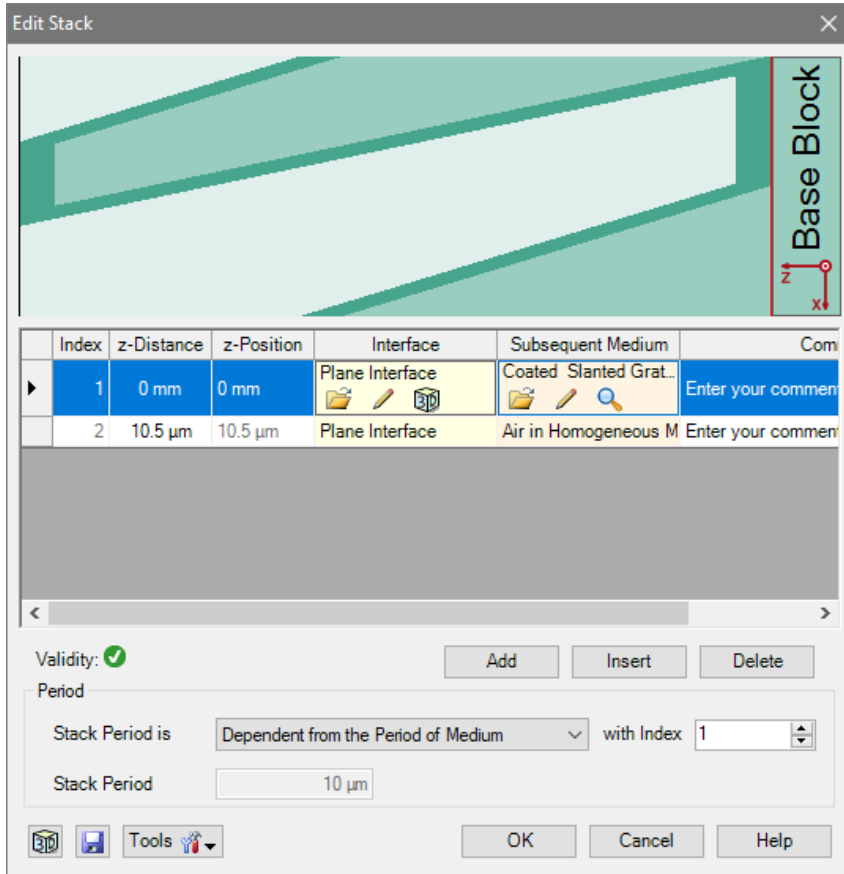# Configuration of Grating Structures by Using Special Media

Abstract

Optical grating structures are widely used for several applications such as spectrometers, near-eye display systems, etc. VirtualLab Fusion provides rigorous analysis of arbitrary grating structures in an easy way by applying the Fourier modal method (FMM). In the Grating Software Package, the grating structure can be configured by using various interfaces or/and media within a stack. The user interface to set up the geometry of a stack is user friendly and can be used to generate even more complex grating structures. In this use case the configuration of grating structures based on special media is explained.

This Use Case Shows ...

- How to configure grating structures in Grating Toolbox by using special media, e.g.:
  - slanted grating medium
  - volume grating medium

- How to change advanced options & inspect defined structure before calculation.

Grating Toolbox Initialization

- Initialization
  - Start ➔
    Grating ➔
    General Grating Light Path
    Diagram
- note: For usage of special type of grating, e.g. volume grating, the specific light path diagram can be chosen directly.
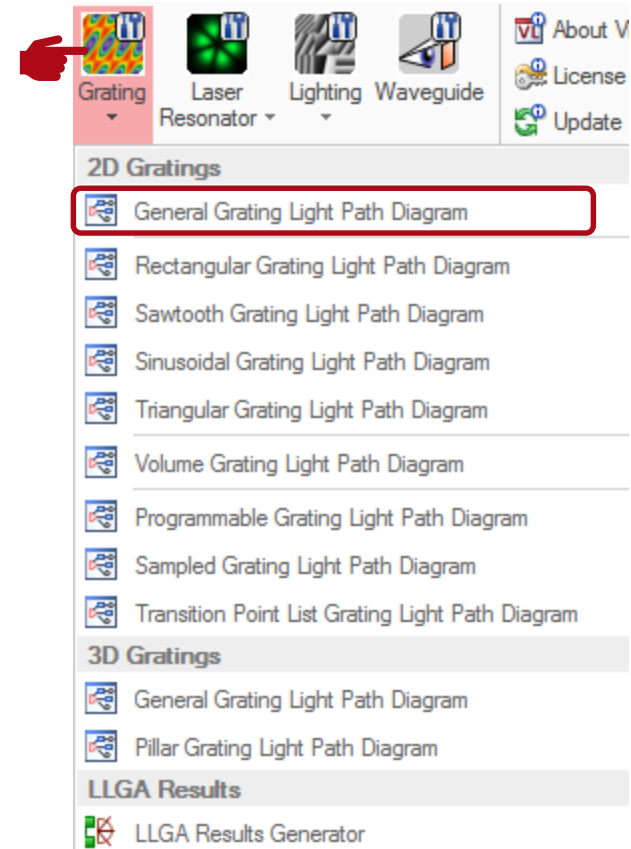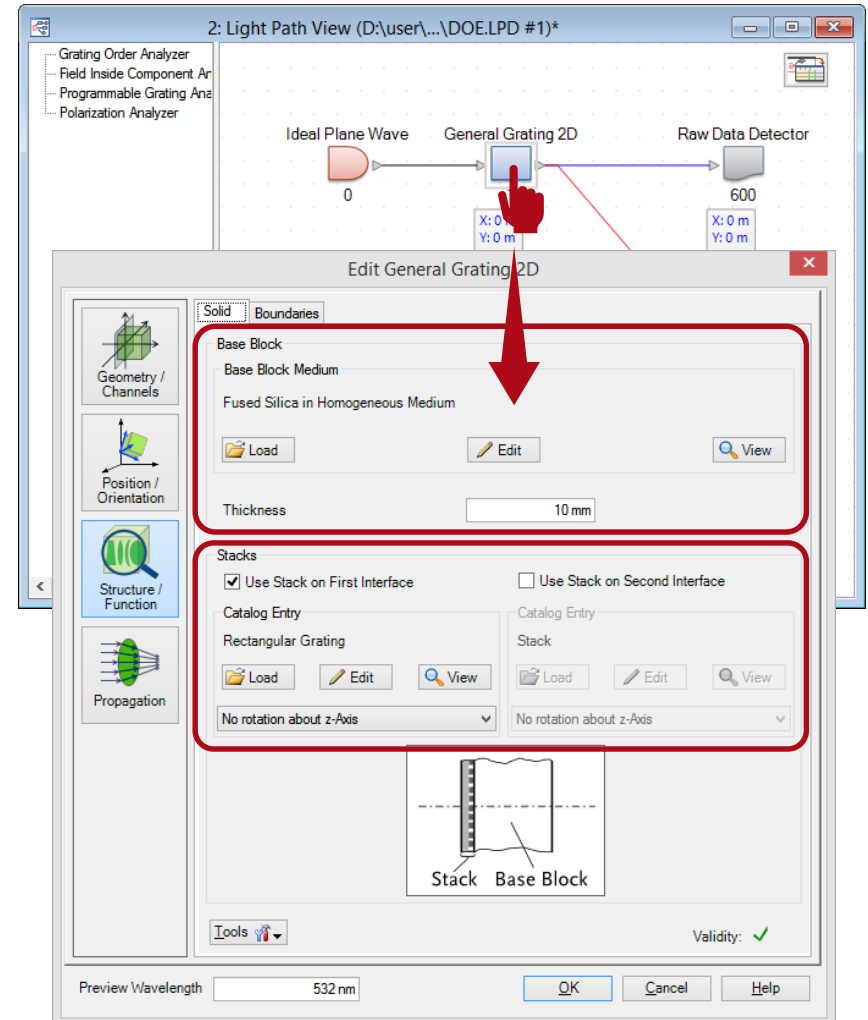
Grating Structure Settings

- First, the thickness and the material of the substrate (*Base Block*) have to be defined.

- In VirtualLab grating structures are defined in a so called stack.

