Analysis of Slanted Gratings for Lightguide Coupling
Abstract

Slanted gratings are commonly used for coupling light into optical lightguides due to their high efficiency in a certain diffraction order. Nowadays, they are often applied in the augmented and mixed reality applications. It will be shown how VirtualLab Fusion can be used to analyze certain slanted grating geometries from literature, with specific parameters like slant angle, fill factor, and modulation depth. In addition, the effect of different incidence angles on the diffraction efficiency is investigated.
Modeling Task

How to calculate the diffraction efficiencies of the coupling grating, with varying grating parameters?

input plane wave
- wavelength: 633 nm
- angle of incidence: 45°
- TE polarized

slanted grating
- period: 596.92 nm
- relative depth
- fill factor
- slant angle

How to calculate the diffraction efficiencies of the coupling grating, with varying grating parameters?

$T^{+1} = ?$

$n = 1.5$

air

to be varied
Grating Parameter | Value & Unit
--- | ---
relative depth | to be varied
slant angle $\varphi$ | -30°
fill factor $c/p$ | 50%

Simulation by Fourier modal method (FMM), also known as RCWA, in VirtualLab Fusion.

Figure from J. Michael Miller, et al., Appl. Opt. 36, 5717-5727 (1997)
Diffraction Efficiency vs. Slant Angle

- $c/p$ = fill factor
- $\varphi$ = slant angle to be varied
- $\lambda$ = wavelength

<table>
<thead>
<tr>
<th>Grating Parameter</th>
<th>Value &amp; Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>relative depth</td>
<td>$1.058\lambda$</td>
</tr>
<tr>
<td>slant angle $\varphi$</td>
<td>to be varied</td>
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<td>fill factor $c/p$</td>
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Figure from J. Michael Miller, et al., Appl. Opt. 36, 5717-5727 (1997)

Simulation by Fourier modal method (FMM), also known as RCWA, in VirtualLab Fusion.
Diffraction Efficiency vs. Fill Factor

$c/p = \text{fill factor}$

**Grating Parameter** | **Value & Unit**
--- | ---
Relative depth | $1.058\lambda$
Slant angle $\varphi$ | $-30^\circ$
Fill factor $c/p$ | \textit{to be varied}

Figure from J. Michael Miller, et al., Appl. Opt. 36, 5717-5727 (1997)

Simulation by Fourier modal method (FMM), also known as RCWA, in VirtualLab Fusion.
**Diffraction Efficiency vs. Angle of Incidence**

input plane wave
- wavelength: 633 nm
- angle of incidence: $45 \pm 10^\circ$
- TE polarized

slanted grating (fixed parameters taken from reference)
- period: 596.92 nm
- relative depth $1.058 \lambda$
- fill factor 50%
- slant angle $-30^\circ$

Grating diffraction efficiency is usually sensitive to the angle of incidence.
Peek into VirtualLab Fusion

convenient definition for slanted gratings

rigorous diffraction efficiency calculation and visualization
Workflow in VirtualLab Fusion

- Configuration of lightguide coupling grating structure
  - Advanced Configuration of Slanted Grating [Use Case]
  - Configuration of Grating Structures by Using Special Media [Use Case]
  - Configuration of Grating Structures by Using Interfaces [Use Case]
- Analyze coupling grating diffraction efficiency
  - Customized Detector for Lightguide Coupling Grating Evaluation [Use Case]
- Check efficiency by scanning over specific parameter
  - Usage of Parameter Run [Use Case]
VirtualLab Fusion Technologies

Free space prisms, plates, cubes, ...

Lenses & freeforms

Apertures & boundaries

Gratings

Diffractive, Fresnel, meta lenses

HOE, CGH, DOE

Micro lens & freeform arrays

SLM & adaptive components

Diffractive beam splitters

Scatterer

Diffusers

Waveguides & fibers

Nonlinear components

Crystals & anisotropic components

Field Solver

1. Scattered light

2. Collimated light
Analysis of Slanted Gratings for Lightguide Coupling

GRT.0009

2.0

VirtualLab Fusion Advanced

2020.1 (Build 1.202)

Application Use Case

- Parametric Optimization and Tolerance Analysis of Slanted Gratings
- Configuration of Grating Structures by Using Special Media