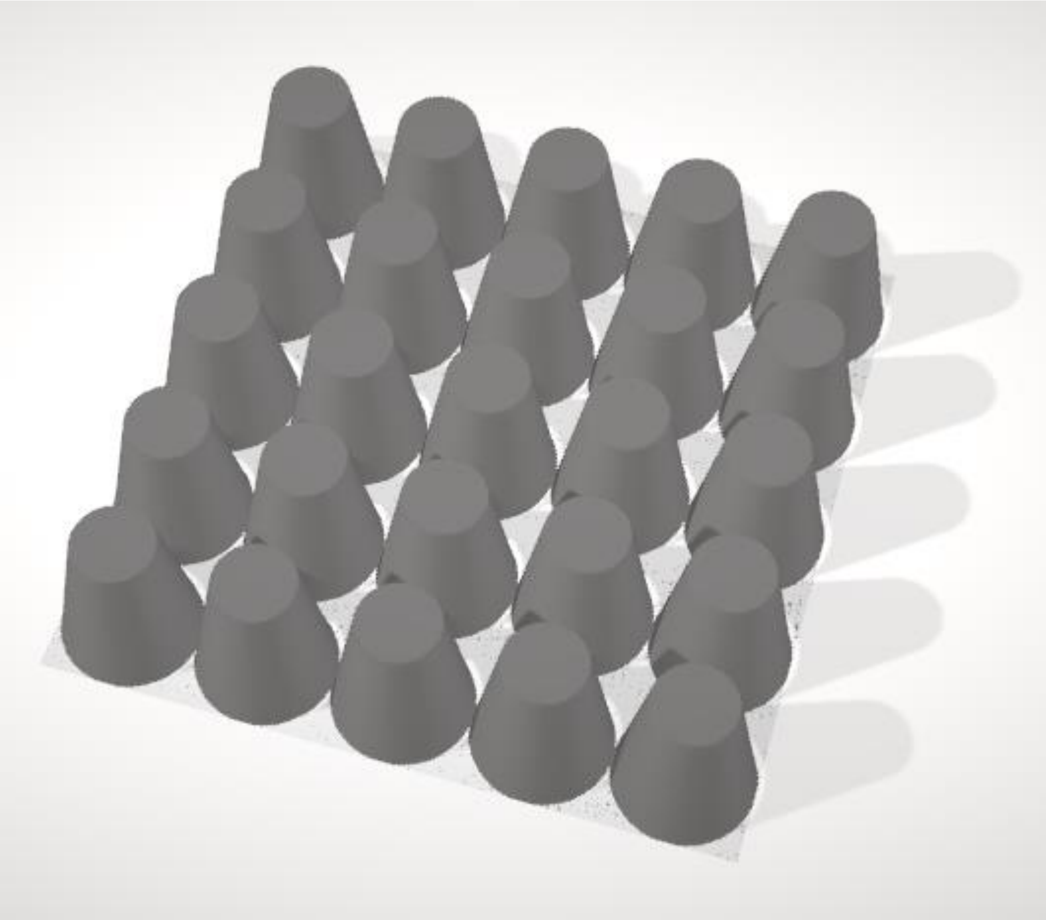
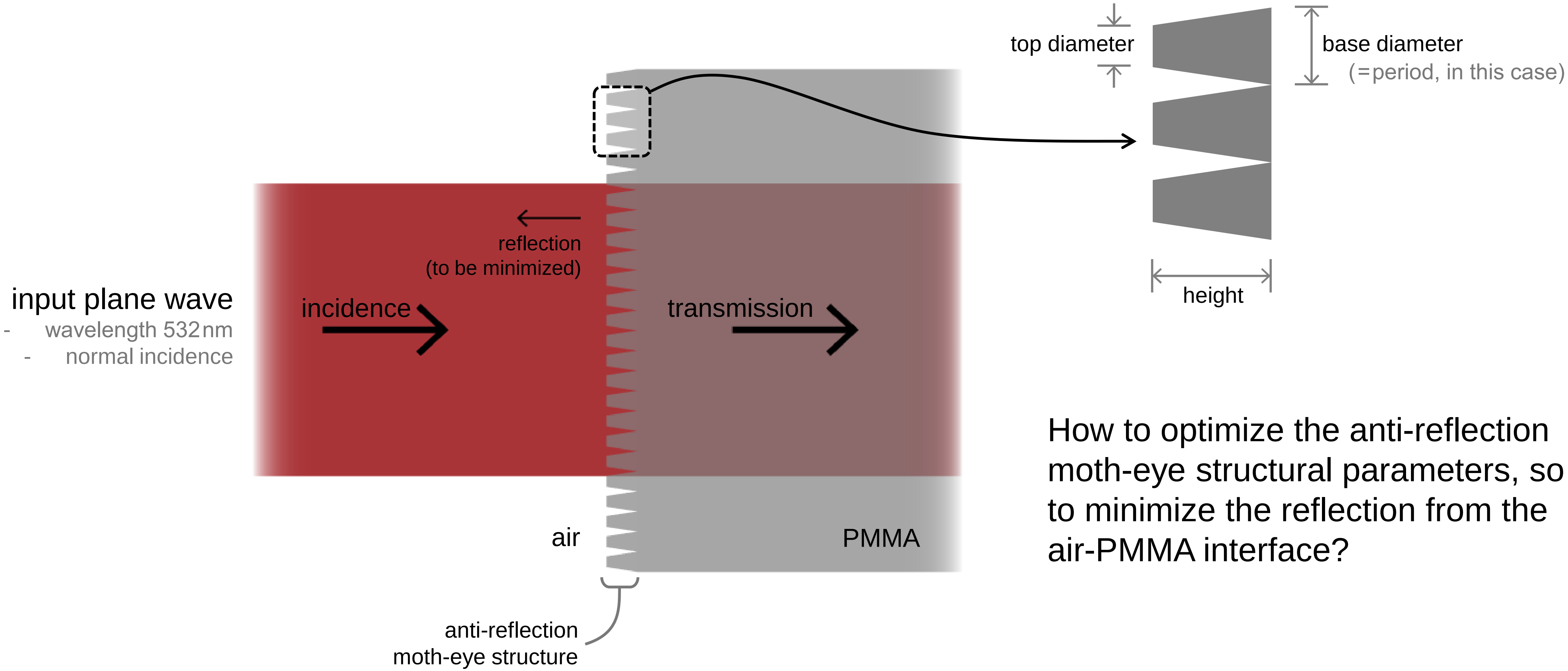
Rigorous Analysis and Design of Anti-Reflective Moth-Eye Structures

