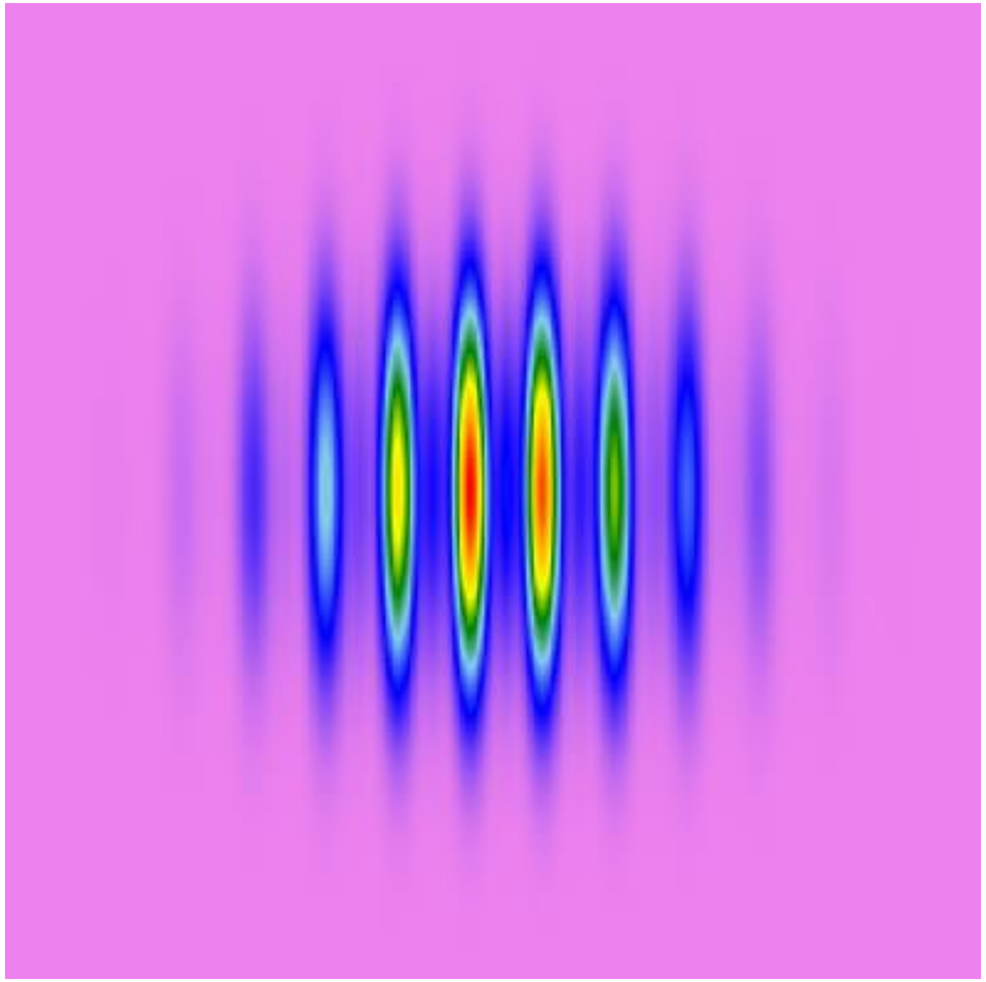
Optical System for Investigation of Micro-Structured Wafer

Abstract

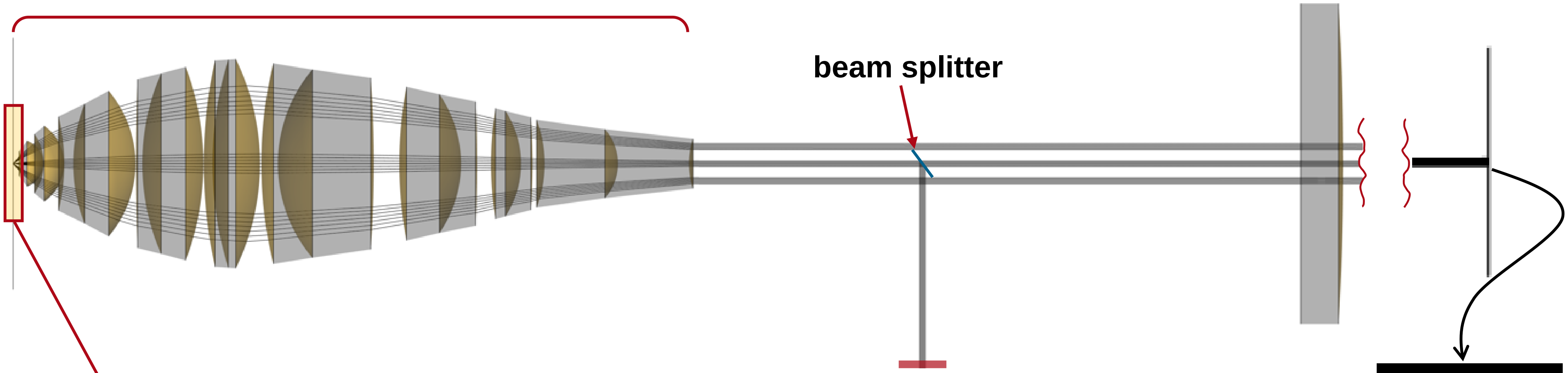


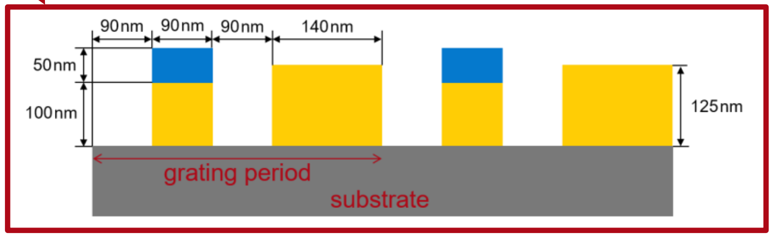
In the semiconductor industry, wafer inspection systems are used to detect defects on a wafer and find their positions. To ensure the necessary image resolution for the microstructures, the inspection system often employs a high-NA objective and works in the UV wavelength range. As an example, a complete wafer inspection system including high-NA focusing and light interaction with microstructures is modeled, and the formation of the image is demonstrated.