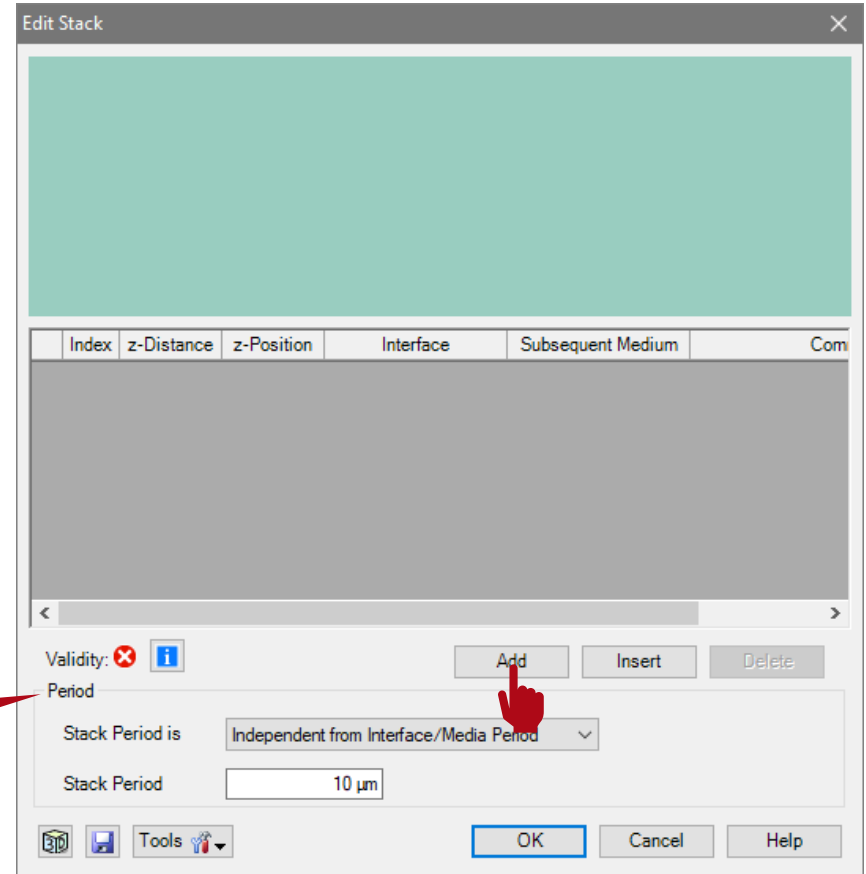- Stacks can be attached to either one or both sides of the substrate.
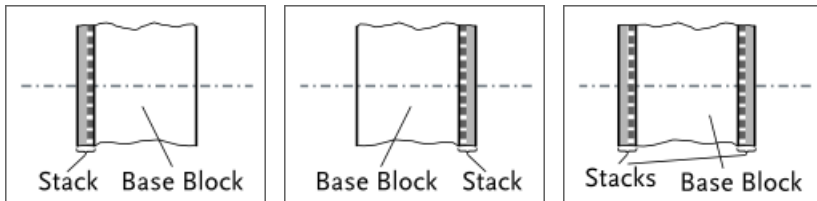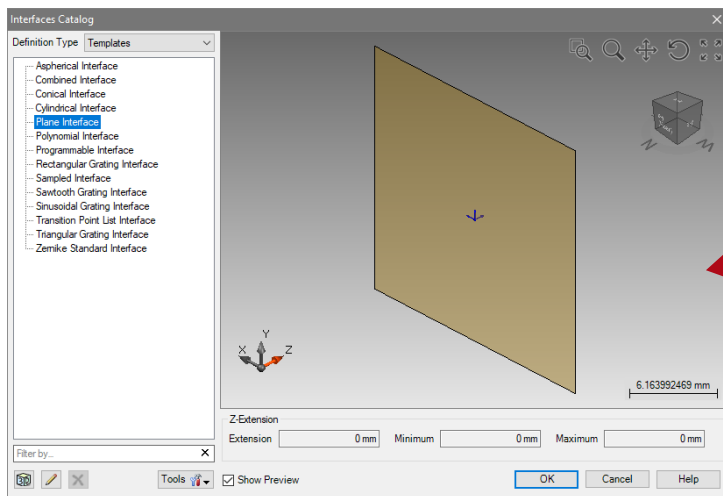

- For example, a stack on the first interface is chosen.

Stack Editor

- In the *Stack Editor* interfaces and media can be added or inserted from catalog.

- In order to define a grating by a special medium, two plane interfaces have to be added, which act as boundaries.

Stack Editor

- The medium between the two plane interfaces can be either homogenous or modulated.

- By using a latter one complex grating structures, like slanted gratings, can be described very efficiently.
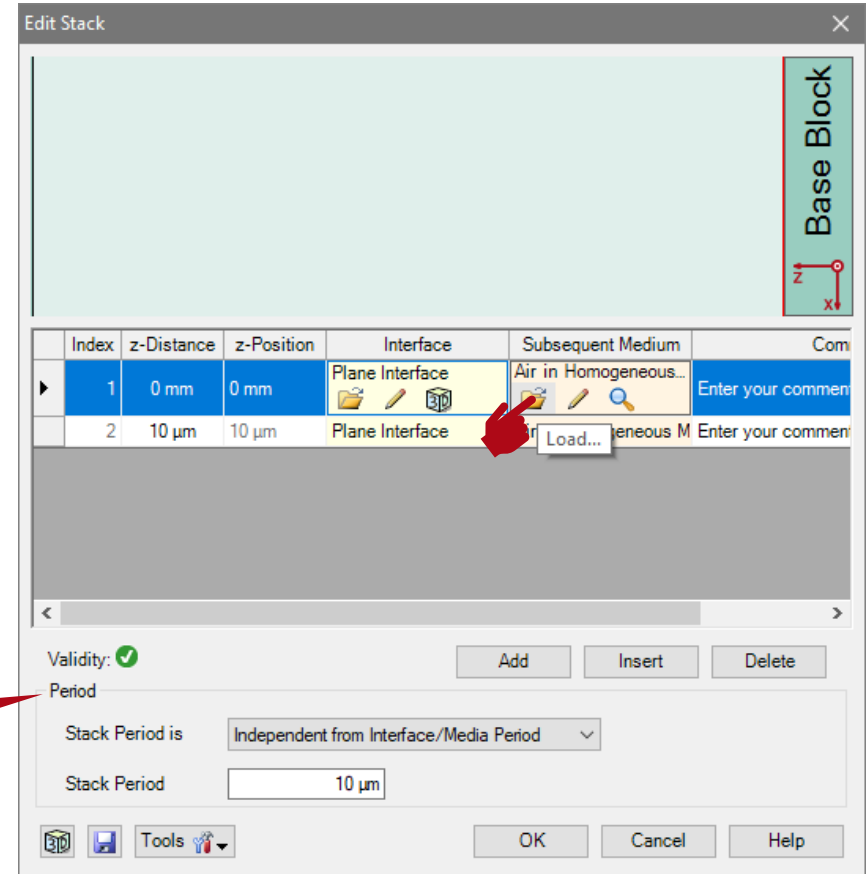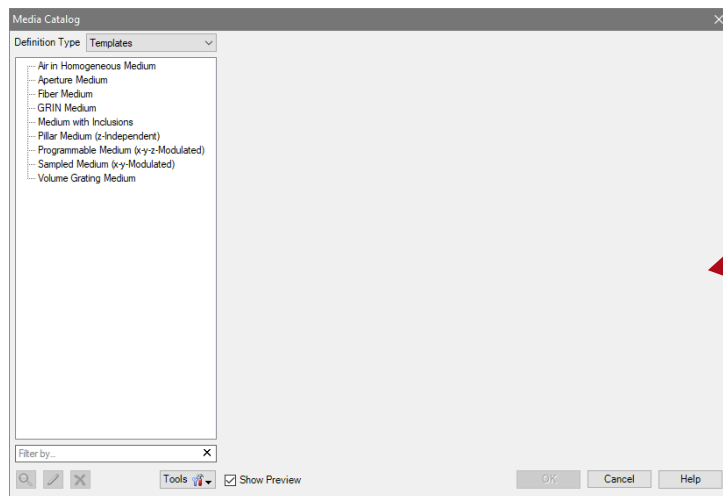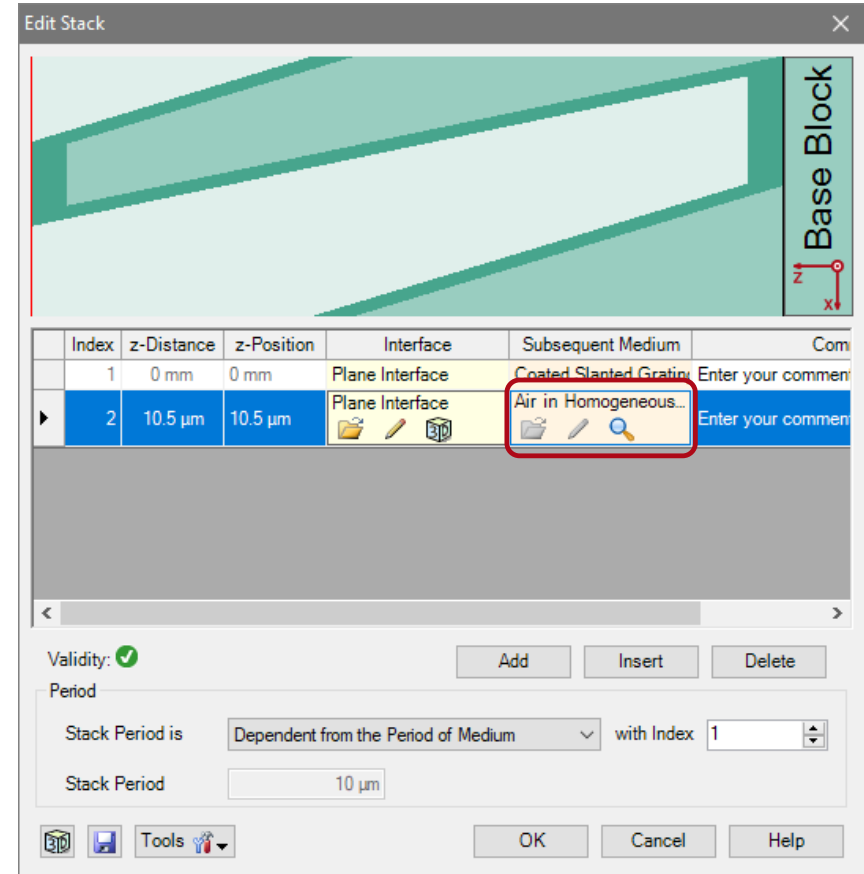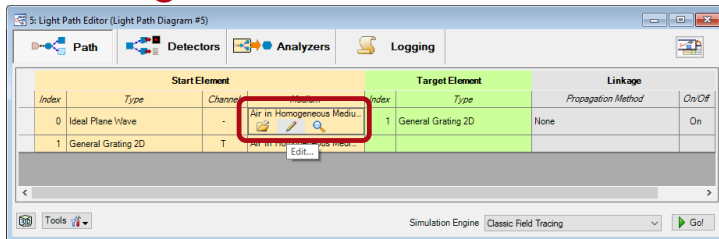
Coated Slanted Grating Medium

