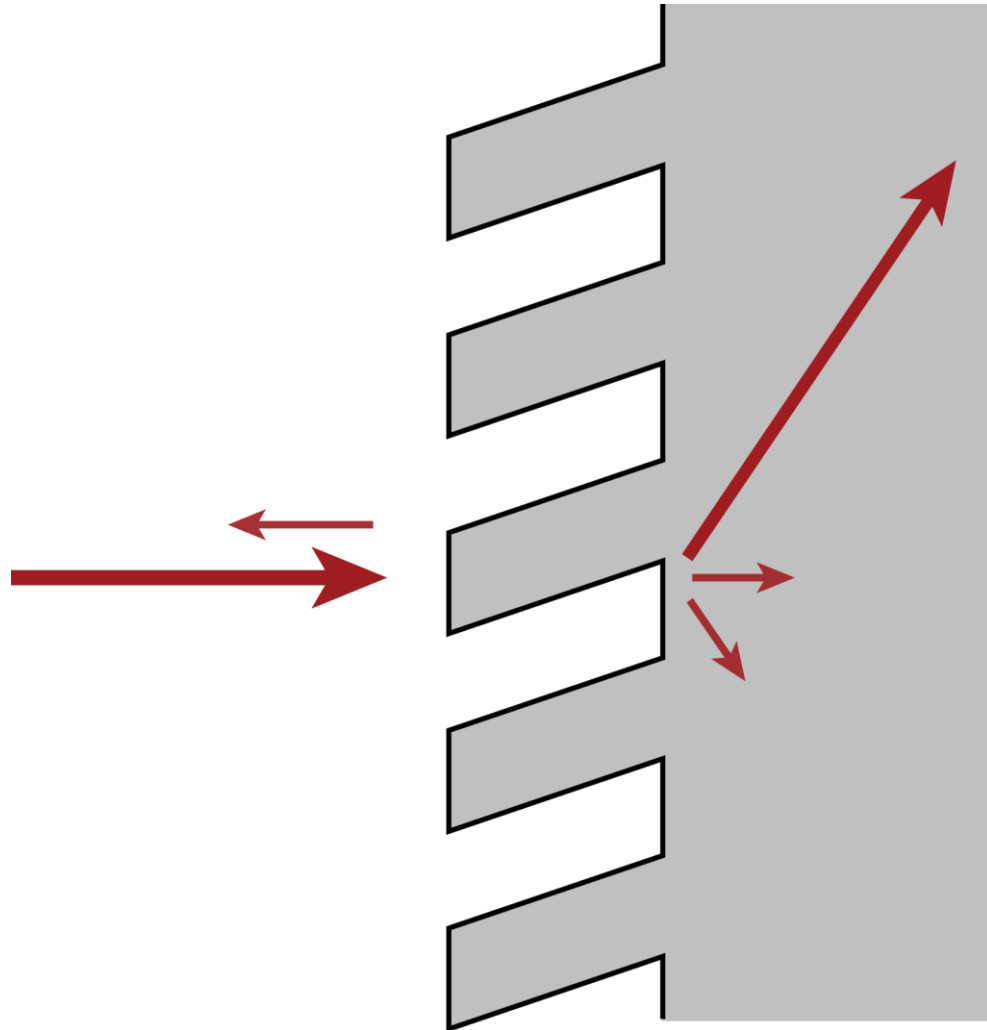


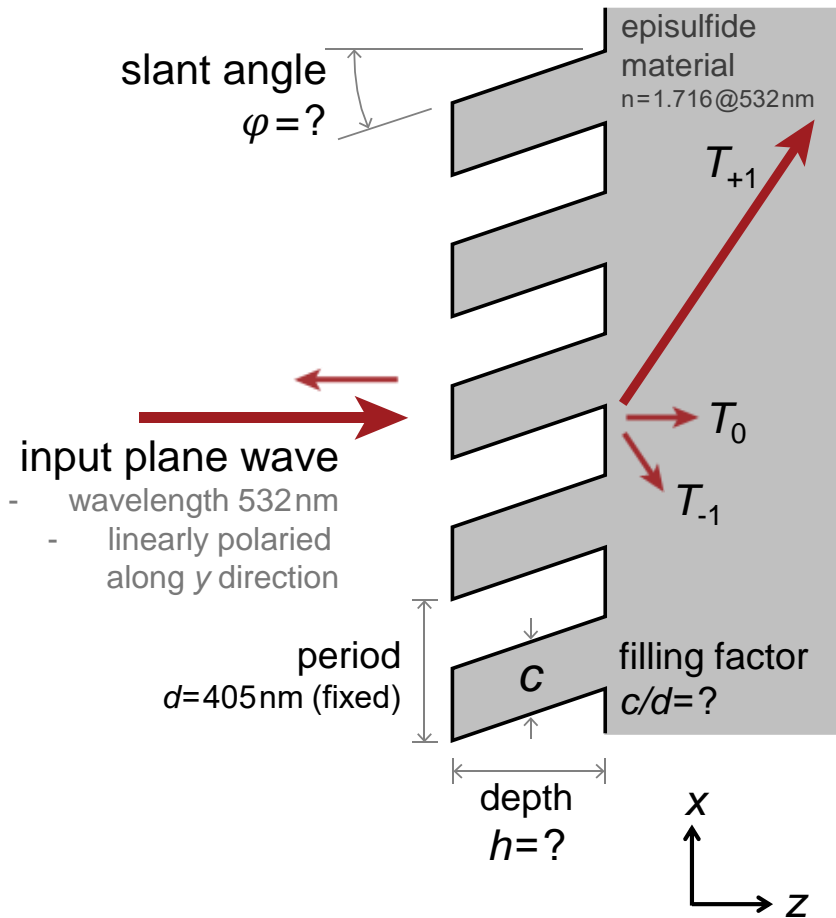
# **Parametric Optimization and Tolerance Analysis of Slanted Gratings**

# Abstract

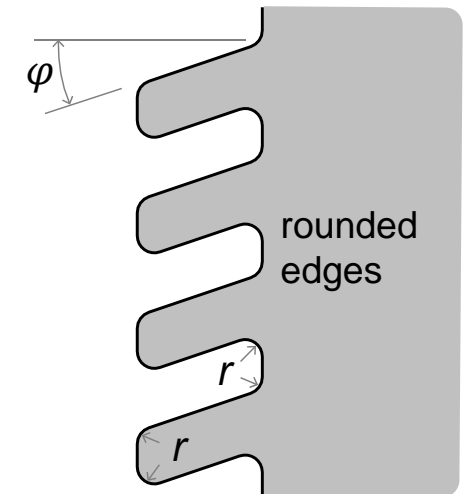
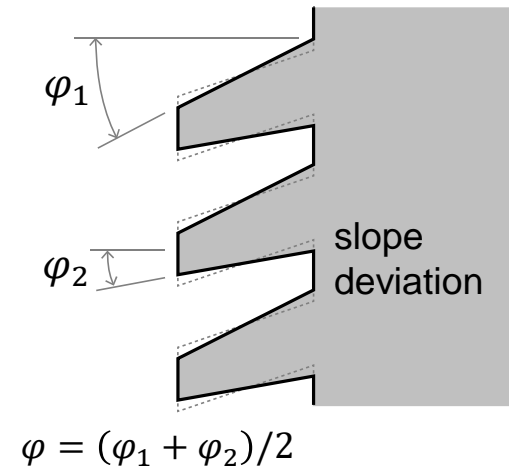


Coupling of light into guiding structures with high efficiency is an important issue for many applications, like backlight, optical interconnector, and near-to-eye displays. For such applications, slanted gratings are well-known for being capable to couple monochromatic light with high efficiency. In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