Task Description

inspection objective
- NA = 0.9
- effective focal length 2 mm
- back focal length 750 µm

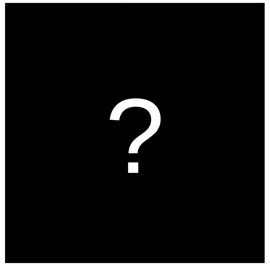
imaging lens
- Newport SPX031AR.10
- effective focal length 500 mm





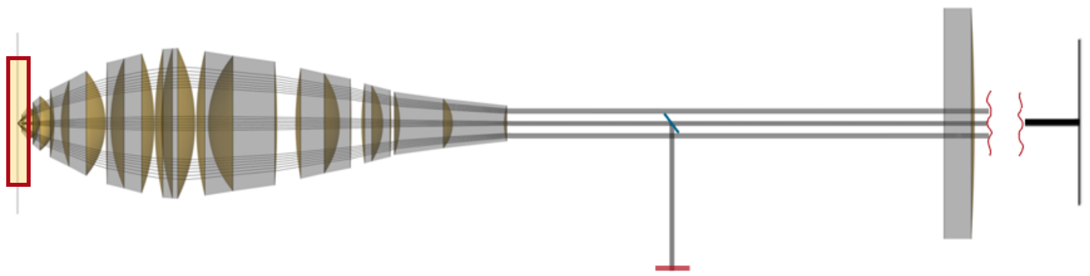
micro-structured wafer

input field
- fundamental Gaussian
- wavelength 266.08 nm
- full divergence angle 0.075°
- circularly polarized



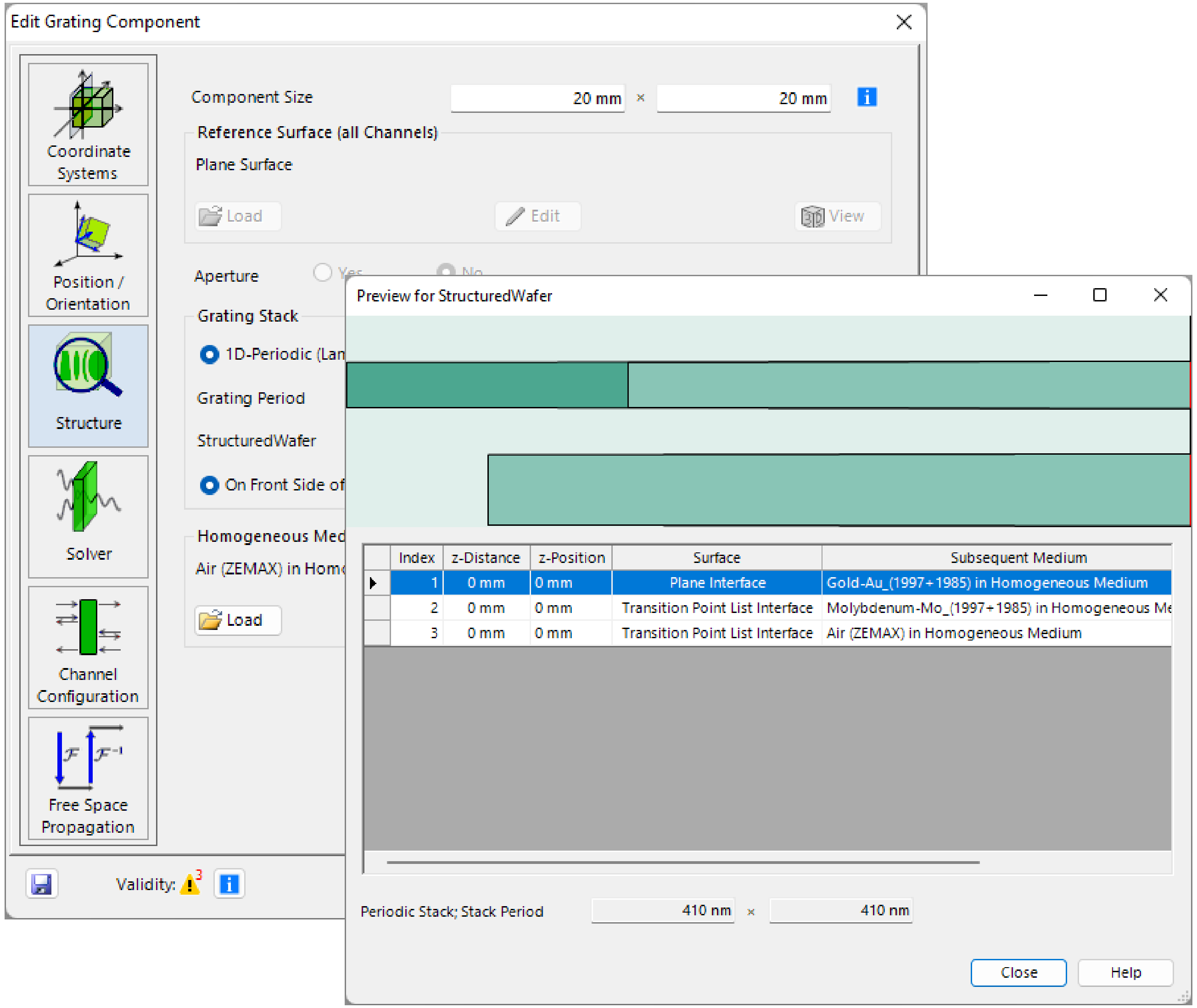
image

Micro-Structured Wafer

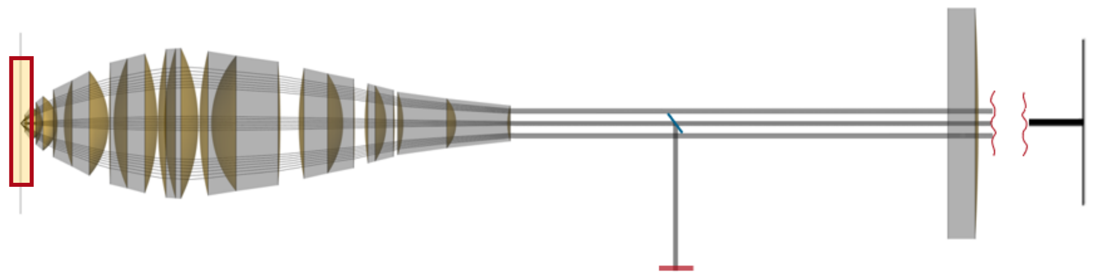


Grating structures, such as the periodic structure used on the wafer, are modeled by defining appropriately shaped surfaces and media in a *Stack*. This *Stack* can then be imported into a variety of different components, depending on the intended use. In this case we have loaded the *Stack* into a *Grating Component* in a general *Optical Setup*, in order to simulate the entire system. For more information, see:

