Half-Mode Gap Waveguide Filtering Power Divider Based on Spoof Surface Plasmon Polariton

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***Abstract*—In this paper, a half-mode gap waveguide (HMGW) filtering power divider (FPD) based on spoof surface plasmon polariton (SSPP) is proposed. The FPD construction is designed by using T-junction with HMGW and SSPP. In the proposed model, the combination of the low-pass characteristics of SSPP and the high-pass characteristics of HMGW enables the bandpass characteristics. The simulated results show that the frequency range of the proposed FPD is 18.8 GHz to 24.7 GHz with insertion loss of 0.8 dB. The in-band magnitude and phase difference of the two output ports are less than 0.33 dB and 2.9°, respectively.**

Keywords— filtering power divider (FPD), half-mode gap waveguide (HMGW), spoof surface plasmon polariton (SSPP)

I. Introduction

In wireless communication systems, filters and power dividers play important roles in the performance and stability of the entire system. Filters can select the frequency according to the engineering requirements. The power divider can distribute the input signal to multiple output ports. In the traditional passive network, the two devices are usually designed independently, and then cascaded together [1], [2], which not only causes an increase in transmission loss, but also occupies a large area, which cannot meet the needs of the high performance of modern communication systems.

In millimeter-wave band, waveguide structures are used to design millimeter-wave devices to minimize transmission losses. However, the problem of electrical contact loss is a knotty problem that needs to be solved. Gap waveguide (GW) has been presented as a solution to solve this problem [3], [4]. Recently, the half-mode gap waveguide has been proposed in [5]. The half-mode waveguides consist of two different pieces. One is the half groove gap on a metal bottom plate, and the other is the cover with metal pins. This half-mode implementation avoids imperfect contact between different metal layers. More importantly, the usage of half-mode cavity can reduce the design size.

In this paper, a half-mode gap waveguide (HMGW) filtering power divider (FPD) based on spoof surface plasmon polariton (SSPP) with wide passband and low insertion is proposed. The power divider construction is employed by a T-junction framework. The upper cut-off frequency of the FPD is realized by the length of the SSPP unit cell. The lower cut-off frequency of the passband can be adjusted by the groove height of HMGW. The bandwidth is from 18.8 GHz to 24.7 GHz (FBW = 27.13%), and the two output ports achieve the good consistencies of magnitude and phase.

II. Design of HMGW and SSPP Unit Cell

In this section, the strategy designed for the HMGW and SSPP unit will be showed. The bed of nails is used a period p = 2.8 mm of pins (length of a square a = 1 mm), height hp = 3.6 mm and air gap ha = 0.4mm. On the metal bottom plate, the groove waveguide uses that height h = 4 mm and the width w = 3.8 mm. The changes in the groove height of HMGW affects the lower cut-off frequency of the passband. The metallic SSPP block is placed on the side wall of the groove. The length, height, and width of the metallic SSPP block are notated by d, hl, and l, and the period of the SSPP unit cell is s. The dispersion curve of the SSPP unit cell is shown in Fig.1. As the frequency increases, the dispersion curve of the SSPP unit gradually reaches an asymptotic frequency of 24.7 GHz, which can be regarded as the upper cut-off frequency. When the cut-off frequency of HWGW is lower than the cut-off frequency of SSPP, the bandpass filter response can be achieved by this hybrid structure.

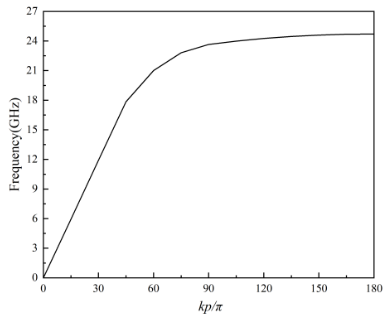

Fig. 1 Dispersion curve of the SSPP unit cell.