Abstract



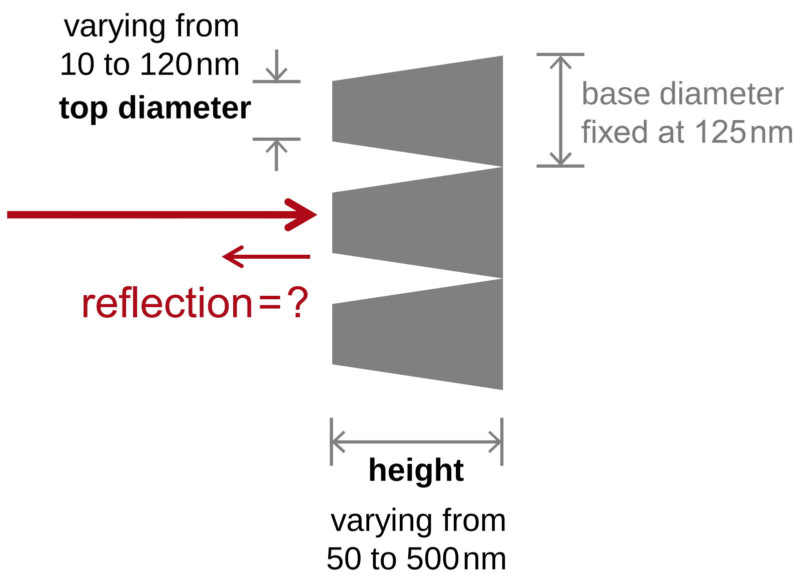
The suppression of reflection at surfaces is of interest for numerous optical applications. One very interesting approach of controlling the reflection at surfaces is the usage of anti-reflective nano- and micro-structures, which are motivated by nature (moth-eye). These structures with feature sizes in the sub-wavelength domain exhibit unique properties concerning wavelength and angular dependency. In this document, the analysis and design of deterministic anti-reflective structures in VirtualLab Fusion is presented.

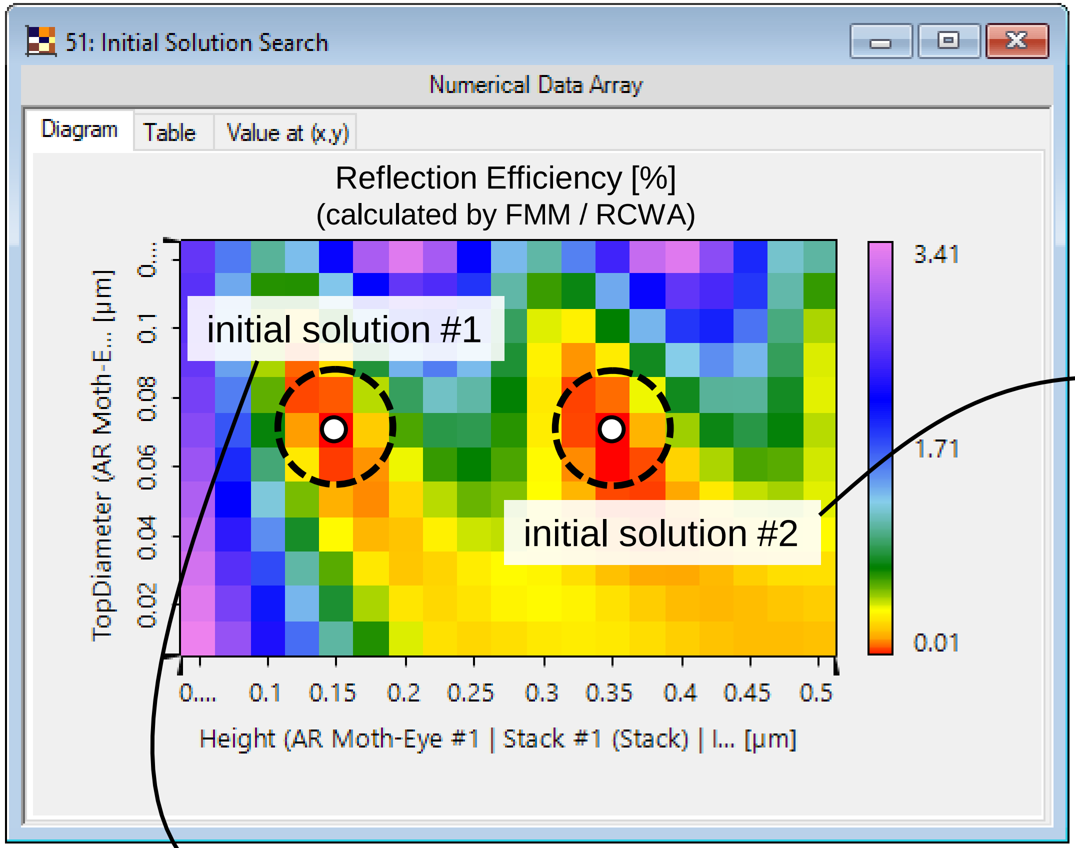
Design Task



How to optimize the anti-reflection moth-eye structural parameters, so to minimize the reflection from the air-PMMA interface?