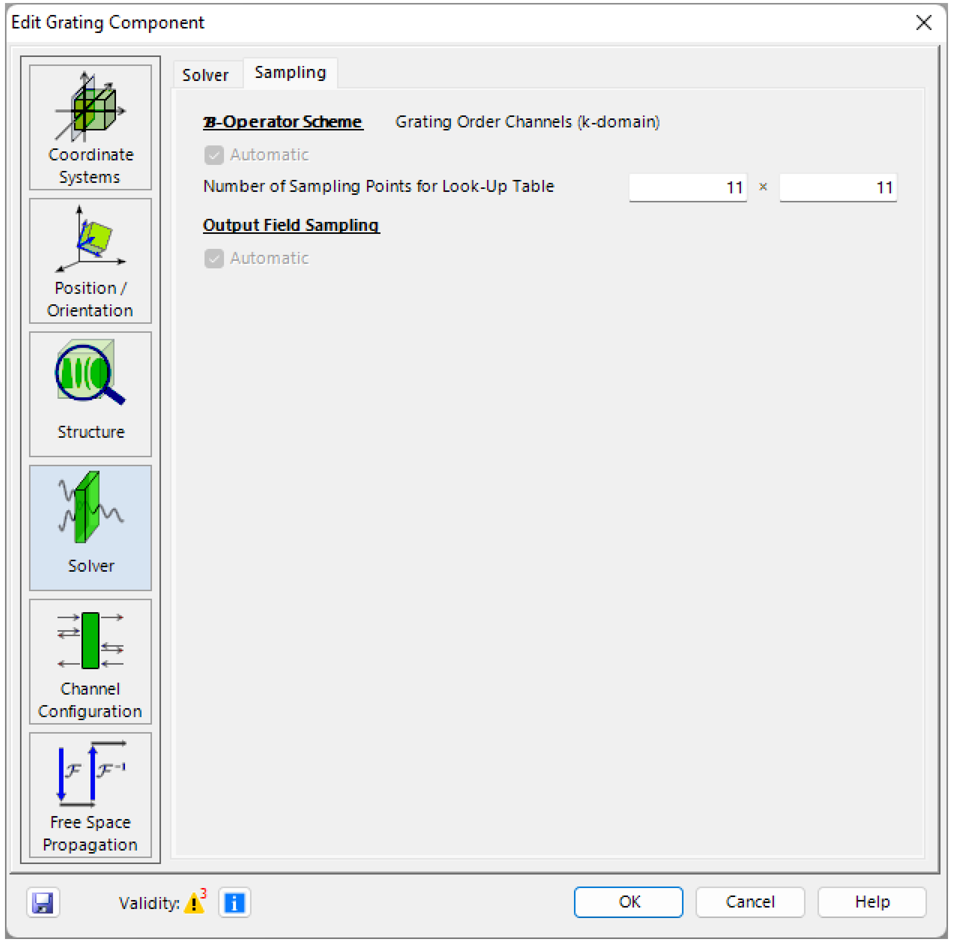
[Grating Component for General Optical Systems]



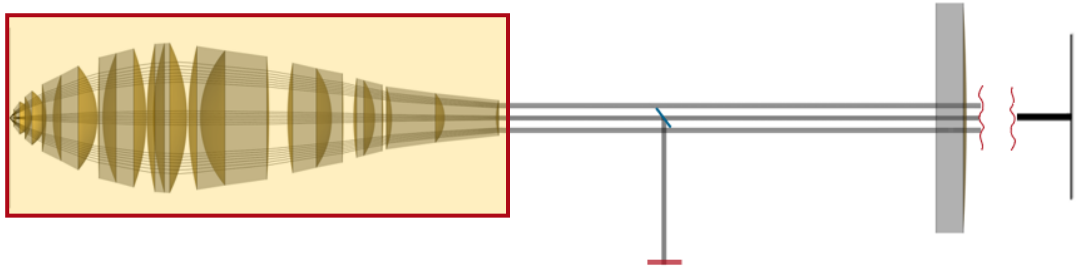
Angular Response of the Micro-Structured Wafer



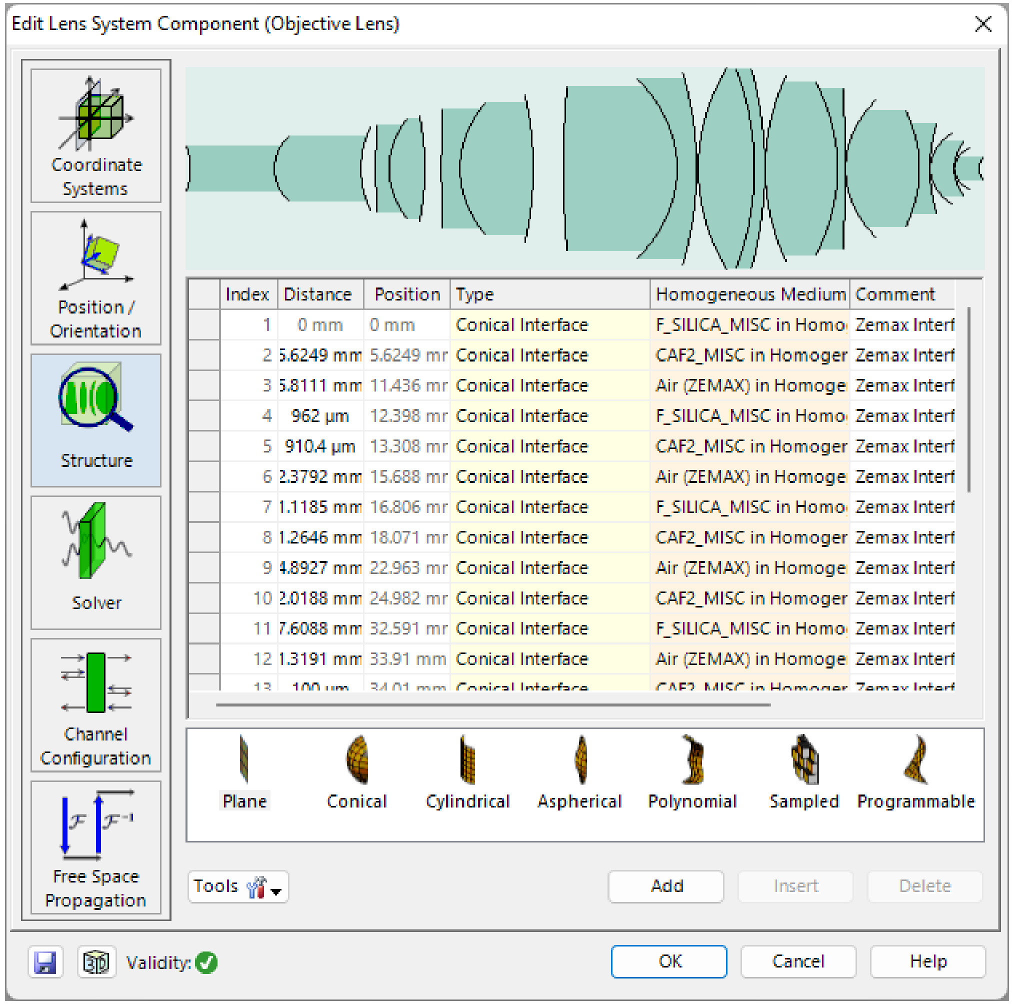
The *Grating Component* uses the Fourier Modal Method (FMM), also known as Rigorous Coupled Wave Analysis (RCWA), which operates in the k-domain. When impinging with High-NA beams, a sufficient number of sampling points in the k-domain needs to be considered to resolve angular sensitive effects. In the *Solver* area of the *Grating Component* users can easily adjust this parameter to ensure a fast but accurate simulation.



