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A Tunable Wide Flat-Top Band-Pass Plasmonic Filter based on Tilted T-Junction Resonators at Near-Infrared

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Abstract: A highly efficient and compact wide flat-top band-pass filter at NIR is realized in a MIM plasmonic waveguide. Besides, simulation results reveal that through tuning the length of resonators, a broadband band-pass transmission can be easily achieved.

1. Introduction

Surface plasmon polaritons (SPPs), that offer a platform for incorporating the electronic and photonic circuits, have received enormous interest as they provide sub-wavelength light confinement and manipulation, as well as contribute to miniaturizing the size of optical components, and are attractive candidates to be used in photonic integrated circuits (PICs). The insulator-metal-insulator (IMI) and metal-insulator-metal (MIM) plasmonic waveguides can be used to carry both electrical and optical signals. The latter takes precedence in PICs, as it enables strong electromagnetic mode confinement with losses that are considered to be within acceptable range [1- 3]. Accordingly, different optical devices based on the plasmonic effect including efficient and sensitive biosensors [4], ultrawide-band power splitters [5], ultra-broadband light absorber [6], and many more are proposed and numerically investigated. Among them, optical filters, are of significant importance, ranging from optical wireless communications to laser experiments, to fluorescence microscopy and colour match imaging. Hence, in this paper, we report the design and simulation results of a tunable and miniaturized wide flat-top band-pass filter that works at near-infrared (NIR). The wide flat-top band-pass filter (FTBPF) was realized by carefully tuning the coupling distance between the bus waveguide and T- junction resonators. Furthermore, we have performed an optimization process while minimizing the size of the device, achieving high-efficiency and wide band-pass at NIR.

2. Device Structure and Numerical Results

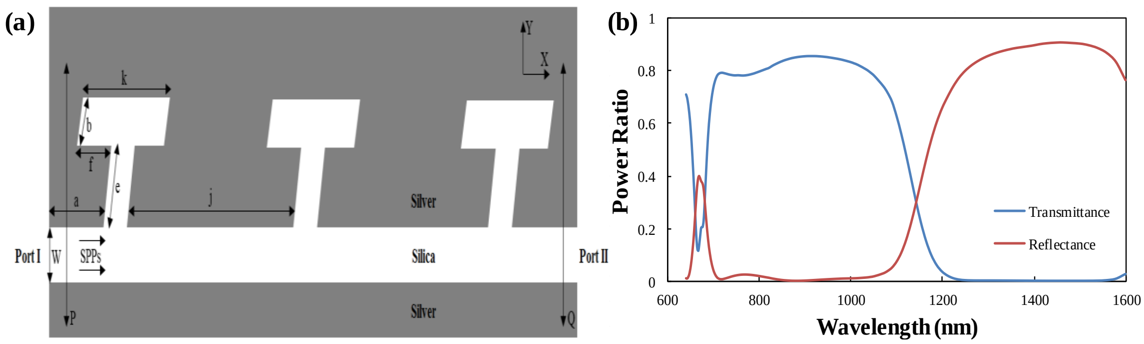

Fig. 1. (a) Schematic configuration of the suggested wide flat-top band-pass filter at NIR. (b) Transmittance and reflectance spectra of the wavelength filter for W= 40 nm, a= 60 nm, e= f= 30 nm, b= 20 nm, k= 80 nm, and j= 100 nm.

Figure 1. (a) illustrates the configuration of the suggested wide FTBPF at NIR. As it is indicated in Fig. 1(a), the device structure is made of two layers of silver, where the complex permittivity used in the model has been taken from experimental data of Johnson and Christy [7], and Silica, having a dielectric constant of 2.5, is utilized as the insulator layer, and is located between the metallic layers. In order to obtain the numerical results in this paper, the following settings are applied; to excite the fundamental TM mode of the waveguide structure, a dipole source was used. The grid sizes are set to be 7 nm × 7 nm along the x and y directions, respectively. Then, to record the incident and transmitted power in the suggested filter, two power monitors P and Q are positioned, as it is exhibited. Thus, the transmission of the device can be characterized as T=Pout/Pi [8]. A full-wave electromagnetic software tool, CST Microwave Studio, with its frequency domain solver, employs the finite element method (FEM) to solve the Maxwell's equations. In Fig. 1. (b), we show the results from the numerical investigation of the designed device with the following geometrical parameters; W= 40 nm, which shows the width of the input port, a= 60 nm, defining the distance from the input port to the T-junction resonator, e= 30 nm, is the initial length of the T-junction, f= 30 nm, accounts for the smaller width of the resonator, b= 20 nm, is the length of the upper side of the resonator, k= 80 nm, indicate the width of the upper side of the resonator, and j= 100 nm, is the distance between the T-junction resonators. According to the Fig. 1. (b), a wide flat-top band-pass occurs from wavelength 705 nm-

1070 nm, with efficiency that is more than 74%. This is comparable to recent studies on the FTBPF [9- 11], and suggests smaller footprint and more efficiency.

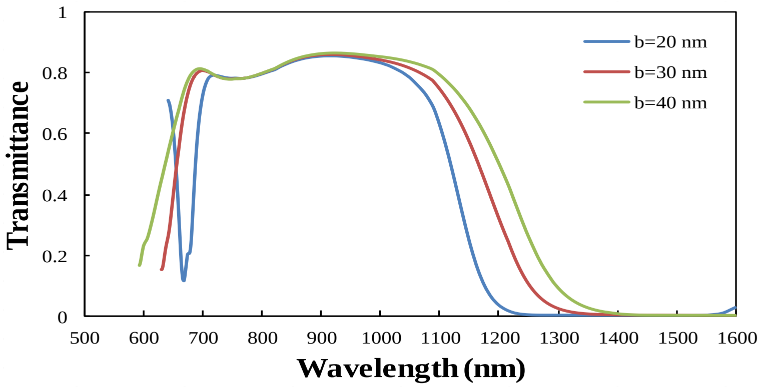

Fig. 2. The transmission spectra as a function of the wavelength for the suggested wide flat-top band-pass plasmonic filter with different lengths of the T-junction resonators.

Figure 2 displays the numerical results of the transmission spectra of the proposed tunable flat-top wavelength filter for b= 20 nm, 30 nm, and 40 nm, whereas all other parameters of the structure are fixed and are similar to Fig. 1. (a). It is shown that by increasing the length of the tilted T-junction resonators, a widening of the output transmission profile is obtained. For example, as it is illustrated in Fig. 2 for the case of b=40 nm, a wide band-pass that leads to a broadening of the signal occurs from wavelength 680 nm to 1100 nm, with an average efficiency of over 78%, and a maximum peak at 929.6 nm with 86.5%. Thus, we have demonstrated that by simply adjusting a structural parameter of the filter, one can easily tune the flat-top band-pass spectrum.

3. Conclusion

In summary, a compact and efficient wide FTBPF is discussed. The simulation results reveal that the bandwidth of the band-pass filter can be easily broadened by varying its geometrical parameters. Because of its size and efficiency, as well as good out-of-band rejection, it would be of great interest to develop the miniaturized yet highly-efficient optical components in PICs and tunable optical wireless communication systems.

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