Materials Today: Proceedings 74 (2023) 389–391

Contents lists available at ScienceDirect

Materials Today: Proceedings

journal homepage: www.elsevier.com/locate/matpr

Nano-plasmonic refractive index sensor based on metallic slit loaded stub resonator

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ARTICLE INFO

Article history:
Available online 3 October 2022

Keywords:
Propagating plasmons
Sub-wavelength confinement
Metal-Insulator-Metal
Fano interference

ABSTRACT

The combination of optical sensing phenomenon with Nano science is a new paradigm shift in point of care sensing devices. Here, a nano-sensor based on propagating Plasmons is investigated. Due to unique feature of plasmonics having long transmission range and confined the signal beyond diffraction limit, the sensor is designed with metal–insulator-metal (MIM) geometry of plasmonic waveguide. The stub resonator is coupled to MIM waveguide for the desired filter characteristics. The metallic slit is incorporated in the resonating structure and the metallic slit is off-center in resonating structure. The presence of the slit tunes the condition of resonance and Fano interference phenomenon emerges. The device is calibrated according to change in the value of refractive index of analyte and we can observe linear relation between the refractive index of analyte and resonance wavelength. The maximum value of sensitivity is achieved as 1990 nm/ RIU. The proposed geometry may open a new path for nano-sensing based optical chips.

Selection and peer-review under responsibility of the scientific committee of the International Conference on Advances in Materials Science, Communication and Microelectronics.

1. Introduction

From 18th century plasmonics plays a vital role in the field of medical diagnosis, environmental monitoring, chemical sensing and many sensing based applications due to some unique features and superior performance with optimized parameters. Plasmonics is electromagnetic phenomenon in which plasmons can be generated at the metal-dielectric interface when the momentum of the photon completely matches with the momentum of free electrons in the metal. Due to surface plasmon resonance(SPR) condition, surface Plasmon polaritrons(SPP) are generated at the interface of metal-dielectric layer [1,2]. SPP are very beneficial in the era of in nano-scale optical devices owing to its exciting features of sub-wavelength confinement. There are two phenomenons for the excitement of plasmons at the metal-dielectric layer: The first one is based on propagating surface plasmons and the other one is based on localized plasmons [5]. The propagating plasmons has wide applications in designing optical circuits, gates, routers, sensors etc. and the deep sub-wavelength confinement along with waveguide feature is achieved if metal–insulator-metal (MIM) geometry is used [6]. The MIM plasmonics structure can also be configurated with many resonator structures like ring waveguide based, cavity based resonating structure etc [7,8]. So in the proposed research, plasmonics based refractive index sensor have been design with the help of stub resonator along with MIM waveguide and the resonator is equipped with off-centric Nano-metallic slit.With the help of metallic slit, fano resonance is generated and the resonance spectrum is split to yield two resonance peaks. The Fano resonance phenomenon of the proposed geometry is also investigated for sensing.

Geometrical Configuration of Waveguide:

Fig. 1 indicates the configuration of MIM waveguide with off centre stub resonator. The metallic slit is added in the resonator of size 20 nm × 50 nm. The metallic slit is off centered from resonator by 50 nm. The geometrical parameters of this configuration are listed in Table 1.

Here ε_∞ = 3.7 denotes the relative permittivity for the infinite frequency, $\gamma = 2.73 \times 10^{17}$ rad/*sec* represents the collision frequency of electrons, $\omega_p = 1.38 \times 10^{16}$ rad/*sec* and ω denotes the plasma frequency and incident light angular frequency respectively [9–11].

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https://doi.org/10.1016/j.matpr.2022.09.325

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