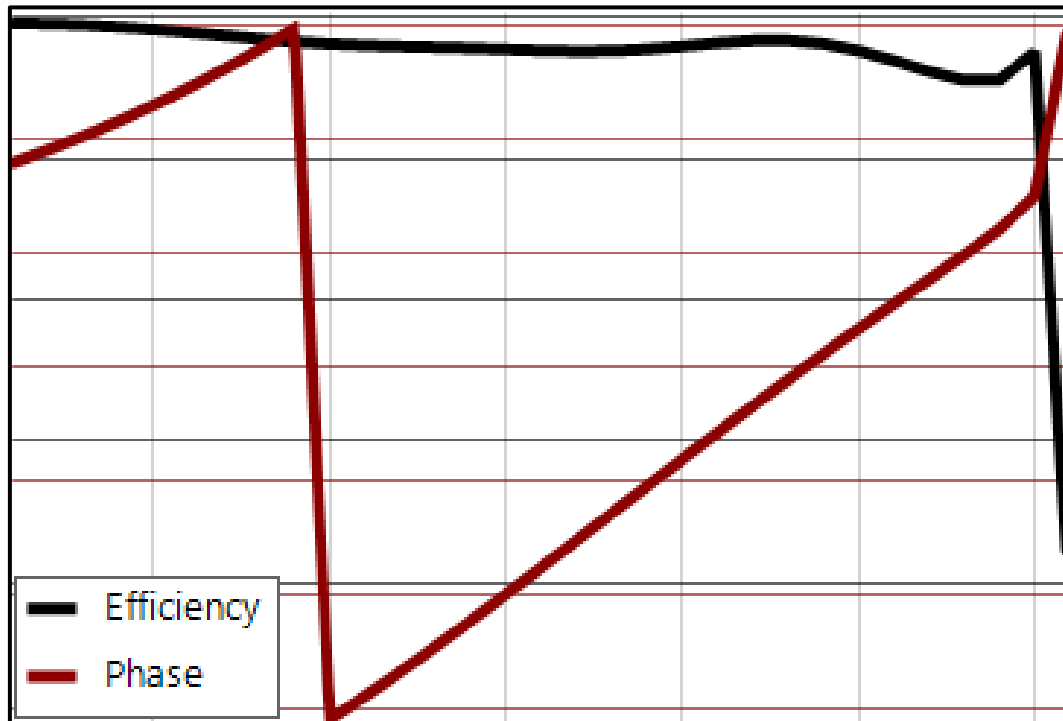


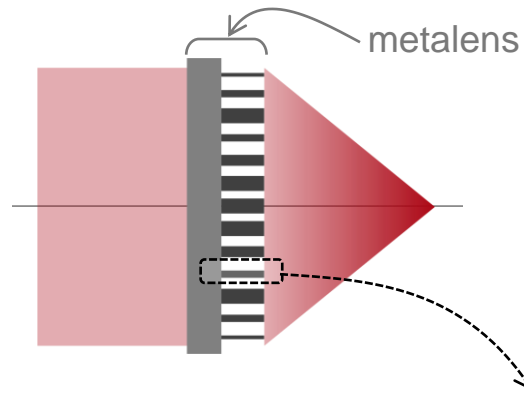
Rigorous Analysis of Nanopillar Metasurface Building Block

