

Surface Plasmon Sensor

Introduction

Tools used: ModePROP, MOST

Surface phenomena such as surface plasmon resonances play an important role in sensor technology since the behavior of electromagnetic fields at material interfaces can be directly correlated to many physical and chemical properties of the materials. These sensing methods have the further benefit of allowing for accurate and non-invasive sensing that can provide immediate results both in and out of a laboratory. Sensors based on surface plasmons are being increasingly incorporated directly into larger systems to detect many properties, including temperature and the presence or concentration of particular compounds in medical, industrial, or other fields.

The need to incorporate optical sensors into a wide variety of applications necessitates the creation of smaller sensors that are easy to fabricate with and used in existing semiconductor technology. However, as the size of any optical device, including sensors, decreases, the need for simulation software increases.

This structure is based on the structure described in Ref. [1].

Structure Overview

This structure consists of a small interferometer in a silicon-on-insulator (SOI) waveguide structure that functions much like a classic Mach-Zehnder device. A small gold plate is embedded in the waveguide so that the material to be studied lies on top of the plate, and the silicon waveguide and oxide buffer layer lie below it. Light incident on the plate from the propagating mode in the SOI waveguide couples into two surface plasmon modes, one on each side of the metal plate. These two modes, because of the different indices present on either side of the plate, will have different propagating constants resulting in a path length difference. The two modes then interfere at the end of the plate resulting in varied power output. The power output can then be correlated to the refractive index of the test material, and therefore the quantity to be detected.

This structure appears in the **RSoft CAD** as:

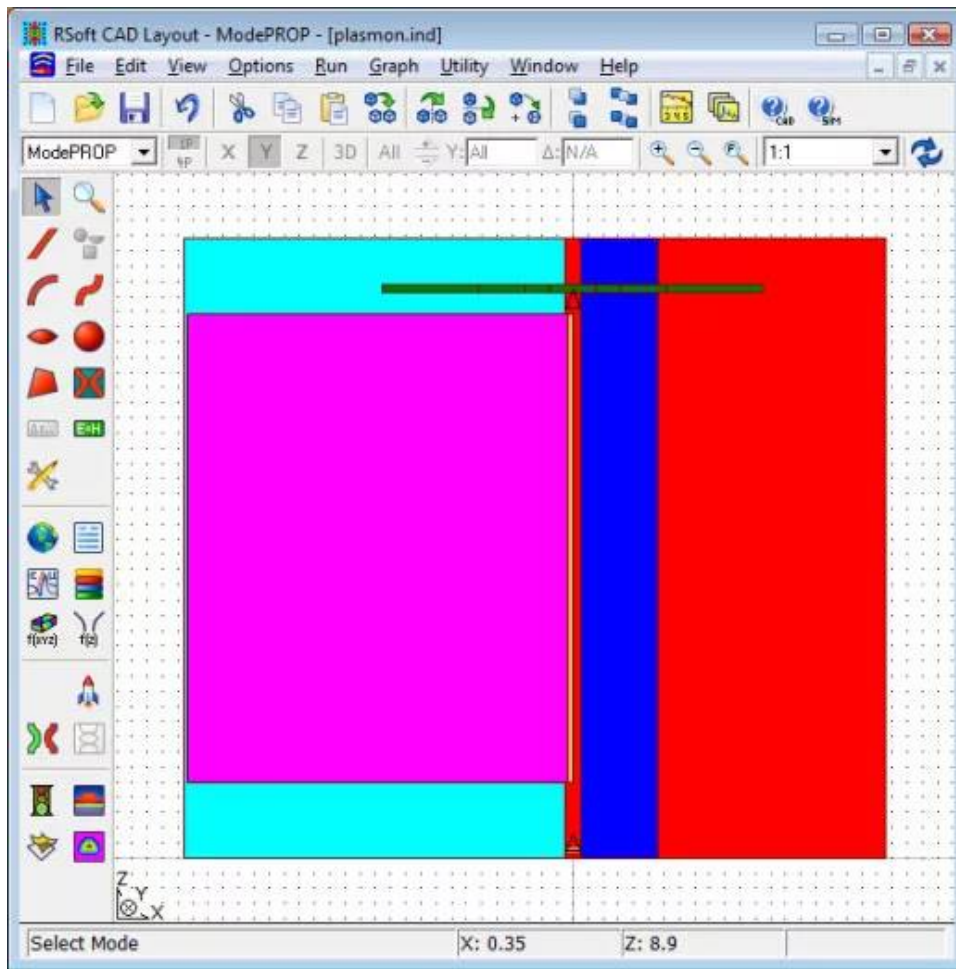


Figure 1. The structure consists of a small interferometer in an SOI waveguide structure

Simulation

The goal of this simulation is to determine how the power output of the structure is correlated to the index of the test material. This can be accomplished by using **MOST** to scan over the index of the test region and measuring the output power.