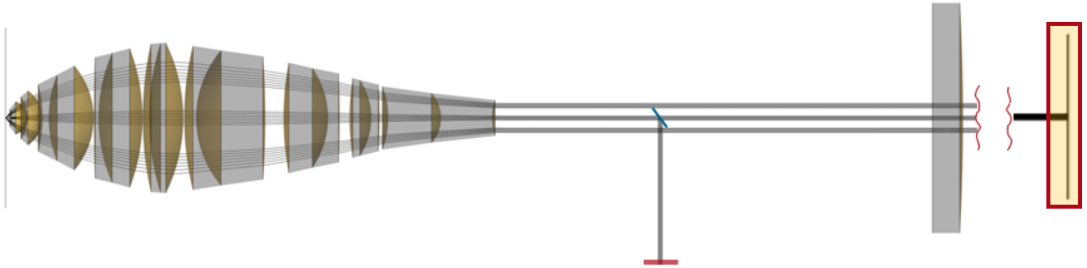
High-NA Objective Lens



The *Lens System Component* allows for the easy definition of a component consisting of an alternating sequence of smooth surfaces and homogeneous, isotropic media. In terms of both the interfaces and the materials, it is possible to choose ready-made entries from the in-built catalogs or to customize your own for maximum flexibility.

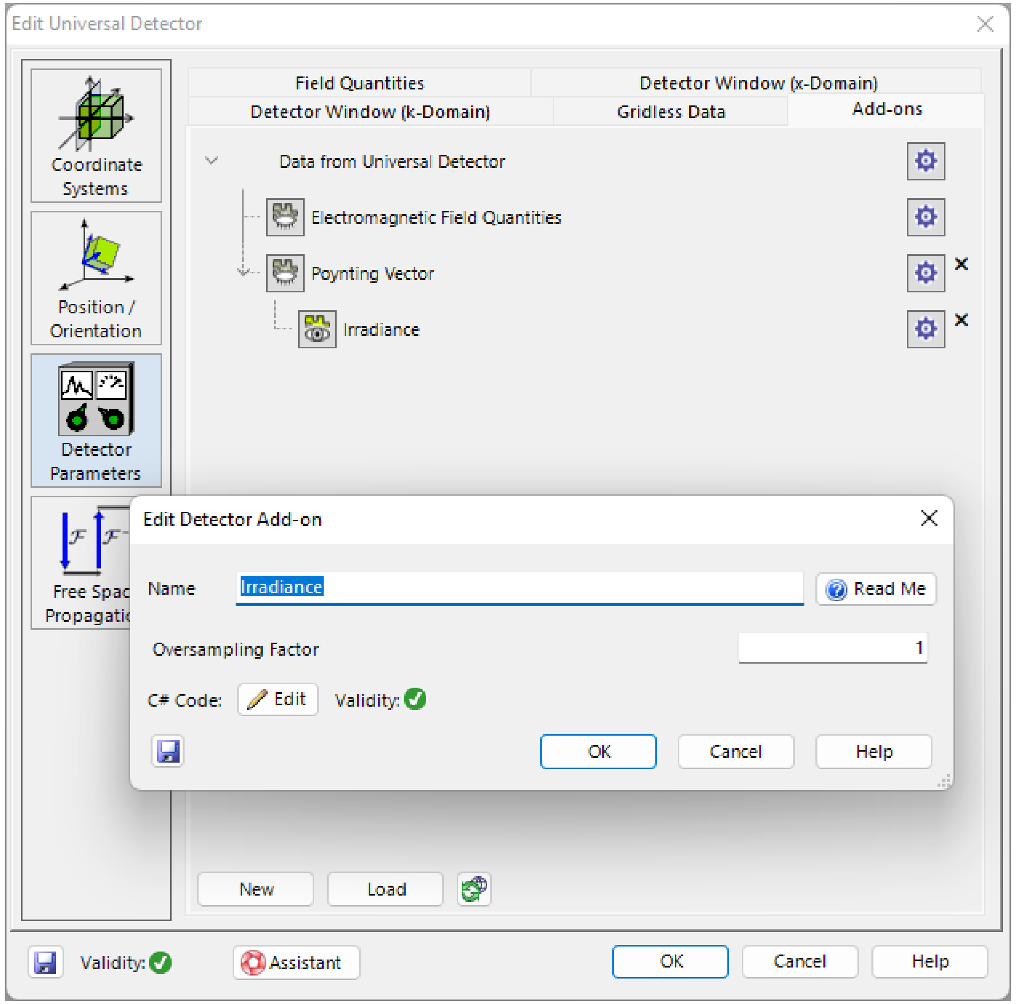


Universal Detector & Detector Add-ons

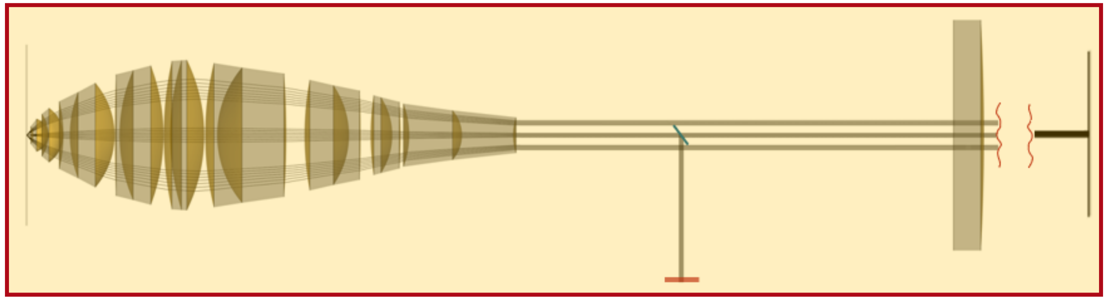


The *Universal Detector* allows the evaluation of the impinging field and the calculation of various physical quantities through so-called *Add-ons*. One of the provided *Add-ons* provides as a result the irradiance in space domain. For more information, see:

[Universal Detector]

