International Journal of Science, Technology and Management (IJSTM) ISSN (online): 2321-774X

Volume 9, Issue 1, 2022

A Study of Dual-Band Metamaterial Absorber

Shourya

Shouryasingh7001@gmail.com

M. Tech Scholar, Department of Electrical & Electronics Engineering, BRCM CET, Bahal, (Haryana), India

Dr. Vivek Kumar

hodeee@brcm.edu.in

Professor & Head, Department of Electrical & Electronics Engineering, BRCM CET, Bahal, (Haryana), India

ABSTRACT

This work focuses on the formulation of the problem based on the inferences drawn out of literature survey. The fill the existing research gaps an attempt has been made here in this research work and a problem has been formulated on the basis of analysis carried out on the previous works reported so far in the literature. A solution has been proposed and reported with result analysis in this work. The problem here is to investigate and design the narrow-band metamaterial absorbers for the infrared frequency spectrum. In this chapter, we studied and analysed the effects of narrow band metamaterial absorbers for Infrared Frequencies. It is suggested to use a fresh, straightforward design for the top layer based on the most typical shape, the circular one. The absorption band may be narrowed based on our theoretical investigation of adjusting the symmetry and homogeneity of the metallic micron circular disc on top. The MIM-based absorber is projected to produce a small absorption peak with some widened absorption bandwidth by modifying the r shape to a circular form. The top layer may be constructed using a periodic arrangement of unit cells comprising circular discs of various sizes to create even broader spectra, we discovered later.

Keywords: THz, MTM, Metamaterial, Absorber

INTRODUCTION

In order to calculate the absorption properties of the absorbers, the following equationis used:

$$\boldsymbol{A(\omega) = 1 - R(\omega) - T(\omega) = 1 - S_{11}{}^2 - S_{21}{}^2} \qquad (1)$$

Where A(ω) = absorption; R(ω) = reflection = $|S_{11}|^2$; T(ω) = transmission = $|S_{21}|^2$; $S_{11}(\omega)$= scattering parameter of reflection; $S_{21}(\omega)$= scattering parameter of transmission. In simulations, the S-parameters are calculated from the power flow through the ports, which are given by the following equations:

$$S_{11}{}^2 = \frac{\sqrt{\text{power reflected from port 1}}}{\sqrt{\text{power incident on port 1}}} \qquad (2)$$

$$S_{21}{}^2 = \frac{\sqrt{\text{power delivered to port 2}}}{\sqrt{\text{power incident on port 1}}} \qquad (3)$$

Due to the existence of the ground plane on the bottom layer, with thickness greater thanthe skin depth, the transmission through the structure can be effectively suppressed, which indicates $S_{21}(\omega) = 0$. So, the absorption equation can be altered to the following:

$$\boldsymbol{A(\omega) = 1 - R(\omega) = 1 - S_{11}{}^2} \qquad (4)$$

To achieve perfect absorption reflection, the surface impedance of the whole structure should be constructed in a way to match to the intrinsic impedance in free space. The free space impedance can be calculated by the following equations.

$$Z_0 = \sqrt{\frac{\mu_0}{\varepsilon_0}} = \sqrt{\frac{4\pi \cdot 10^{-7}}{10^7/4\pi c^2}} = 377\Omega \qquad (5)$$

Where Z_0 is free space impedance, $\varepsilon_0 = 10^7/4\pi c^2\ Fm^{-1}$ is the permittivity of the freespace, $\mu_0 = 4\pi \cdot 10^{-7}\ Hm^{-1}$ is the permeability of the free space. The surface impedance $Z(\omega)$ of the structure is calculated by the following equations:

$$Z(\omega) = Z_0\sqrt{\frac{\mu_r(\omega)}{\varepsilon_r(\omega)}} = Z_0 \qquad (6)$$

Where μ_r (ω) = μ_1 + iμ_2 is the complex relative magnetic permeability, and ε_r (ω) $= \varepsilon_1$ + iε_2 is the complex relative electric permittivity. By tuning the resonance to achieve equivalent permittivity and permeability, the impedance of metamaterial can match the free space impedance, the maximum absorption can be achieved once the following condition established:

$$|S_{11}(\omega)| = \left|\frac{Z(\omega) - Z_0}{Z(\omega) + Z_0}\right| = 0 \qquad (7)$$

PROBLEM STATEMENT

A metamaterial absorber should have crucial properties such as angular response and polarization sensitivity depending on the usage. For example, polarization-dependent absorption and tiny acceptance angles are typical characteristics of metamaterial reflectors based on counter plasmons, which can be exploited for sensing applications. On the other hand, it is possible to significantly increase the absorption efficiency by using a broad acceptance angle and polarization insensitivity. Specifically for non-invasive standoff chemical electrochemical sensors, where the chemical is inherently spread over a wide field of view with random orientations of molecular structures, resulting in stochastic incident angles and polarizations, both the acceptance angle and polarization sensitivity of the dampers play an important role in maximizing the total absorption.

