An Absorptive/Transmissive Frequency Selective Surface with a High-selectivity Passband

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***Abstract*—An absorptive/transmissive frequency selective surface (FSS) with absorption bands at both sides of a passband is presented. A triple-layer structure consisting of a lossy and two lossless FSS was employed to achieve the characteristics of transmitting the in-band wave and absorbing the out-of-band wave. Simulation results show that a passband with a center frequency of 5 GHz and a minimum insertion-loss of 1.2 dB was obtained. An ultrawide band from 2.3 to 7.9 GHz with S_{11} < -10 dB is achieved under normal incidence.**

Keywords*—*absorptive/transmissive frequency selective surface; FSS; rabsorber; absorber; filter

I. Introduction

Frequency selective surfaces (FSS) with absorptive band and transmissive windows have attracted growing attentions in recent years [1]. They are often called rasorbers [2], which is a combination of the words radome and absorber, since they can be regarded as radar absorbers with transparent windows. They are also called absorptive/transmissive frequency selective surface (ATFSS) since they have the characteristics of being transparent to incident electromagnetic waves in certain passbands and absorptive outside of the passbands. They can be used in reducing radar cross-section (RCS) of stealthy radomes over a wide frequency band, and in decreasing mutual interference among different subsystems that composed of large communication systems. The designs of ATFSS which use two or three layers of FSS with certain spacing have been reported in some of the literature [3]- [5]. The concept, analysis, and design of a three-dimentional (3D) frequency selective rasorber (FSR) based on a two-dimentional (2D) periodic array of multimode cavities was presented in [6], [7].

In this paper, we design an ATFSS with a high-selectivity passband in between two absorptive bands. The ATFSS has three layers of FSS, two of which are lossless and one is lossy. The results show that fractional bandwidth of the lower and higher absorption bandwidth are 64% and 28%, respectively

II. Configuration of the ATFSS

The configuration of the presented ATFSS is shown in Fig. 1. Two different FSS, whose cells are shown in Fig. 1(a) and 1(b), respectively, were applied. Each cell of the first FSS consists of a four-legged loaded element and eight lumped resistors. It acts as an absorber that transmits in-band wave and absorbs part of the incident power of the out-of-band signal. The cell of the second is square loop slot. It functions as a filter that is transparent to the incident wave in a certain band while reflecting the other frequencies for which it acts as a ground plane.

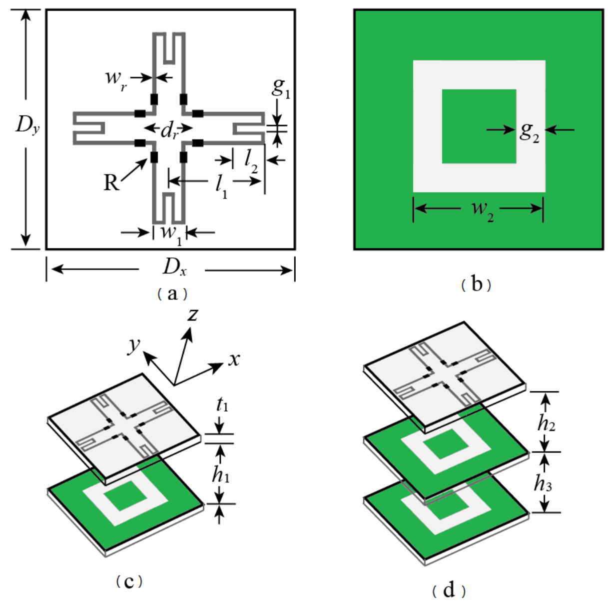
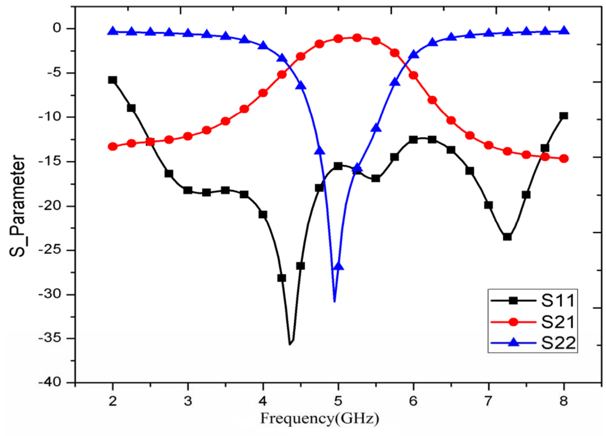


