APPLICATION NOTE

Achieving High-Efficiency Photonics Design: Significant Reduction in Man-Hours

Using RSoft MOST (Multi-Variable Optimization and Scanning Tool)

KEYSIGHT

Overview

Variable scanning and optimization are crucial for designing photonic devices. **MOST (Multi-Variable Optimization and Scanning Tool), a tool within RSoft Photonic Device Tools**, enables multi-variable scanning and optimization by treating any design parameter as a scan variable. Combined with various RSoft simulation tools such as the Finite-Difference Time-Domain (FDTD) method, Rigorous Coupled-Wave Analysis (RCWA) method, and Beam Propagation Method (BPM), it enables efficient design and evaluation. Furthermore, its interface integrates with other simulation tools, allowing users to easily execute simulations and plot results simply by configuring variables, outputs, and optimization metrics.

MOST offers the following three main functions:

- **MOST Scanner:**

  Performs **parameter scans and plots scan results**. Supports both single and multiple scan variables, with results plotable as line graphs, contour plots, or other custom formats.

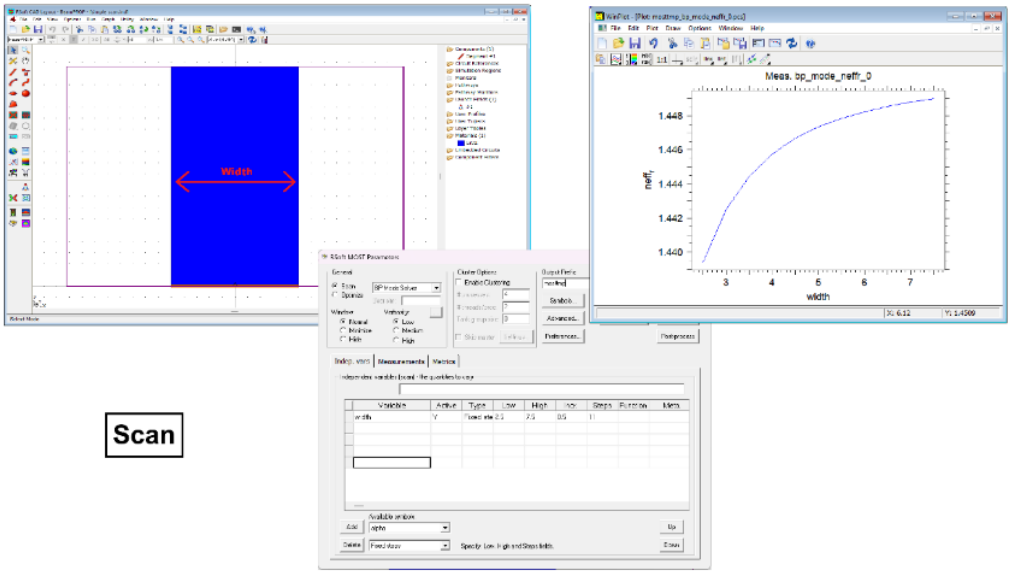
- **MOST Cluster:**

  Performs **clustering calculations for parameter scans and certain optimizations**. Typically, parameter scans require running a large number of simulations, and the number of processes becomes enormous, especially for multiple variables, making completion time-consuming. Using MOST Cluster allows **multiple calculations to run in parallel, significantly reducing total computation time.**

- **MOST Optimizer:**

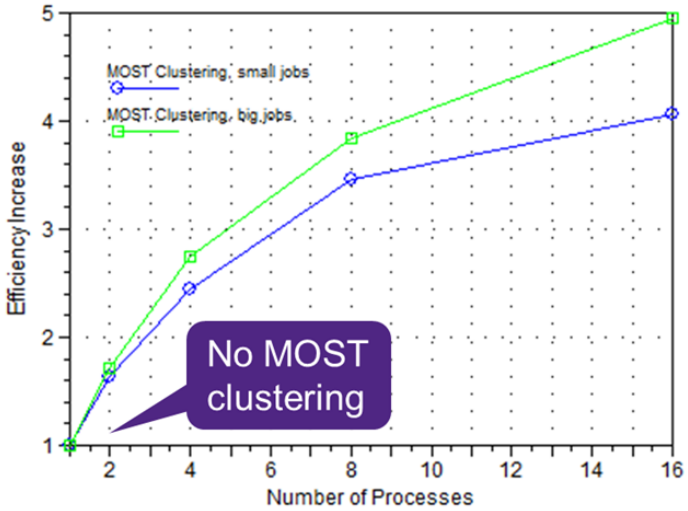
  You can execute **optimization processes using specified variables and evaluation metrics**. Optimization operates via algorithms to minimize or eliminate the value of any given evaluation metric. **Multiple** algorithms are available, including those for **one-dimensional variables, multi-dimensional variables, local optimization, and global optimization.** Selecting the appropriate algorithm for your optimization conditions enables better results.