III. Design of Filtering Power Divider

The structure of the HMGW FPD based on SSPP structure is shown in Fig. 2. The top and side views of the FPD are shown in Fig. 3 and Fig. 4. The FPD uses the T-junction framework. The pentagonal prism on the T-branch centerline is to enhance impedance matching. The FPD can be divided into five parts, as illustrated in Fig. 2. Part 1 is an input port. Part 2 is an input branch. Part 3 is the SSPP structure, in which the length of the metallic blocks of SSPP determine the upper cut-off frequency. Part 4 is a SSPP transition to output port, with the unit cell length decreasing from d=2.5 mm to 1.46 mm. It can be seen that the length of the metallic SSPP blocks is gradually changing to achieve impedance matching. Part 5 is an output port. The input and output ports use WR-34 standard waveguide (8.64mm×4.32mm).

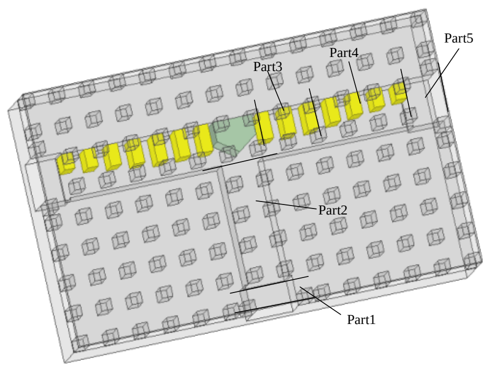

Fig. 2 3-D view of the proposed FPD.

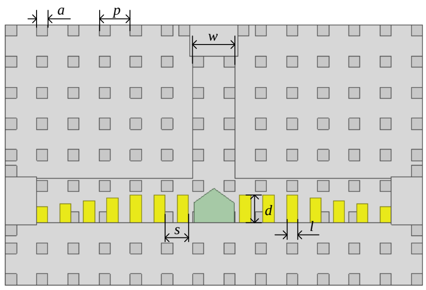

Fig. 3 Top view of the proposed FPD.

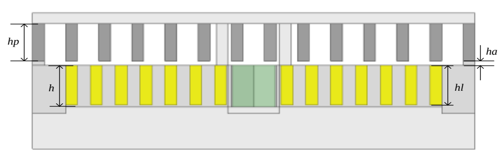

Fig. 4 Side view of the proposed FPD.

The simulation results of HMGW FPD are shown in Fig. 5 and Fig. 6. The return loss (RL) is below -10 dB from 18.8 GHz to 24.7 GHz (FBW = 27.13%). The minimum insertion loss (IL) is 0.8 dB, and the simulated magnitude and phase differences between the two output ports are lower than 0.33 dB and 2.9°, respectively.

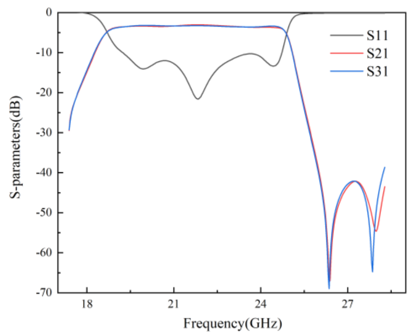

Fig. 5 Simulated S-parameters results of the proposed FPD.

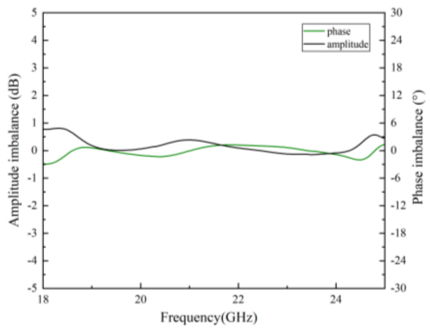

Fig. 6 Simulated phase and amplitude imbalance of the proposed FPD.

IV. Conclusion

In this paper, a HMGW FPD based on SSPP with wideband and low insertion loss is presented. The simulated results of the FPD show excellent performance from 18.8 GHz to 24.7 GHz with bandwidth of 27.13% and IL of 0.8 dB. The magnitude difference between the two output ports is within 0.33 dB, while the phase difference is within 2.9°. The good performance of the FPD shows that it is suitable for millimeter-wave devices for wireless systems.

Acknowledgment

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