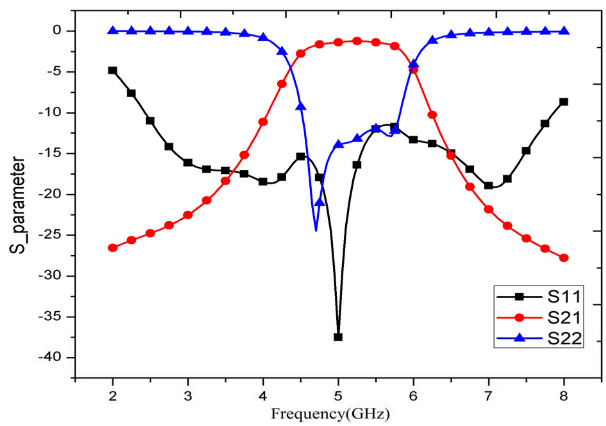
Fig. 1 Configurations of the proposed ATFSS. (a) Four-legged loaded element. (b) Square loop slot element. (c) Two-layer ATFSS. (d) Three-layer ATFSS

The length of the element space, D_x and D_y, and the length of the loaded legs, L_1 and L_2, affect the center frequency of the passband. The resistance of the lumped resistors affects the absorptivity. Both outer side length and inner side length of the slots affect the center frequency of passband, while the width of the slot determine the bandwidth of the passband. Both FSS are printed on a substrate with permittivity of 4.4, thickness of 0.8 mm, and loss angle tangent (tanδ) of 0.02.

Two FSS were cascaded to form the presented ATFSS. Fig. 1(c) shows the first ATFSS with one layer of absorptive FSS and one layer of filtering FSS. In order to increase the selectivity of the passband, a third layer of FSS was added, as shown in Fig. 1(d). The performance of the ATFSS is investigated in the following section. Detailed dimensions of the configuration shown in Fig. 1 are as follows: R= 100 Ω, D_x= D_y= 28 mm, l_1= 25 mm, l_2= 3.4 mm, w_1= 3 mm, w_2= 12



(a)



(b)

Fig. 2 Simulated transmission and reflection coefficients. (a) Two-

mm, w_r= 0.8 mm, g_1= 0.5 mm, g_2= 3.5 mm, t_1= 0.8 mm, d_r= 4.2 mm, h_1= 12 mm, h_2= 12 mm, h_3= 12 mm.

III. Simulation and Results

Fig. 2 shows the simulated transmission and reflection coefficients of the proposed ATFSS under normal incidence. Fig. 2(a) exhibits that a transmission window range from 4.5 to 5.8 GHz with the insertion loss less than 3 dB was obtained . S_{11} in the figure denote the reflection coefficient for the wave propagating along the -z direction, and S_{22} denote the reflection coefficient for the wave propagating along the +z direction. The band of S_{11} < -10 dB covered from 2.3 to 7.9 GHz, which was much wider than that of S_{22} < -10 dB and the bandwidth of the passband.

Fig. 2(b) shows the results of the ATFSS shown in Fig.1*d*. It is clear that compared with the transmission coefficient shown in Fig. 2(a), sharper roll-off edges at both sides of passband was gotten with one more layer of FSS was used. A transmission window ranged from 4.5 to 5.5 GHz with a minimum insertion loss of 1.2 dB was achieved. The band of S_{11} < -10 dB covered from 2.35 to 7.9 GHz, which was slightly narrower than the former, was obtained.

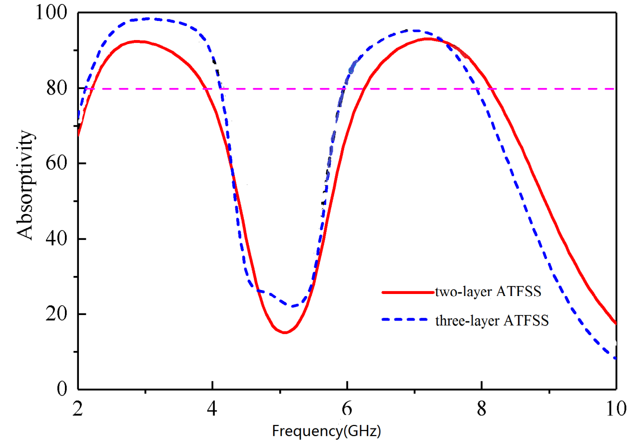


Fig. 3 Absorptivity of the ATFSS

According to the equation, A=1- $|S_{11}|^2$- $|S_{21}|^2$, where A represents the absorptivity of the ATFSS. Fig. 3 shows the results. It is clear that two absorption bands are obtained on both sides of the passband. For the two-layer ATFSS, the fractional bandwidth of the lower and higher absorption band for an absorption rate higher than 80% are 55% and 26%, respectively. For the three-layer ATFSS, the lower and higher absorption bandwidth are 64% and 28%, respectively.

IV. Conclusions

Two basic periodic FSS elements, one of which acts as an absorber and the other acts as a filter, were utilized to construct an ATFSS. By cascading the absorptive FSS and the filtering FSS, an ATFSS with two absorption bands that are below and above a passband was obtained. In order to increase the selectivity of the passband, a third layer was added. The results show that the maximum absorptivity, the bandwidth of the absorption rate higher than 80%, and the selectivity of the passband were increased with third layer was added.

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