Abstract



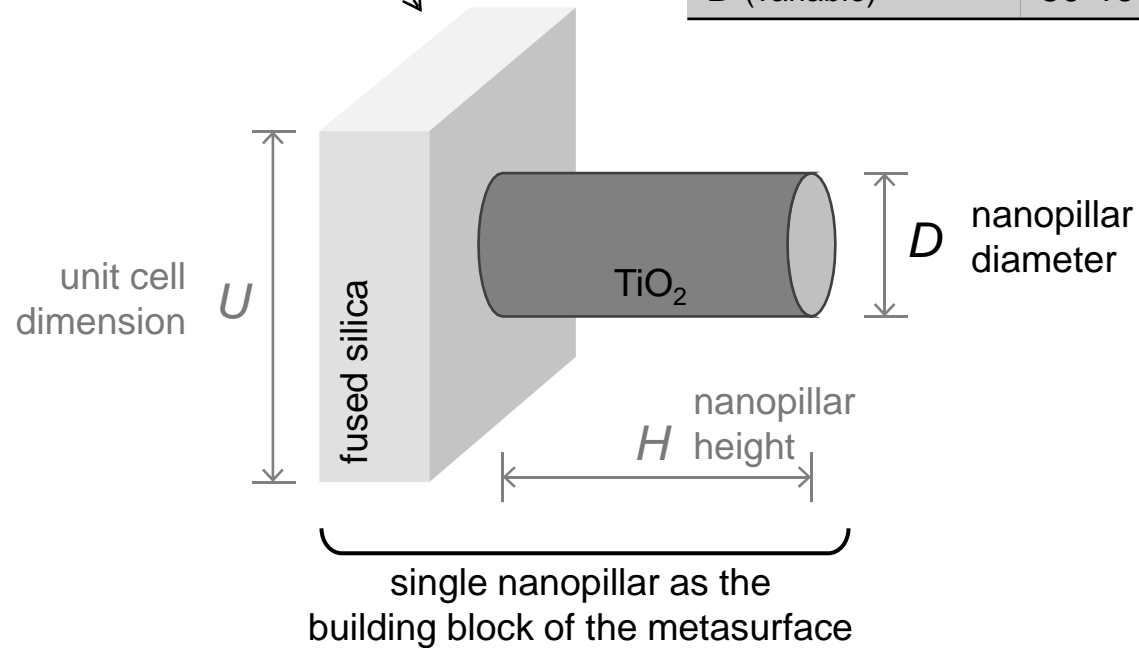
With advanced fabrication techniques, people have demonstrated metalenses for visible wavelengths with high numerical apertures. A metalens is usually constructed with spatially varying nanostructures as its building blocks. In this example, we analyze the nanopillar structure which is used to compose polarization-insensitive metalenses. With the Fourier modal method (FMM, also known as RCWA), the amplitude and phase transmission of such nanopillars are calculated rigorously.

Modeling Task



parameters from M. Khorasaninejad,
Nano Lett. 2016, 16, 7229-7234

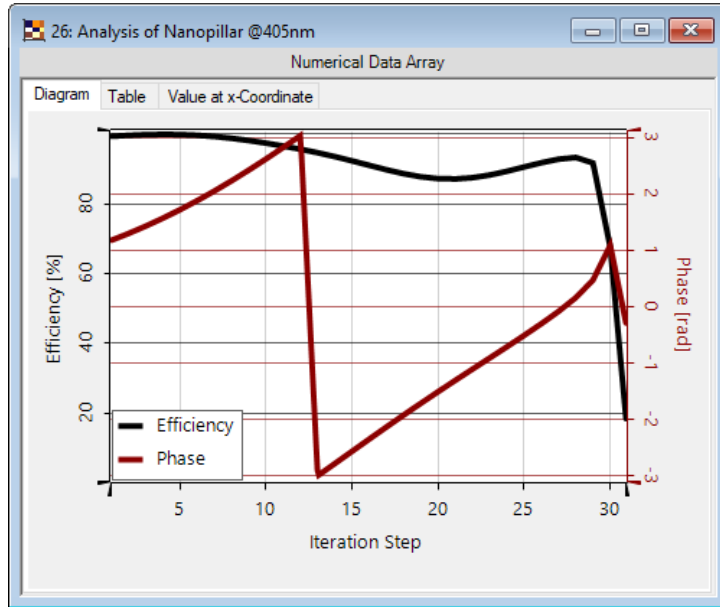
Nanopillars No.	#1 (405nm)	#2 (532nm)	#3 (660nm)
U	180nm	250nm	350nm
H	400nm	600nm	600nm
D (variable)	80-155nm	100-220nm	100-320nm



