Chapter 6
Study of Novel Design of Multi-Band and Broad-Band Metamaterial Microwave Absorber

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ABSTRACT

The artificially engineered materials termed as metamaterials (MMs) possess unnatural electromagnetic (EM) properties with μ < 0 and ε < 0 due to their geometrical and structural uniqueness. This resulted in diversified study of MMs from the GHz to THz range with one of the potential application as microwave absorber. In this chapter, a case study has been taken up with a unique design of a MM microwave absorber that exhibits multi-band as well as broad-band absorptance within 5GHz - 40GHz. The proposed structure consists of a square ring and a "+" shaped patch at its centre and the scaled "+" shaped patches at four corners. The proposed MM absorber exhibited absorptance peaks of 99.74%, 98.58%, 90.00%, 90.04%, 84.74%, and 94.94% at 6.33 GHz, 14.08 GHz, 28.92 GHz, 32.48 GHz, 33.84 GHz, and 37.69 GHz, respectively, with a broad-band lying within frequency range of 32 GHz to 37 GHz. The MM behavior is studied in terms of normalized matched impedance, effective permeability, and surface current distribution with potential application in stealth technology.

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INTRODUCTION

Metamaterials

A material's electromagnetic (EM) properties are described in terms of permittivity and permeability values, which can be either negative or positive. Table 1 depicts the classification of the materials based on positive or negative values of and .

Table 1. Material classification based on the values of $\tilde{\varepsilon}$ and $\tilde{\mu}$

$\tilde{\varepsilon}$	$\tilde{\mu}$	**Classification of Material**
+	+	"double-positive" (DPS)
-	+	"single-negative" (SNG) or "epsilon-negative" (ENG)
+	-	"single-negative" (SNG) or "mu-negative" (MNG)
-	-	"double-negative" (DNG) or "metamaterial" (MM)

Source: Kshetrimayum (2004)

The artificially engineered ENG material was combined with MNG material to generate the metamaterial (Smith et al., 1999). The term "metamaterial" was given by (Walser, 2001). A new class of materials known as metamaterials (MMs) have been artificially synthesized and are not present in nature. These artificially engineered materials possess unusual electromagnetic (EM) characteristics that are absent from materials that are present in nature, such as effective permittivity and permeability values that are less than zero (Smith et al., 1999). Unusual electromagnetic properties result from the structure's geometry, periodic arrangement, and orientation. The composition of the material has nothing to do with these peculiar electromagnetic properties. Metamaterials are sub-wavelength metallic structures that are arranged in a periodic or irregular pattern and their EM material properties are derived from the geometry of the device rather than directly from the material's composition or band structure.

The periodically structured microwires exhibit negative value of effective permittivity $\tilde{\varepsilon}$ below plasma frequency. A plasma is a density wave of electron gas. Plasmons exist in metals. The electrons in metals are loosely coupled to the atoms and are so free to move. A plasmon is a wave of synchronised oscillations made up of billions of electrons in an electron gas. The electrons oscillate violently at a resonance frequency known as the plasmon frequency ω_p. Metal electrons respond to an electric field by producing an opposite screening field, therefore an electric field cannot exist inside a metal. Since an electromagnetic wave cannot pass through