iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 7 **Issue:** V **Month of publication:** May 2019

DOI: https://doi.org/10.22214/ijraset.2019.5615

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.177
Volume 7 Issue V, May 2019- Available at www.ijraset.com

Design of Metal-Insulator-Metal based Plasmonic Ultra-Wide Band U-Shaped resonators based Band-Pass Filter

P. Osman[1], P V Sridevi[2], K V S N Raju[3]
[1]*Department of Electronics and Communication Engineering, Samuel George Institute of Engineering & Technology, Markapur, Andhra Pradesh, India.*
[2]*P V Sridevi, Department of Electronics and Communication Engineering, A U College of Engineering (A), Andhra University, Vishakapatnam, Andhra Pradesh, India.*
[3]*K V S N Raju, Department of ECE, S.R.K.R.Engineering College, Bhimavaram, Andhra Pradesh, India.*

Abstract: In this paper design and full wave simulation of an ultra-wide band U-shaped resonator band-pass filter using metal-insulator-metal plasmonic waveguide for wireless applications. A U shaped multiple resonator are cascaded in order to form a plasmonic ultra-wide band band-pass filter. The variation in reflection and transmission coefficients has been analysed using commercially available software CST microwave studio. The filter is designed and analysed and operated at optical wavelengths which are used in the photonic integrated circuits (PCI).
Keywords: Plasmonics, UWB, Band-pass filter, PCI, MIM Waveguide.

I. INTRODUCTION

Surface plasmon polaritons (SPPs) are the electro-magnetic (EM) waves that travel along the metal-insulator-metal (MIM) [1-3] interface. The EM waves are enhanced with low propagation losses and model shape at optical wavelengths [4-5]. The various kinds of filters has been studied and reported in [6-7], This mode is similar to the transverse electro-magnetic mode, hence equivalent transmission line can be equipped using this model. The different kind of MIM waveguides such as multiplexers, filters, duplexers, de-multiplexers, splitters has been reported [8-11] at O, S, C, L and U optical wavelengths. In order to cover all these wavelengths a single band desired ultra-wide U-shaped resonator band band-pass filter has been designed and analyzed in this paper.

This filter will reduce size and power consumption, most of the research works are operated at low frequencies (GHz) [12] in order to increase the efficiency of the filter we propose a compact metal-insulator-metal based plasmonic ultra-wide band U-shaped resonators based band-pass filter. Keeping that fact in mind we has been analyzed reflection and transmission coefficients of the ultra-wide band U-shaped resonators based band-pass filter. The reflection and transmission coefficients has been analyzed using commercially available software CST microwave suite.

II. ANALYSIS OF MIM WAVEGUIDE BASED ULTRA-WIDE BAND BAND-PASS FILTER

The proposed ultra-wide band U-shaped resonators based band-pass filter using metal-insulator-metal plasmonic waveguide has been designed with the cascading of symmetrical five U shaped stubs. The characteristics of the ultra-wide band U-shaped resonator band-pass filter using metal-insulator-metal plasmonic waveguide has been analysed with insulator refractive index and width of the feed-lines are fixed. The filter is formed with the five U shape resonators with same coupling gap. The band-pass filter parameters can be calculated using following equations:

$$BW = (\omega_U - \omega_L)/\omega_c$$

Where $\omega_c = \sqrt{\omega_U \omega_L}$

$$Z_{0,odd} = Z_0 * \frac{1 - Z_0\, k\, cosec(\emptyset_c) + (Z_0\, k)^2}{1 - (Z_0\, k)^2 \cot(\emptyset_c)}$$

$$Z_{0,even} = Z_0 * \frac{1 + Z_0\, k\, cosec(\emptyset_c) + (Z_0\, k)^2}{1 - (Z_0\, k)^2 \cot(\emptyset_c)}$$

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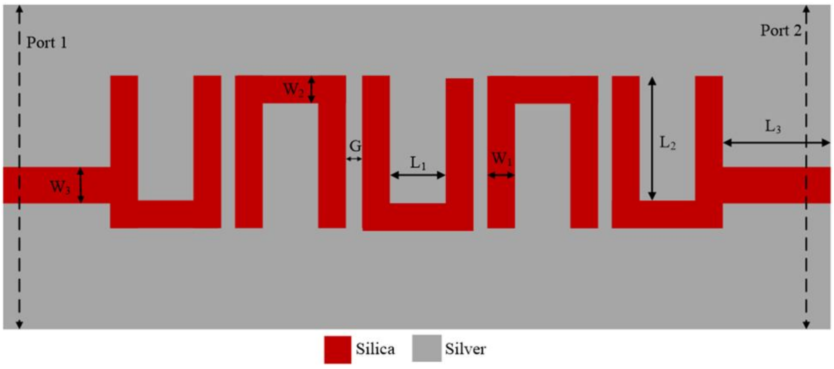

Fig. 1 Geometry of metal-insulator-metal based plasmonic ultra-wide band band-pass filter.