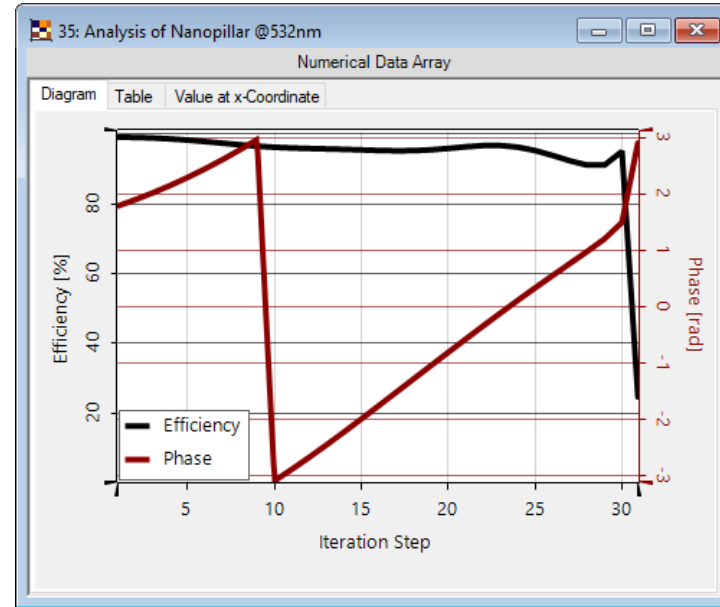
By varying the nanopillar diameter, the metasurface building block is supposed to have phase modulation covering 2π . How to evaluate such nanopillar structure rigorously?

