

Multimode Calculations of a Metal Clad Waveguide

Products: FemSIM

Applications: Waveguides and Fibers

Introduction

This application note will demonstrate the use of **FemSIM** to compute the modes in a metal-clad circular waveguide used in a sub-wavelength metal cladded disc laser. Mode analysis will help to determine the optimum use of the gain materials (1).

Our Finite Element Mode solver, FemSIM, is a powerful tool to calculate waveguide modes with a full vector solution, and will simultaneously solve for guided, leaky, and radiation modes. When designing a structure that supports a large number of leaky or radiation modes, it is common to want to solve only for the guided modes. To do this in FemSIM, we can solve for a large number of modes and sort them by lowest loss. Sorting by lowest loss will bring guided modes to the top of the list, since they typically have a lower loss than leaky/radiation modes. Additionally, FemSIM can output a subset of the calculated modes, so it is not necessary to save all the computed leaky/radiation modes.

Structure and Simulation Setups

Figure 1 shows the cross section of the metal clad waveguide with the materials used for each layer and their thickness. The real and imaginary values of the refractive index at a specific wavelength of $\text{In}_{0.53}\text{Ga}_{0.47}\text{As}$ is calculated based on ternary material function in RSoft material edit:

```
nkinterp2_real("InAs","GaAs",0.53,free_space_wavelength,1)
nkinterp2_image("InAs","GaAs",0.53,free_space_wavelength,1)
```

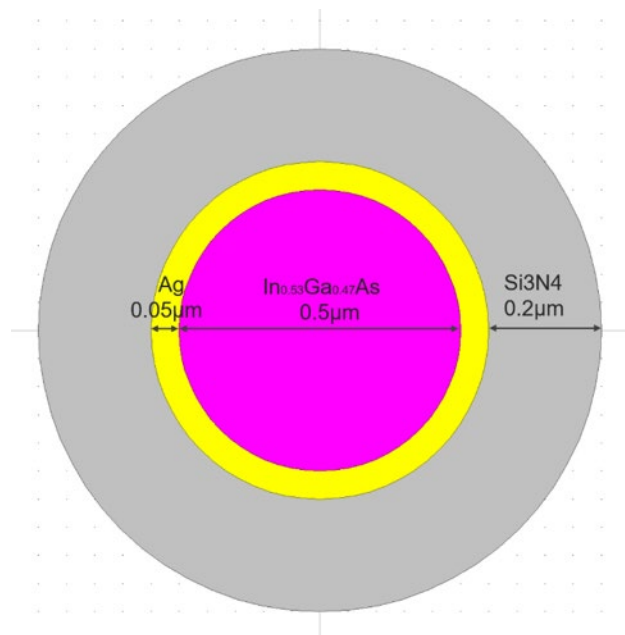


Figure 1. Cross Section of Metal Clad Waveguide with materials and dimensions

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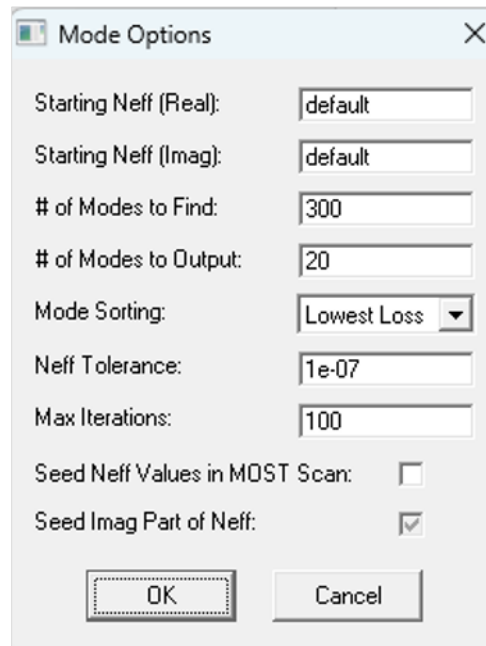


Figure 2. Mode Option Settings

Fig.2 shows the mode option settings in FemSIM. In order to calculate only the guided modes in this simulation, we let FemSIM calculate 300 modes, sort the calculated modes by lowest loss, and then output the 20 modes with the lowest loss.

Additionally, note that the H-field formulation in Advanced... setting dialog was picked for this simulation due to the discontinuity of the E field at the metal interface. At the end of the simulation, FemSIM will output all six field components (E, H) of the computed modes as well as the Poynting vector in the Z direction (S). Figure 3 shows S for one of the calculated modes.

Simulation Results

Figure 3 shows S_z for one of the calculated modes.

