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

A plasmon laser sensor for intermodal interface patterns based on image processing

A Thesis

Submitted to the Department of Laser & Optoelectronics Engineering, the University of Technology in Partial Fulfillment of the Requirements for the Degree of Master of Science In Laser Engineering

By
Amnah Saleh Hassan

B.S.c. Laser and Optoelectronics Engineering Department University of Technology (2010)

Supervised by

Prof. **Dr. Razi J. Al-Azawi**

Assist. Prof. **Dr. Ali A. Alwahib**

1444 AH **2022 AD**

ABSTRACT

Over the last few decades, researchers have shown significant interest in a Surface Plasmon Resonance (SPR) based waveguide. This type of work showed a distinguished specification that enabled this interest in experimental and theoretical research. The present work concentrates on single and multilayers of plasmonic material theoretically. The waveguide design was modeled and numerically designed using Finite Difference Eigenmode (FDE) and done through the lumerical simulation software. the advantages of using waveguides in the optical sensor are tiny size, durability, the ability to realize various optical functions on a single chip, multi- channel sensing, robustness, immunity to electromagnetic interference (EI), high sensitivity, low cost, and very short response time. The application of waveguides is used in environmental monitoring, clinical diagnostics, adulteration detection, chemical, and biological applications. Three plasmonic materials were examined in this research: gold, silver, and copper. For all plasmonic materials, graphene was used as a coating layer. This thesis includes five parts; the first part is the effect of thickness on plasmonic materials. The following part is the effect of changing the refractive index. The third part is to study the effect of two layers on the absorption by adding the gold layer to both silver and copper metals and adding the copper layer above the gold metal; the last is adding the graphene above all used metals. The fourth part is modeling for all our work to explain the best option for the absorption, and the last part compares the result of simulation and image processing through the study of mode profile.

On the other hand, the sensitivity, FWHM, FOM, and resonance wavelength for all the metal layer designs were calculated. The obtained results found that the best sensitivity with silver metal is(112 nm/RIU) with a thickness of 30nm and absorption was (166.6) at a 1.1 refractive index. However, when adding the graphene layer (G) 6nm thick above the silver metal, the absorption becomes (191.5). The best absorption with gold metal is (254.2) with a thickness of 30nm at the refractive air index, and when the analyte's refractive index is increased, the absorption is increased reaching to (259.8) at a 1.3 refractive index. The sensitivity of the gold layer at 30nm thickness is (64nm/RIU), and (72nm/RIU) when coated with the graphene layer. Also, the sensitivity of the copper layer is (71 nm/RIU), and was (104 nm/RIU) when coated with a graphene layer (G). The result of modeling showed the best option according to absorption is gold metal coated with graphene layer (G), the absorbance reached 266 at the thickness of 30nm and refractive index 1.3. The result comparison between the results of simulation and image processing was matched.