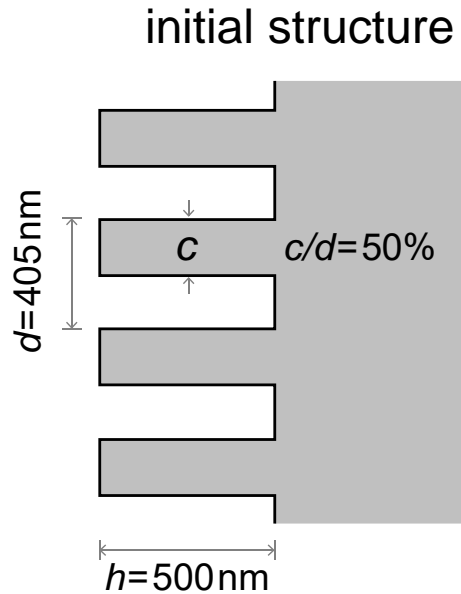


How to optimize the  $T_{+1}$  order diffraction efficiency, by adjusting the slant angle  $\varphi$ , grating depth  $h$ , and filling factor  $c/d$ ?

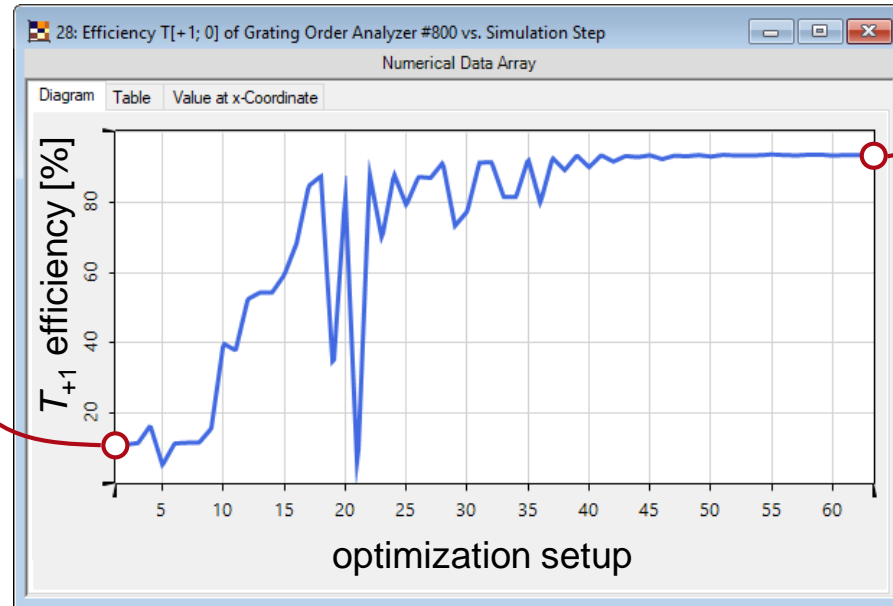


In addition, how to evaluate the grating performance with the slope deviation and the rounded edges due to the fabrication technique taken into account?