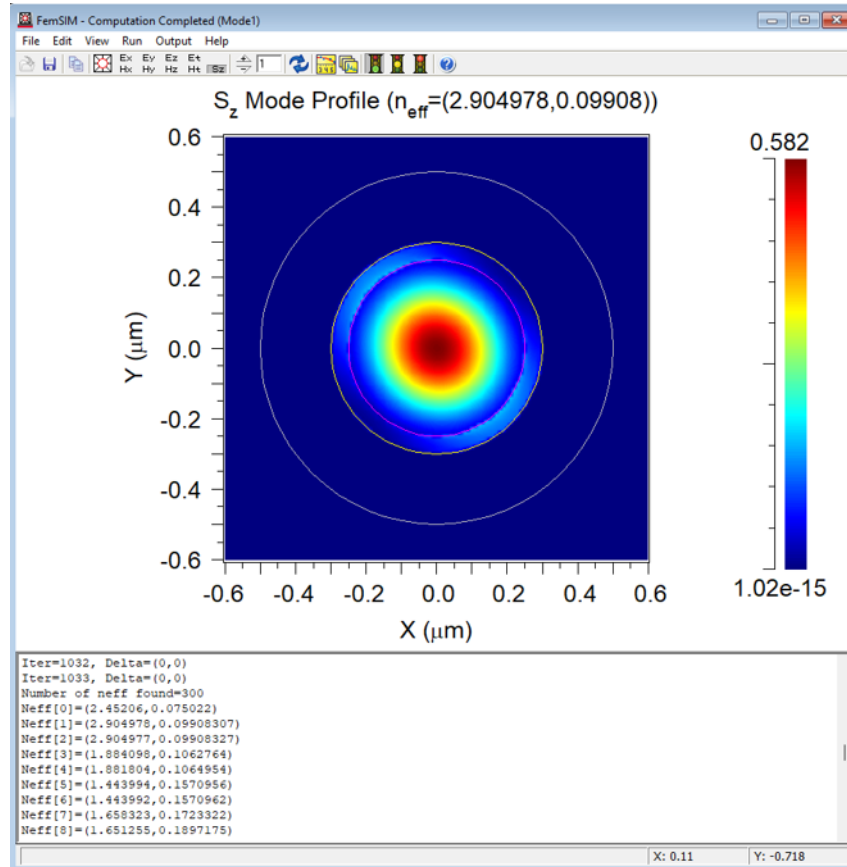


Figure 3. FemSIM simulation window after simulation is completed

Sometimes people want to view the $|E|$ and $|H|$ distributions for the calculated modes. We can use the mathmat utility to obtain this result easily. The mathmat commands that can be used to obtain $|E|$ and $|H|$ are:

mathmat "sqrt(__a^2+__b^2+__c^2)" Mode_ex.m00 Mode_ey.m00 Mode_ez.m00 > Mode_E.m00

mathmat "sqrt(__a^2+__b^2+__c^2)" Mode_hx.m00 Mode_hy.m00 Mode_hz.m00 > Mode_H.m00

where 'Mode' is the Output Prefix used for the simulation. Figure 4 shows the $|E|$, $|H|$, and S_z distributions of five modes for this waveguide.

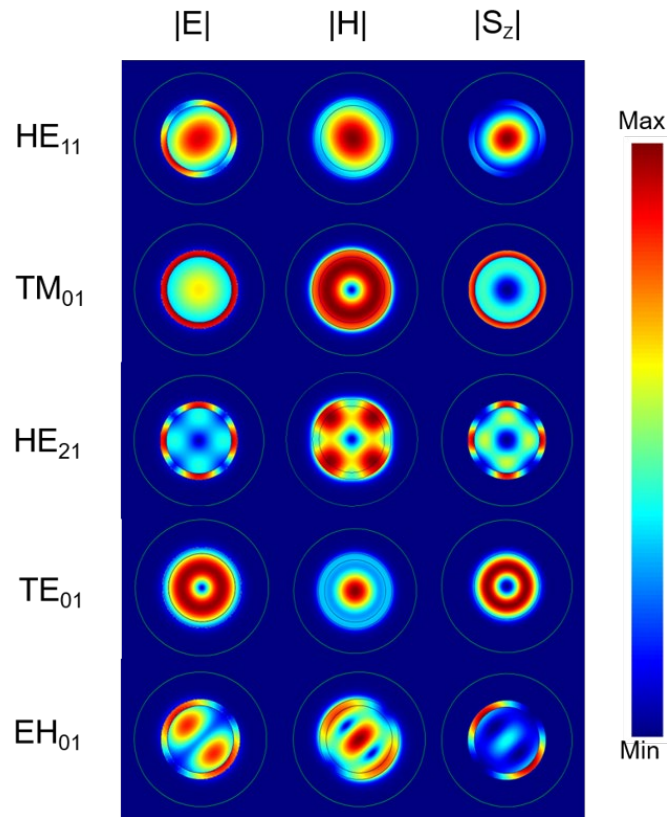


Figure 3. Five lowest order mode patterns ($|E|$, $|H|$, and S) are plotted correspondingly. Power nodes at the waveguide center are observed in TM, HE, and TE modes.

Example files

Supporting Files for RSoft Application Note "Design Reflective Polarizers for Multimode Calculations of a Metal Clad Waveguide "

References

C. Lu and S. Chuang, "A surface-emitting 3D metal-nanocavity laser: proposal and theory," Opt. Express 19, 13225-13244 (2011).

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