Nanopillar Analysis vs. Pillar Diameter

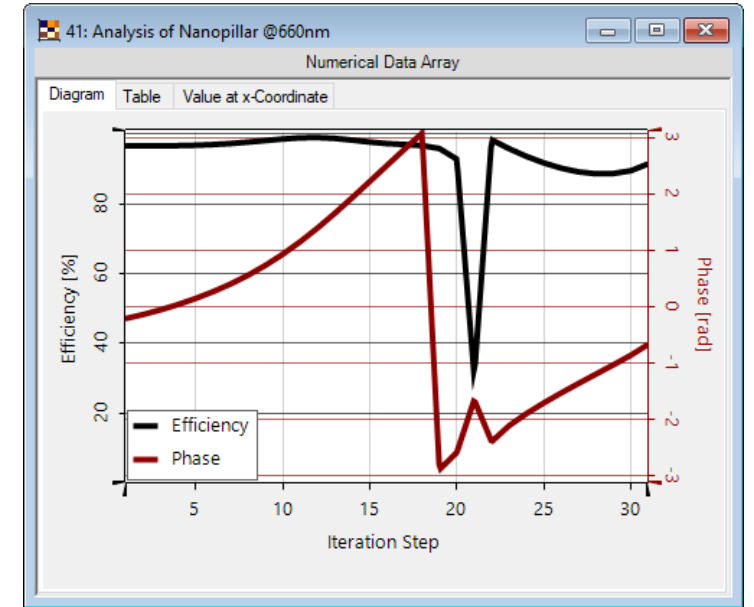
nanopillar #1



nanopillar #2



nanopillar #3



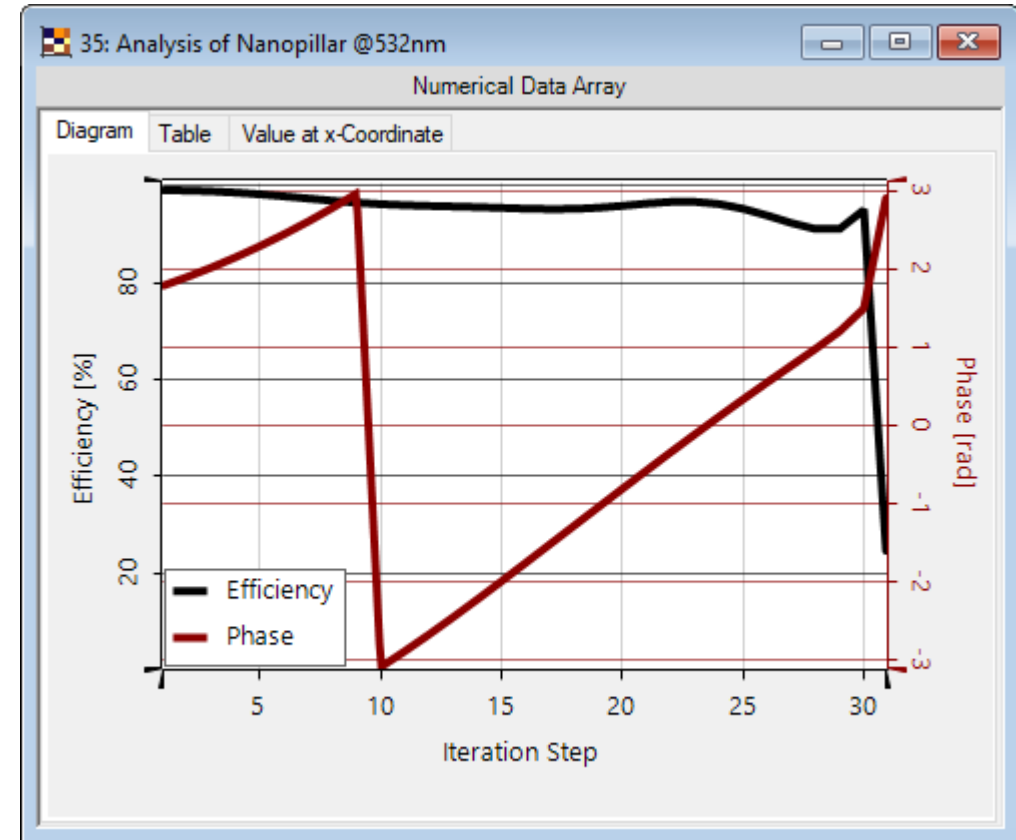
Nanopillars No.	#1 (405nm)	#2 (532nm)	#3 (660nm)
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<i>D</i> (variable)	80-155nm	100-220nm	100-320nm

Nanopillar Analysis vs. Pillar Diameter

- The phase modulation covers 2π range, and it changes almost linearly with pillar diameter, which enables convenient phase control.
- The transmission efficiency remains above 90% for varying pillar diameter over the design range.

Nanopillars No.	#1 (405nm)	#2 (532nm)	#3 (660nm)
<i>U</i>	180nm	250nm	350nm
<i>H</i>	400nm	600nm	600nm
<i>D</i> (variable)	80-155nm	100-220nm	100-320nm