- In the catalog category "LightTrans Defined" the *coated slanted grating medium* can be found.

- This type of medium enables the use of slanted grating structures either with or without an additional coating.

- In this example, a grating made of fused silica with a coating consisting of chromium is located on a glass substrate.

- In the view of the stack editor, different materials are indicated by other colors based on their index of refraction (dark means higher).
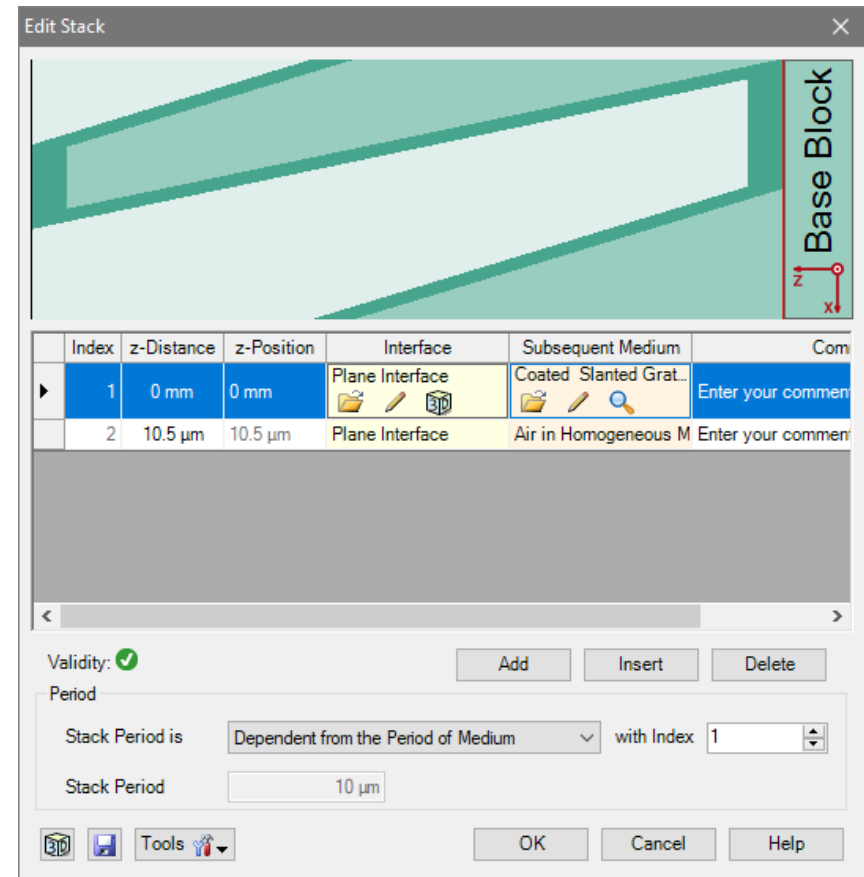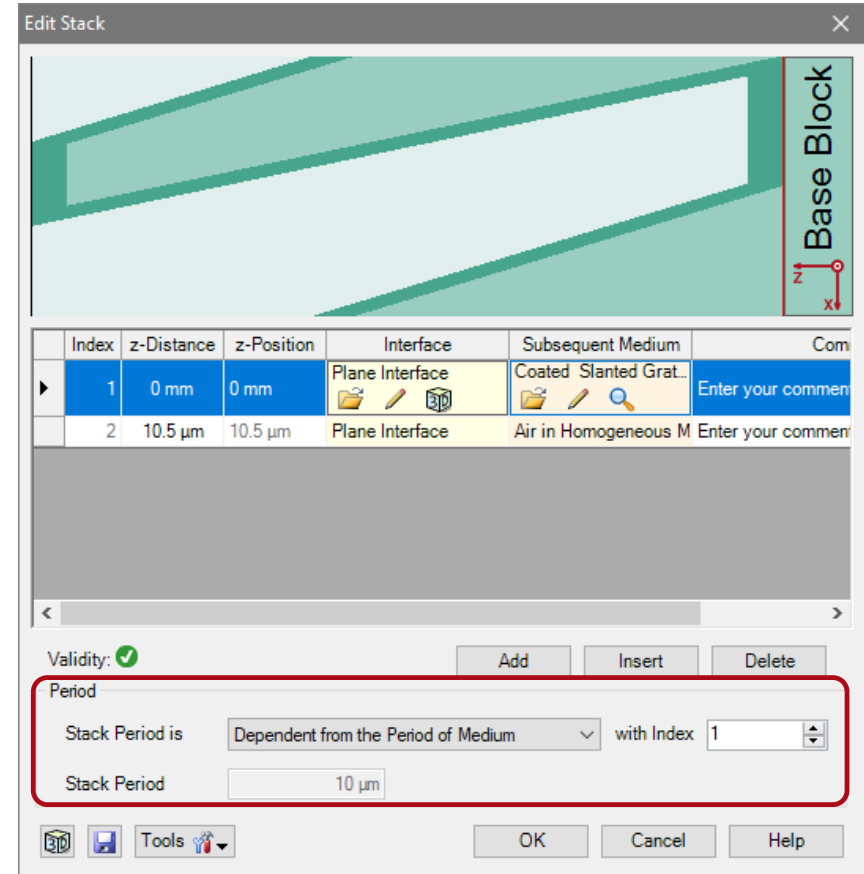
Coated Slanted Grating Medium

- Please note: the order of the interfaces is always counted from the surface of the substrate.

- The selected interface is highlighted red in the view.

- Further, the medium in front of the grating (means behind last interface) can not be defined here. It is automatically taken from the material in front of the grating component.