Scanning over Parameter Space for Initial Solutions

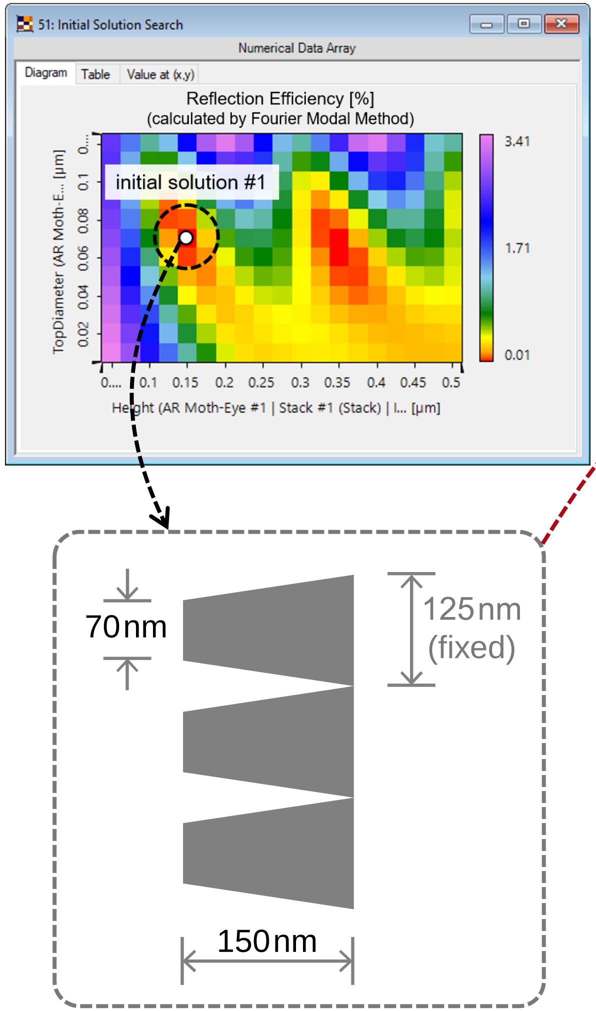




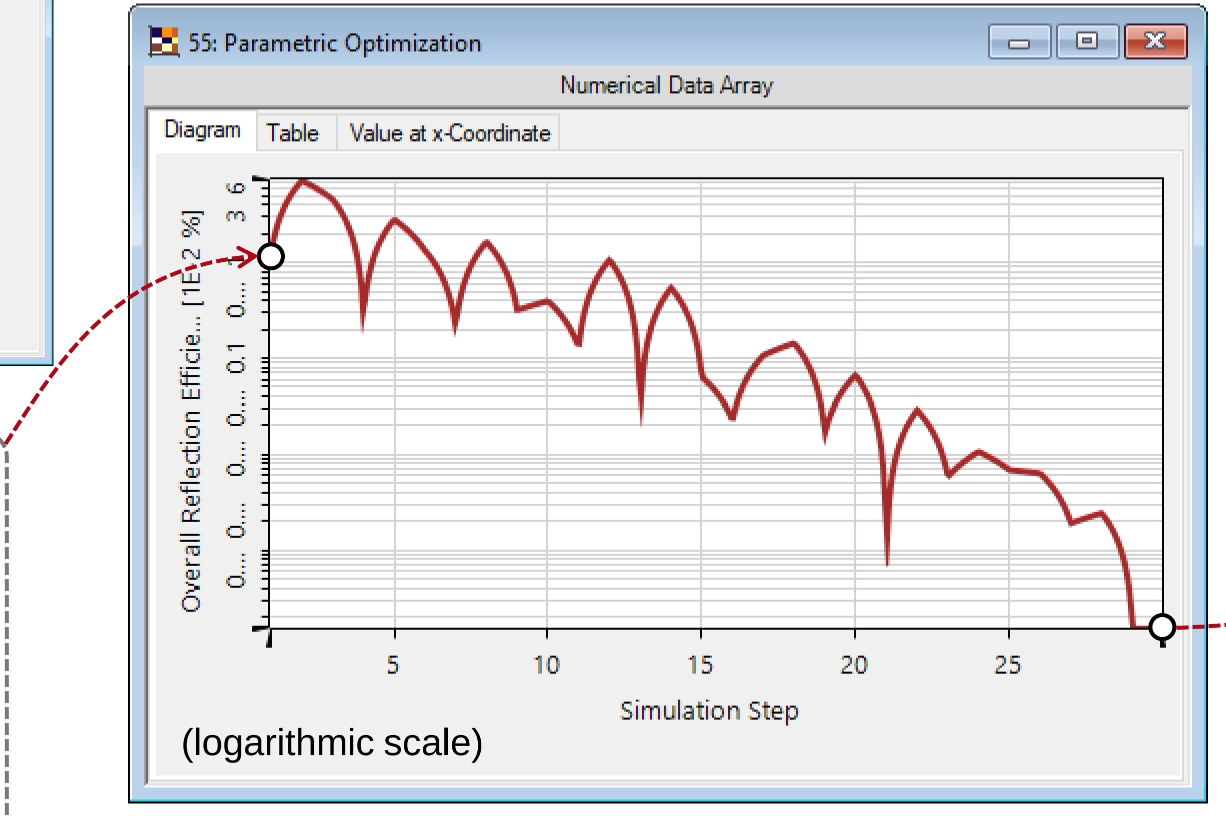
relatively higher aspect ratio and maybe not the first choice for fabrication

relatively smaller aspect ratio and therefore preferable for fabrication

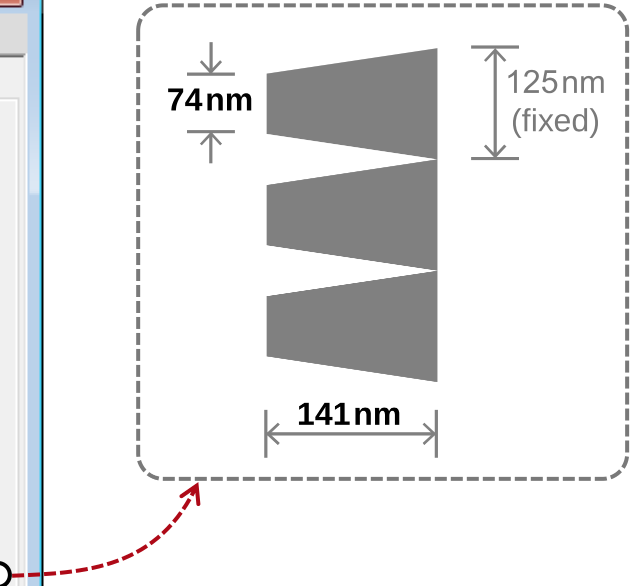
Parametric Optimization for Initial Solution #1



