Abstract

In this thesis, we have designed and analyzed photonic crystal fiber (PCF) sensors using finite element method based COMSOL Multiphysics software. The proposed sensors are refractive index sensors based on the surface plasmon resonance phenomenon. The motivation behind this work is to design photonic crystal fiber sensors that provide high wavelength sensitivity, amplitude sensitivity, figure of merit, and resolution for a wide range of analyte sample refractive index range. Different sensor structures have been designed and analyzed to enhance sensitivity performance. These sensor structures can easily be fabricated with the help of newly available technologies such as the stack and draw method, sol-gel method, etc.

In this thesis, complete research work has been divided into **six chapters.**

This thesis has been organized into seven chapters. **Chapter – 1** has an introduction where we discuss about photonic crystals and it different type. Optical fibers, light guidance through optical fiber, its type, and the merits and demerits of optical fiber. An overview of PCF, light guidance through different kinds of PCF, and sensing properties of PCF are explained in this chapter. This chapter includes a numerical simulation study of PCF, a theoretical explanation of the surface plasmon resonance (SPR) phenomenon, and some fundamental theoretical formulations to explain the optical properties of PCF.

A detailed literature review of PCF and the motivation of this thesis has also been included in this chapter. **In 2nd Chapter**, we designed and analyzed a PCF with metal wires on both sides of the outer portion of the PCF based on the SPR concept. In this chapter, we have compared three plasmonic materials, copper, gold, and silver, on the basis of their maximum wavelength sensitivity, amplitude resolution, and sensor resolution.

Next in the row, **Chapter – 3** has polished PCF sensors for analyte RI range 1.30 – 1.40 on both sides. Gold (Au) and TiO_2 have been polished on both sides to enhance the sensitivity response of the proposed sensor structure. **Chapter – 4** has a rectangular shape cladding type PCF sensor based on the SPR technique. Using this PCF structure with Gold (Au) plasmonic material and TiO_2-based adhesive layer, the sensitive response has tremendous growth, and enhanced sensor resolution has been observed. In the **5th Chapter**, a dual – core PCF has been modeled and analyzed using the SPR phenomenon for a wider range of analyte sample RI range 1.21 – 1.39. This sensor provides high wavelength sensitivity, amplitude sensitivity, and sensor resolution. It is the widest range of analyte samples that covers applications in different sensing fields such as medical, chemical, food and beverage, etc. In the last **Chapter 6** a detailed conclusion and summary of the complete thesis have been organized.