- This material can be changed in the *Light Path Editor*.
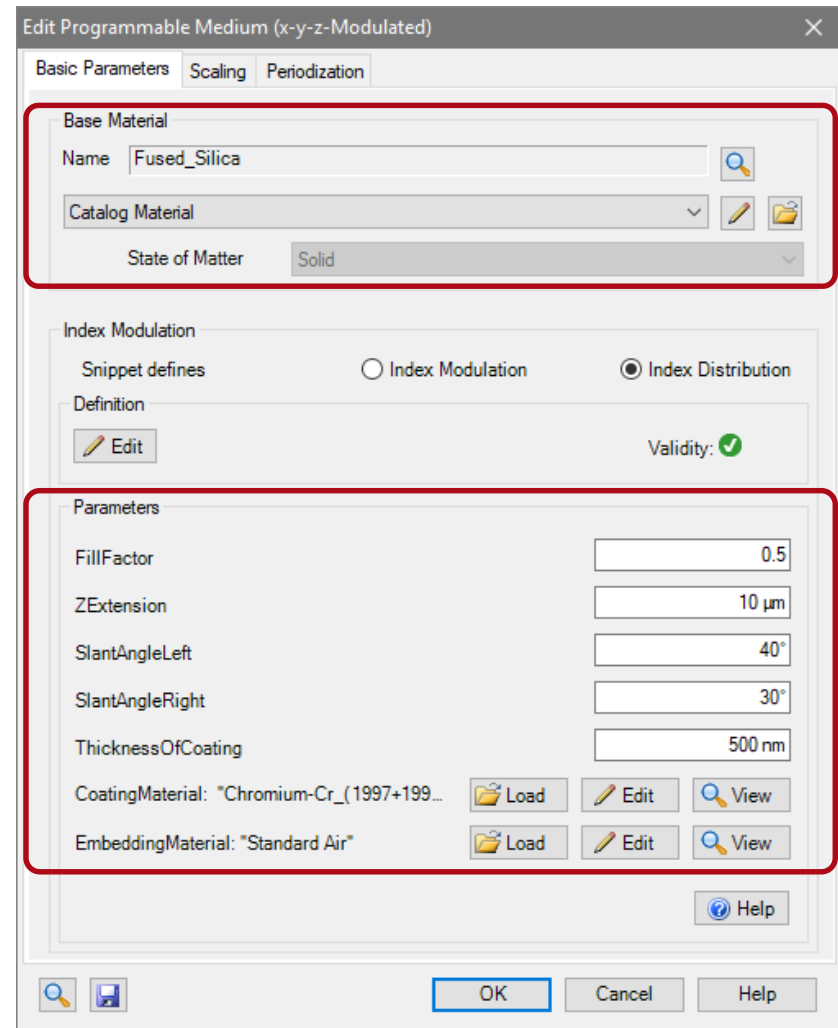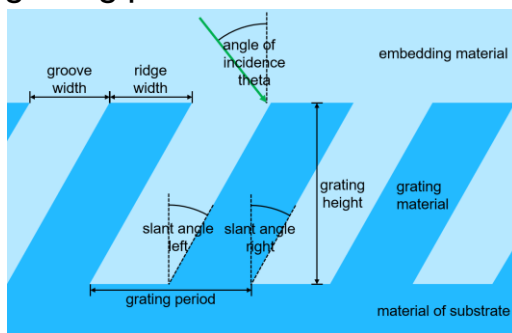
Coated Slanted Grating Medium

- The *Stack Period* allows to control the period of the whole configuration.

- This period is also taken for the periodic boundary conditions of the FMM algorithm.

- In case of simple grating structures, it is recommended to choose the option *Dependent from Period of Medium* and select the proper index of the periodic medium.
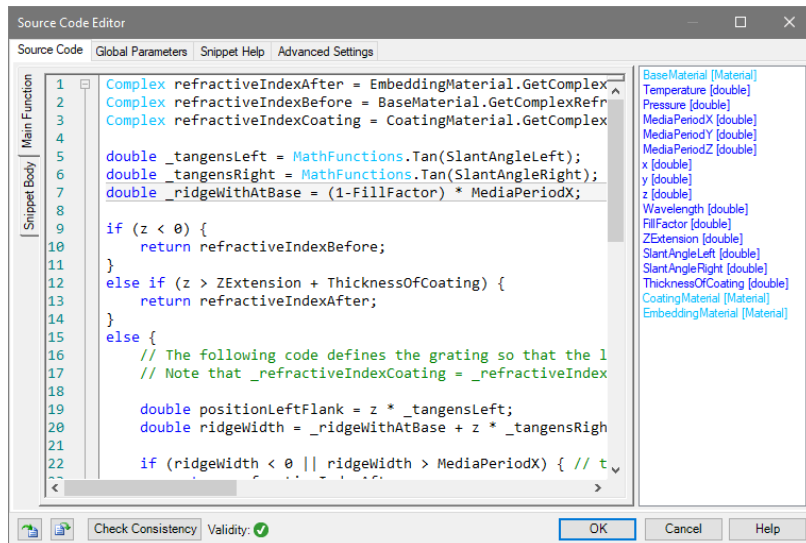
Coated Slanted Grating Medium Parameters

The coated slanted grating is a programable medium and defined by the following parameters:

- base material (material of grating)
- fill factor
- z-extension (grating height along z-direction)
- slant angle of side walls (left and right)
- thickness of coating
- material of coating
- embedding material (material of grooves)
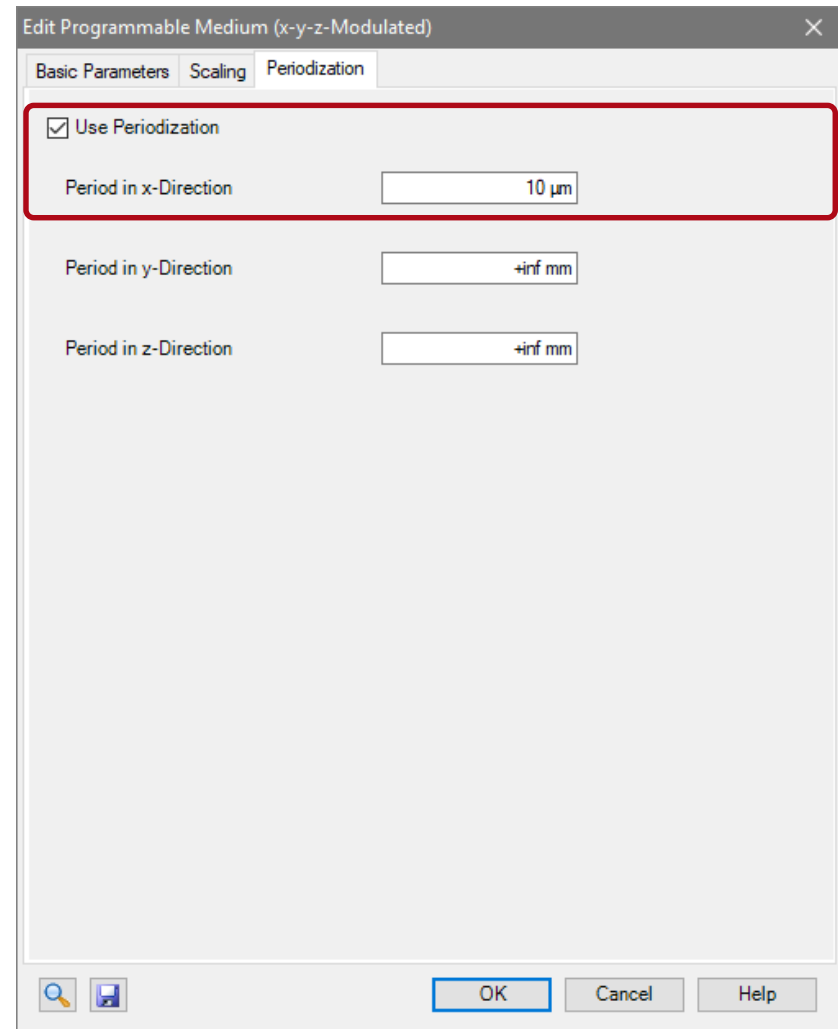- grating period

Coated Slanted Grating Medium Parameters

- As this is a general programmable medium, the grating period has to be set in the periodization tab.