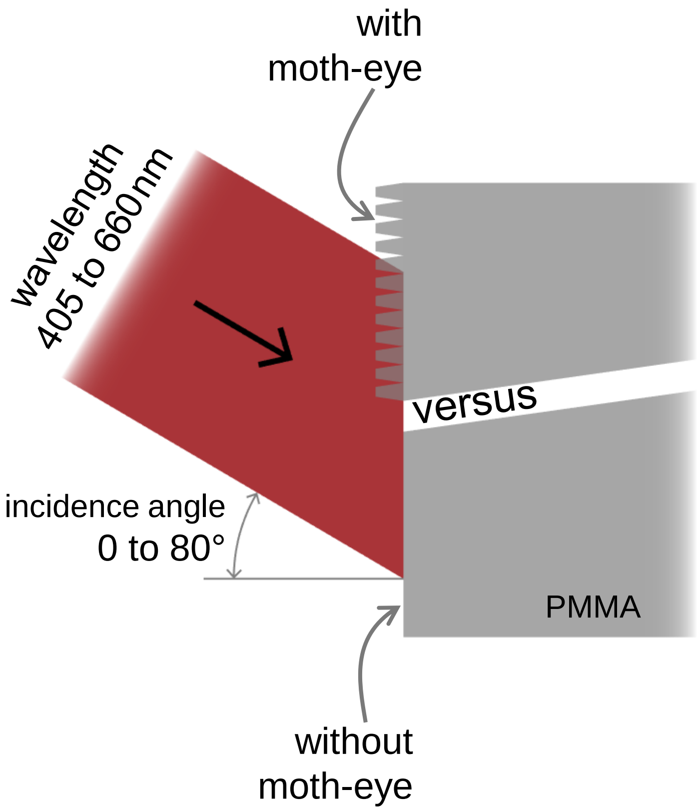
parametric optimization by downhill simplex method
(each iteration calculated by FMM / RCWA)



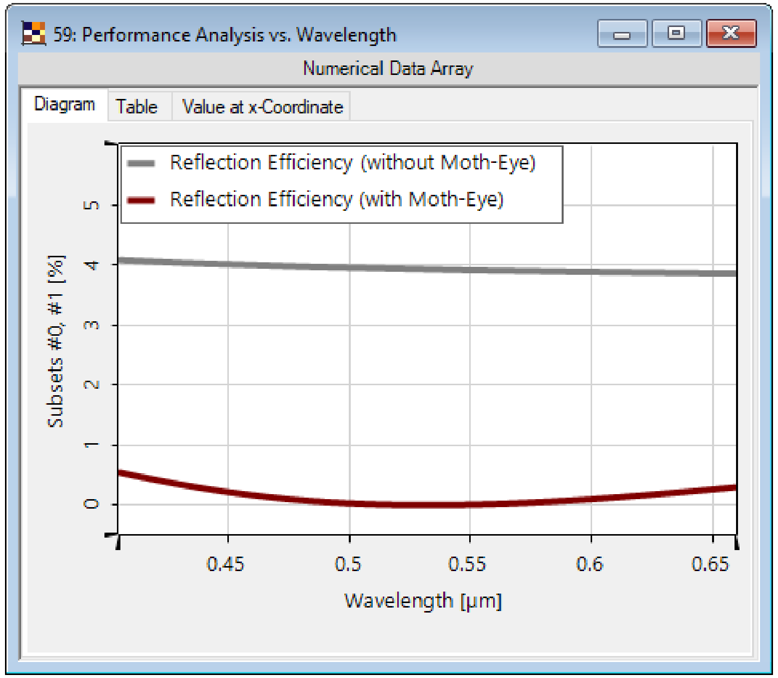
final design #1



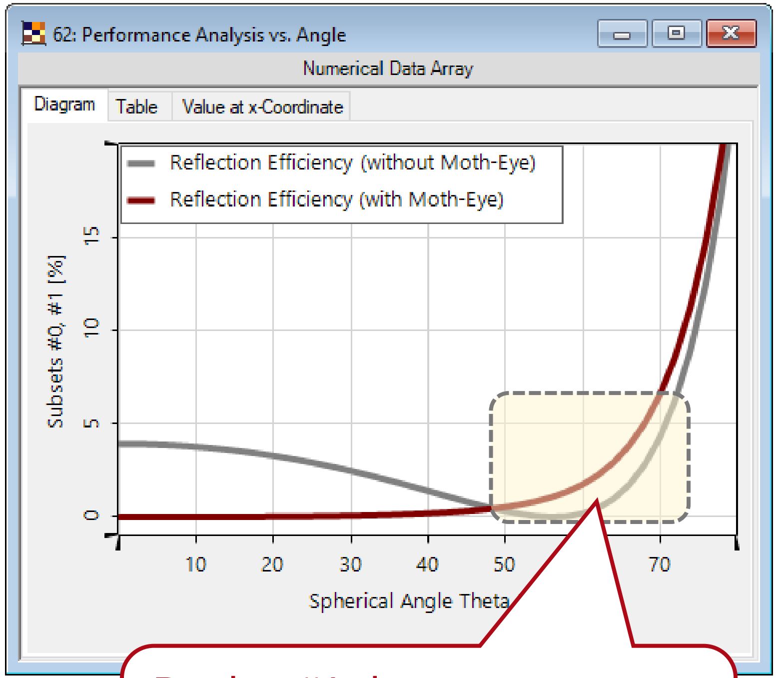
Performance Analysis of Final Design #1



reflection efficiency vs. wavelength
(at normal incidence)

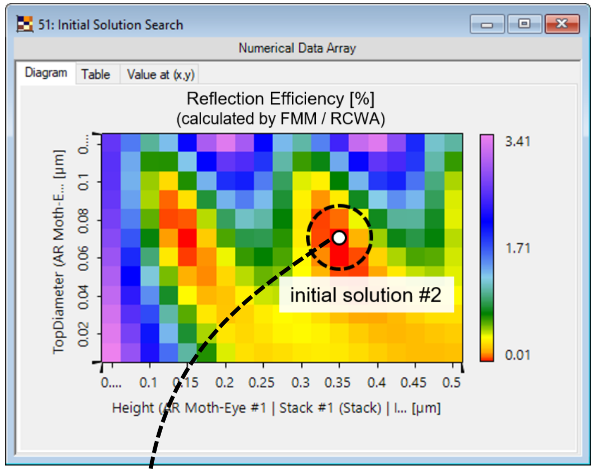


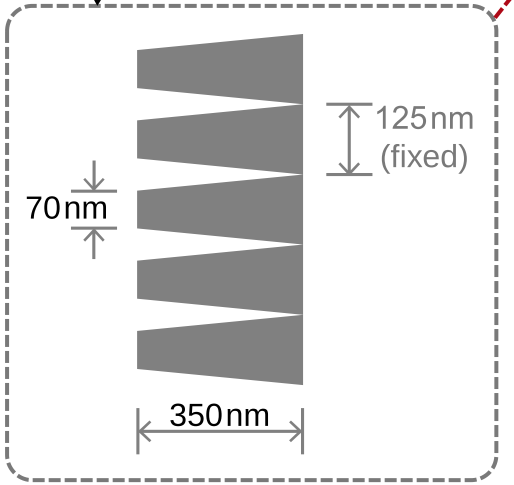
reflection efficiency vs. angle
(at 532 nm wavelength)