Simulation at a Single Value of the Test Refractive Index

The results of one simulation with a test index of 1.3 are shown below. **ModePROP** indicates that for this index, the transmission was 0.007.

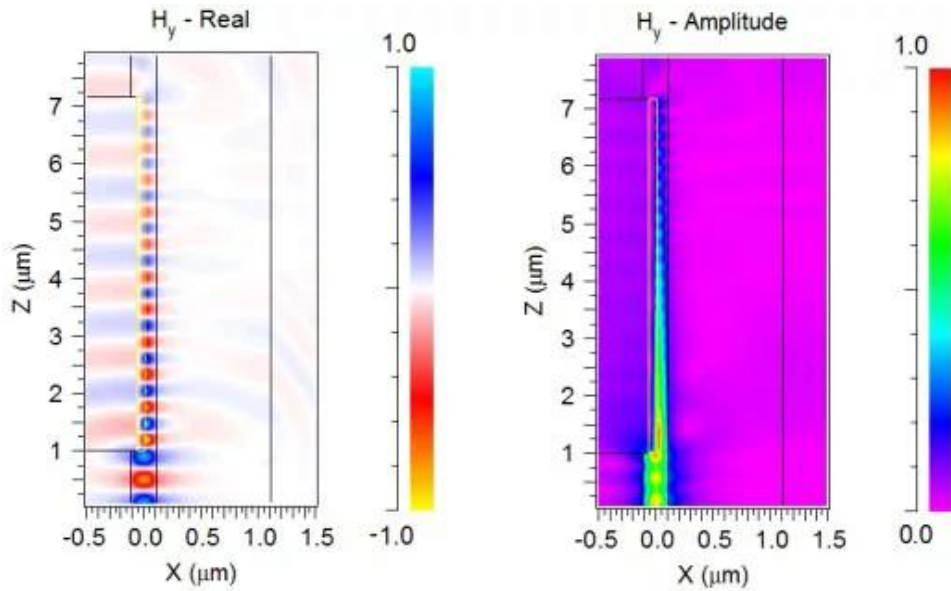


Figure 2. Simulation results

Scanning over the Test Refractive Index

Furthermore, a scan can be done to determine the correlation between the test refractive index and the output power of the device.

MOST was used to scan over the test index and record the output power of the device. The scan results show a strong resonance where the pi phase shift occurs and the two surface plasmon modes destructively interfere.

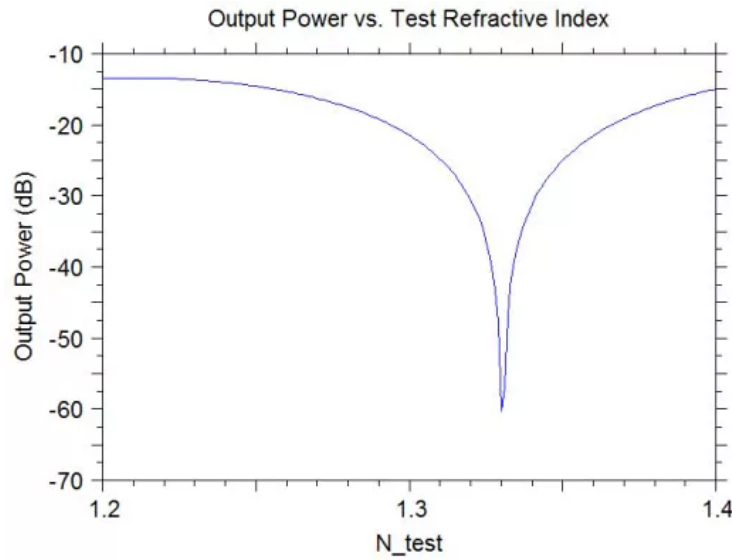


Figure 3. Scan results

This output, along with information about how the quantity of the material to be measured changes the refractive index, can be used to correlate the output power to the quantity to be measured.

References

- [1] P. Debackere et al. Surface plasmon interferometer in silicon-on-insulator: novel concept for an integrated biosensor Optics Express 14, 7063 (2006)