

Arrayed Waveguide Grating Design

Optimizing AWG design for low loss and high efficiency

Introduction

The RSoft Photonic Device Tools Arrayed Waveguide Grating (AWG) Utility features include:

- Easy and self-consistent switching between 2D, 3D, 3D Effective Index Method (EIM)
- Versatile simulation capabilities for AWGs in any material system, including pre-defined silica and silicon
- Simplified simulation flow for advanced simulations
- Layout robustness

This example illustrates a 3D EIM simulation of an Si_3N_4 -based AWG.

As with most optical devices, minimizing loss in AWGs is critical, especially for low power applications. Typical sources of loss include fiber-to-chip coupling, material absorption, bending, waveguide scattering, and transitioning between the free propagation region (FPR) and the arrayed waveguides. An ultra-thin core waveguide AWG [1,2], as illustrated in Figures 1 and 2, uses a wide single-mode waveguide. This reduces scattering losses caused by sidewall imperfections, and increases the coupling from a typical fiber mode due to the large mode size.

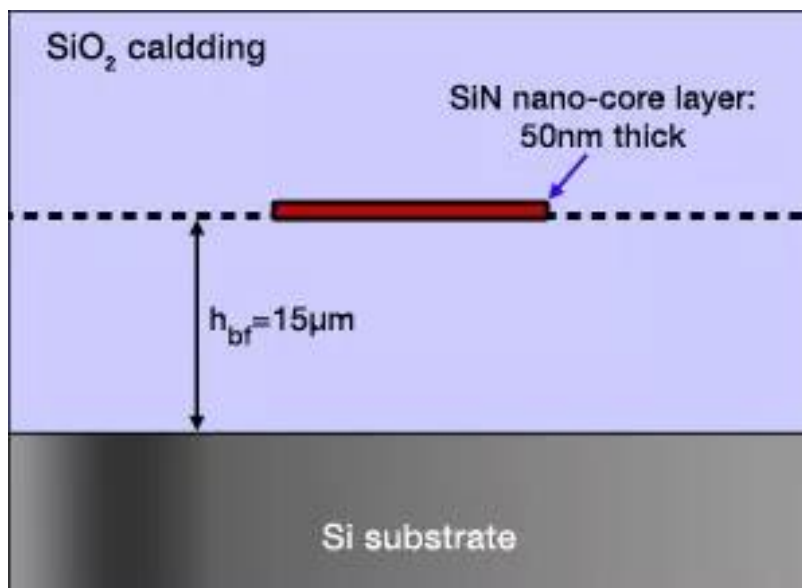


Figure 1. The cross-section of the low-loss buried optical waveguide

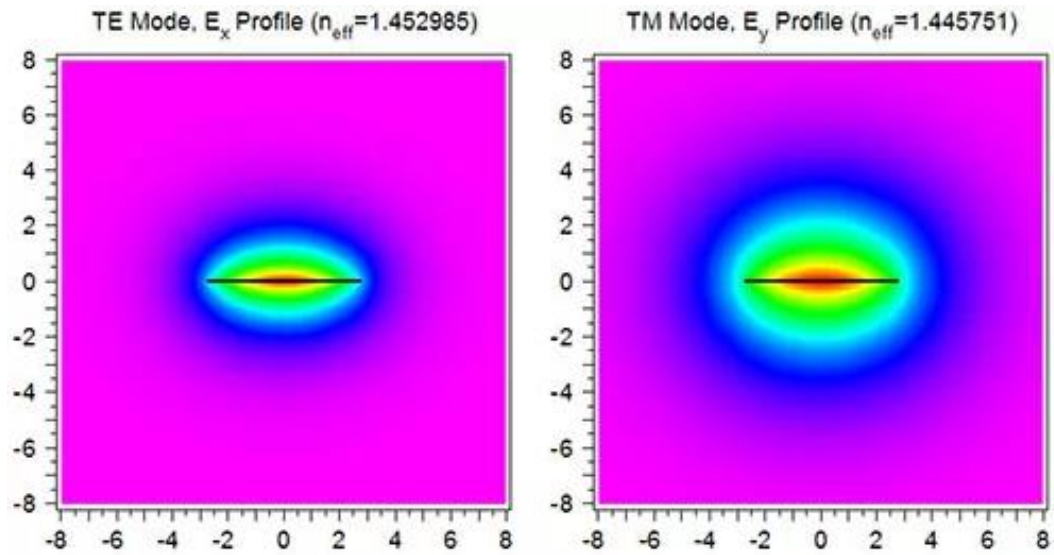


Figure 2. Mode profiles

The AWG design in Figure 3 is based on the following parameters:

- waveguide width and height: 5.5 μm and 50 nm
- center wavelength: 1550 nm
- arrayed waveguides: 150
- number of channels: 16, with 1.6 nm spacing
- minimum bending radius: 4000 μm , corresponding to a bending loss of 0.02 dB/cm, as calculated by FemSIM software
- input and output port spacing: 125 μm , aligning with typical fiber diameters