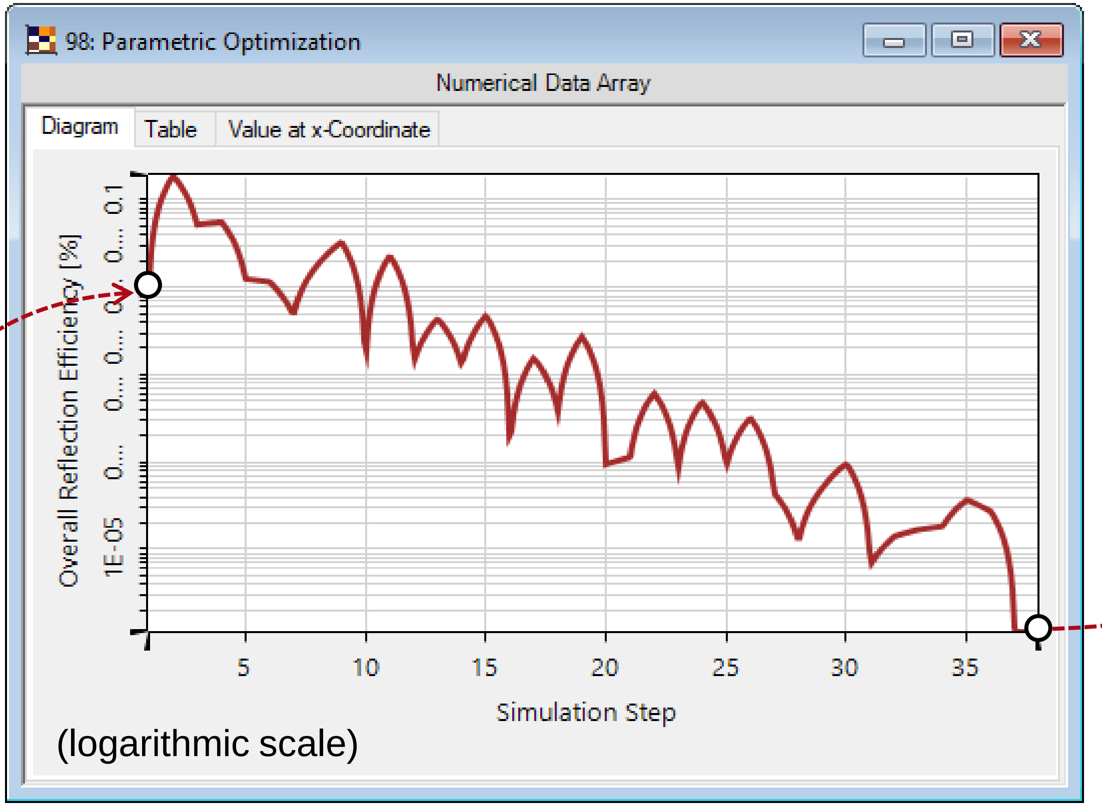
Design #1 does not suppress reflection effectively for incidence over 50°.

Parametric Optimization for Initial Solution #2

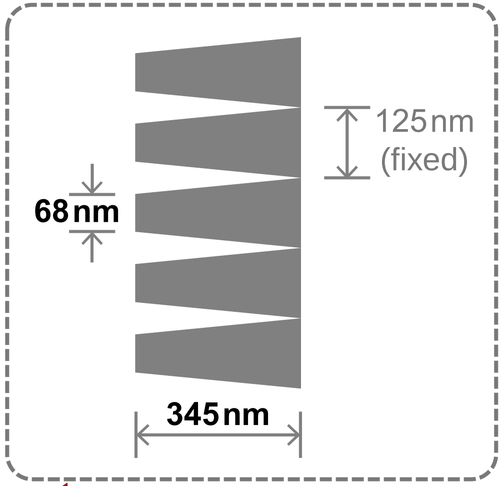




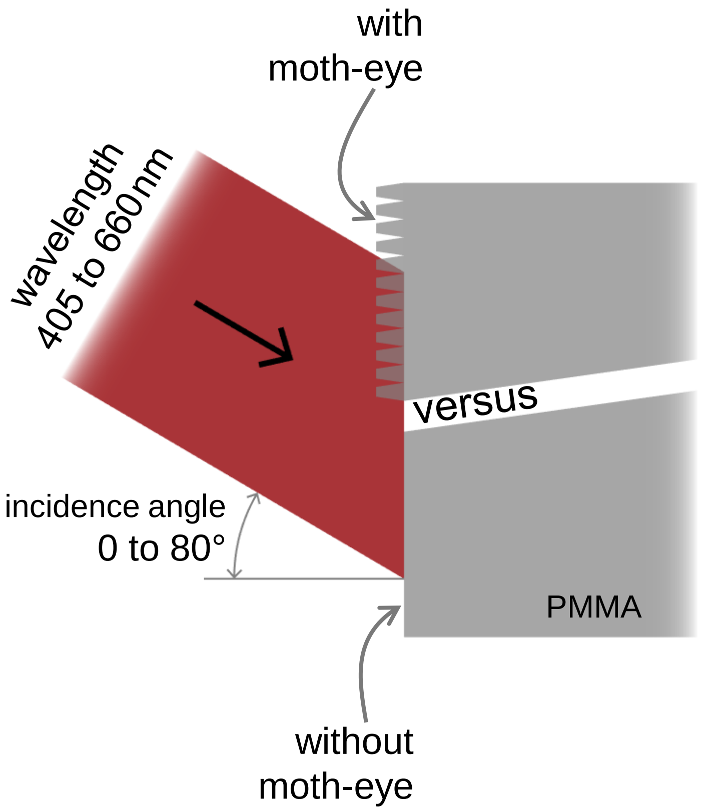
parametric optimization by downhill simplex method
(each iteration calculated by FMM / RCWA)



