Dual-band Composite Broadband Absorbing Material Based on Frequency Selective Surface

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Abstract*—In this paper, A multi-layered composite wideband absorbing material covering dual band is designed and fabricated. The upper layer is a traditional absorber while the lower one is a dual-frequency frequency selective surface (FSS) formed by a square ring and an improved Jerusalem cross structure. The absorbing band has been broadened significantly compared with those of the traditional absorber without FSS. The absorbing bandwidth has been improved from 66% to 112%, within which the reflectivity is lower than -10 dB level over a range of 3.9-13.75GHz. With the advantage of wide absorption band, the absorbing material covering C and X bands can be implemented in mobile communications, environmental protection, physical protection and absorption of electromagnetic wave shielding *etc.

***Keywords*—broadband, frequency selective surface, composite absorbing material**

I. INTRODUCTION

With the science and technology developing rapidly, all kinds of products and technologies based on electromagnetic wave emerged. However, the environmental problems triggered by electromagnetic radiation is also growing, the cumulative effects have direct and indirect harm to human body. In order to control electromagnetic pollution, eliminate electromagnetic interference and improve the absorption of electromagnetic compatibility shield, looking for materials which can withstand and weaken the electromagnetic radiation has become a major subject of materials science. Recently, many reports on the application of conventional absorbing material (AM) and FSS [1-2] have been presented, while the bandwidth is not wide enough when FSS or AM is used separately. What's more, a lot of studies show that the combination of AM and FSS can expand the absorbing bandwidth of the materials[3-5]. Nevertheless, the bandwidth of absorbing band is still cannot cover the C and X bands that widely used in communication fields.

Aims to overcome the deficiency of the existing technology, a dual-band composite broadband absorbing material based on frequency selective surface is proposed in this paper. The simulation analysis shows that the reflectivity is lower than -10 dB level in a frequency range of 3.9-13.75GHz. By introducing additional absorption band, the absorbing bandwidth of the composite absorbing material at low frequency has been broadened covering C and X bands.

II. WIDEBAND AM DESIGN

As is known to all, the operating band of FSS or AM is not wide enough when they are used in separate. Impedance adjusting with great freedom of FSS makes it easier for AM to match with free space when the FSS is loaded on it, so as to make AM achieve better absorbing effect. In the meanwhile, the resonant frequency of FSS can be adjusted to be close to that of the AM hence to form a broader absorbing band [5]. Inspired by this idea, a novel wideband AM (WAM) with FSS is proposed. The structure of the WAM and the unit form of the loaded FSS is shown in Figure 1, and the design values of the WAM are listed in Table 1.The FSS formed by a square ring and an improved Jerusalem cross structure is milled on the top layer of the substrate FR4 with a relative permittivity as ε_r = 4.4 and the metal ground is on the bottom layer, finally the original AM is on the FSS.

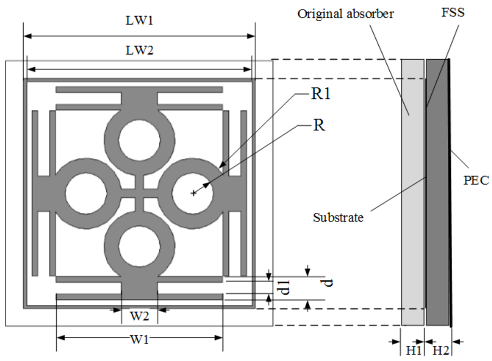

Fig. 1. Unit of the wideband AM.

TABLE I. Design Parameters and values

Parameter	Value	Parameter	Value
LW1	3.9	R	0.35
LW2	3.8	R1	0.6
W1	2.8	d	0.4

W2	0.6	d1	0.2
H1	1.2	H2	1.3

According to the transmission line theory, the structure of the equivalent transmission line circuit diagram is shown in Figure 2. Original AM and substrate materials are equivalent to the transmission line of L1 and L2 respectively, the characteristic impedance of a transmission line is determined by the corresponding wave impedance, FSS is equivalent to a parallel resonate RLC circuit, the metal plate is equal to the terminal short circuit, the inductance and capacitance are mainly determined by the structure and the size of FSS.

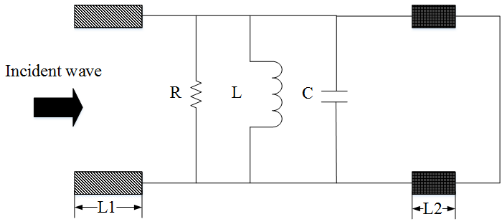

Fig. 2. Equivalent transmission line circuit.

Thus, the multi-layered absorber can be optimized to match its equivalent admittance with the free-space admittance over a wide frequency range. The four circular rings and H structures can increase the current pathes on the surface and enhance the tunability of the resonance unit.

III. SIMULATION AND ANALYSIS

The simulations are implemented using the analysis software HFSS 15 by ANSYS, which is based on the finite element method algorithm. The comparison of the reflection coefficient of AM and WAM between transmission of FSS is given in Figure 3. The reflection coefficient bandwidth of the AM is 66% covering 6.4 GHz~12.7GHz, within which S_{11} is below than −10 dB. The minimum value is −30 dB at 8.6GHz. The working frequency of the FSS is 14GHz and 15GHz, exhibiting dual stop-band characteristics. When FSS is loaded on the AM, the bandwidth is broadened to 112% covering 3.9 GHz~13.75GHz with three valleys of −14dB at 4.1GHz , −25dB at 6.4GHz and −16.5dB at 9.5GHz.

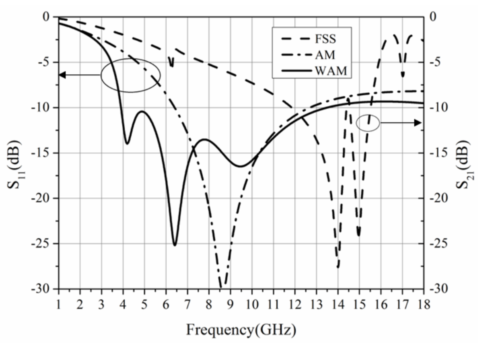

Fig. 3. Transmission of FSS, Reflection of the AM and WAM.

The simulation analysis shows that the embedded FSS can improve the impedance matching characteristics, which changes the reflection. By introducing additional absorption band, the absorbing bandwidth of the composite absorbing material at low frequency band has been broadened. The absorption rate of WAM is given in Figure 4. In the vicinity of 6.8GHz, the absorption rate of composite broadband absorbing material is nearly 100% and the absorption rate in C and X bands is over 90%.

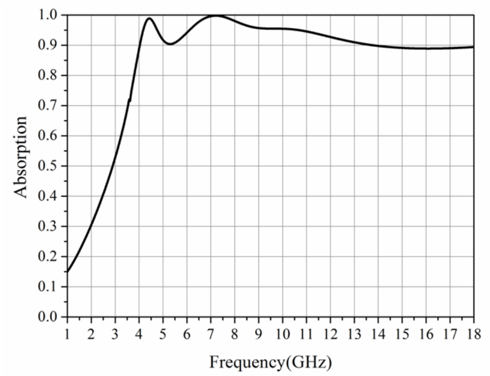

Fig. 4. The absorption rate of WAM.

IV. CONLUSION

In this paper, a dual-band composite broadband absorbing material based on of frequency selective surface is presented, the absorbing bandwidth at low frequency has been broadened significantly from 66% to 112% with the embedded FSS and the absorbing material shows good absorbing characteristics over the C and X bands.

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