# Parametric Optimization for 1<sup>st</sup> Order

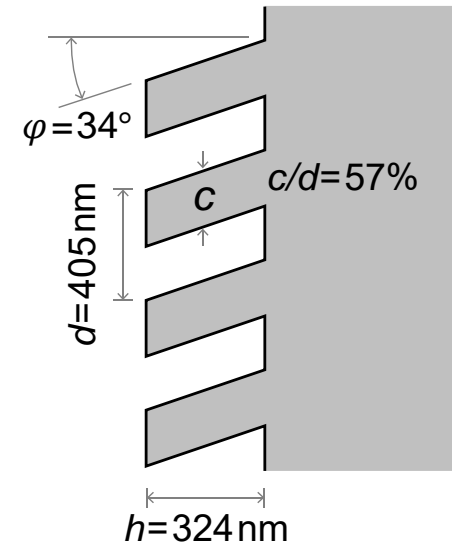


Order	Efficiency
-1	11.551%
0	72.795%
+1	11.551%



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

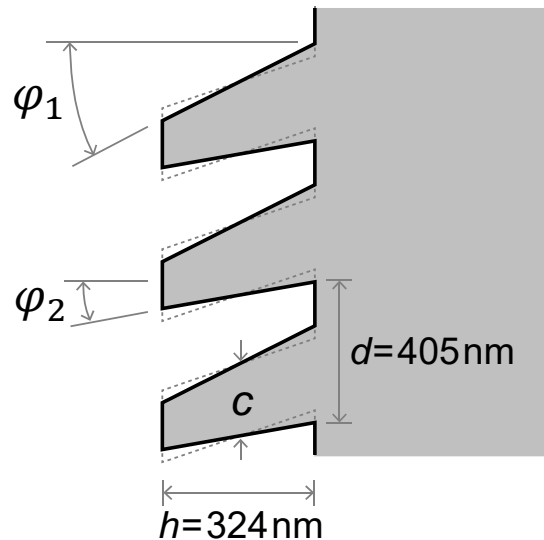
optimized structure



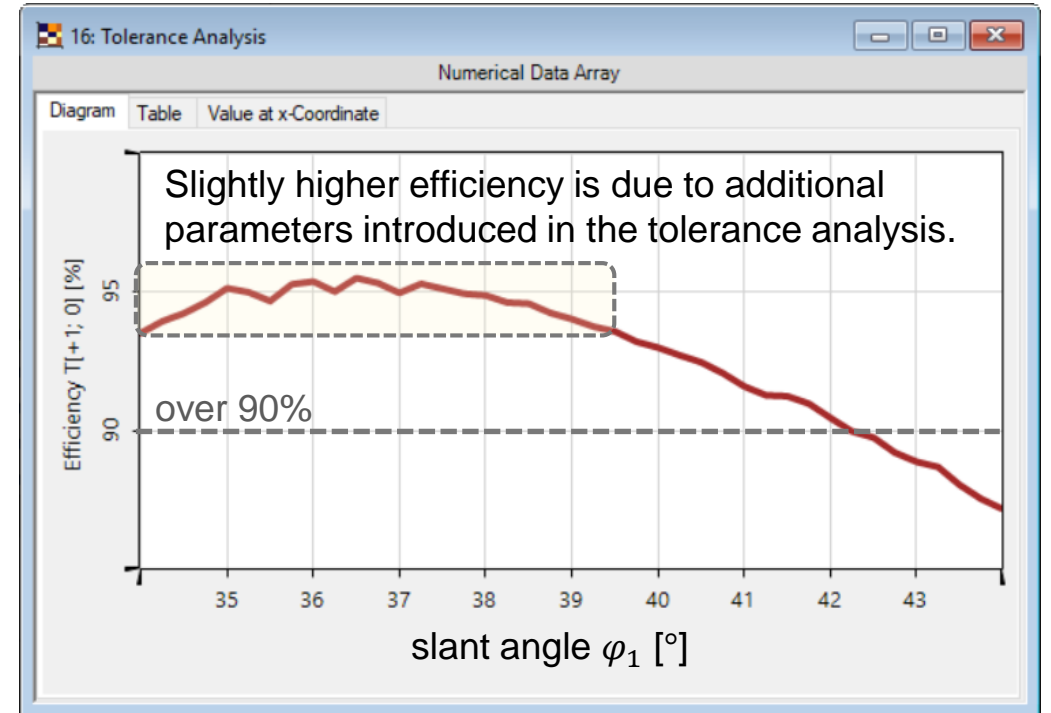
Order	Efficiency
-1	3.257%
0	0.365%
<b>+1</b>	<b>93.659%</b>

# 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.



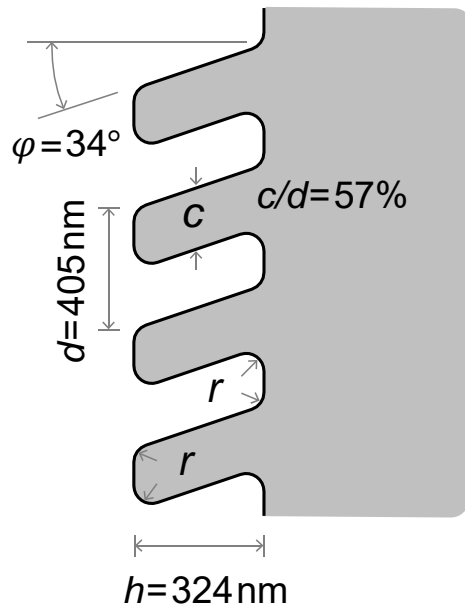
- fixed average slant angle  $\varphi = (\varphi_1 + \varphi_2)/2 = 34^\circ$
- fixed filling factor (average)  $c/d = 57\%$
- varying  $\varphi_1$  from  $34$  to  $44^\circ$