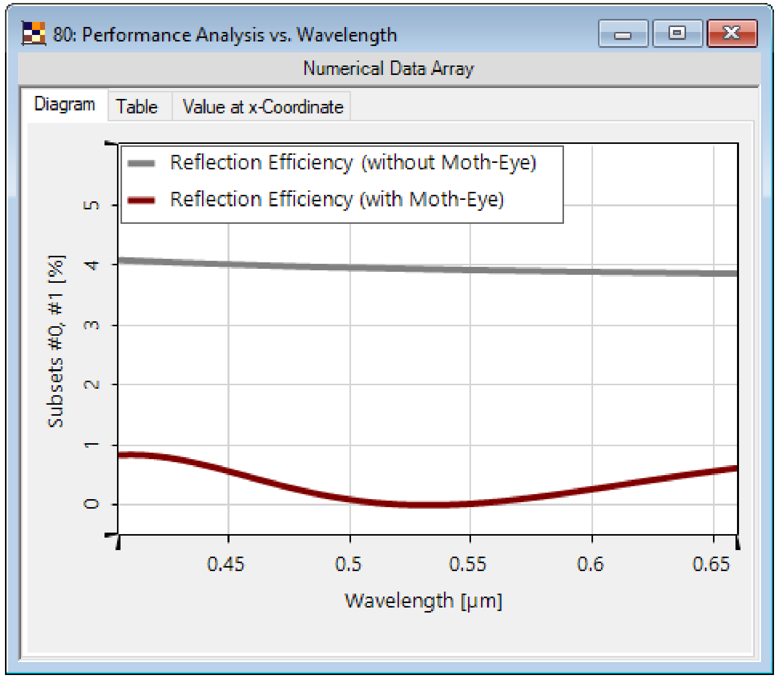
final design #2



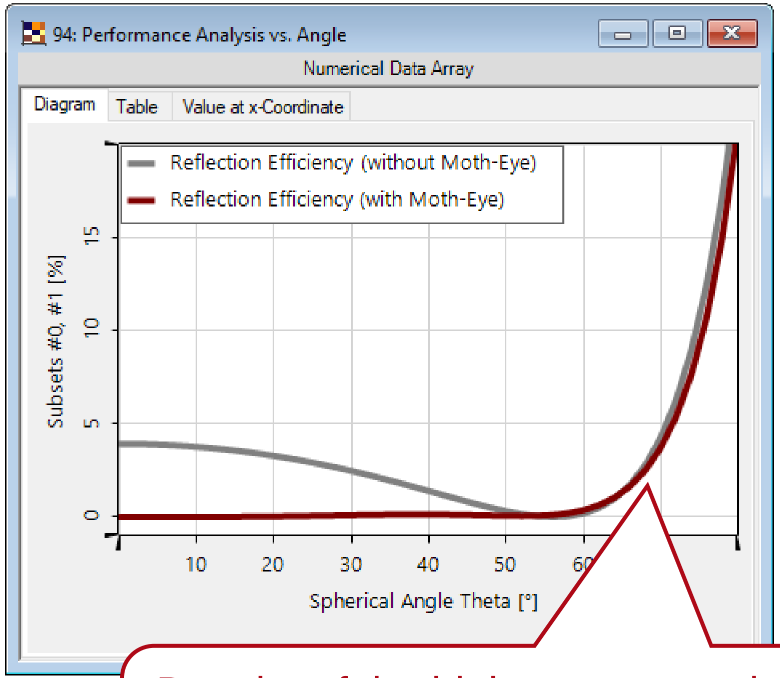
Performance Analysis of Final Design #2



reflection efficiency vs. wavelength
(at normal incidence)



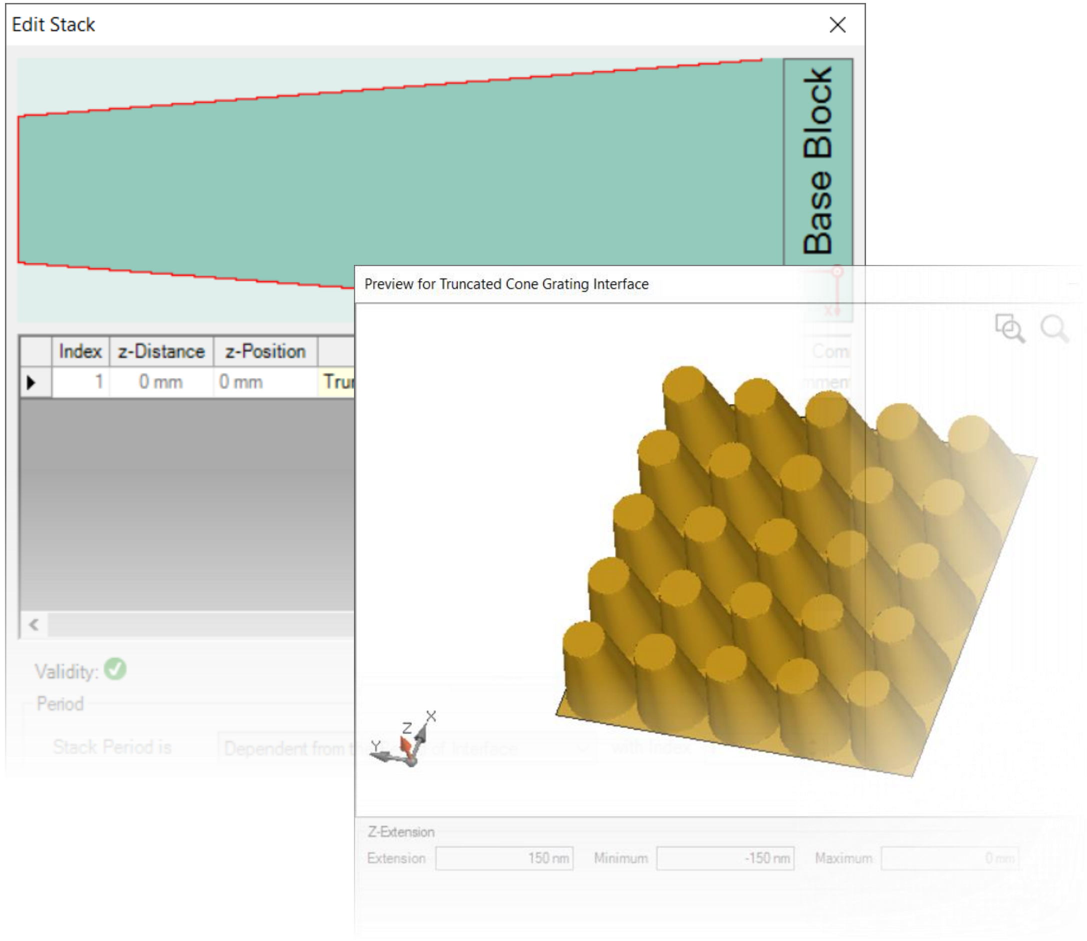
reflection efficiency vs. angle
(at 532 nm wavelength)