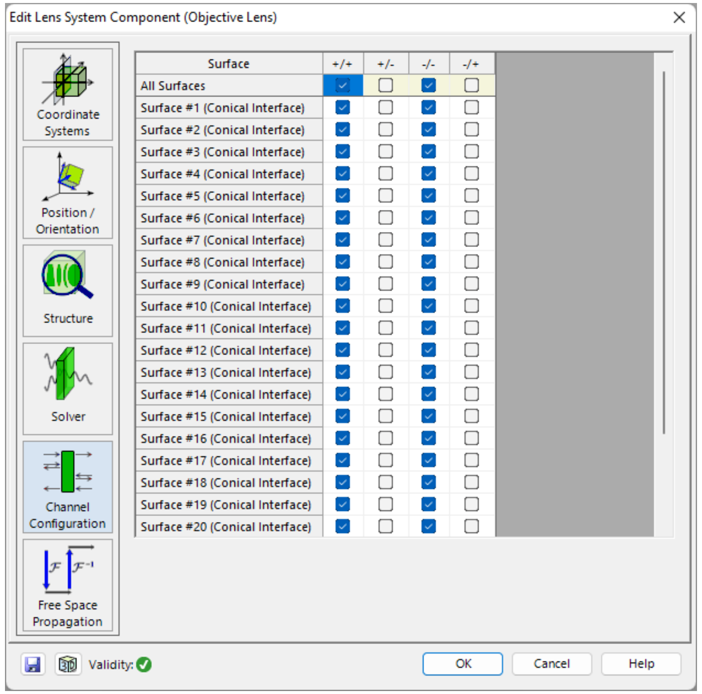


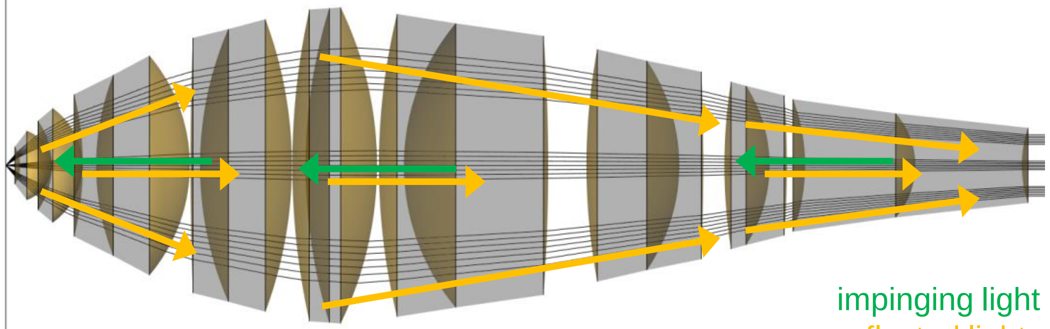
Non-Sequential Tracing



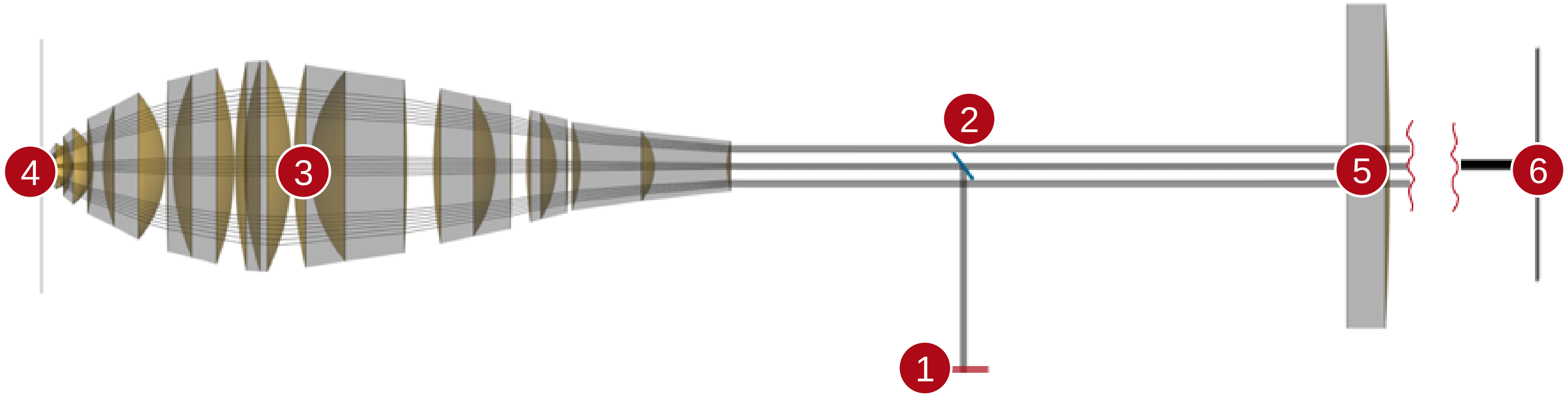
With the channel configuration mode toggle set to *Manual Configuration*, the user can specify, for each surface in the system, which channels to open for the simulation. When the simulation is run, a preliminary analysis of the active light paths will be performed (by the so-called *Light Path Finder*). The field will then be traced along these light paths by the engine, to the detectors present in the system.

[Channel Setting for Non-Sequential Tracing]