- This means also, that the definition of the grating and its parameters can easily adapted by adjusting the code, which defines the structure.
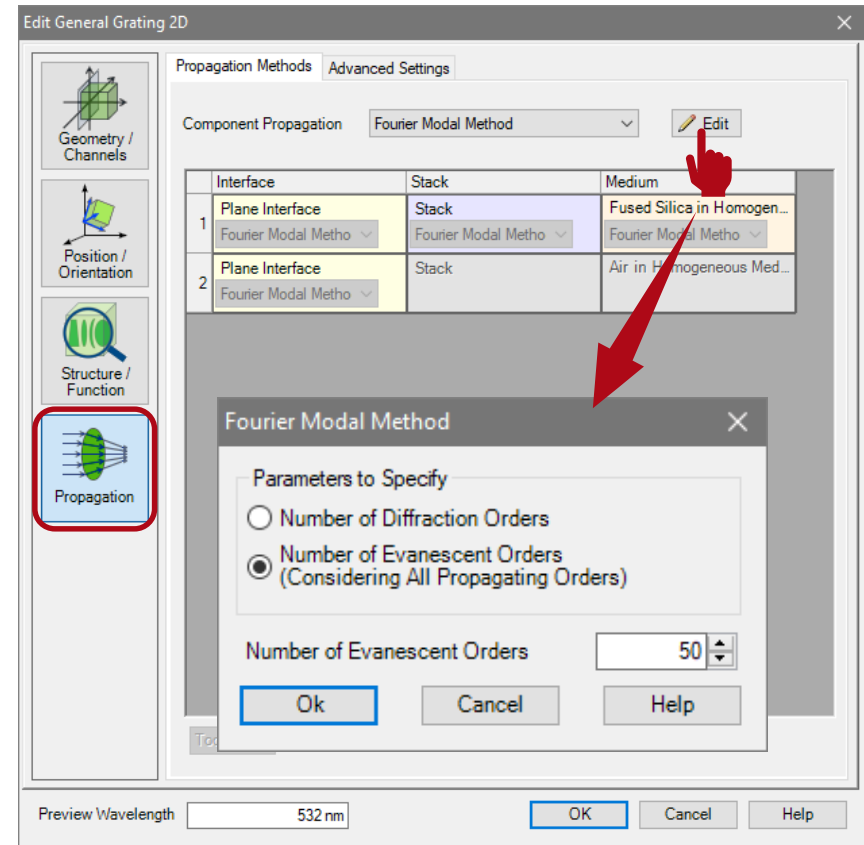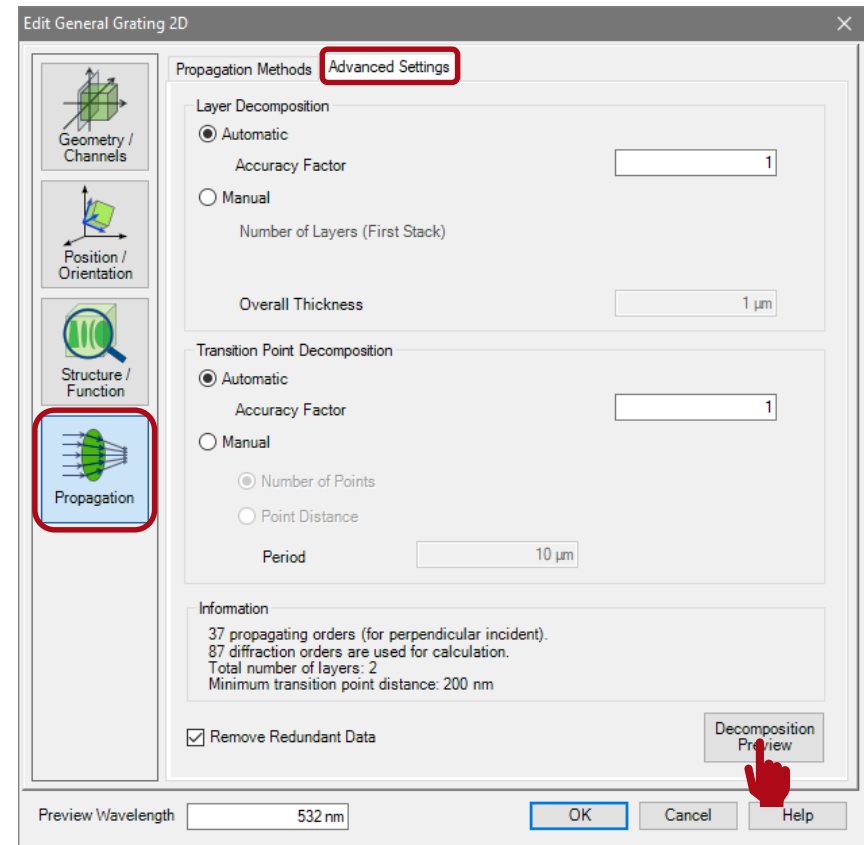
Advanced Options & Information

- In the propagation menu several advanced options are available.

- The propagation method tab allows to edit the accuracy settings of the FMM algorithm.

- Either the numbers of considered total orders or evanescent orders can be set.

- This might be useful, if metallic gratings are considered.

- In contrast, in case of dielectric gratings, the default setting will be sufficient.
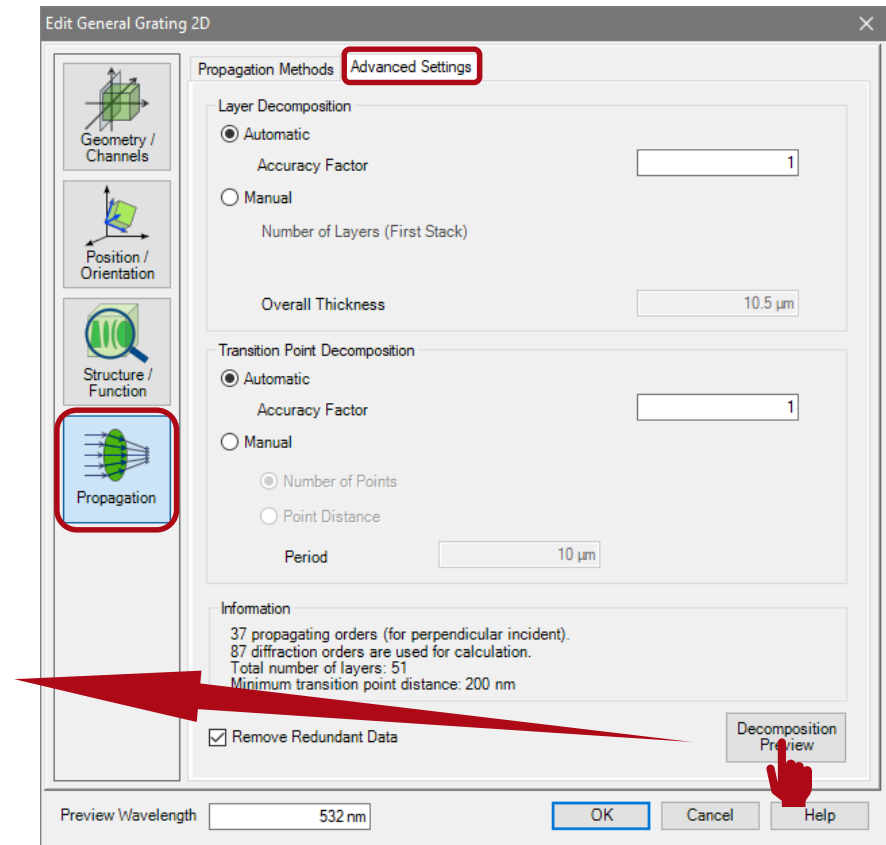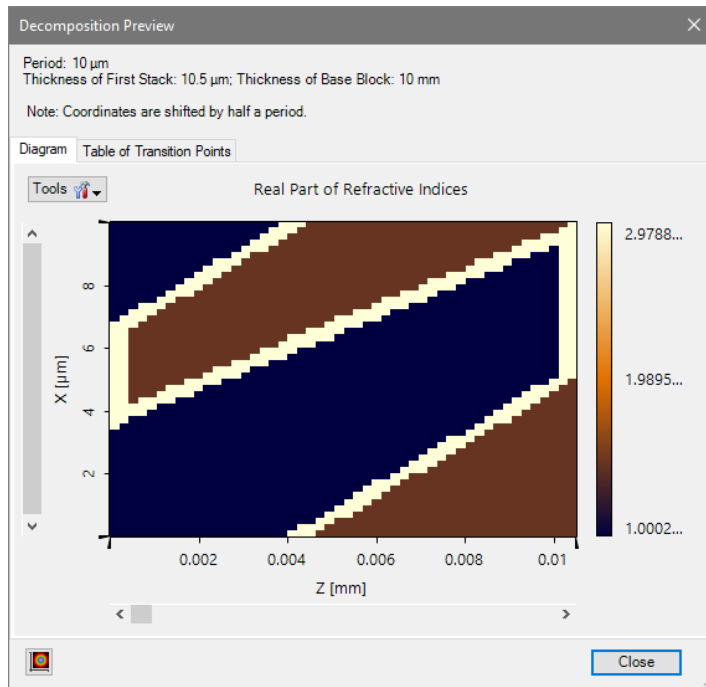
Advanced Options & Information

- The *Advanced Settings* tab provides information about the decomposition of the structure.

- The *Layer Decomposition* and *Transition Point Decomposition* settings can be used to adjust the discretization of the structure. The default settings are appropriate for nearly all grating structures.

- Further, information about the number of layers and transition points are provided.

- The *Decomposition Preview* button provides a depiction of the structure data which are used for the FMM calculation. The refractive index is illustrated by a color scale.

Advanced Options & Information

- The decomposition preview of the defined coated slanted grating.