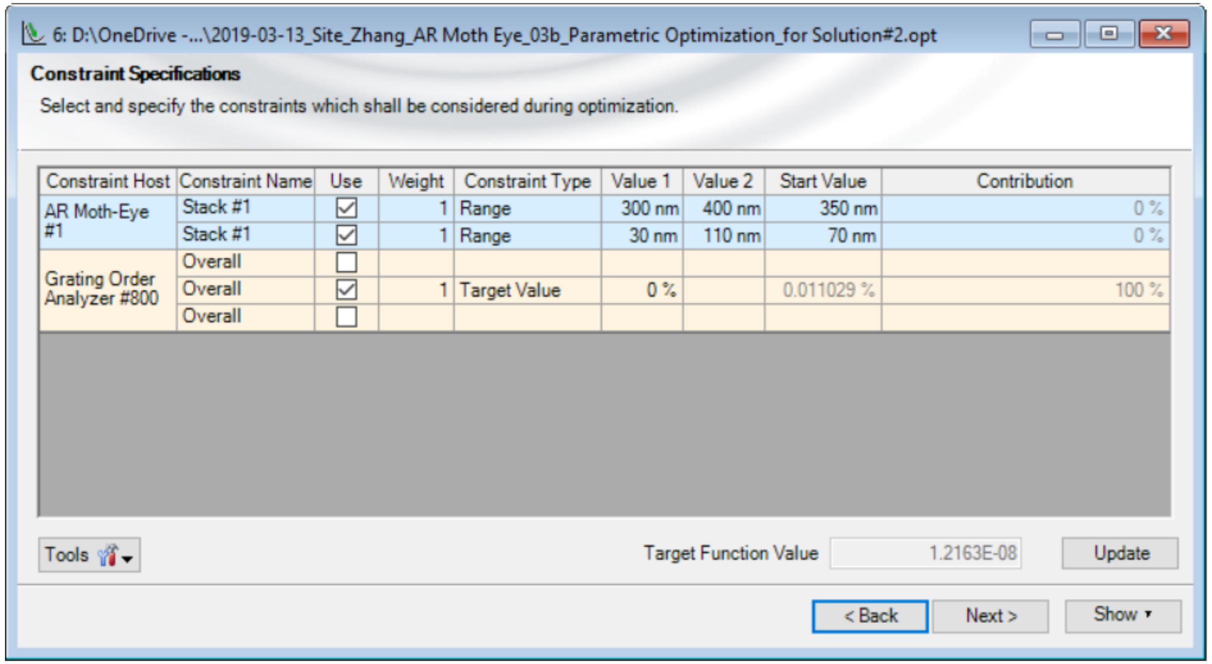
Despite of the higher aspect ratio, design #2 suppresses reflection better for higher incidence angles.

Peek into VirtualLab Fusion

grating structure editor with preview

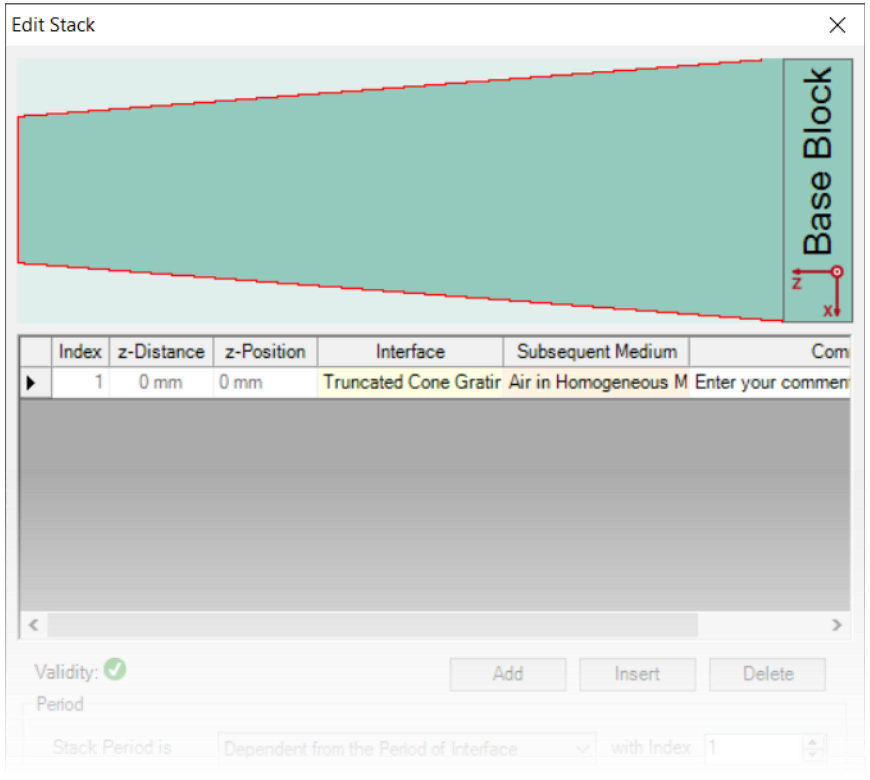


parametric optimization tools
with flexible variable and merit function definition

