A Wideband Bandstop FSS with Tripole Loop

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***Abstract*- In this paper, a microwave spatial band stop radome operating in x-band based on frequency selective surfaces (FSS) is presented. To meet the demand of wideband and large incident wave angle， a tripole loop FSS is designed as a multilayer sandwiched structure. The two FSS layers are developed to increase bandwidth of the stop band for the TE and TM mode wave. The simulation results show that the FSS has a wideband which up to 50% and 20% for TE and TM mode, respectively. A practical the FSS structure has also been fabricated and tested. Measurements indicate that the FSS has a band stop characteristics at large incident angle which range from 0° to 60° for TE and TM at X-band in the microwave anechoic chamber.**

I. INTRODUCTION

Frequency selective surface（FSS）structures are periodic structures that can be used to control and manipulate the propagation of electromagnetic waves for more than four decades[1-4]. Frequency selective surfaces are usually constructed from periodically arranged metallic patches of arbitrary geometries or their complimentary geometry having aperture elements similar to patches within a metallic screen, and these surfaces exhibit total reflection or transmission, for the patches and apertures respectively[5]. A number of FSS structures have been investigated, which can function as pass band or as stop band over the desired frequency range. The reflection and transmission performance of each FSS is determined by the shape of the metal patches or slots, the dimension of the structure, the periodicity of the array, the lattice of the array and the supporting dielectric characteristics of the substrate[6]. In the classical book on the subject of frequency selective surface written by Ben A. Munk, various applications of FSS have been mentioned. They have been adoped in many applications such as radomes, dichroic subreflectors, RCS augmentation, photonic band gap structures, and in low-probability of intercept systems[7]. The antenna mounted on a mask etched with FSS structure which works as spatial band pass filter can deflect out of band signals while the desired signals go through. For building wireless security, the conventional reflection / transmission type FSS may be placed in the building wall so as to provide isolation and reduce interference between adjacent vicinities[8]. The frequency selective property of FSS makes them potential candidates for military and civilian applications.

One of the most important challenges behind the design of the wideband bandstop FSS is its bandwidth for the large incident angle. In order to meet the specifications of frequency band steady at the situation of large incident angle, a hexagon is chosen for the cell shape which can make the configuration of tripole loop more compact than the square cell. The periodicity of the printed patterns is about half of the wavelength of operating frequency. The dielectric profile of the FSS panel is a multilayer sandwiched construction to meet the bandwidth specifications. All simulations have been done by ANSOFT HFSS software based on FEM.

II. TRIPOLE LOOP FSS LAYER DESIGN AND SIMULATION

Figure 1 shows the dielectric profile of the proposed FSS screen. FSS structure is printed on a FR4 dielectric layer, the distance between two FSS layers is H1 which is about one-fourth wavelength. The stop band bandwidth has been effected by the distance between the FSS structure layers. FSS configuration designed and fabricated with standard PCB process, and the photograph is shown in Figure 2. Table I lists the corresponding values length of each section figure out in Figure 2. In order to minimize the effects of dielectric on the properties of the periodic surface, the thickness of dielectric substrate chosen for development of two identical FSS PCB layers is very thin (0.127mm). Hexagonal lattice structure is selected as the variation in the resonant frequency of the grid are smaller, resulting in a stable resonance frequency, particularly in the case of large incidence angle. It also helps to maintain the radome surface periodicity required by the application.

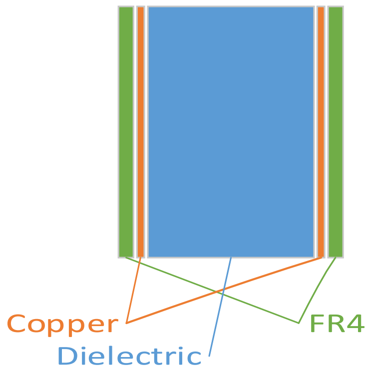

Figure 1 FSS layer structure

Tripole loop FSS is one of the best choice as spatial bandstop filter blocking transmission of the arbitrary polarization signal in large incident angle which is typical of the nose cone cover. It is considerably more broadbanded than the four-legged case[7]. Compared to the Jerusalem Cross and the cross structure, tripole loop show better performance in a large incident angle .The basic design of a Tripole element FSS is taken from [4].Ref [9] designs a broadband band pass FSS

Correspondence should be addressed to Guang Hua, huaguang@seu.edu.cn structure with hexagonal cell and tripole slot which reached a 1Ghz transparent bandwidth at X-band.