- VirtualLab suggests a discretization in 51 layers (1 layer is representing the substrate)

# Advanced Options & Information

- If the numbers of layers and transition points are increased (e.g. by a factor of 2), the discretization becomes less rough.
(because a medium is sampled both values have to be increased)
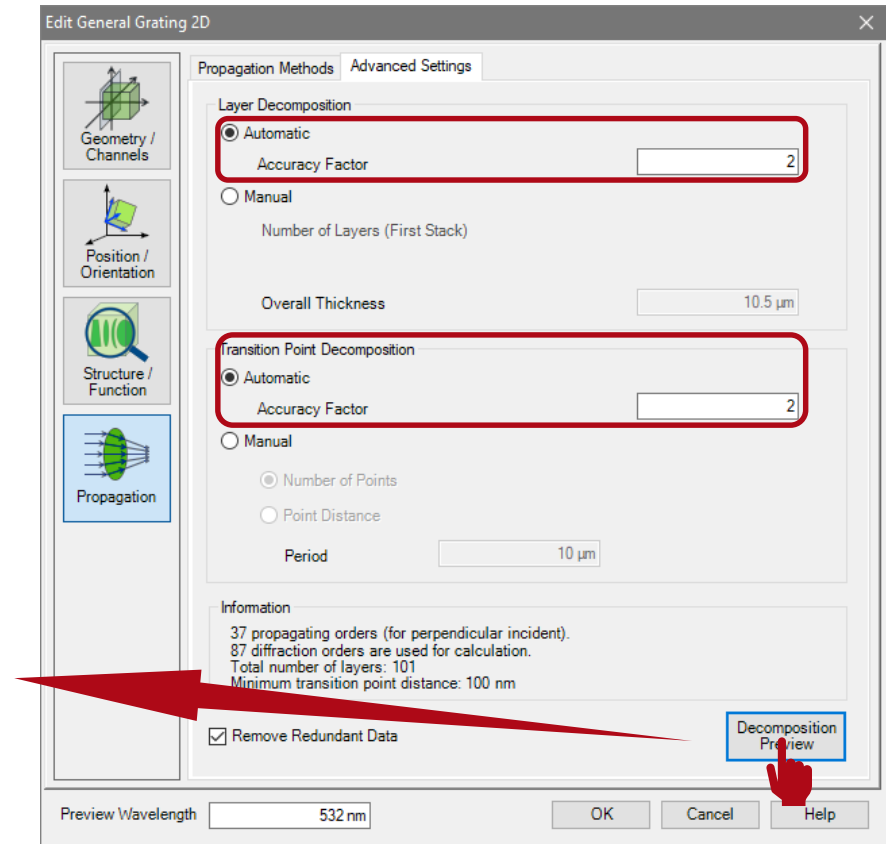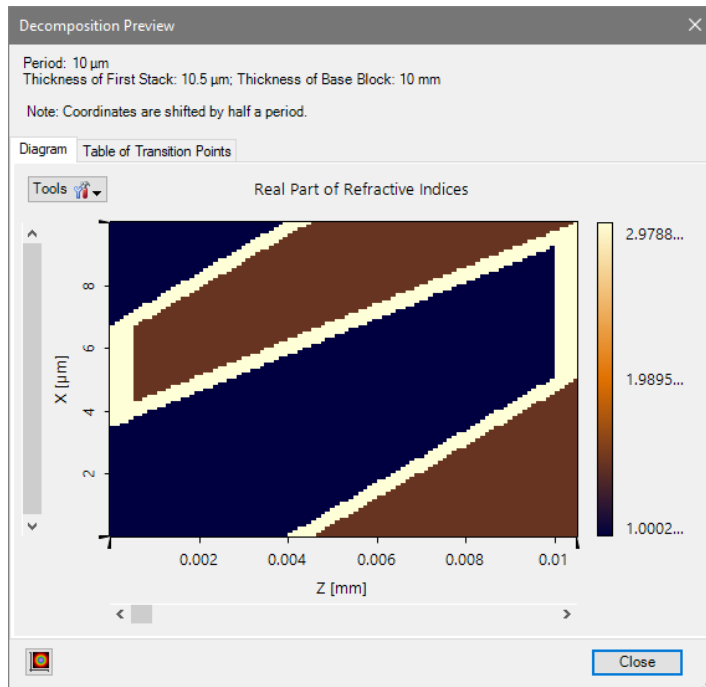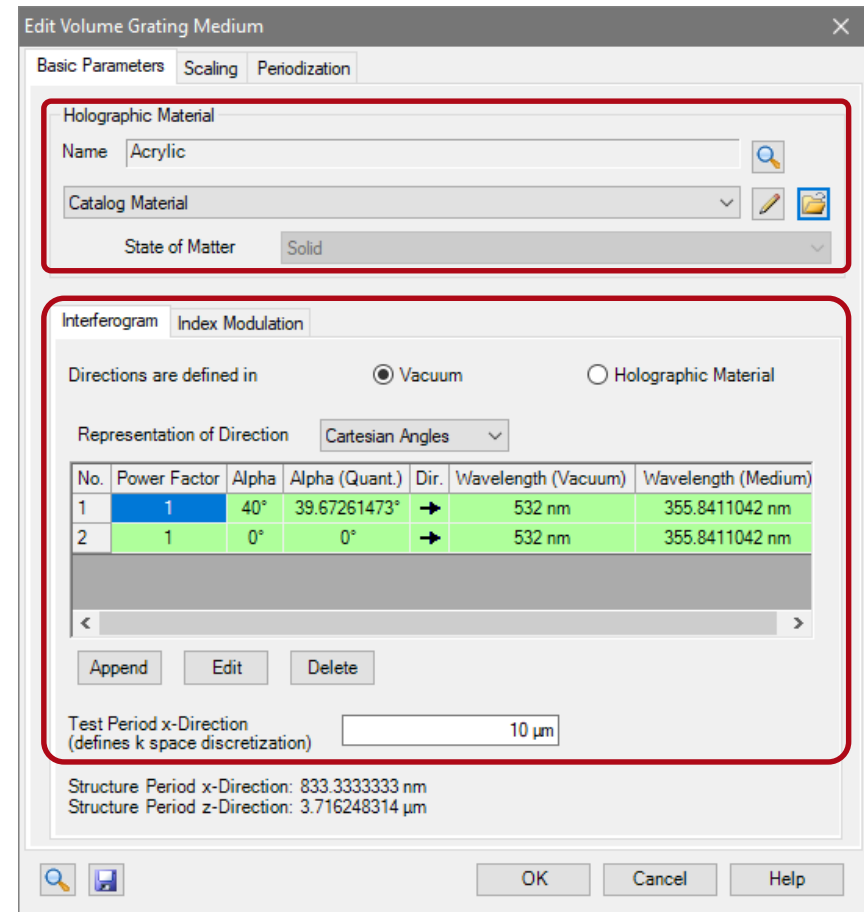
Volume Grating Medium

Volume Grating Medium

- Another type of medium which can be used for the configuration of gratings is the volume grating medium.

- This interface allows to configure a modulations of the refractive index, which was e.g. generated by holographic exposure.

- Again, two plane interfaces are used as boundaries of the medium.
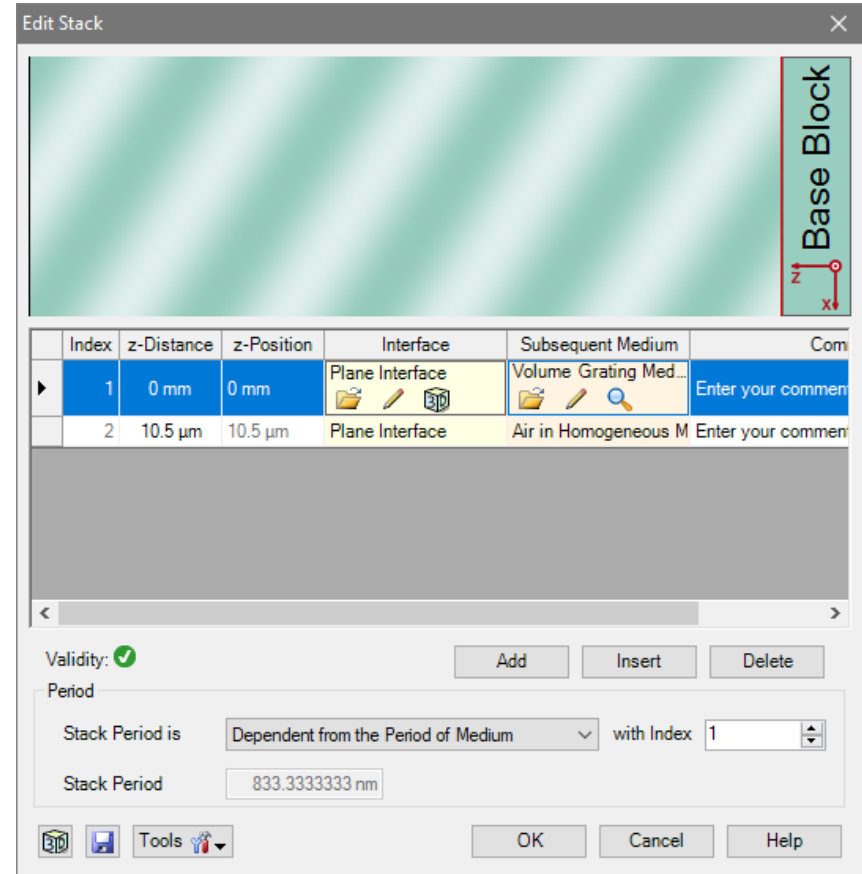
Volume Grating Medium Parameters

- In order to describe volume grating VirtualLab simulates the interference pattern of a certain number on impinging waves.