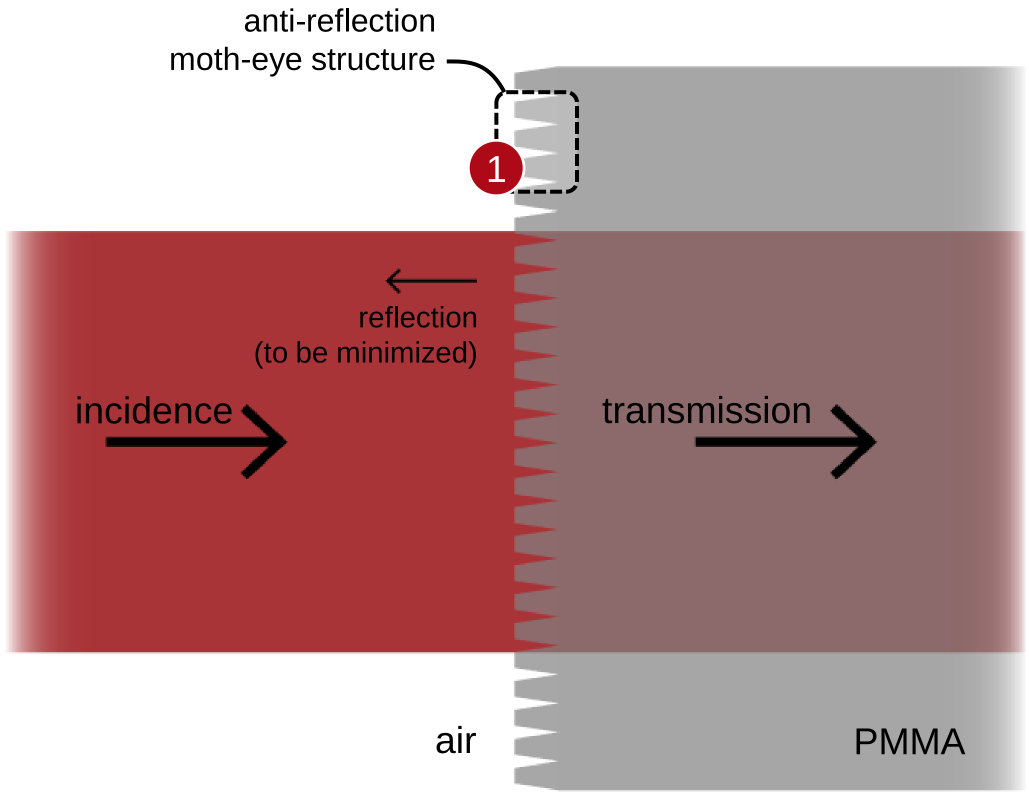


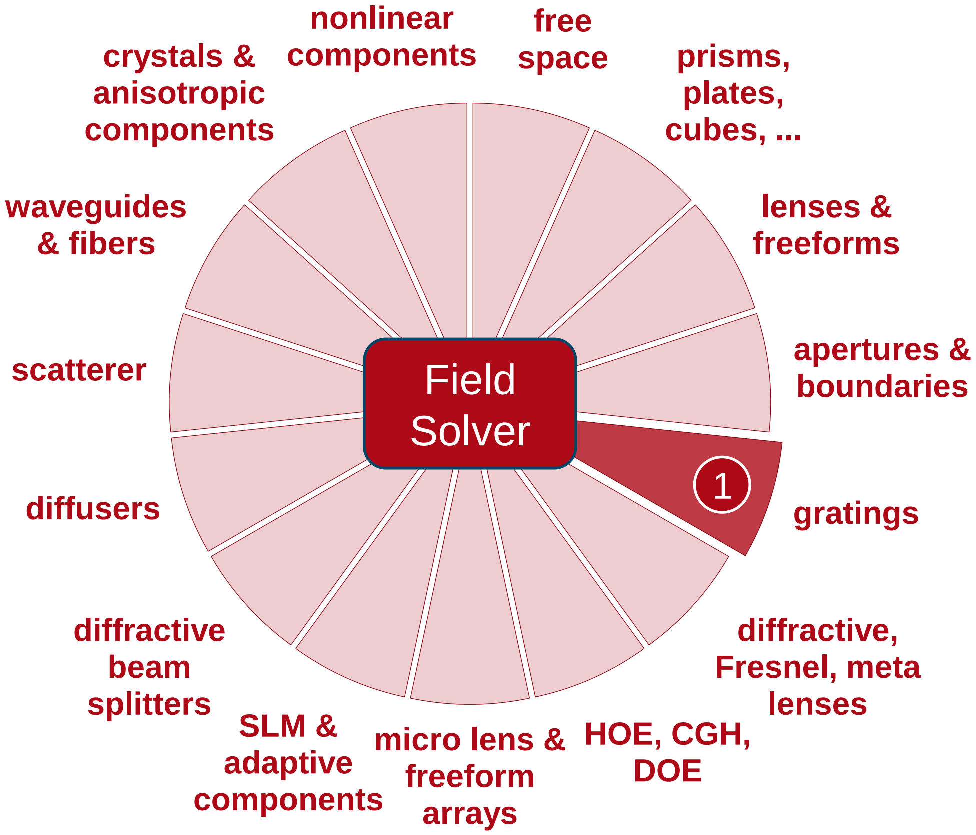
Workflow in VirtualLab Fusion

- Construct grating structure
  - Configuration of Grating Structures by Using Interfaces [Use Case]
  - Configuration of Grating Structures by Using Special Media [Use Case]
- Analyze grating diffraction efficiency
  - Grating Order Analyzer [Use Case]
- Search for initial solutions with Parameter Run
  - Usage of the Parameter Run Document [Use Case]
- Find final design with Parametric Optimization
  - Introduction to the Parametric Optimization Document [Use Case]



VirtualLab Fusion Technologies





Document Information

title	Rigorous Analysis and Design of Anti-Reflective Moth-Eye Structures
document code	GRT.0011
version	1.0
toolbox(es)	Grating Toolbox
VL version used for simulations	7.4.0.49
category	Application Use Case
further reading	- Parametric Optimization and Tolerance Analysis of Slanted Gratings - Optimization of Lightguide Coupling Grating for Single Incidence Direction