The proposed ultra-wide band U-shaped resonators based band-pass filter using metal-insulator-metal plasmonic waveguide has been designed with silver as a metal and silica as a insulator with fixed parameters of silver [13] as $\varepsilon_\infty = 3.7$, $\omega_p = 1.38 \times 10^{16}$ rad/s, $\Upsilon = 2.73 \times 10^{13}$ rad/s and silica as $\varepsilon_i = 2.50$. We carried out a full-wave simulation with a perfect boundary conditions with a time step of $\Delta t = \Delta x/2c$, where c is the velocity of light in vacuum and with a mesh size of 5 x 5 (nm). Full-wave simulation has been carried out using CST micro-wave studio.

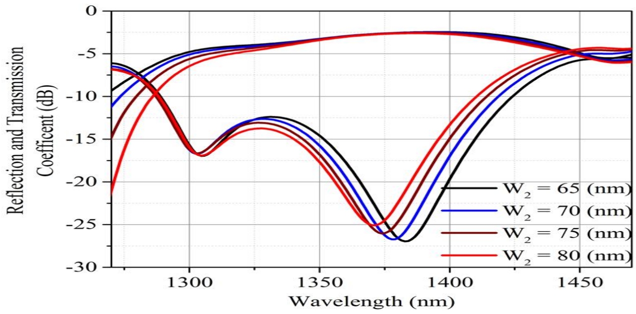

Fig. 1 Reflection and transmission coefficient with wavelength as a function with width (w_2).

The geometry of the proposed ultra-wide band U-shaped resonators based band-pass filter using metal-insulator-metal plasmonic waveguide has been shown in Fig. 1. The filter is formed with the symmetrical U shaped five resonators and with an equal coupling gap G. The dimensions of UWB filter are W_1 = 75 nm, W_2 = 70 nm,W_3 = 100 nm, length L_1 = 300 nm, L_2 = 500 nm, L_3 = 250 nm, and coupling gap G = 8 nm.

Fig. 2 represents the variation in reflection and transmission coefficient for the proposed ultra-wide band U-shaped resonators based band-pass filter using metal-insulator-metal plasmonic waveguide with respect to width W_2.The Fig.3 represents the variation in reflection and transmission confections of the proposed filter with respect to with width W_1. The filter operates at desired optical bands O and E respectively. As it is operated in O and E band it is operating in two bands it is mentioned as ultra-wide band filter. Fig.4 shows the field distribution at wavelength 1377(nm).

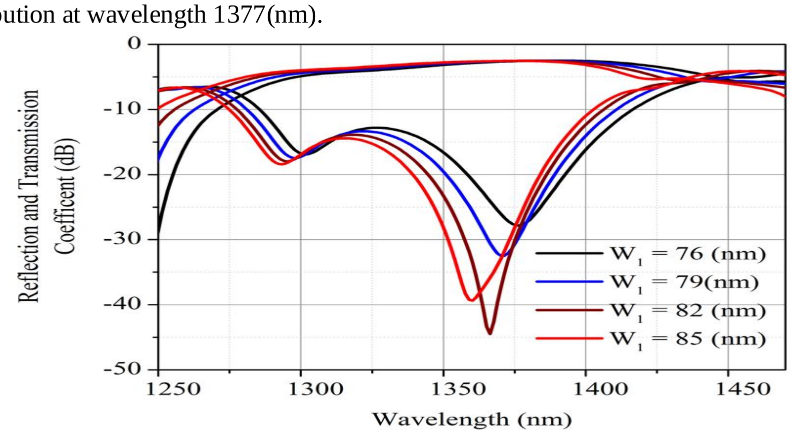

Fig. 3 Reflection and transmission coefficient with wavelength as a function with width (w_1).

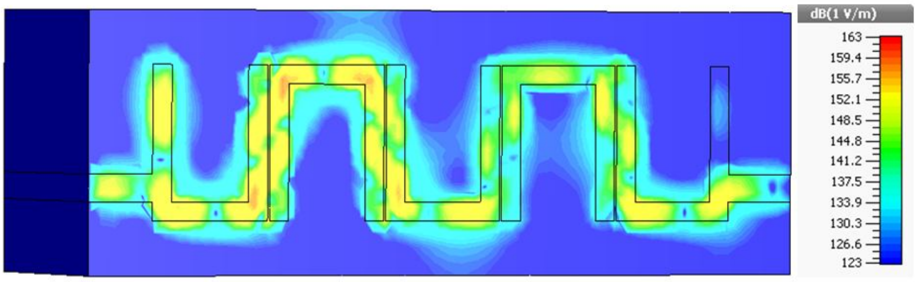

Fig. 4 Field distribution at wavelength λ = 1377 nm.

