Republic of Iraq
Ministry of Higher Education and scientific Research
University of Technology
Department of Laser and Optoelectronics Engineering

Design and Simulation of Fiber-Optics Biosensor-based Evanescent Wave

Thesis

Submitted to the Department of Laser and Optoelectronics Engineering, Universityof Technology in Partial Fulfillment of the Requirements for Master Degree of Science in Optoelectronics Engineering

By

Sara Mohammed Tariq Jassim

(*B.Sc.2016*)

Supervised by

Assist. Prof. Dr. Makram Abdulmutaleb Fakhri

2022 AD **1443 AH**

ABSTRACT

Recently, fiber-optic has been widely used in the development of sensing devices due to its high sensitivity, compact size, ease of fabrication and operation, low cost and so on.

In this thesis, single-mode fiber SMF-28e (8.2μm diameter) is used to propose an unclad single-mode fiber-optic sensor (USMFOS) by using COMSOL Multiphysics 5.1 simulation program finite element method (FEM). The central portion of the fiber cladding was removed and replaced by gold nanoparticles (Au NPs) attached to the fiber core. This sensor was immersed in different liquids with different refractive indices (RIs) and tested by COMSOL.

The key parameters of this sensor are the thickness of Au NPs and the RI of the analytic liquids.

First, Au NPs of 40nm thickness was deposited on the core. Then, the sensor was immersed in air, water, colon tissue, and liver tissue. The confinement loss (α_{CL})amplitude (S_a) and wavelength(S_λ) sensitivity, resolution (R), sensing length ($L_s(\lambda, n_a)$), and figure of merit (FOM) were calculated at wavelength of 0.65μm and RI range from 1.00027632~1.3754 for these liquids. The best results were obtained for colon tissue with maximum α_{CL} =1524.84(dB/m), S_a=-10.595[RIU]$^{-1}$, S_λ=4301.07[nm/RIU], R=2.33×10^{-5}[RIU] $L_s(\lambda, n_a)$=6.65×10^{-4}(m), and FOM=40.64[RIU]$^{-1}$.

Second, Au NPs of 50 thickness was used to coat the fiber core and the sensor was immersed in air, water, colon tissue, blood plasma, liver tissue and pentanol ($C_5H_{11}OH$) at RI range from 1.00027632~1.4053. The best results were obtained for blood plasma with α_{CL} =1231430(dB/m), S_a=-45.80[RIU]$^{-1}$, S_λ=10638.297[nm/RIU], R=9.4×10^{-6}[RIU], $L_s(\lambda, n_a)$=8.12×10^{-5} (m), and FOM=153.73[RIU]$^{-1}$.

Third, a comparison between 30, 40, 50nm thickness of Au NPs was presented when the sensor was immersed in air, water, colon tissue, and liver tissue at RI range from 1.00027632~1.3754. The best results were obtained for 50nm for colon tissue with α_{CL} =13197.43(dB/m), S_a=18.83182[RIU]$^{-1}$, S_λ=16129.03[nm/RIU], R=6.2×10^{-6}[RIU] $L_s(\lambda, n_a)$=7.58×10^{-5}(m), and FOM=245.98[RIU]$^{-1}$.The thickness of analyte layers was also compared at 3, 4, and 5μm. It was found that there is no effect on the confinement loss of the sensor.

Finally, the thickness of Au NPs was chosen to be 50nm when the sensor was immersed in NaCl-deionized(DI), sucrose-deionized(DI) water, and glycerol-deionized(DI) water solutions of RI range from 1.00027632~1.39. The best results were obtained for glycerol-DI water with α_{CL} =34285.40(dB/m), S_a=-2.68[RIU]$^{-1}$, S_λ=3157.89[nm/RIU], R=3.16×10^{-5}[RIU] $L_s(\lambda, n_a)$=2.92×10^{-5}(m), and FOM=45.73[RIU]$^{-1}$.