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

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

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

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

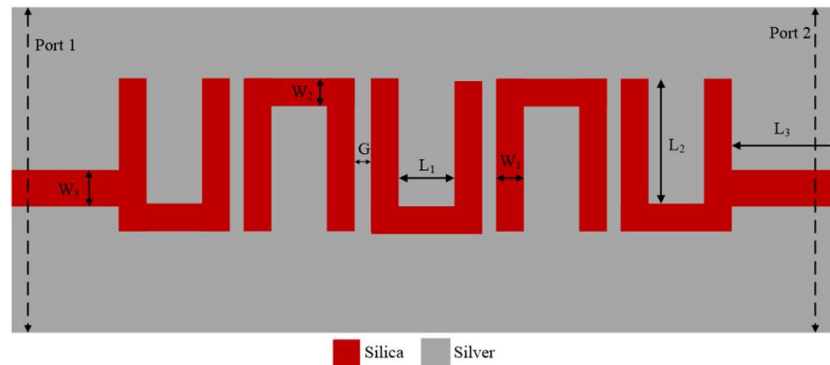


Fig. 1 Geometry of metal-insulator-metal based plasmonic ultra-wide band band-pass filter.

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  $\epsilon_{\infty} = 3.7$ ,  $\omega_p = 1.38 \times 10^{16}$  rad/s,  $\gamma = 2.73 \times 10^{13}$  rad/s and silica as  $\epsilon_i = 2.50$ . 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  $5 \times 5$  (nm). Full-wave simulation has been carried out using CST micro-wave studio.

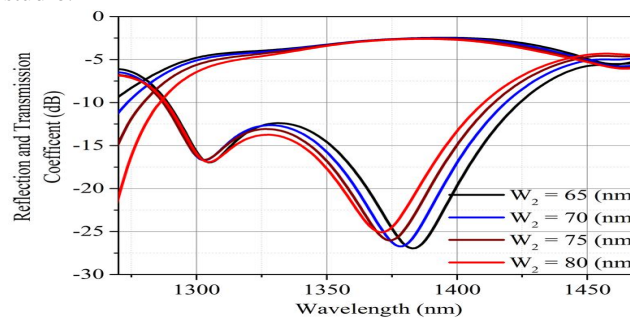


Fig. 1 Reflection and transmission coefficient with wavelength as a function with width ( $w_2$ ).

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 coefficients of the proposed filter with respect to 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).

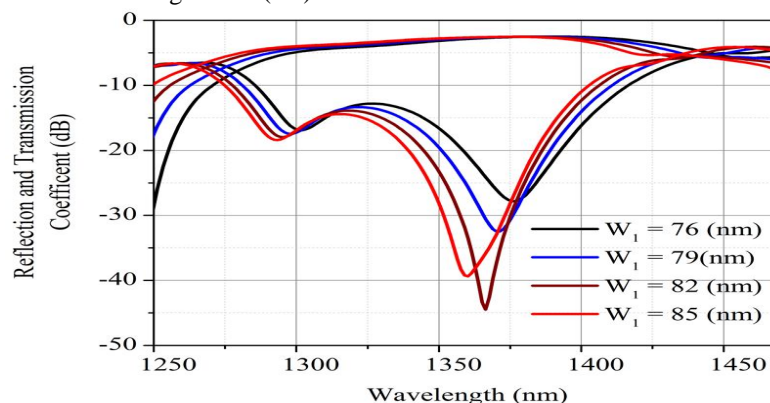


Fig. 3 Reflection and transmission coefficient with wavelength as a function with width ( $w_1$ ).