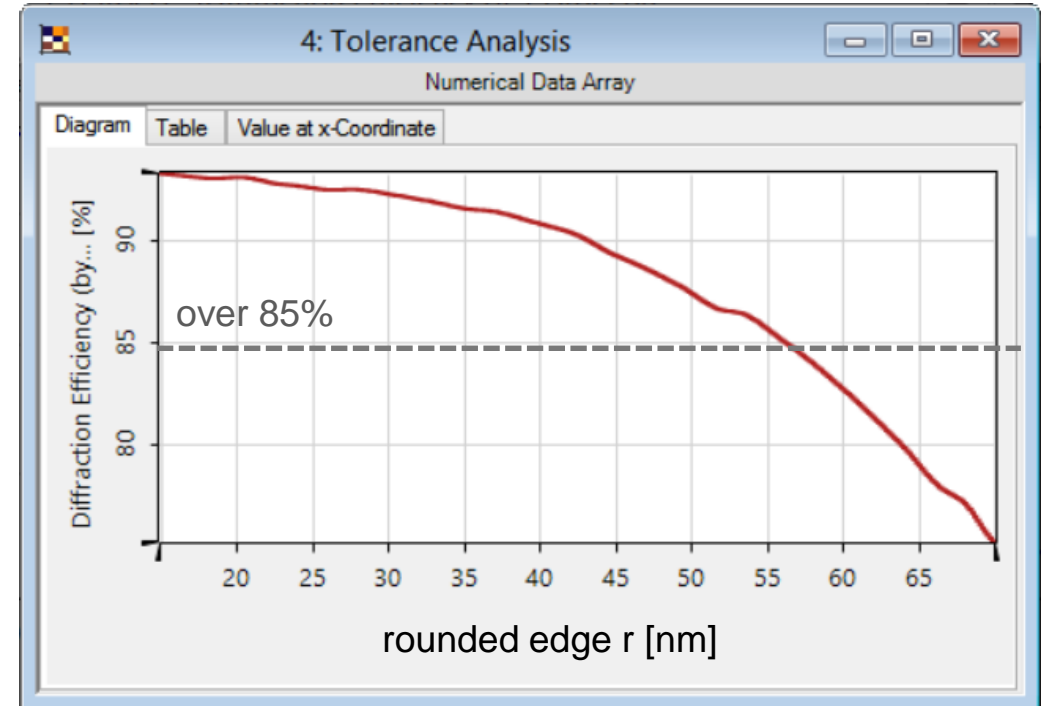
Rigorous simulation with Fourier modal method (FMM), for tolerance analysis over 50 steps, takes 30 seconds.

# 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  $\varphi = 34^\circ$
- 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

The 'Edit Stack' window shows a table of layers:

Index	z-Distance	z-Position	Interface	Subs...
1	0 mm	0 mm	Plane Interface	Slanted
2	324 nm	324 nm	Plane Interface	Vacu...

The 'Edit Slanted Grating Medium' dialog box has the following settings:

- Grating Material: Name: Non-Dispersive Material (n=1.716), Defined by Constant Refractive Index: 1.716, State of Matter: Solid
- Groove Material: Name: Vacuum, Catalog Material: Vacuum, State of Matter: Gas or Vacuum
- Fill Factor: 57%, Refers to: Bottom
- z-Extension: 324 nm
- Slant Angle Left: 34°, Slant Angle Right: 34°
- Apply Coating:

parametric optimization of grating parameters

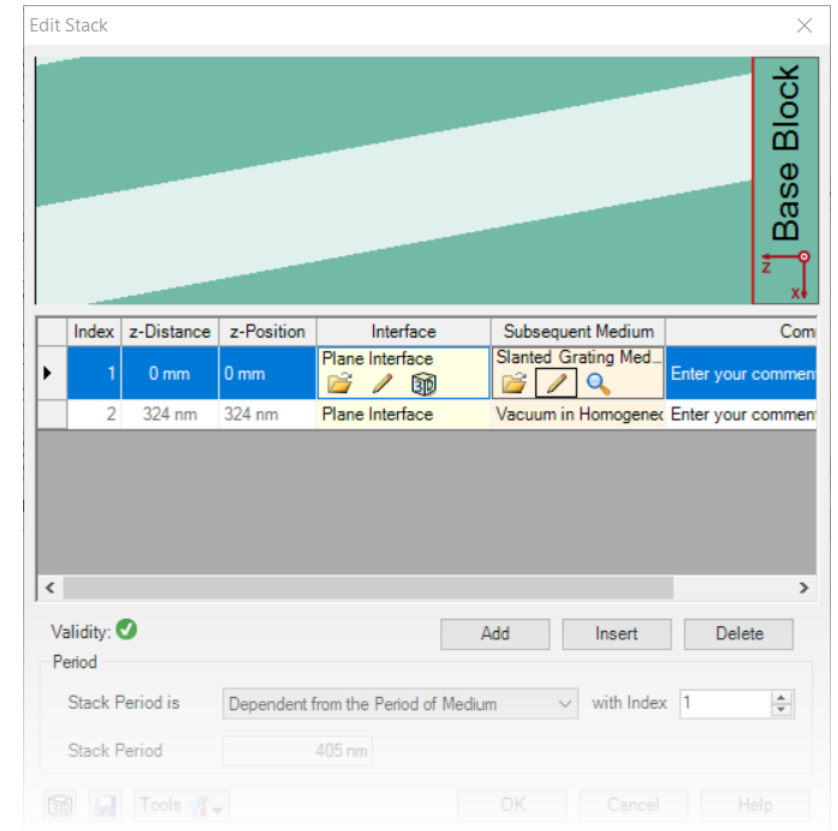
The 'Constraint Specifications' dialog box shows a table of constraints:

Constraint Name	Use	Weight	Constraint Type	Value 1	Value 2	Start Value	Contribution
Stack #1	<input checked="" type="checkbox"/>	1	Range	20 %	80 %	50 %	0 %
Stack #1	<input checked="" type="checkbox"/>	1	Range	200 nm	1 μm	500 nm	0 %
Stack #1	<input checked="" type="checkbox"/>	1	Range	0°	40°	0°	0 %
Efficiency T[+1]	<input checked="" type="checkbox"/>	1	Target Value	100 %		11.551 %	100 %