- First, a holographic medium has to be chosen, that provides the initial index of refraction.

- Further, the period and orientation of the index modulation are controlled by the angle of incidence (alpha) and wavelength of reference and signal wave.

- Moreover, by introducing a quantized k-space respectively incidence angle, the numerical effort can be reduced significantly.
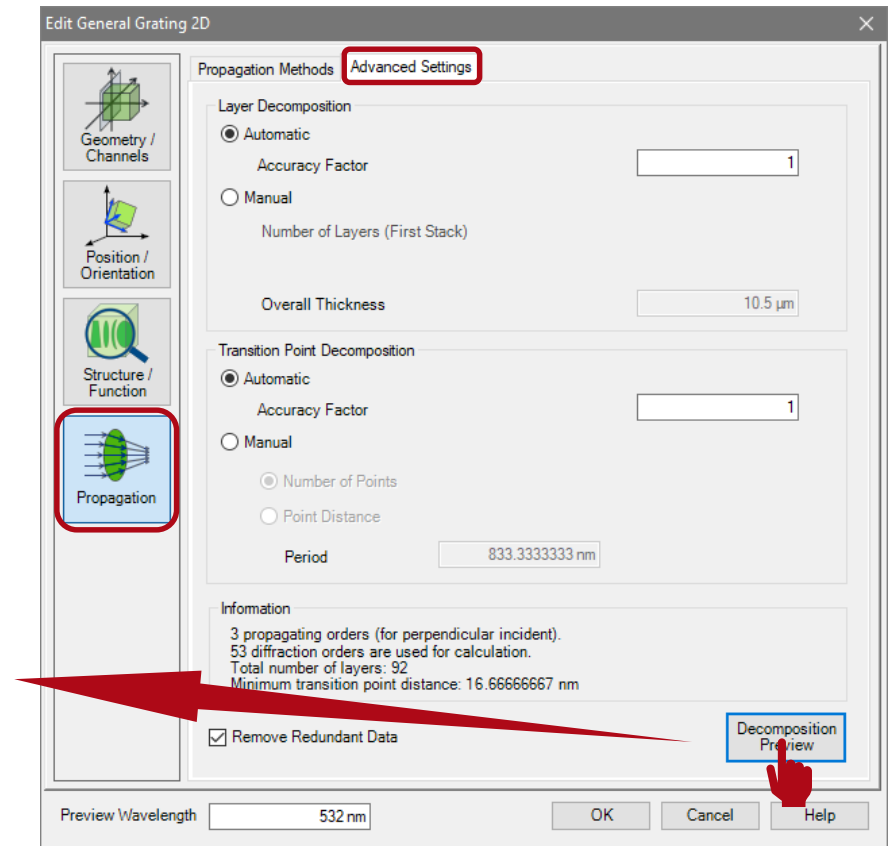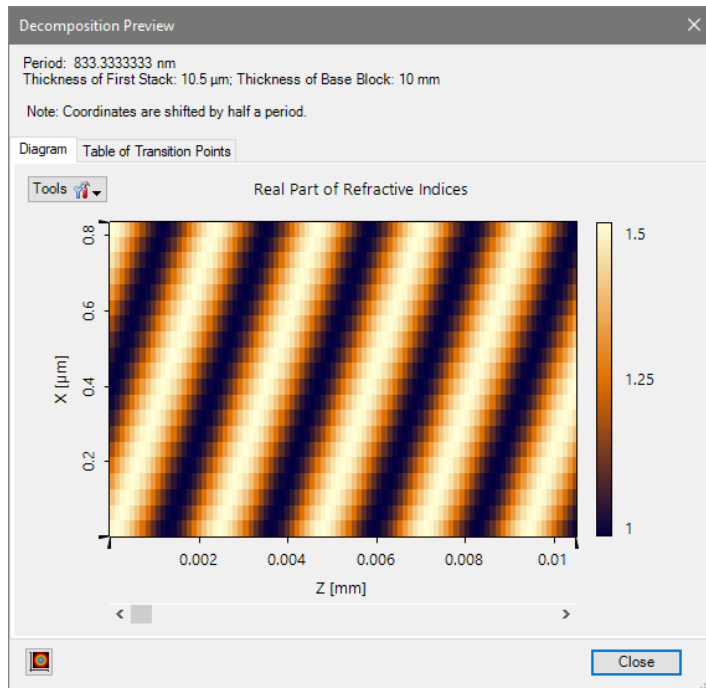 (pls. also see further documentation concerning volume gratings).

