A dual-band polarization insensitive metamaterial absorber with split ring resonator

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Abstract

A dual-band polarization insensitive absorber has been designed and studied in this work. Unlike previous dual band absorber composed of composite structures, only one square metal ring with a slit at the middle of each side has been designed to achieve dual-band absorption. The calculated results show two distinct absorption peaks of 0.96 at 10 GHz and 0.99 at 20 GHz. This dual-band absorber has many potential applications in scientific and technological areas because of its excellent absorption characteristics and concise structure.

I. Introduction

Metamaterials have attracted considerable interest due to their unique properties such as negative refraction, cloaking and superlensing. [1-3] Recently, metamaterials are used to design the perfect electromagnetic energy absorber. [4] After then, perfect absorber over wide range of frequencies, including microwaves, [5] THz, [6-7] IR,[8] and optical [9-10] have been investigated. Many characteristic absorber, for example, polarization insensitive absorption, [5] wide angle absorption [10] or dual-band absorption, [6-7] have achieved with various structures. It is worth paying more attention on dual-band absorber because of its potentially wide application areas such as transceiver system，spectroscopic imagers or detectors. Lately, polarization insensitive dual-band absorbers work at different frequency band have been reported. [11-12] These dual-band absorbers are designed by using composite square rings structure with different geometrical dimensions. A small ring is embedded in the bigger one. Each absorption peak corresponding to one of the composite rings. Moreover, due to the symmetric structure in the unit cell, the absorption peaks are insensitive to the polarization of the incident beam, which provides more efficient absorption for the nonpolarized incident beam. However, these structures are very complicated for both design and fabrication.

In this paper, we demonstrate a concise structured dual-band polarization insensitive absorber. Only one metal square ring simply with slits at the middle of each side are used to design dual band absorber. This split ring and metal plane separated by a dielectric spacer structure. Two distinct nearly 100% absorption peaks appear at 10 GHz and at 20GHz. The positions of the two peaks can be controlled by the width of the slits. In addition, both of the two peaks are also polarization insensitive.

II. Numerical model and simulations

Figure 1 shows the schematic structure of the dual-band absorber. The dual-band absorber consists of three layers. The top layer consists of an array of square copper ring with a slit at the middle of each side. The middle and bottom layer are FR4 and copper film, respectively. The parameters of the absorber, as shown in Figure 1, are a=10 mm, L=9.6 mm, w=0.5 mm, t_1=0.018 mm, t_2=0.78 mm and t_3=0.018 mm. g is the slit width and be set with different values in this letter. The electric conductivity of copper is $\sigma=5.8\times10^7$ s/m and the electric permittivity of dielectric spacer is $\varepsilon=\varepsilon_1+i\varepsilon_2=4+0.08i$, which corresponds to a loss tangent $\tan(\delta)=0.02$. The incident wave propagates along z axis and the boundary conditions in the metal plane are set as periodic boundary conditions.

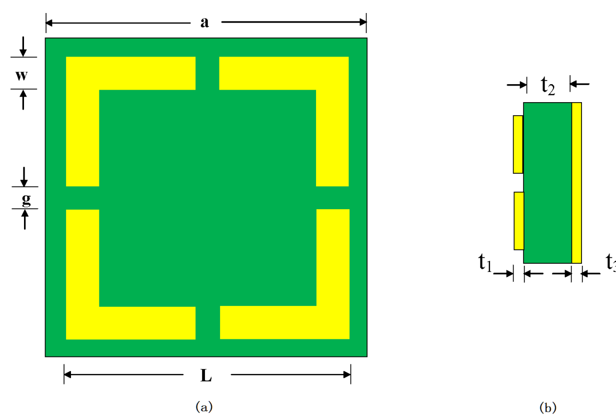

Figure 1. (Color online) Schematic structure of the dual-band absorber: (a) Top view and (b) side view of the absorber layers

To investigate the absorption spectra of the dual-band absorber, the finite-difference-time-domain (FDTD) method is employed. Assume that the absorption, reflectance and transmittance spectrums are $A(\omega)$, $R(\omega)$, and $T(\omega)$, respectively. The absorption $A(\omega)$ can be obtained by $A(\omega)=1-R(\omega)-T(\omega)$. Due to the metal ground plane, the transmission is zero, then the absorptivity $A(\omega)=1-R(\omega)$.