nanopillar #2



Appendix: Refractive Index of TiO₂

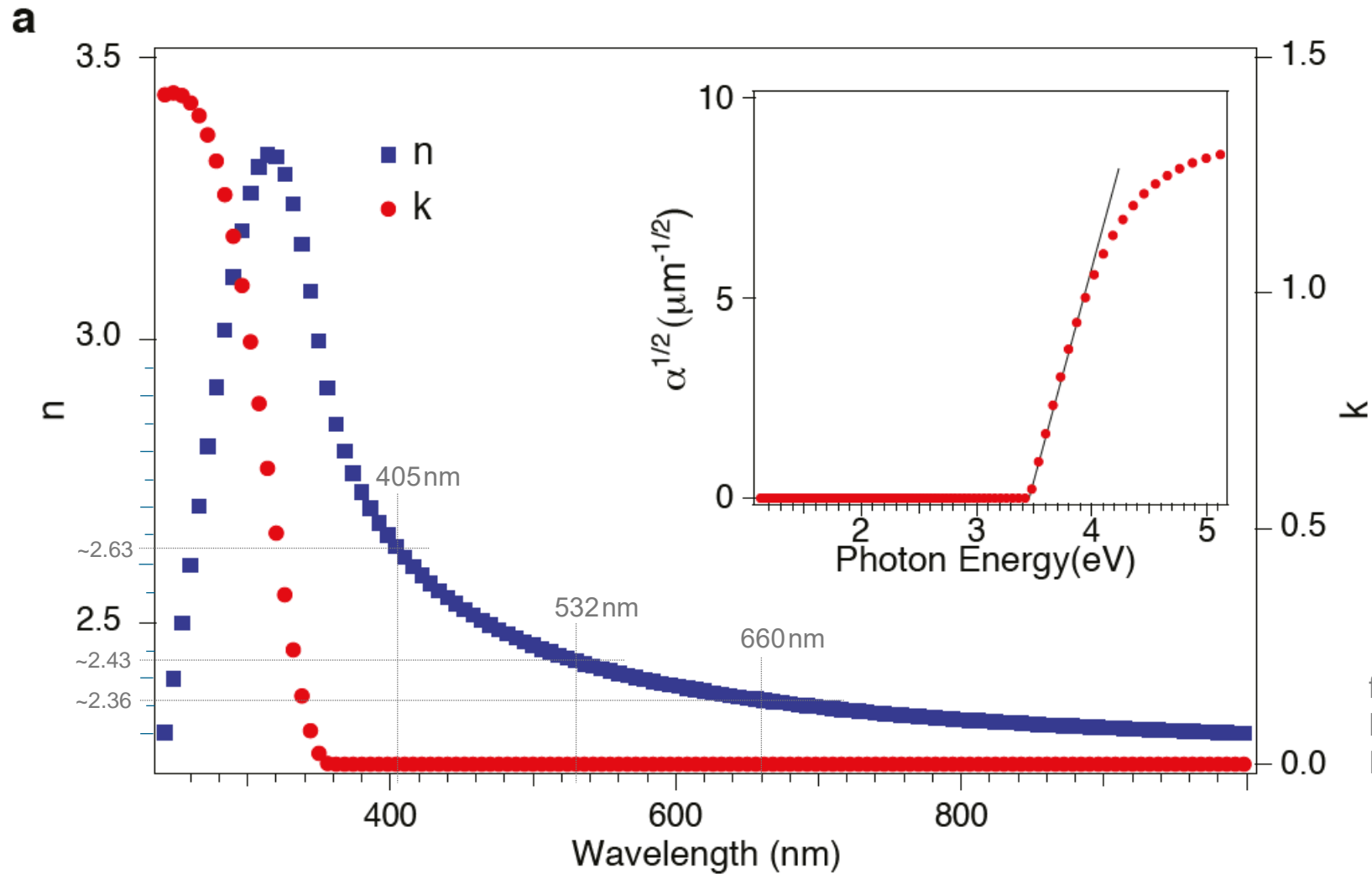


figure from R. C. Devlin, M. Khorasaninejad, W.-T. Chen, J. Oh, F. Capasso, arXiv:1603.02735 (2016)

Peek into VirtualLab Fusion

flexible pillar structure definition

The screenshot displays the 'Edit Stack' window with a table of layers and the 'Source Code Editor' window showing a C# script for defining a pillar structure.

Index	z-Distance	z-Position	Interface	Subsequent Medium	Comments
1	0 mm	0 mm	Plane Interface	Non-Dispersive Materi	Enter your comment
2	600 nm	600 nm	Programmable Interfac	Air in Homogeneous M	Enter your comment

```
1 double height = 0.0;
2
3 // convert to radial distance
4 double rho = Math.Sqrt(x * x + y * y);
5 if(rho <= 0.5 * Diameter)
6 {
7     height = Height;
8 }
9
10 return height;
```