Cell size A, the length of L and L1 play a significant role for the resonance frequency, while the width of the loop determines the width of stop band. The distance between two FSS layers is also one of the important factors affecting the bandwidth. The circumference of the loop is approximately the length of the wavelength of the operating frequency. A symmetric structure can be obtained for the angle of each pole is set to 120 degrees. The symmetry of the loop makes the stable performance at different azimuth angles available. The analysis of the proposed FSS structure is completed by using the Ansoft HFSS software. As shown in Figure 3 and Figure 4, a wide stop band can be obtained which is 5 GHz under -10 dB for TE mode wave and more than 2 GHz for TM mode. It can be seen that a relative bandwidth up to 50% and 20% for TE and TM mode waves have been achieved for incidence angle is 60°, respectively. For different pitch angles, TE wave exists a small frequency offset, and the bandwidth of TM wave becomes narrow as the pitch angle increases. In a large incident angle, the electrical length of cell is different for different polarization resulting bandwidth difference. Compared to the large angle of incidence, periodic structures characteristics are more clearly demonstrated for a small angle of incidence.

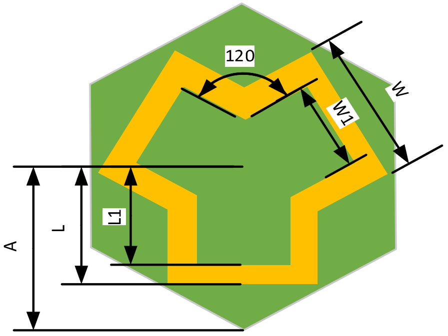

Figure 2 The parameters of FSS dimensions（top view）

TABLE I

Values of design parameters（unit：mm）

A	H1	L	W	L1	W1
7.2	7.6	5.05	6	3.8	4.5

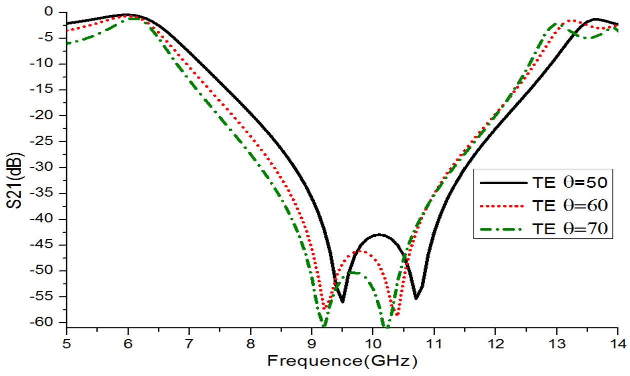

Figure 3 Simulated FSS performance curves for TE mode

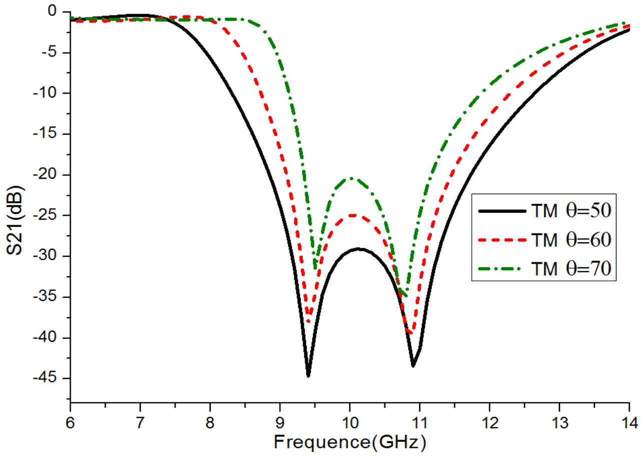

Figure 4 Simulated FSS performance curves for TM mode

Figure 5. Photograph of the tripole loop FSS PCB

III. EXPERIMENTAL VERIFICATION

A photograph of the tripole loop FSS PCB layer of the radome is shown in Figure 5. Tripole FSS structure is etched on a 300mm × 300mm dielectric layer. Thickness of intermediate dielectric layer sandwiched between FSS about 1cm.The measurements of tripole FSS screen are carried out in the microwave anechoic chamber where the spacing between the two horns antennas is adjusted so that the FSS radome panel sample is irradiated a plane wave in far field of the transmitting antenna. As shown in Figure 6, FSS screen covers in the receiving horn antenna which is placed on the turntable to test the bandstop characteristics of the periodic structure.

The measurement of S-parameters in the case of incident angle ⍰ from 0° to 90° for TE mode is presented in Figure 7 and TM mode in Figure 8. There is a significant stopband from 0 degrees to 60 degree at 10 GHz both for TE and TM mode wave and also a blocking band at 8 GHz and 12 GHz. Because of the limits of manufacturing technology and measurement environment, the experimental results are not as good as simulated. The distance between the two FSS structure layers influences the bandwidth and the resonance frequency.As shown in Figure 7 and Figure 8，dielectric thickness of the intermediate layer is slightly larger than the simulation, results in the experimental are not as good as simulation when incident angle is 60 degree for TE mode. The offset of receiving antenna result in a shift for stopband in testing. The transmission coefficient is greater than 0 in the presence is caused by the existence of the pole.The antenna pattern exist some poles at certain angle while the transmission coefficient of FSS is relatively flat, which result in the differences are greater than 0dB at poles，as shown in Figure 9.Improvements can be done by adding absorbing material around FSS structure to make more accurate measurements.