Variables for scanning and optimization include not only user-defined variables but also internal variables related to simulation conditions, such as wavelength and incident angle. The figure below shows a simple air-clad waveguide where a scan is performed using width as a parameter, outputting the effective refractive index as a graph.



Scan

The figure below compares speeds when clustering is applied. With the computational efficiency of non-clustered calculations set to 1, the horizontal axis shows the number of parallel computing processes, and the vertical axis shows the improvement rate in computational efficiency. It illustrates the improvement rate in computational efficiency when clustering is applied to both large and small computational load jobs. Computational efficiency improves as the number of partitioned processes increases. Furthermore, larger jobs tend to benefit more from clustering.



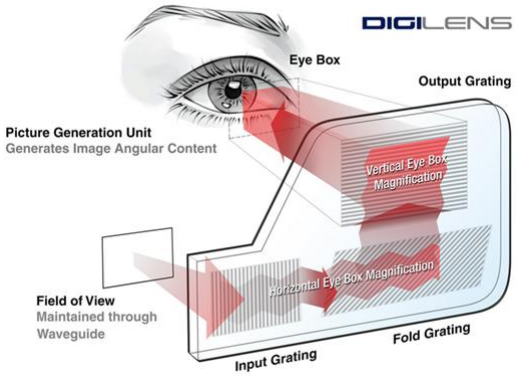
Case Study

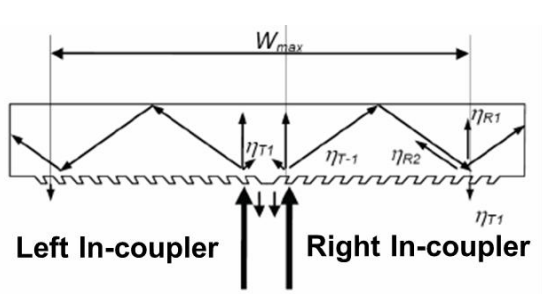
AR/VR Grating

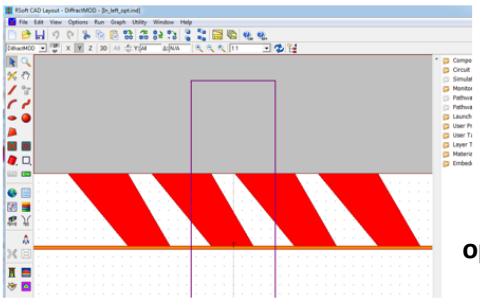
Next-generation AR/VR systems require the introduction of new optical and photonic technologies to enhance user immersion in the display and provide a comfortable visual experience even during prolonged use.

For tilted gratings used in AR/VR systems, **propagation into specific diffraction orders** is required to achieve high-quality images. The input coupler on the right must enhance first-order diffraction efficiency, while the left side requires enhanced 1st-order diffraction efficiency. To improve these diffraction efficiencies, **the DiffractMOD propagation analysis tool and MOST Optimizer**, both utilizing **the RCWA method**, are employed for structural optimization.

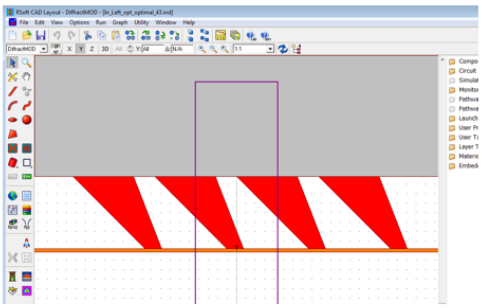
In this case study, **five parameters were optimized**: **period, height, tilt angles on both left and right sides, and top-bottom width**. A genetic algorithm was employed, with the evaluation metric set to **maximize the transmission rate of 1st-order light**. The figure shows the structure before and after optimization, along with the propagation calculation results post-optimization. The structural parameters were optimized, maximizing the transmission rate of 1st-order light.