III. CONCLUSION

In this article we had designed and analysed of an ultra-wide band U-shaped resonator band-pass filter using metal-insulator-metal plasmonic waveguide for wireless applications. The UWB band pass filter is formed by cascading U shaped structures in order to form a plasmonic ultra-wide band band-pass filter. The reflection and transmission characteristics has been analysed at optical wavelengths O, S, C, L and U. The return loss of an A U shaped multiple resonator is minimum of -28dB. The variation in reflection and transmission coefficients has been analysed using commercially available software CST microwave studio. The filter is designed and analysed and operated at optical wavelengths which are further used in the development of photonic integrated circuits (PCI).

IV. ACKNOWLEDGMENT

The authors acknowledge support by the Andhra University, Vishakhapatnam, and Andhra Pradesh, India.

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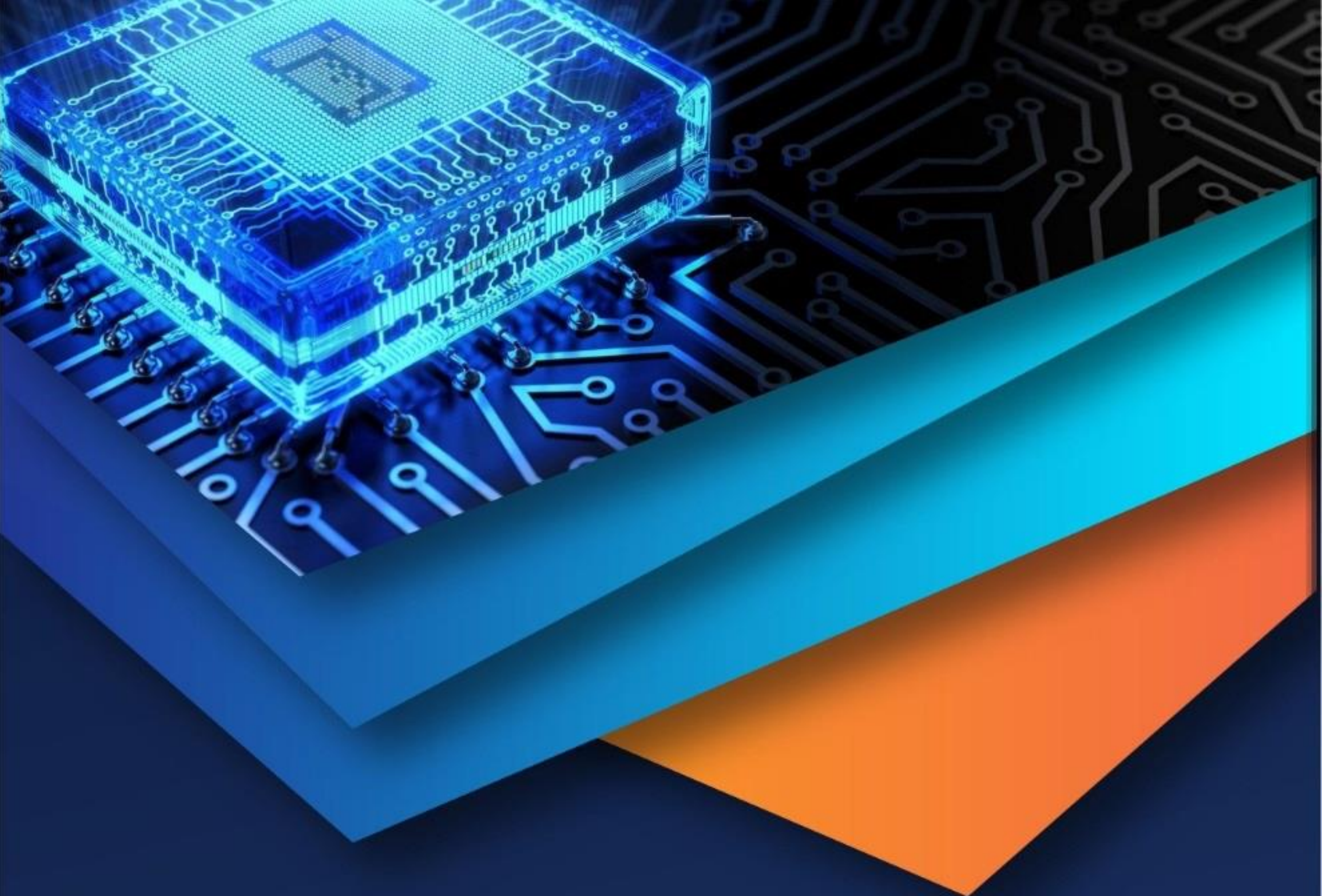

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