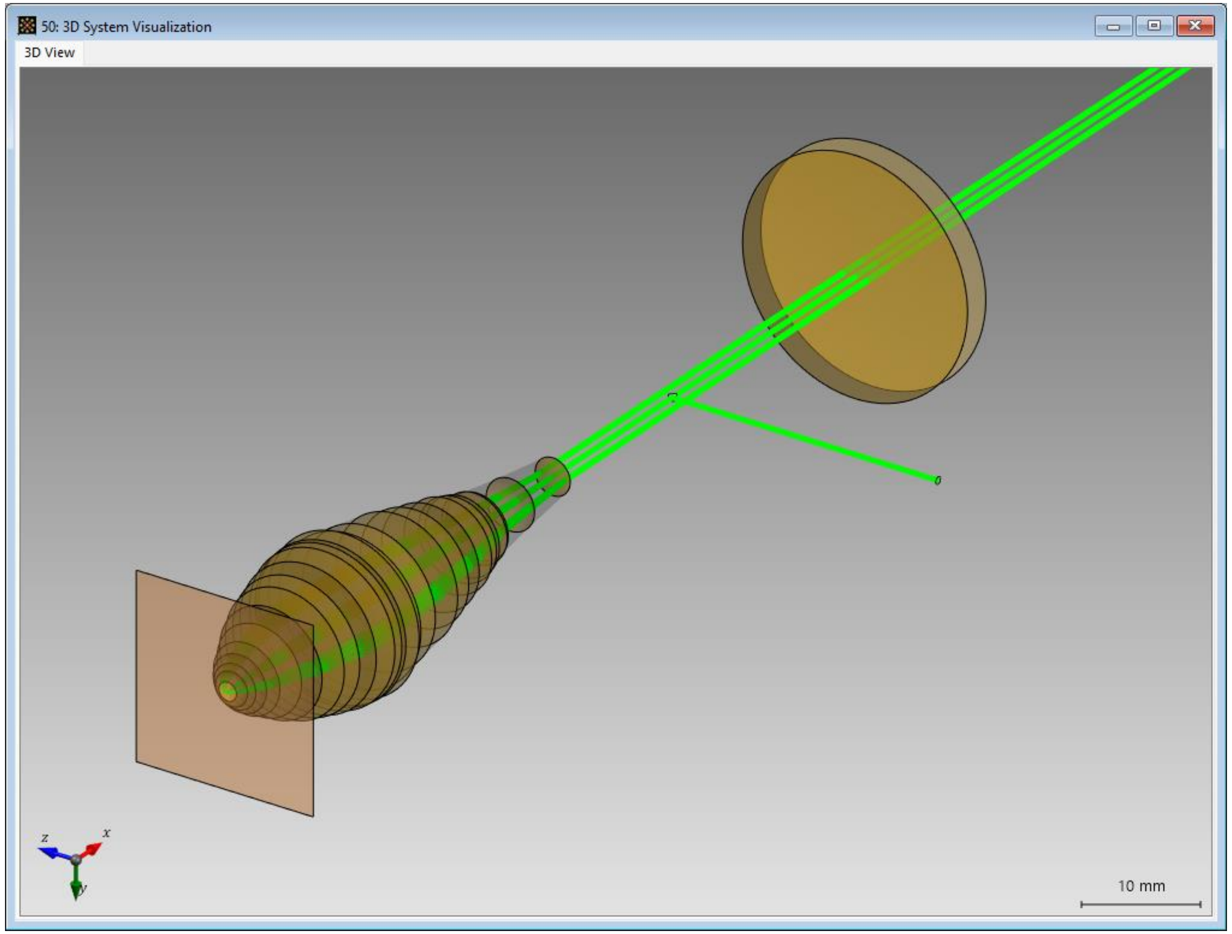


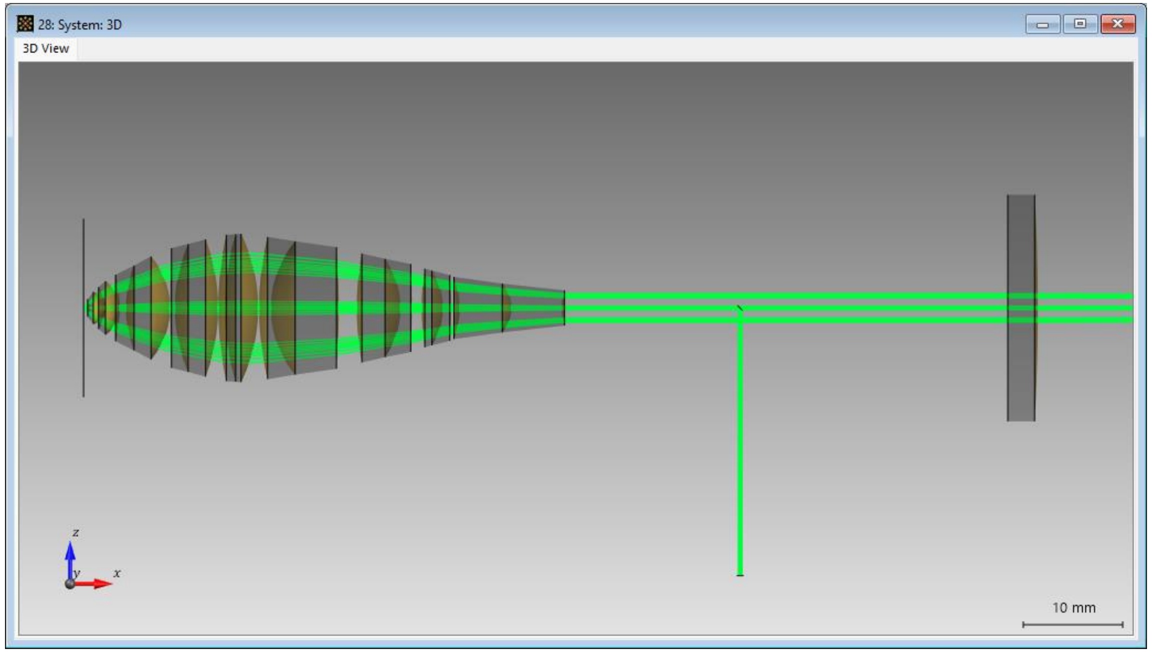
Summary – Components...



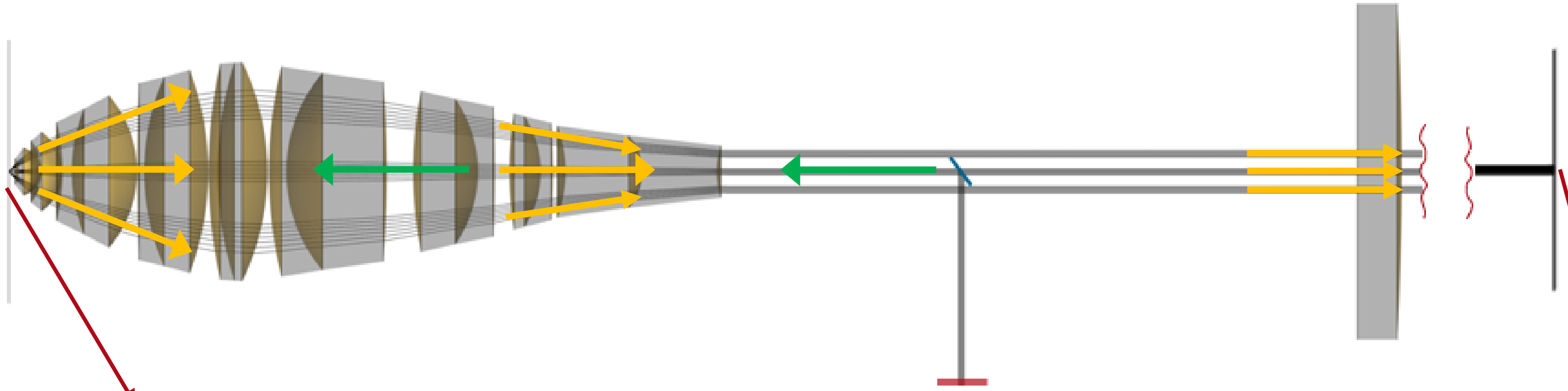
… of Optical System	… in VirtualLab Fusion	Model/Solver/Detected Magnitude
1. source	*Gaussian Wave*	spatial Gaussian function
2. beam splitter	*Ideal Beam Splitter*	transmission function
3. inspection objective	*Lens System Component*	Local Plane Interface Approximation (LPIA)
4. wafer	*Grating Component*	Fourier Modal Method (FMM)/Rigorous Coupled Wave Analysis (RCWA)
5. imaging lens	*Lens System Component*	Local Plane Interface Approximation (LPIA)
6. detector	*Universal Detector* with *Irradiance Add-on*	irradiance