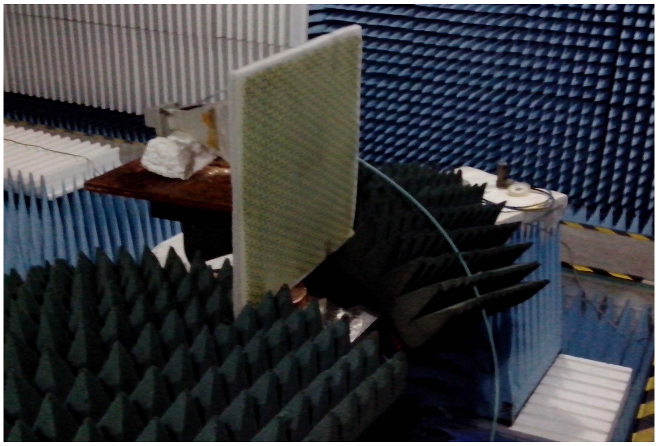

Figure 6 Test environment

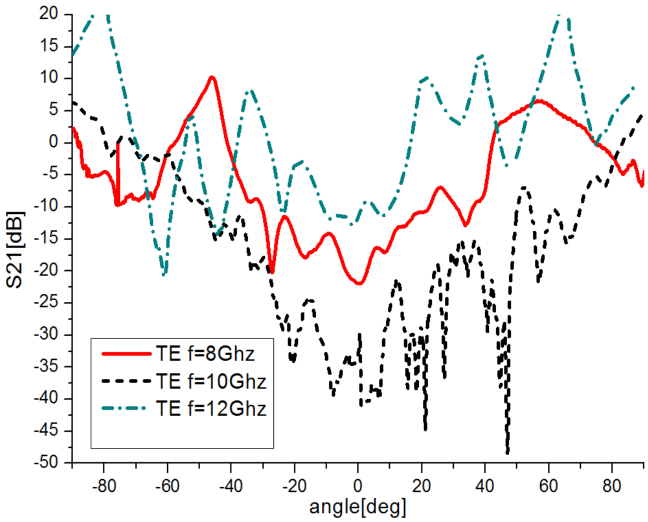

Figure 7 Measured transmission coefficient of TE mode wave

IV. ACKNOWLEDGEMENT

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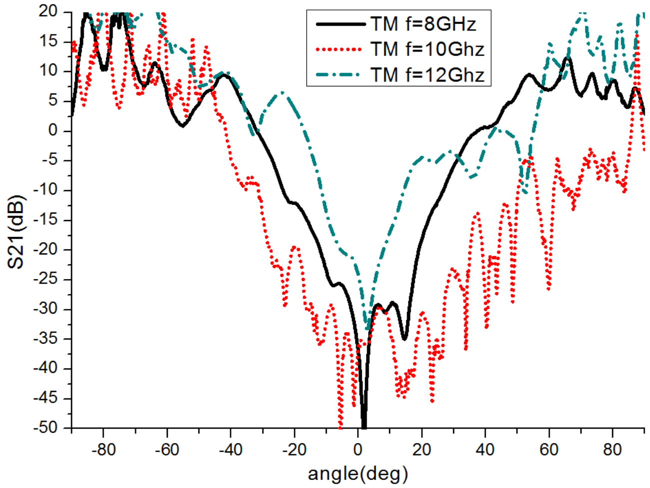

Figure 8 Measured transmission coefficient of TM mode wave

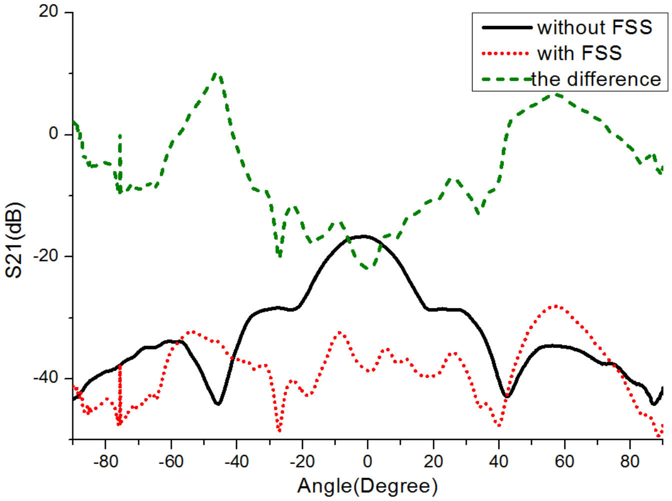

Figure 9 Measured transmission coefficient with/without FSS and the difference at 8 GHz

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