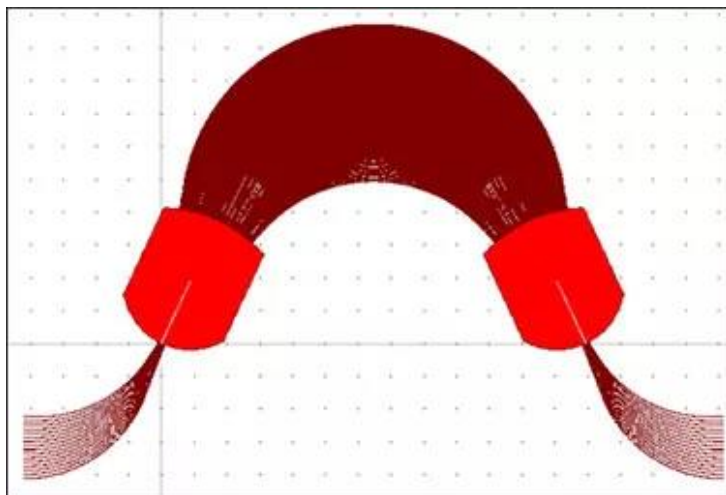


Figure 3. The layout of the designed AWG (de), with the help of FemSIM software

Since this structure is significantly larger than the operating wavelength by approximately 1-2 cm on each side, it's impossible to simulate with a highly memory-intensive algorithm such as finite-difference time-domain (FDTD). Instead, this example uses the Beam Propagation Method (BPM), a proven and efficient method for simulating AWGs in both 2D and 3D.

For this example, 3D effective index method (EIM) reduces the 3D structure into an equivalent 2D model. While this is the default mode of the AWG Utility, it's also simple to switch to a full 3D simulation. The 3D EIM results shown in Figures 4 and 5 confirm that this is a well-distributed, low-loss, and low-crosstalk AWG design.

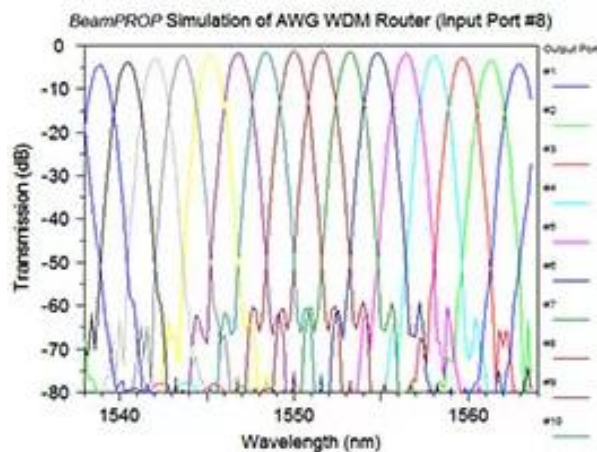


Figure 4. 2D EIM simulation results for 16 channels

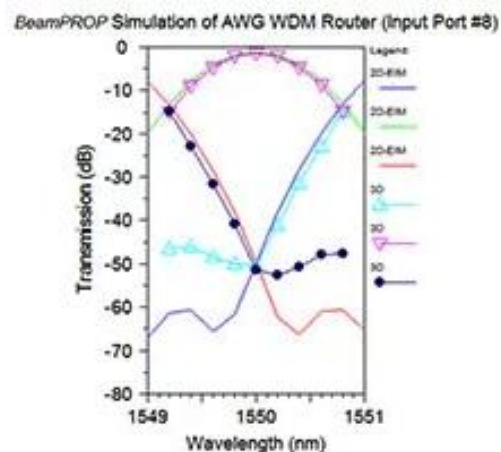


Figure 5. Comparison of the full 3D and 2D EIM results

A full 3D simulation was also performed for one wavelength channel, and the comparison can be seen in Figures 4 and 5. The 3D results, which match well with the 3D EIM results, require approximately 100 times more computation time.

Conclusion

RSoft's AWG Utility provides an efficient, accurate, and easy-to-use tool to model AWG devices. If you have any questions about the use of the AWG utility, visit <https://www.keysight.com/find/email-support>.

References

- [1] J. F. Bauters, M. J. R. Heck, D. John, D. Dai, M.-C. Tien, J. S. Barton, A. Leinse, R. G. Heideman, D. J. Blumenthal, and J. E. Bowers, "Ultra-low-loss high-aspect-ratio Si₃N₄ waveguides," Opt. Express 19(4), 3163–3174 (2011).
- [2] Daoxin Dai,* Zhi Wang, Jared F. Bauters, M.-C. Tien, Martijn J. R. Heck, Daniel J. Blumenthal, and John E Bowers, "Low-loss Si₃N₄ arrayed-waveguide grating (de)multiplexer using nano-core optical waveguides," Opt. Express 19(15), 14133 (2011).

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