System Impressions

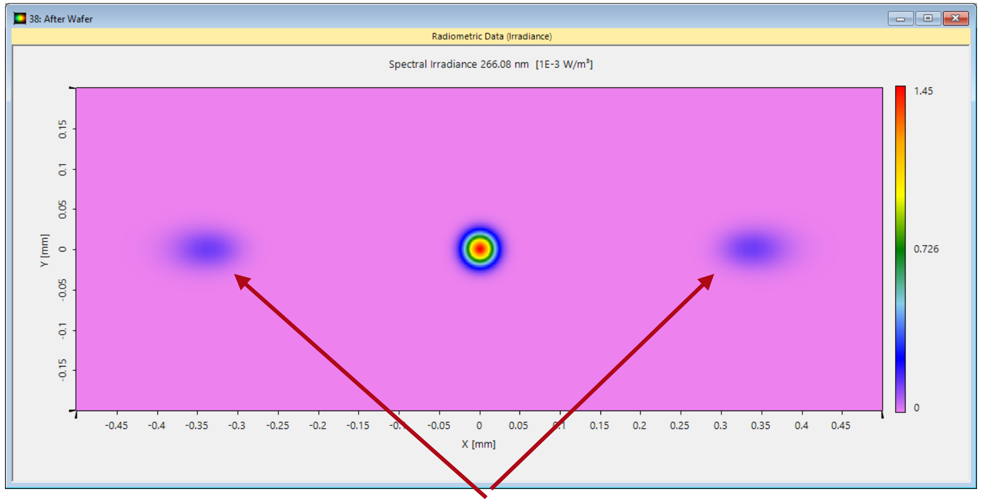




Field Tracing Results

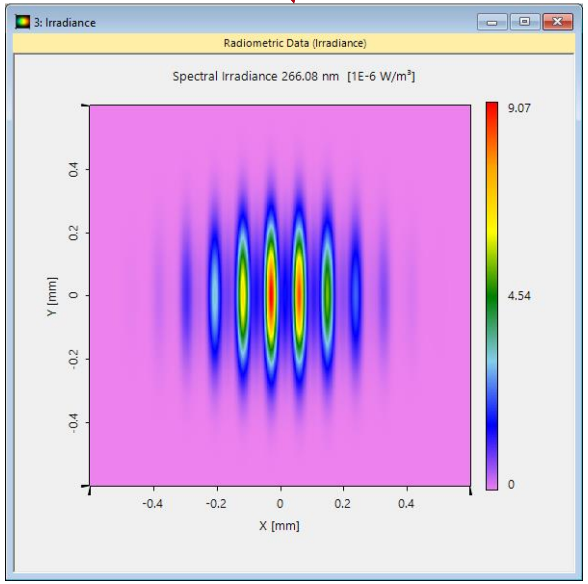


~ 100 µm behind micro-structured wafer



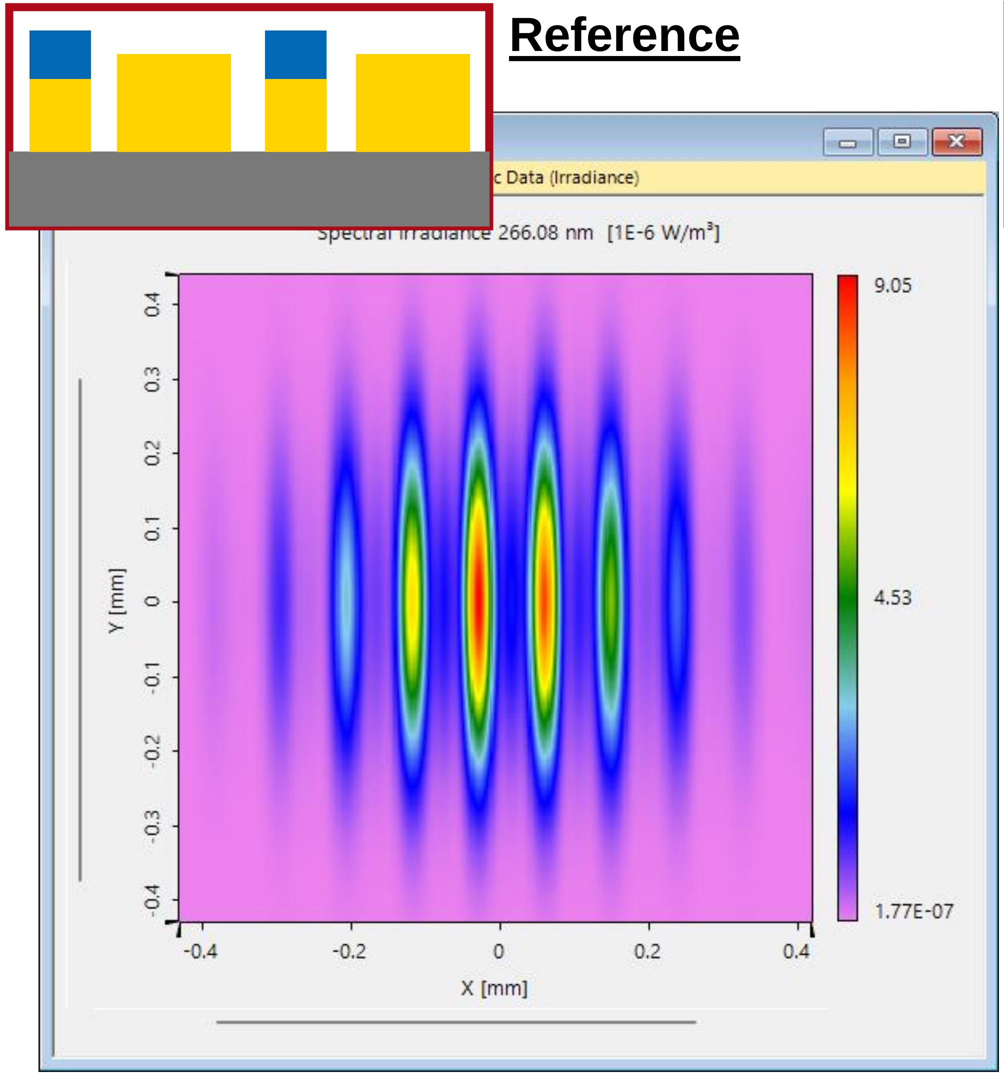
1st diffraction orders

Image is formed by interference of different diffraction orders.

