Optimization of Lightguide Coupling Grating for Single Incidence Direction
Abstract

Coupling of light into a lightguide is of major interest for various applications in modern optics. In VirtualLab Fusion, with the Fourier modal method (FMM, also known as RCWA) and parametric optimization tools, one can optimize the real grating geometries so to achieve best coupling efficiencies for specific diffraction orders. This example shows the design strategy for optimizing a rectangular grating for one specific incidence direction to obtain the optimum lightguide coupling efficiency.
Optimization Task

How to optimize the rectangular grating structure to couple a single-direction input plane wave into a planar lightguide with maximum efficiency?

- grating period $p=410\,\text{nm}$
- modulation depth $h=\,?$
- fill factor $c/p=\,?$

- wavelength $532\,\text{nm}$
- angle of incidence $0^\circ$ or $15^\circ$
- linearly polarized along x-axis
Search for Initial Solutions (Normal Incidence)

scanning over grating parameter space:
- modulation depth $h$ from 200 to 1200 nm
- fill factor $c/p$ from 10 to 90%

Using a rough scanning over grating parameter space, one can find possible initial solutions and avoid missing the global optimum.

Seems to be less sensitive to tolerance
Initial solutions are used as starting point for parametric optimizations.

**Final Design #1**
- Efficiency: 16.1%
- Modulation depth: 966 nm
- Fill factor: 56%

**Final Design #2**
- Efficiency: 15.7%
- Modulation depth: 374 nm
- Fill factor: 59.2%

Smaller aspect ratio, preferable for fabrication.
Initial Solutions and Final Designs for 15° Incidence

rough scanning over parameter space

The optimized grating parameters are quite different, and the efficiency is lower.

Final Design

- efficiency: 2.2%
- modulation depth: 221 nm
- fill factor: 67.8%
Peek into VirtualLab Fusion

Parameter Run

Parametric Optimization
Workflow in VirtualLab Fusion

- Configuration of lightguide coupling grating structure
  - 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]
- Rough scanning of parameters to find initial solutions
  - Usage of the Parameter Run Document [Use Case]
- Further optimization of grating structure based on parametric optimization
lightguiding

1st diffraction order

plane wave

VirtualLab Fusion Technologies

Field Solver

- 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
- crystals & anisotropic components
- nonlinear components

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| further reading | - [Analysis of Slanted Gratings for Lightguide Coupling](#)  
- [Optimization of Binary Grating for Lightguide Coupling over Desired FOV](#)  
- [Optimization of Slanted Grating for Lightguide Coupling over Desired FOV](#) |