

Preface

Various kinds of materials have been employed since the beginning to develop new ideas and discoveries that take technology to the next level. Most conventional materials have significant limitations in obtaining unusual characteristics for various application fields. Therefore, a novel approach that may be used in nearly every field has been inspired by a composite substance known as a metamaterial, which comprises unexpected characteristics. Metamaterial is an artificially constructed material that provides unique and improved performance. Metamaterial is absent from its natural state and has relative permeability (μ) and permittivity (ϵ) amplitudes that are not possible for common materials. Practically speaking, a metamaterial is a manufactured composite material that interacts differently with light and sound waves than standard natural materials. For example, light propagation in waveguides and free space may be controlled in a metamaterial, making electromagnetic wavefront manipulation very intriguing for a variety of applications. Indeed, the invention of a metamaterial allows for the control of light by applying external electric and magnetic signals, hence improving signal absorption and harvesting efficiency.

Researchers have become quite interested in metamaterial research in recent years since it has become a hot issue. This is due to the unusual material characteristics of metamaterials, which heavily rely on the geometrical structure of metamaterial molecules rather than the composition of the material. In addition, metamaterials have demonstrated robust electric and magnetic reactions to control the direction, phase, amplitude, wavelength, and polarization of electromagnetic waves. These properties make metamaterials very applicable to a wide range of industries, including optical cloaking, satellite applications, microwave antennae, compact electric and magnetic dipole antennas, sensors, SAR reduction, and superlens. Scholars are also aware of the existence of left-handed metamaterial, which has gained notoriety since the discovery of its remarkable features. The Russian physicist Victor Veselago conducted the first investigation into the theory of left-handed metamaterials in the 1960s. Veselago reported on a theoretical study on the electromagnetic properties of an artificial material in which the real values of both electric permittivity and magnetic permeability are negative at specific frequencies. Veselago also illustrated the phenomenon of negative refractive index, in which the direction of energy flow is opposite to that of the phase velocity. This theory draws significant conclusions that apply to almost all electromagnetic phenomena.

Due to the unique properties of metamaterials, various conferences, scientific papers, and articles are being published either in journals or even as book chapters. Although these contributions have high value to metamaterials, they are all limited or focused on either metamaterials or metasurfaces only. Therefore, this book aims to address the engineering of both metamaterials and metasurfaces for the aspect of the current twenty-first century. We introduced several unique and compact metamaterial and metasurface for SAR reduction, terahertz frequency, medical, absorber, and

RCS reduction applications. The summary of each chapter is as follows: Chapter 1 by Mohammad Rashed Iqbal Faruque and Tayaallen Ramachandran, explores a comprehensive overview of metamaterials and their properties and the most prevalent structural designs for microwave and terahertz frequencies. Chapter 2 by Mohammad Rashed Iqbal Faruque, Md. Ikbal Hossain and Sabina Yasmin introduced reviews on metamaterial and other SAR reduction techniques and specially analysis of mobile casing materials for specific absorption rate (SAR) reduction applications. Moreover, this chapter analyzes the SAR effects for 5G Cellular Networks. Chapter 3 by Mohammad Rashed Iqbal Faruque and Rasheduzzaman Sifat presents terahertz sensor based on conventional metamaterial absorber with unique properties likely, ultra-thin, wide-band for hazardous gas sensing application. Chapter 4 by Mohammad Rashed Iqbal Faruque and Mehdi Hassanpour provides a thorough exploration of radiation protection, spanning fundamental concepts to the latest technologies. Chapter 5 by Mohammad Rashed Iqbal Faruque, Marzieh Hassanpour critically analyzes how metamaterials contribute to the enhancement of safety and precision in radiation therapy. Chapter 6 by Mohammad Rashed Iqbal Faruque and Md. Bellal Hossain explores the comprehensive exploration of metamaterial absorbers, providing a detailed understanding of historical evolution to practical applications. Chapter 7 by Mohammad Rashed Iqbal Faruque and Md. Bellal Hossain navigates the domain of coding metamaterials, emphasizing their distinctive properties and pivotal role in RCS reduction and EMI shielding. Chapter 8 by Mohammad Rashed Iqbal Faruque and Air Mohammad Siddiky introduced a metamaterial incorporated microwave sensor with enhanced where split ring-based metamaterial increases the compactness of the design and the accumulation of the electromagnetic layer on the conducting surface.

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