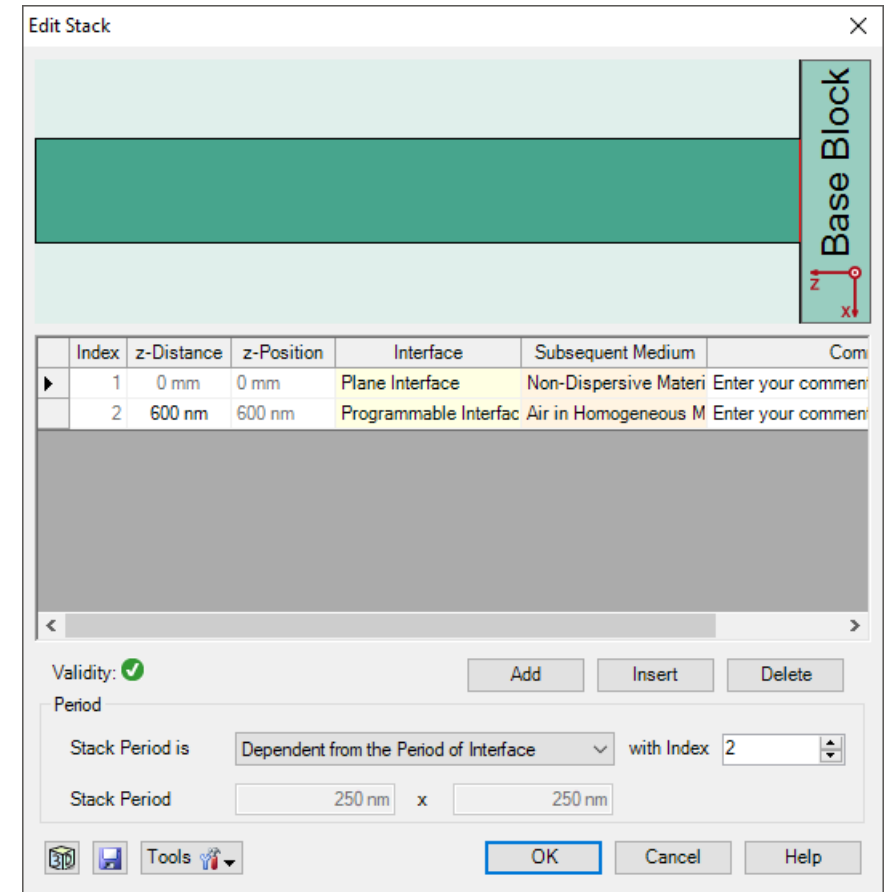
customized structure via programming

The screenshot displays the 'Edit Grating Order Analyzer' window and a 'Numerical Data Array' plot showing Amplitude and Phase versus Diameter.