IMPLEMENTATION

In order to calculate the absorption properties of the absorbers, the following equation is used:

$$A(\omega) = 1 - R(\omega) - T(\omega)$$

This work focuses on the formulation of the problem based on the inferences drawn out of literature survey. The fill the existing research gaps an attempt has been made here in this research work and a problem has been formulated on the basis of analysis carried out on the previous works reported so far in the literature. A solution has been proposed and reported with result analysis in this work. The problem here is to investigate and design the narrow-band metamaterial absorbers for the infrared frequency spectrum. In this chapter, we studied and analysed the effects of narrow band metamaterial absorbers for Infrared Frequencies. It is suggested to use a fresh, straightforward design for the top layer based on the most typical shape, the circular one. The absorption band may be narrowed based on our theoretical investigation of adjusting the symmetry and homogeneity of the metallic micron circular disc on top. The MIM-based absorber is projected to produce a small absorption peak with some widened absorption bandwidth by modifying the r shape to a circular form. The top layer may be constructed using a periodic arrangement of unit cells comprising circular discs of various sizes to create even broader spectra, we discovered later. This results in a larger bandwidth of greater than 50% absorbance between 2.80 m and 3.90 m.

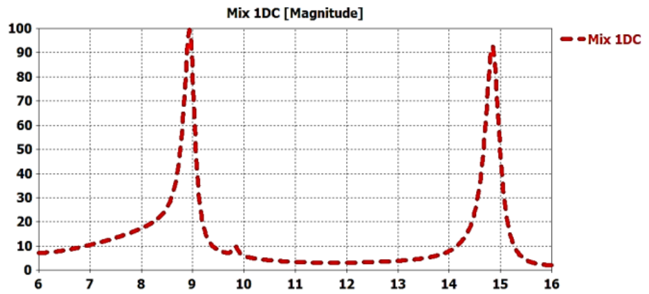
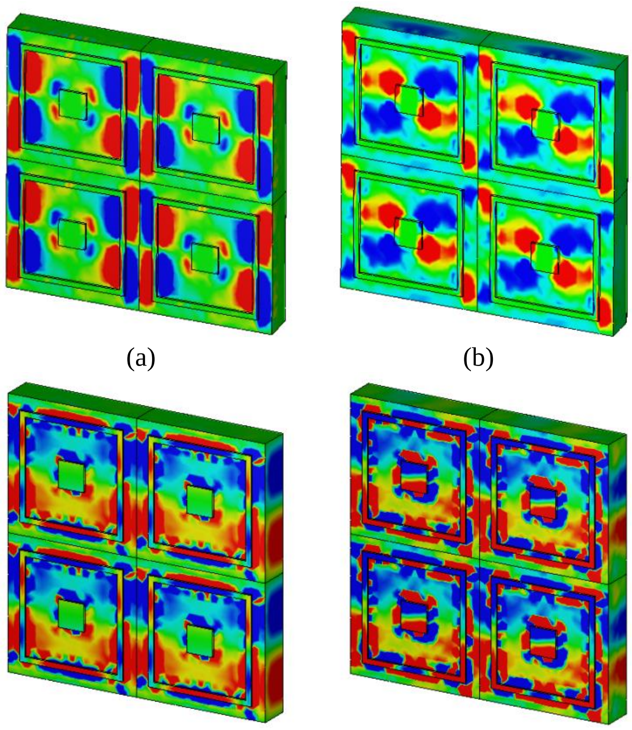


Figure 1. Absorption Spectra for TE and TM Polarization

RESULTS & DISCUSSION



(a) (b)

(c) (d)

Figure 2. Displays the x component of calculated flux and electrical field profiles at resonant frequencies (a) low

frequency (b) high frequency (c) Displays the z component of calculated flux and electrical field profiles at resonant frequencies, low frequency (d) high frequency

The electrostatic current (|E| and real |Ez|) spectra for the planned absorber at the previously discovered absorption peak are shown in Figures 3.5 and 3.6 (110 THz). The electric field |E| is notably cantered on the ascending and descending baselines of the circular ring construction for port 1 in mode f=110 THz. So, an overall conclusion can be derived from the electric field analysis that at the resonant frequency most of the electric field with high intensity are located near the circular metal disk only. Therefore, the metal disk can be considered as the resonator in the proposed trilayered structure. The electric field distributions clearly display the excitation of an electric dipole resonance at the resonant wavelength.