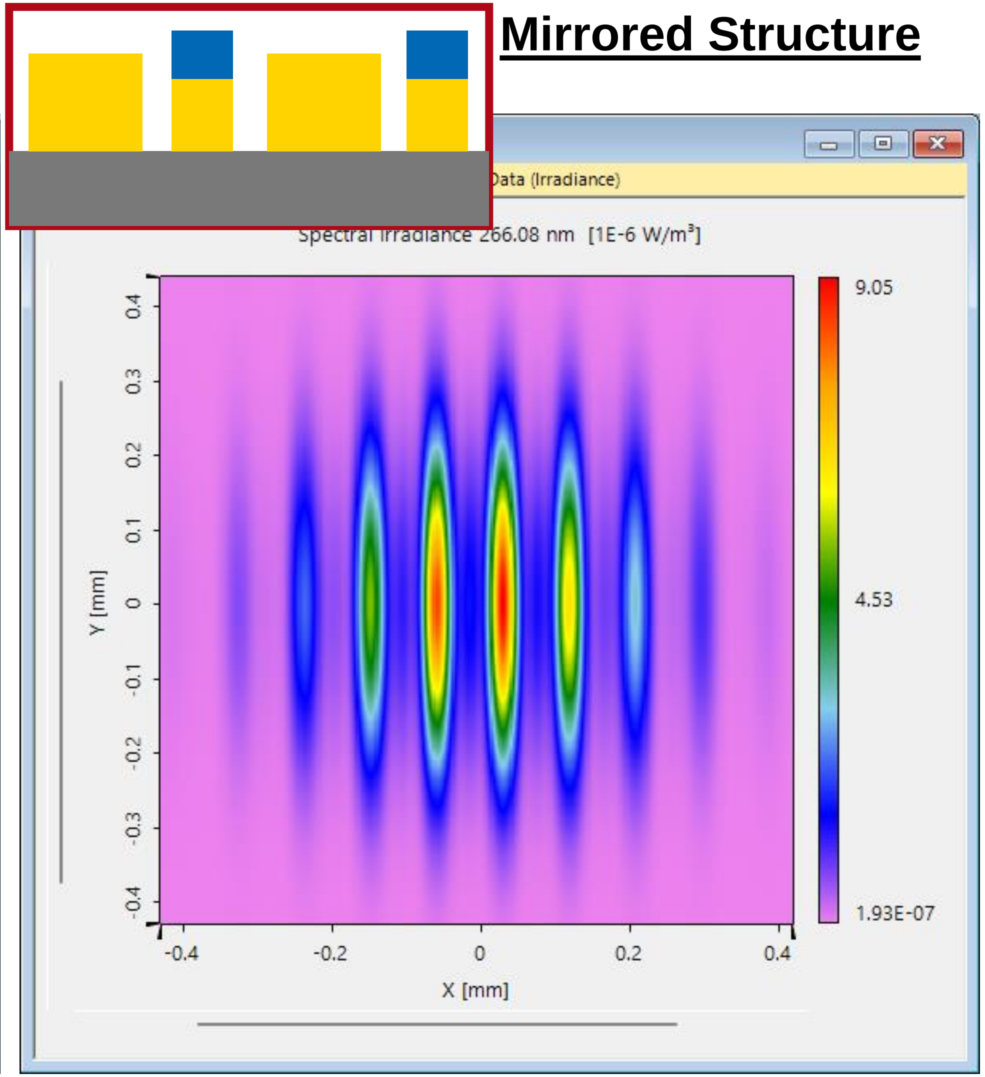


Asymmetry of the Result

Reference

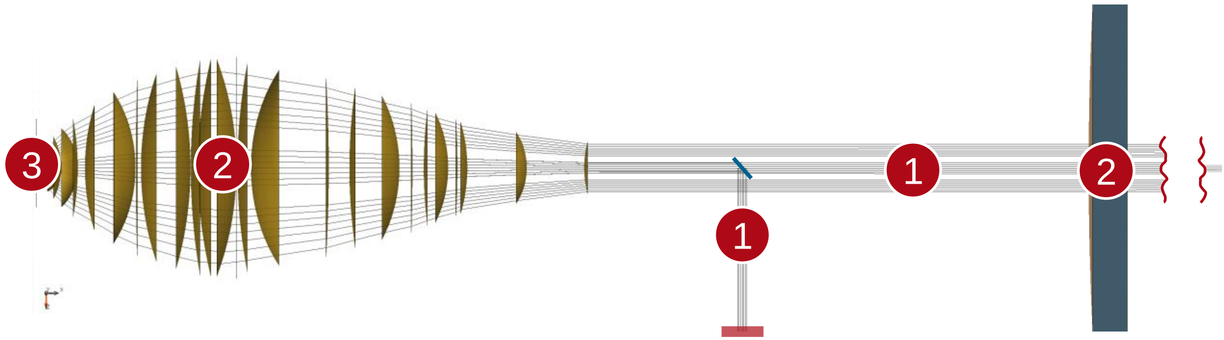


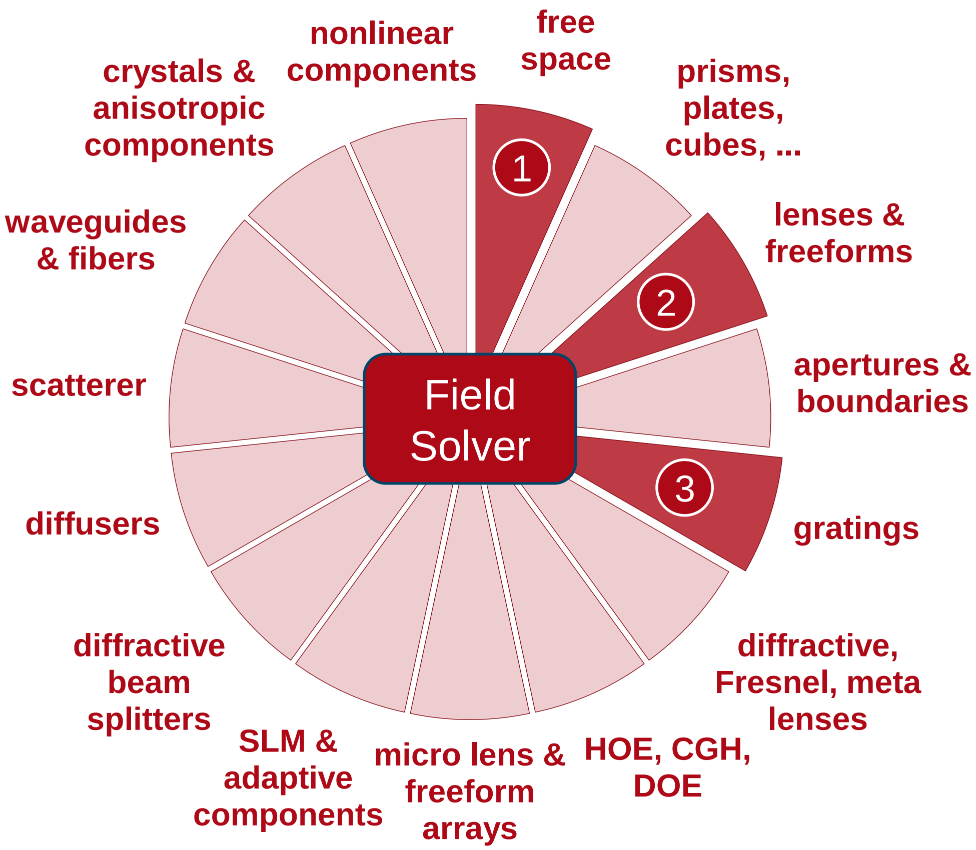
Mirrored Structure



The asymmetric nature of the grating also leads to a slight asymmetry in the interference. Whether the grating is mirrored can be identified in the result, which will also appear mirrored.

VirtualLab Fusion Technologies





Document Information

title	Optical System for Investigation of Micro-Structured Wafer
document code	MIC.0023
document version	2.1
software edition	VirtualLab Fusion Advanced
software version	2023.1 (Build 1.556)
category	Application Use Case
further reading	• Universal Detector • Channel Setting for Non-Sequential Tracing • Grating Component for General Optical Systems