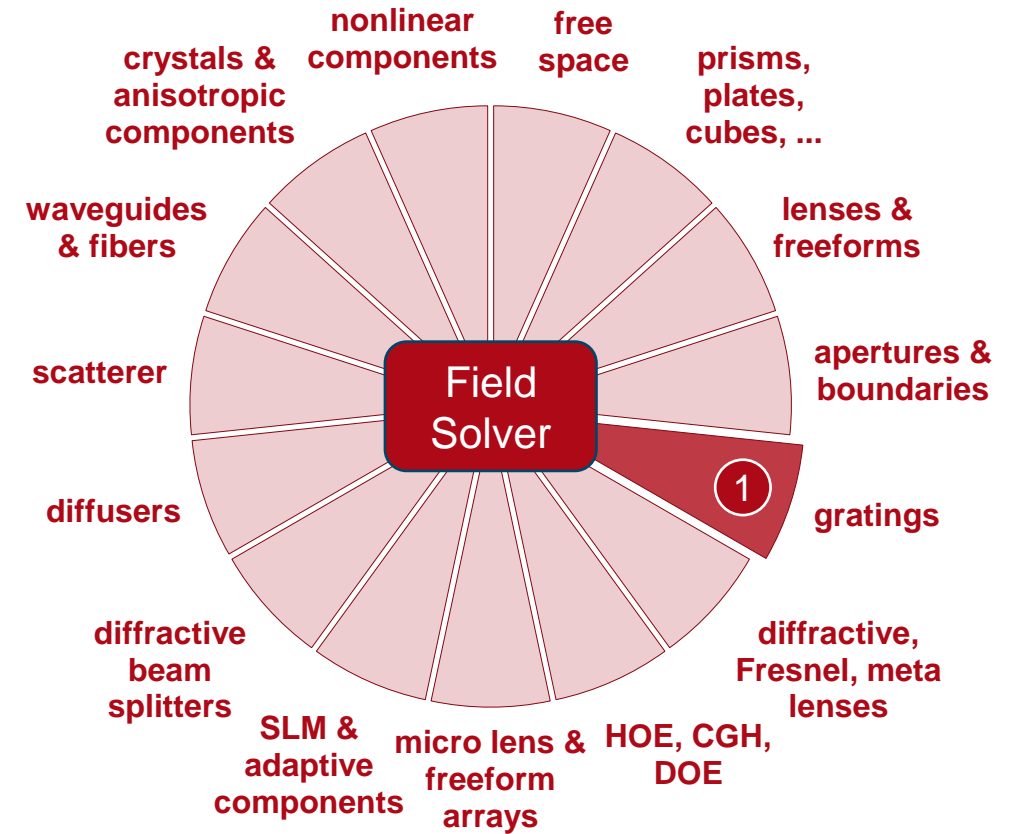
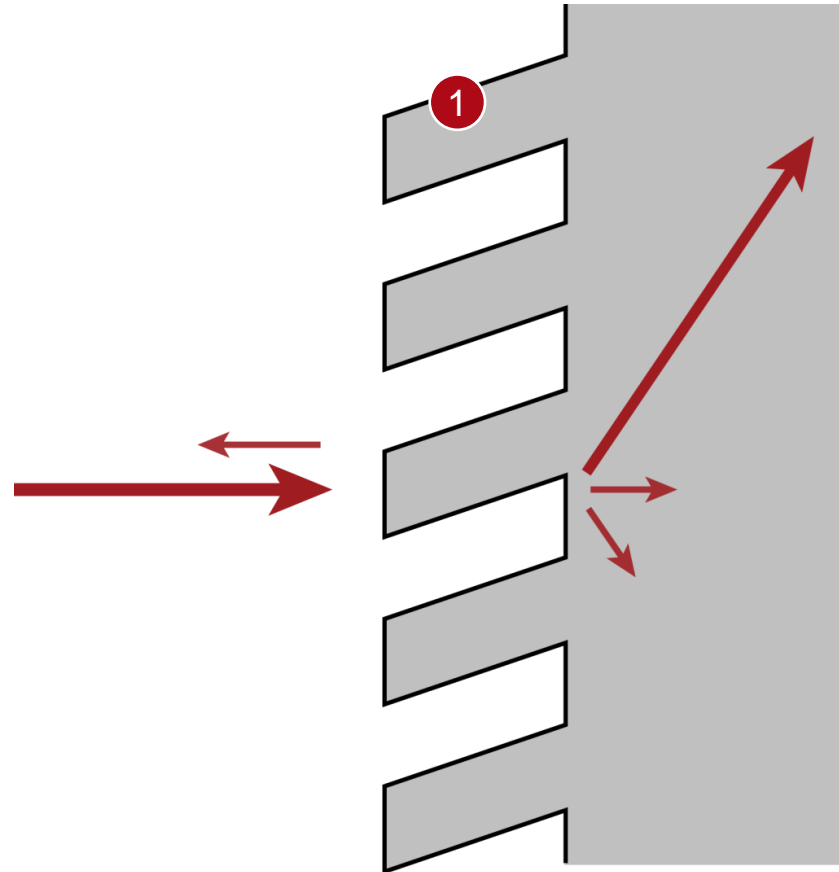


- fixed average slant angle $\varphi = 34^\circ$
- fixed filling factor $c/d = 57\%$
- varying r from 15nm 70nm



Rigorous simulation with Fourier modal method (FMM).

VirtualLab Fusion Technologies



Document Information

title	Parametric Optimization and Tolerance Analysis of Slanted Gratings
document code	GRT.0007
document version	1.2
software edition	VirtualLab Fusion Advanced
software version	2021.1 (Build 1.180)
category	Application Use Case
further reading	<ul style="list-style-type: none">• <u>Analysis of Slanted Gratings for Lightguide Coupling</u>• <u>Optimization of Lightguide Coupling Grating for Single Incidence Direction</u>• <u>Introduction to the Parametric Optimization Document</u>• <u>Advanced Configuration of Slanted Gratings</u>• <u>Configuration of Grating Structures by Using Interfaces</u>• <u>Grating Order Analyzer</u>