Figure 2 presents the absorption spectra with the width of slits equals 1.1mm. The calculated results show two distinct absorption peaks of 0.96 at 10 GHz and 0.99 at 20 GHz. Compared to the absorber reported, our design are more simple

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978-1-4673-1604-0/12/$31.00 ©2012 IEEE

and easily fabricated. Besides, we also investigate the effect of the width (g) of slits on absorption spectra. It is found that the two absorption peaks are strongly influenced by the width of the slits, As shown in Figure 3, with g increasing from 0.5mm to 1.5mm, both two peaks are blue shift. The inner picture shows peak 2 around 20 GHz is more sensitive to the width changing compare to the other peak around 10 GHz. However, it should be emphasized that the absorption of the two peaks remain higher than 0.9 while g takes any value mentioned above.

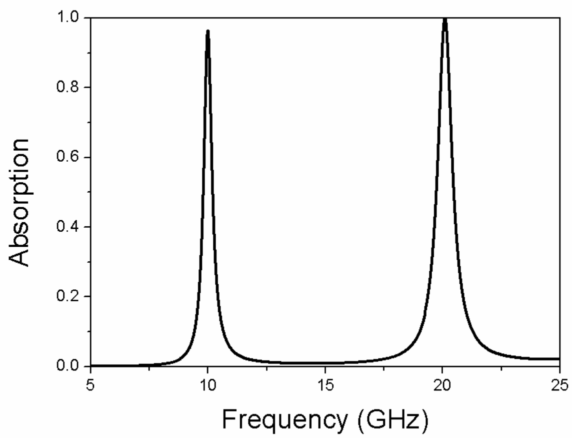

Figure 2 (Color online) Simulated absorption spectra of the dual-band absorber with a=10 mm, L=9.6 mm, w=0.5 mm, g=1.1 mm, t_1=0.018 mm, t_2=0.78 mm and t_3=0.018 mm.

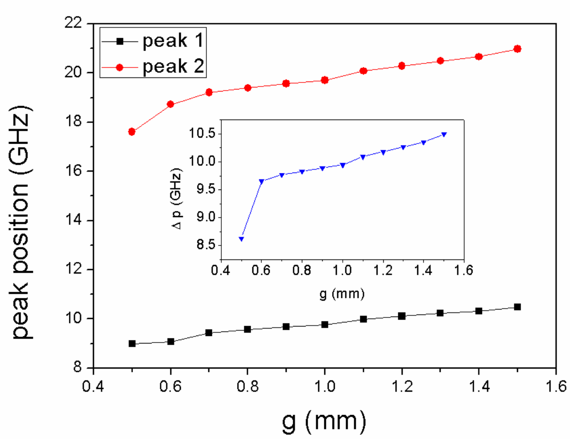

Figure 3 (Color online) The position of the absorption peaks as a function of the width of the slits. Inner: peak spacing of peak 2 and peak 1 with different slit width.

III. Conclusion

We demonstrate a dual-band polarization insensitive absorber in this letter. The calculated results show two distinct absorption peaks of 0.96 at 10 GHz and 0.99 at 20 GHz. In addition, the positions of the two peaks are found strongly influenced by the width of the slits. The peak 2 is more sensitive to the width changing compare to the peak 1. This dual-band absorber provided a promise application respect owning to its excellent characteristics and concise structure.

Acknowledgements

This work was supported in part by the State Key Program for Basic Research of China grants (2011CB922004); the National Natural Science Foundation of China grants (61006090, 10725418, 10874196, 10990104, 11104299 and 60976092); the Fund of Shanghai Science and Technology Foundation grants (09DJ1400203, and 10JC1416100).

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