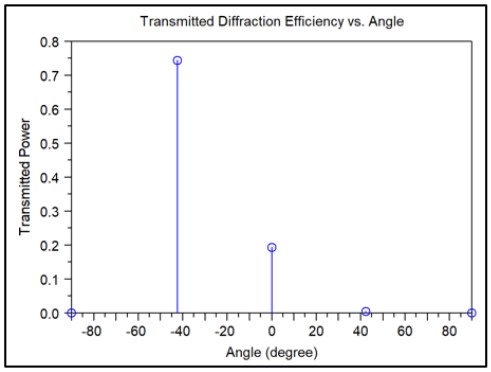


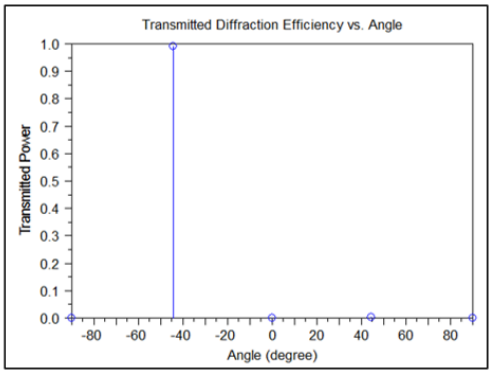




optimize



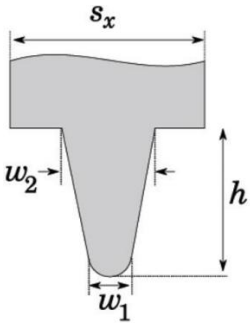


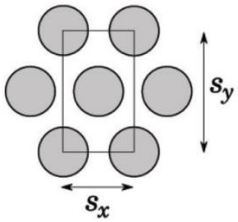


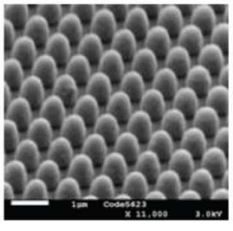
Moth Eye Anti-Reflection Structure

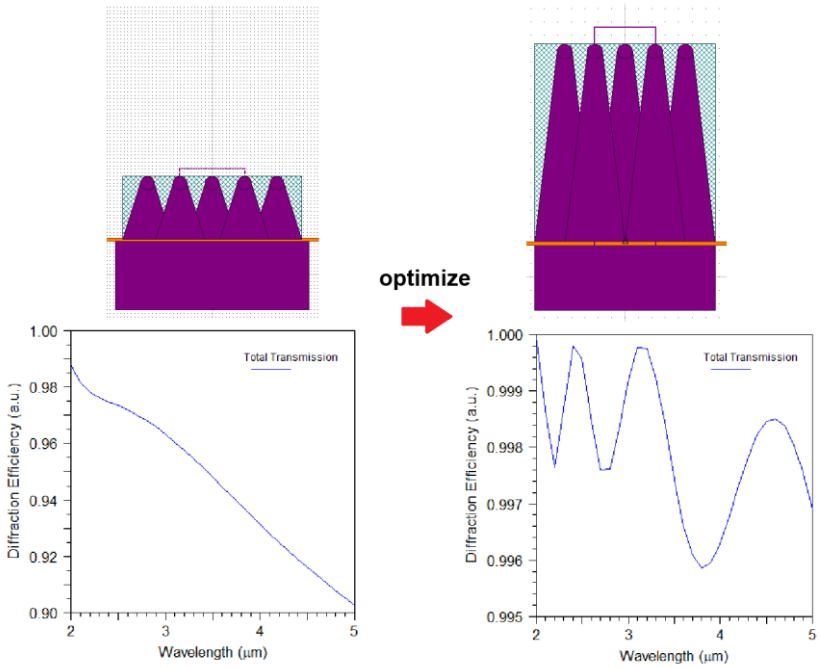
Micro-scale structures formed on optical interfaces are known as an effective method for reducing Fresnel reflection. Among these, **the moth-eye structure,** inspired by the eyes of moths, is **one of the most effective nanostructures for reducing reflection**. Moth-eye structures are used in numerous applications, including laser systems, solar power generation, LEDs, electronic displays, and optical fibers.

In this case study, we optimize the shape of a moth-eye structure for optical fibers. Similar to the **AR/VR grating** case study, we use **DiffractMOD and MOST Optimizer** to optimize **three parameters**: **top diameter, height, and period** (equivalent to the bottom diameter). Employing a genetic algorithm, we set the evaluation metric to **maximize the average transmission rate at wavelengths between 2 and 5 μm**. The figure shows the propagation calculation results after optimization. The average transmission rate is 99.804% between 2 and 5 μm.
As demonstrated, **evaluation metrics using multiple calculation results**, such as the average across multiple wavelengths, can also be set.









Summary

MOST is a tool that integrates with **RSoft's various simulation tools**, enabling efficient **multi-variable parameter scanning and optimization** in photonic device design. It supports scanning and optimization of single or multiple variables, including user-defined variables and internal variables related to simulation conditions. Plotting results and post-processing can also be easily configured. Furthermore, parallel computing via MOST Cluster and machine clustering significantly reduce computation time even for large-scale simulations. MOST Optimizer allows flexible selection of evaluation metrics and algorithms, supporting optimization cases such as gratings for AR/VR and moss-eye anti-reflection structures. Its intuitive interface enables a **seamless workflow from design exploration to optimization and result visualization**, greatly enhancing productivity in research and development.

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