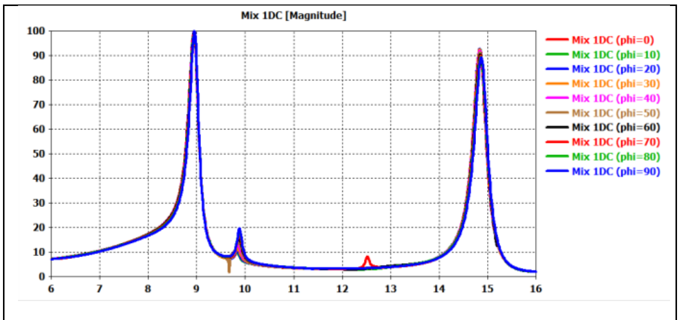


Figure 3. Polarization Plot for different Angles

CONCLUSION

By altering a variety of structural components, such as cross length and insulation thickness, the absorption frequencies may be altered to higher or lower values. The overall number of resonance bands and the absorption frequencies may both be altered by altering the structural arrangements. This single-band absorber with high absorption is adjustable and has applications in terahertz imaging and detection, among other technological fields.

REFERENCES

[1] W. Dallenbach and W. Kleinsteuber, “Reflection and absorption of decimeter-waves by plane dielectric layers,” Hochfreq. u Elektroak, vol. 51, pp. 152–156, 1938.

[2] W. W. Salisbury, “Absorbent body for electromagnetic waves,” jun 1952

[3] J. Pendry, A. Holden, W. Stewart, and I. Youngs, “Extremely low frequency plasmons in metallic microstructures,” Physical Review Letters, vol. 76, no. 11, pp. 4773–4776, 1996. [Online].

[4] D. R. Smith, “Metamaterials and Negative Refractive Index,” Science, vol. 305, no. 5685, pp. 788–792, aug 2004. [Online].

[5] S. B. Glybovski, S. A. Tretyakov, P. A. Belov, Y. S.Kivshar, and C. R. Simovski, “Metasurfaces: From microwaves to visible,” Physics Reports, vol. 634, pp. 1–72, 2016. [Online].

[6] N. Engheta, “Thin absorbing screens using metamaterial surfaces,” in IEEE Antennas and Propagation Society International Symposium (IEEE Cat. No.02CH37313), vol. 2, no. June. IEEE, 2002, pp. 392–395. [Online]. Available: http://ieeexplore.ieee.org/document/1016106/

[7] A. Alu, A. Salandrino, and N. Engheta, “Parallel, series, and intermediate interconnections ` of optical nanocircuit elements 2 Nanocircuit and physical interpretation,” Journal of the Optical Society of America B, vol. 24, no. 12, p. 3014, dec 2007. [Online].

[8] H. Luo, Y. Z. Cheng, and R. Z. Gong, “Numerical study of metamaterial absorber and extending absorbance bandwidth based on multi-square patches,” European Physical Journal B, vol. 81, no. 4, pp. 387–392, 2011.

[9] C. Sabah, F. Dincer, M. Karaaslan, E. Unal, O. Akgol, and E. Demirel, “Perfect metamaterial absorber with polarization and incident angle independencies based on ring and cross-wire resonators for shielding and a sensor application,” Optics Communications, vol. 322, pp. 137–142, 2014. [Online]. Available: http://dx.doi.org/10.1016/j.optcom.2014.02.036

[10] F. Hu, Y. Qian, Z. Li, J. Niu, K. Nie, X. Xiong, W. Zhang, and Z. Peng, “Design of a tunable terahertz narrowband metamaterial absorber based on an electrostatically actuated MEMS cantilever and split ring resonator array,” Journal of Optics, vol. 15, no. 5, p. 55101, 2013. [Online].