Target Function Value: 0.78233

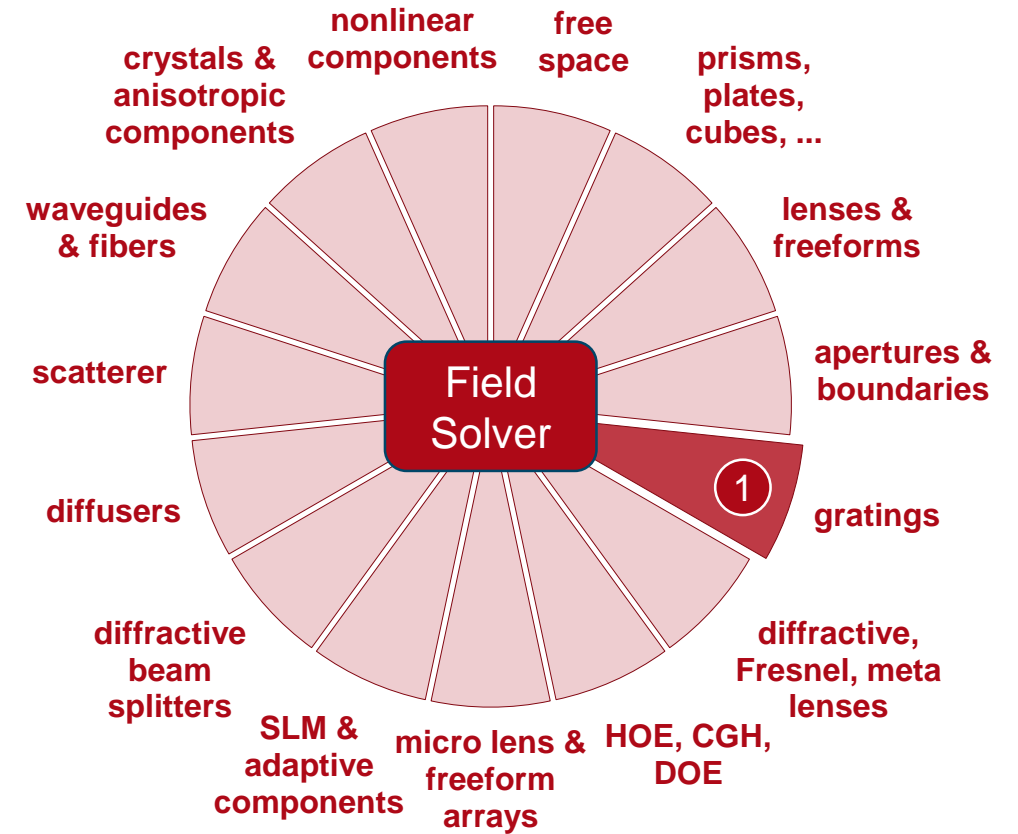
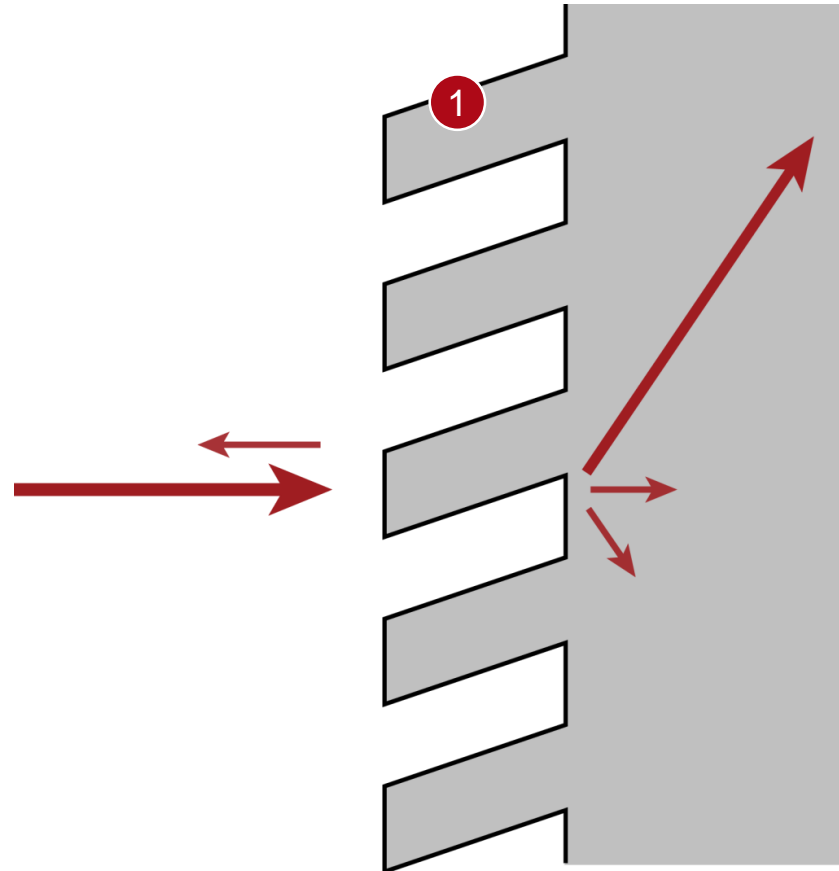
# Workflow in VirtualLab Fusion

- 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

title	Parametric Optimization and Tolerance Analysis of Slanted Gratings
document code	GRT.0007
version	1.2
toolbox(es)	Grating Toolbox
VL version used for simulations	7.6.0.78
category	Application Use Case
further reading	<ul style="list-style-type: none"><li>- <a href="#"><u>Parametric Optimization and Tolerance Analysis of Slanted Gratings</u></a></li><li>- <a href="#"><u>Optimization of Lightguide Coupling Grating for Single Incidence Direction</u></a></li></ul>