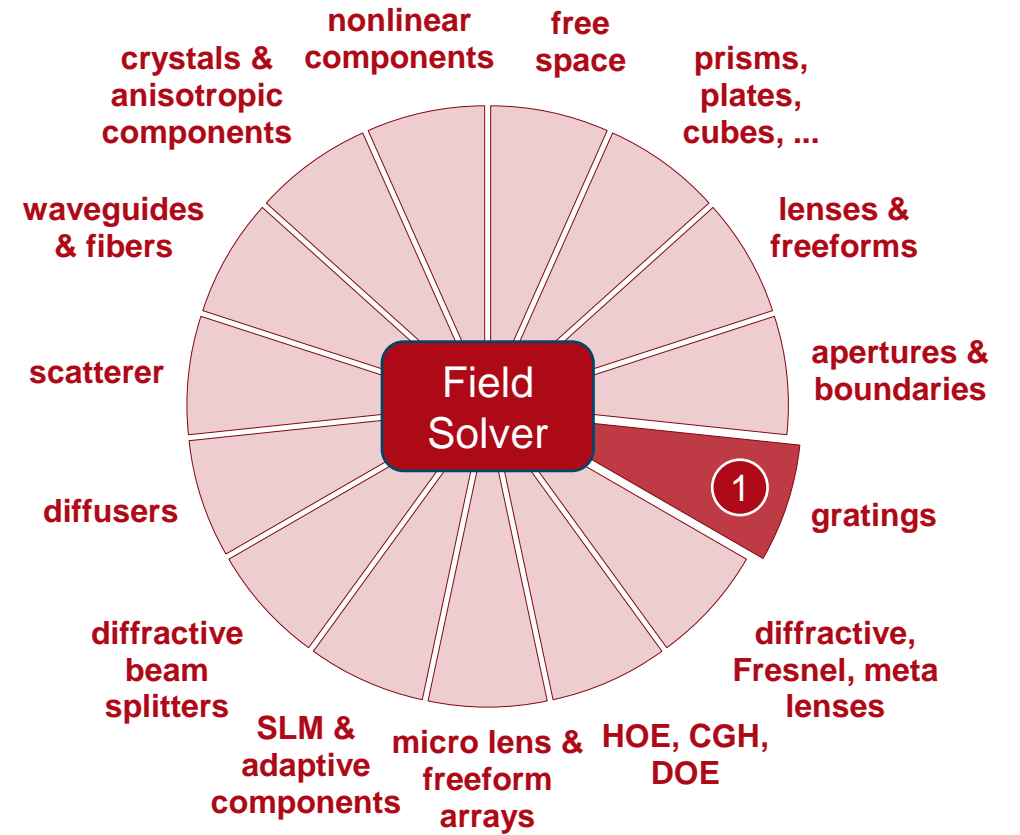
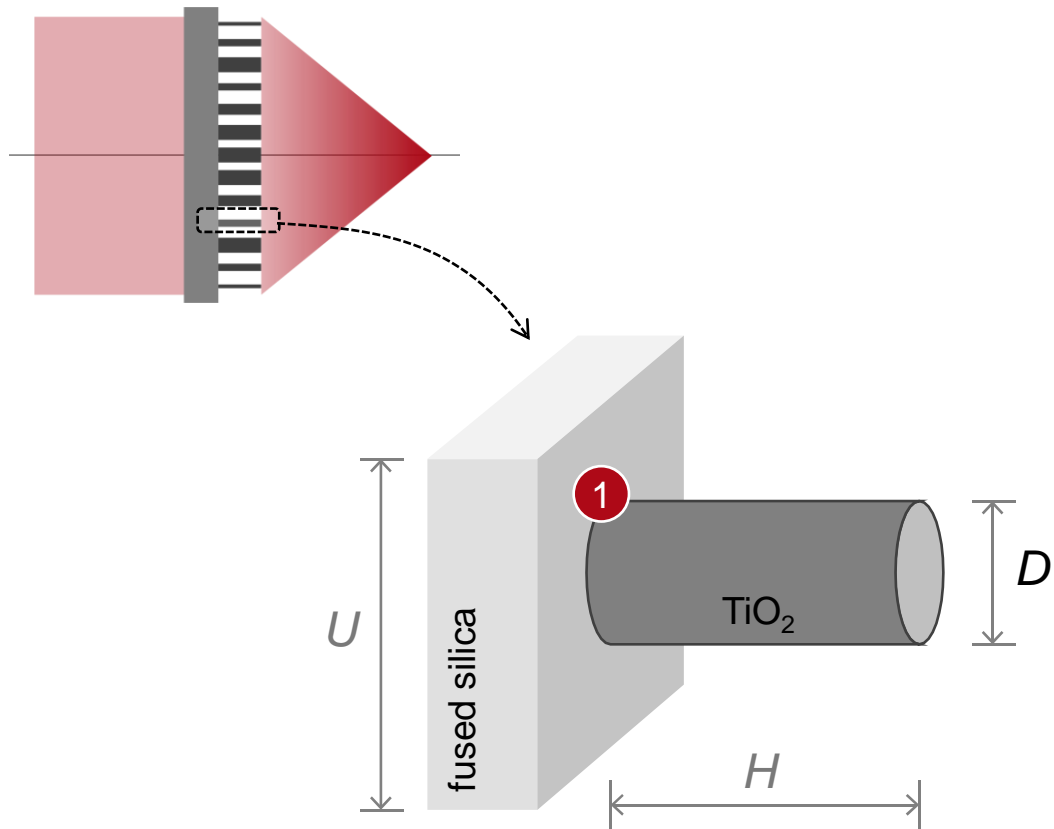
access to full vectorial and complex-valued information

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]
- Check influence from specific parameters with Parameter Run
 - [Usage of the Parameter Run Document](#) [Use Case]



VirtualLab Fusion Technologies



Document Information

title	Rigorous Analysis of Nanopillar Metasurface Building Block
document code	GRT.0012
version	1.2
edition	VirtualLab Fusion Advanced
software version	2020.1 (Build 1.202)
category	Application Use Case
further reading	<ul style="list-style-type: none">- <u>Ultra-Sparse Dielectric Nano-Wire Grid Polarizers</u>- <u>Investigation of Polarization State of Diffraction Orders</u>- <u>Rigorous Analysis and Design of Anti-Reflective Moth-Eye Structures</u>