A Novel Free-standing Evanescent Waveguide for Sensing

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Abstract

Introduction
The monitoring of bacteria concentration in drain fluid is the most common way to estimate the success of a colon surgery. However, the lack of efficient method to follow the development of E.coli in drain fluid after surgery is often fatal to the patient. The proposed device can reduce the diagnostic time to a few minutes with a low cost solution. In this investigation, a MEMS-based waveguide is fabricated for E.coli detection in patients' drain fluid after colon surgery. The surface of the functionalized waveguide can capture E.coli, which sensed by the evanescent waves on both sides of the waveguide surface. In result, the power transmitted through the optical path is affected compared with another reference one. To reduce the coupling loss and misalignment effect, tapered couplers are designed to be added to the input and output of the waveguide.

Model definition
A waveguide core embedded in air consists of two parts. The straight part works as the sensing region, and the other tapered part is a coupler connected to the fiber. There is an alignment issue. So the model is setup to factor out the transmittance varying depending on different taper angle, so that we can investigate the relationship between transmittance and taper angle. Because the propagation is much longer than the wavelength, Electromagnetic Waves, Beam Envelopes interface and Electromagnetic Waves, Frequency Domain are both suitable. Here we adopt the ewfd interface in COMSOL Multiphysics®. There are perfectly matched layers (PMLs) around and the remaining space between the waveguide and the PMLs is filled with air. The ports are at the boundary between core domain and the PML. The interior port boundaries with PML backing require the silt condition. The port orientation is specified to define the inward direction for the S-parameter calculation. Since higher order modes are not our interest in the simulation, the combination of Domain-backed type slit port and PMLs is used.

The wave is excited at the port on the right side (port 1) and the other port (port 2) are on the left side. "Numeric" is chosen as "the type of port". Two types of materials are involved in by "Blank Material", which are air and Su-8 respectively. The waveguide is meshed using "Free Triangular" and refined. The remaining is mapped. Three steps are brought in in the Study, Step 1(Boundary Mode Analysis for Port 1), Step 2, (Boundary Mode Analysis 2 for Port 2) and Step 3 (Frequency Domain). To factor out the transmittance varying depending on different taper angle, Parametric Sweep is also adopted.

Results

To determine the structural dimension, the relationship between alpha and transmittance need to be researched. 1D Plot Group is chosen for Parametric Solutions. The influences of angle variables on the transmittance are expected to be plotted. So we bring in Global Evaluation to calculate the transmittance (abs(ewfd.S21)^2) of the waveguide.

Figures used in the abstract

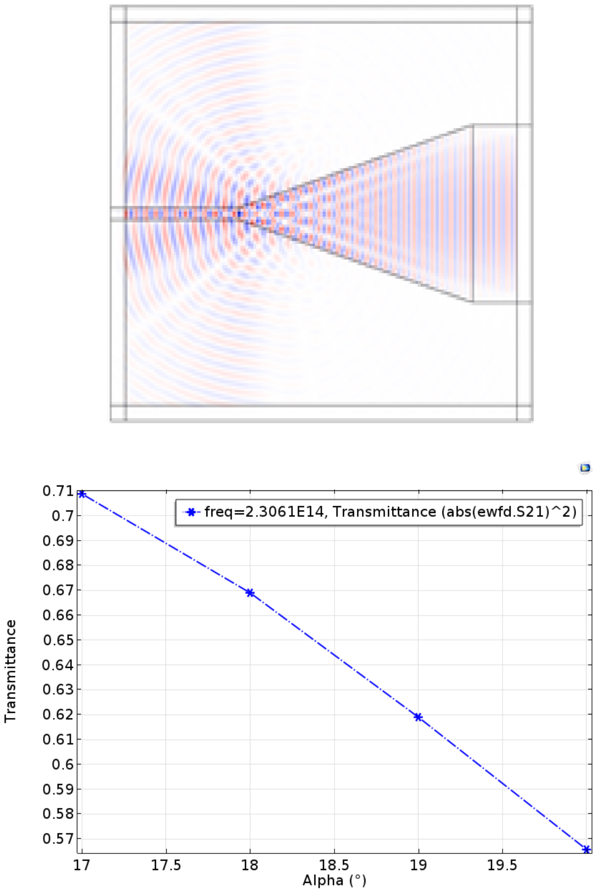

Figure 1: Top: the electric field in tapered waveguide, bottom: transmittance vs alpha for the waveguide.