Volume Grating Medium Parameters

- The resulting period of the volume grating can be found either in the setting or stack dialog.
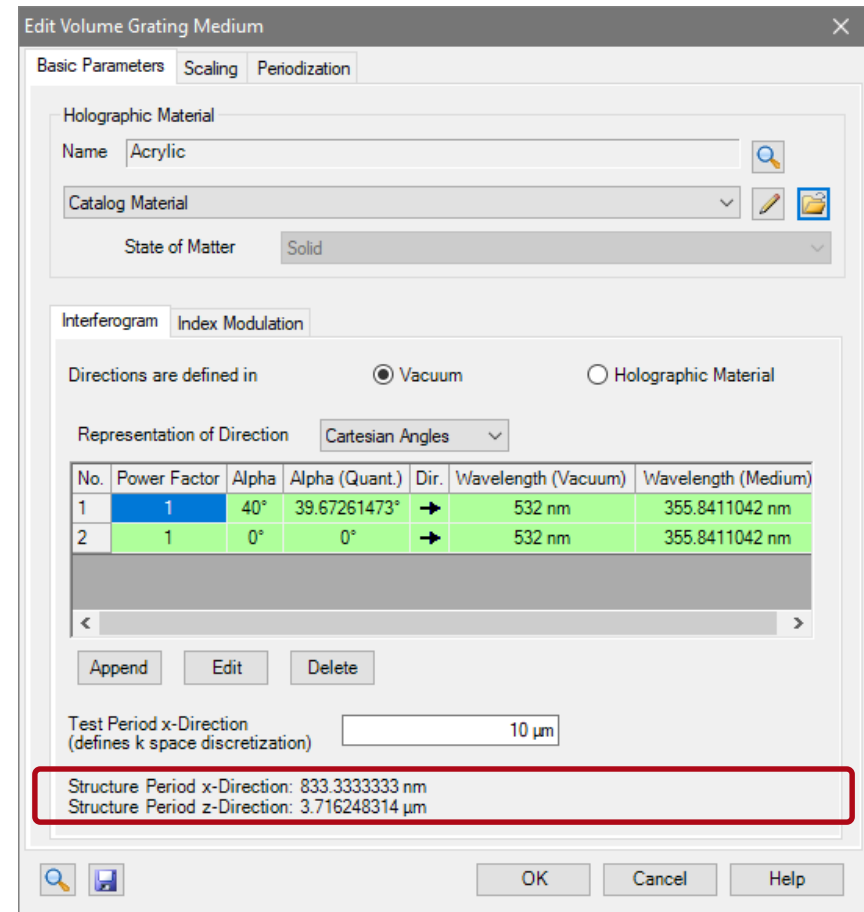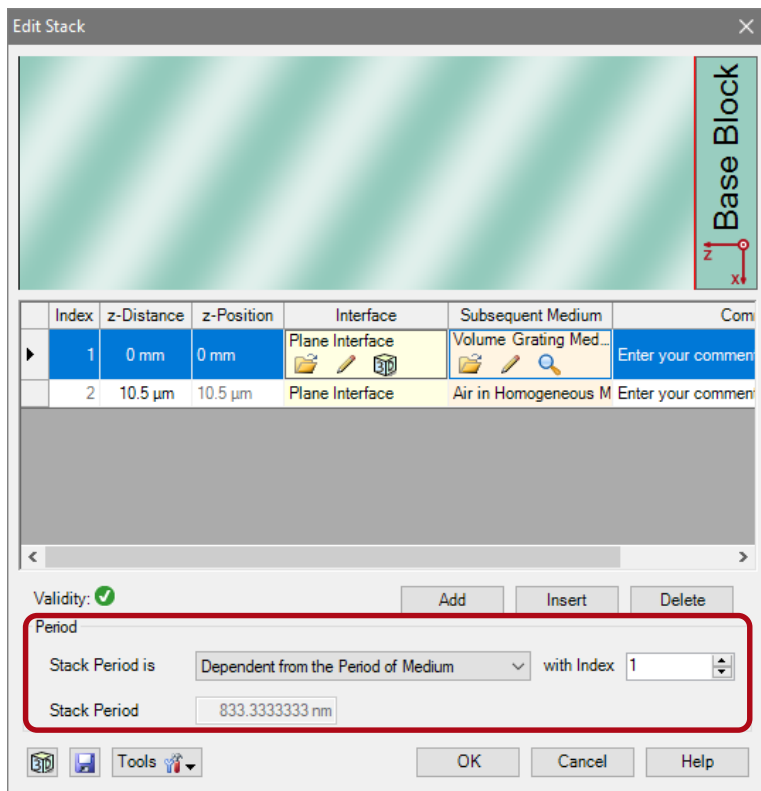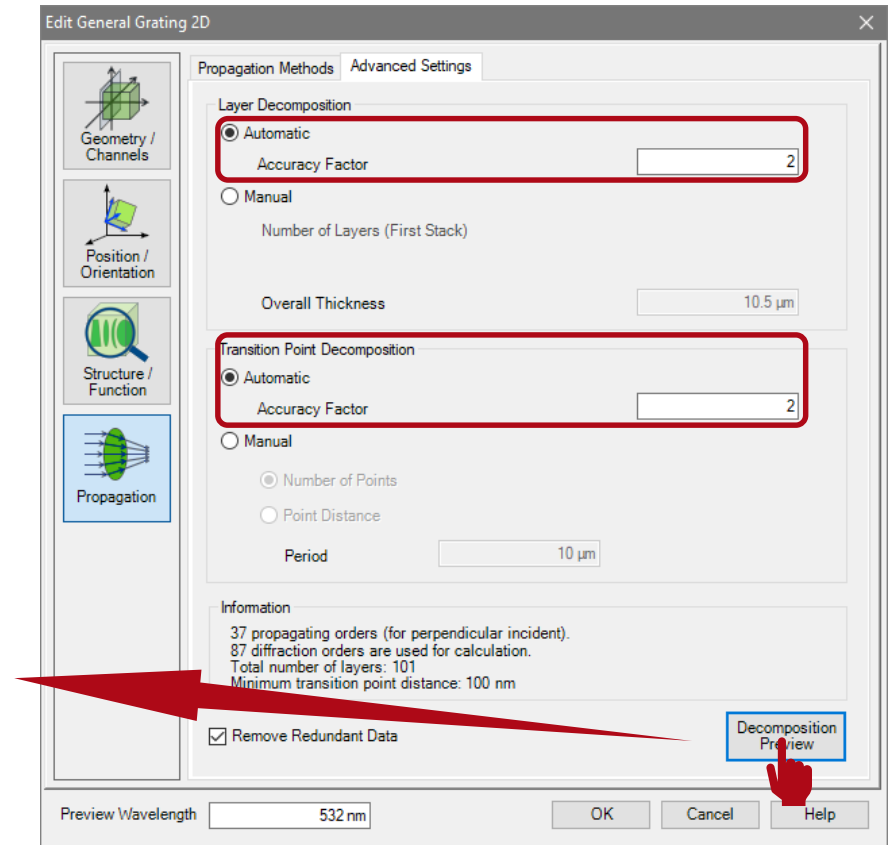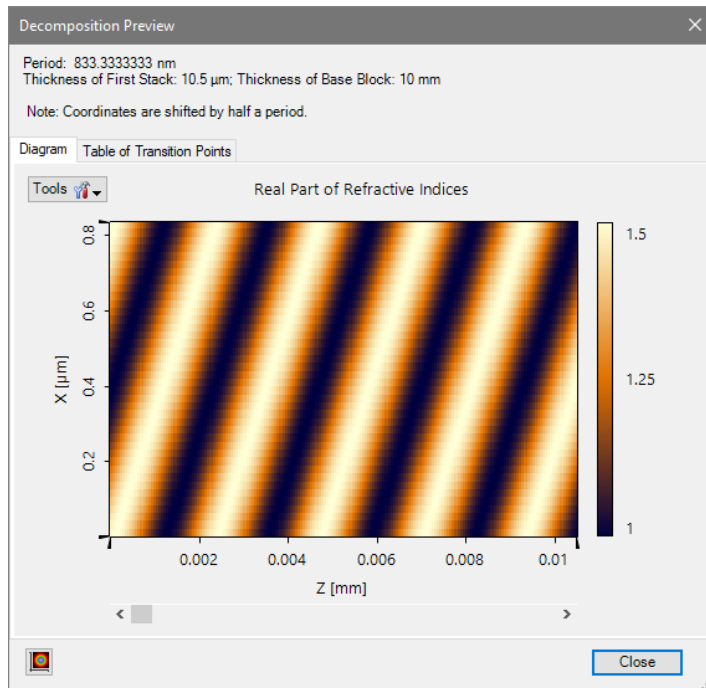
Advanced Options & Information

- Again, the data of the decomposed structure can be adjusted and investigated on the advanced settings tab page.

# Advanced Options & Information

- If the numbers of layers and transition points are increased (e.g. by a factor of 2), the discretization becomes smoother, at the expense of an increased numerical effort.

Remark on the Position of the Detector

Remark on the Detector Position

- In VirtualLab the detector is located subsequent to the substrate in air by default.

- This is necessary if the grating is included in a complex optical setup.

- However, the perfect plane and parallel substrate may cause some interference effects, which not occur in reality.

- Thus, for calculation of just grating efficiencies it is appropriate to set the detector inside the substrate material (likewise to most of grating evaluation software).

- This avoids the undesired influence of those interference effects.
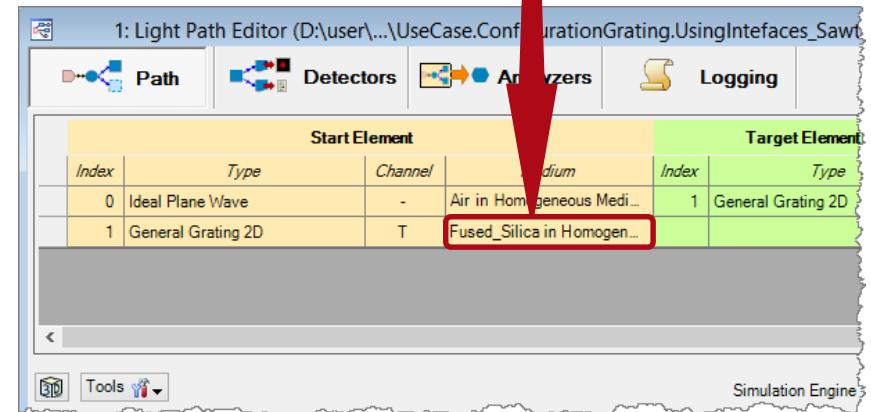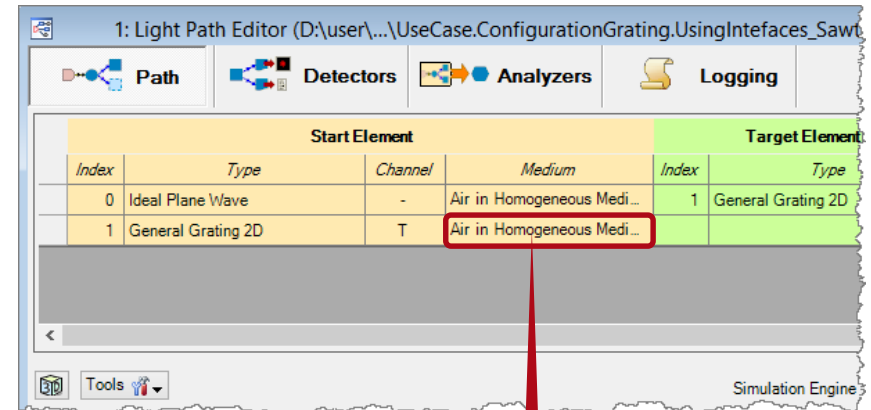
Document Information

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category	Feature Use Case