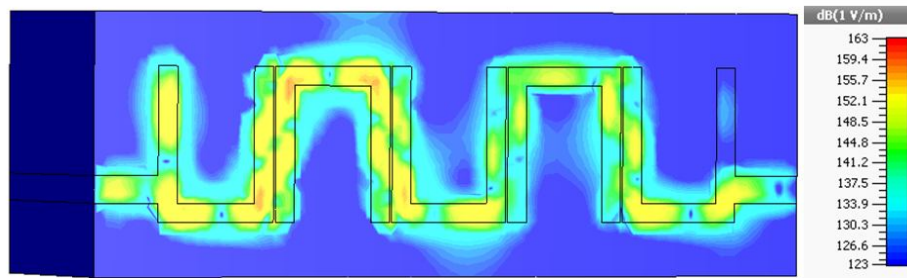


Fig. 4 Field distribution at wavelength  $\lambda = 1377$  nm.

### 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

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### REFERENCES

- [1] J. H. Zhu, Q. J. Wang, P. Shum, and X. G. Huang, "A Simple Nanometric Plasmonic Narrow-Band Filter Structure Based on Metal-Insulator-Metal Waveguide," *IEEE Trans. on Nanotech.*, vol. 10, no. 6, pp. 1371-1376, Nov. 2011.
- [2] R. Zafar and M. Salim, "Analysis of asymmetry of Fano resonance in plasmonic metal-insulator-metal waveguide," *J. photonics*, vol. 23, pp. 1-6, Nov. 2016.
- [3] B. H. Cheng, Y. Lai, and Y. Lan, "Plasmonic Photonic Bloch Oscillations in Composite Metal-Insulator-Metal Waveguide Structure," *Plasmonics*, vol. 9, no. 1, pp. 137-142, Jul. 2013.
- [4] M. Wu, Z. Han, and V. Van, "Conductor-gap-silicon plasmonic waveguides and passive components at subwavelength scale," *Opt. Express*, vol. 18, no. 11, pp. 11728-11736, May 2010.
- [5] D. F. P. Pile and D. K. Gramotnev, "Plasmonic subwavelength waveguides: next to zero losses at sharp bends," *Opt. Lett.*, vol. 30, no. 10, pp. 1186-1188, May 2005.
- [6] Chityala, R.K. Nanoplasmonic concurrent dual-band antennas using metal-insulator-metal step impedance resonators. *Microw. Opt. Technol. Lett.* 2019.
- [7] Ravi Kiran Chityala and Vinay Kumar Chandubatl, "Concurrent dualband nanoplasmonic MIM slot waveguide based directional Coupler," *International Jour. of Elect. And Elect. Rese.*, vol. 7, no. 1, pp. 217-219, Dec. 2014.
- [8] W. Mu and J. B. Ketterson, "Long-range surface plasmon polaritons propagating on a dielectric waveguide support," *Opt. Lett.*, vol. 36, no. 23, pp. 4713-4715, Dec. 2011.
- [9] W. Liu, R. Zhong, J. Zhou, Y. Zhang, and M. Hu, "Investigations on a nano-scale periodical waveguide structure taking surface plasmon polaritons into consideration," *J. Phys. D: Appl. Phys.* vol. 45, no. 20, pp. 205104 (1-9), May 2012.
- [10] P. Taylor, C. Li, D. Qi, J. Xin, and F. Hao, "Metal-insulator-metal plasmonic waveguide for low-distortion slow light at telecom frequencies," *J. Modern Opt.* Vol. 61, no. 8, pp. 37-41, Nov. 2014.
- [11] G. Veronis, S. Fan, and S. Member, "Modes of Subwavelength Plasmonic Slot Waveguides," *J. Lightwave Tech.*, vol. 25, no. 9, pp. 2511-2521, Sept. 2007.
- [12] C. H. Kim and K. Chang, "Ultra-Wideband (UWB) Ring Resonator Bandpass Filter With a Notched Band," *IEEE Micro. Wirel. Comp. Lett.*, vol. 21, no. 4, pp. 206-208, Apr. 2011.
- [13] Johnson and Christy, "Optical Constants of Noble Metals," *Phys. Rev. Lett.*, vol. 6, no. 12, pp. 4370-4379, Dec. 1972.





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