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Parametric data-driven optimization approach on plasmonic based ring resonator

Priyanka Sharma *, Rukhsar Zafar, Rahul Pandey

Department of Electronics and Communication Engineering, Swami Keshvanand Institute of Technology, Management & Gramothan, Jaipur, India

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ABSTRACT

In this paper, a plasmonic based ring resonator is being investigated. The metallic portion of plasmonic waveguide is chosen to be silver while the insulating material is air. The structure is numerically analyzed through Finite Difference in Time Domain (FDTD) method. To accurately model the relationship between the design parameter (radius of the ring) and the resonance condition of the resonator, a Machine Learning (ML) approach is applied. The ML model is trained on a dataset and tested for obtained results. The simulated results show that the proposed model is able to achieve the accuracy of prediction. The data driven optimization technique is being used for finding out the appropriate resonance condition of ring resonator. The proposed model is able to achieve good prediction accuracy (>90 %). The predicted result can be utilized in designing desired plasmonic devices like sensors, splitter, optical gates etc.

Selection and peer-review under responsibility of the scientific committee of the 3rd International Conference on "Advancement in Nanoelectronics and Communication Technologies".

1. Introduction

The tremendous development in the field of optical devices has led to the progressive control over the flow of light [1]. Recent research in the field of photonic crystals and fibers has concluded that the light can be easily moulded in photonic structures [2–4]. The related features are promoted with the latest surge of progress in the field of nano-technology. The amalgam of advances in the field of nano-science and photonics devices have led to many important technological applications which includes photonic structures supported solar cells [4], optical-microscopy [5], optical sources and detectors [6–7], multiplexers and demultiplexers [8], buffers [9–10]. The distinguished features of nano-photonics devices may rule over the conventional uses of light wave and play a nontrivial role in the field of the telecommunication industries [9], chemical and bio-sensing and medical science [11]. However, the manipulation and control of optical signals is rather limited by the diffraction law and signal is confined in comparatively large wavelength scale [12]. Recently, a new field of nano-science has emerged that is viable to control the flow of light over sub-wavelength scale. The technology is named as Plasmonics and is broadly categorized as Propagating Plasmonics and Localized Plasmonics [13,14,26,27]. This categorization is based on the topology of materials being used. But in both the techniques, the underlying physics is based on the excitation of electromagnetic wave into the metal-dielectric interface that leads to generation of plasmons. A major footstep of research is being noticed in the related field of Propagating Plasmonics or Surface Plasmons Polaritons (SPPs) that are terahertz electromagnetic waves coupled with collective oscillation of electron plasma in metal [13]. SPPs are excited when the excitation wavelength is in resonance with free electron (available on surface of metals) collision frequency. The propagating plasmons are well confined in the direction perpendicular to the interface and propagate tightly around the interface. The special geometry of SPP waveguide i.e. Metal-Insulator-Metal (MIM) waveguide allows the signal to be confined beyond diffraction limit and does support nano-sized features for optical devices [13–15,28–30].

The MIM waveguide is appealing technique to design various plasmonic devices, such as buffers [10], sensors [16–17], optical gates [18], de-multiplexers [19], filters [20] etc. The variety of applications of plasmonics can be controlled easily through resonating structures [16–20]. The ring resonator is considered to be more efficient resonating structure as it recirculates the light confined in the cavity and found to be more efficient owing to its feature of being highly sensitive, compact size and real-time mon-

* Corresponding author.

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