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ORIGINAL RESEARCH ARTICLE

Metamaterial Wave Absorber for Harvesting Electromagnetic Energy with Dispersion Characteristics Using Palm Oil Frond Graphitic Carbon

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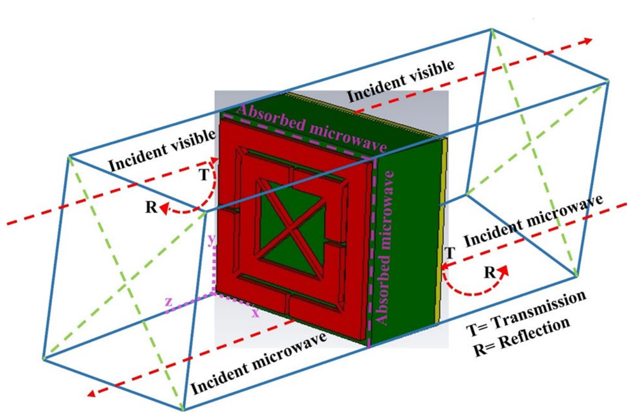
Abstract

A metamaterial wave absorber (MWA) optimized for high-performance absorbers to harvest electromagnetic energy is designed for operation within the terahertz (THz) frequency range using renewable palm oil frond graphitic carbon (POFGC). The structural composition of the MWA consists of double split-ring resonators configured in rotational symmetry. The fundamental component of the design has three distinct layers: (1) the bottom layer, composed of a metallic substance with gold that exhibits a lossy metal characteristic; (2) the middle layer, made of a lossy dielectric material referred to as silicon dioxide (SiO_2); and (3) the top layer crafted from POFGC. The findings reveal that the absorber achieves a broad absorption spectrum, with simulated results from CST software indicating absorption peaks at 414, 708, 981, and 1242 THz. These results demonstrate high absorption levels of 99.989, 99.999, 99.988, and 99.999% for typical incident electromagnetic waves. The structural dimensions (590×590 nm^2) are designed to deliver remarkable performance across the visible spectrum and infrared frequency ranges. The energy harvester exhibits independent polarization at various angles, including 0°, 45°, 90°, 135°, 180°, and 225°. It has excellent harvesting capabilities across multiple angles of incidence from 0° to 80°, including the whole operational spectrum. A comparative investigation of the circuit indicates enhanced performance of the metamaterial wave absorber, demonstrating its potential for exceptional functionality inside the advanced design system (ADS) software. Furthermore, the structures under consideration, which were simulated using the HFSS (high-frequency structure simulator) tool, demonstrate strong agreement with the highest level of absorption seen at each resonance peak in the CST simulation outcomes. This paper introduces an alternative protocol, expressed in terms of the phase velocity of the mode, for use with the restricted asymmetric structure to find optimum dispersion. The study highlights the exceptional properties of POFGC, including its high absorption capacity, insensitivity to angles, and effective dispersion properties.

Graphical Abstract



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Extended author information available on the last page of the article

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