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Editorial

Modern Trends in Metamaterial Applications

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The concept of metamaterials, which has been enunciated in the pivotal works of V. G. Veselago and J. B. Pendry, has drastically altered our way of thinking about light-matter interactions and greatly enriched the fields of classical and quantum electrodynamics. It has become apparent over the last decade that the propagation of electromagnetic waves can be manipulated almost at will using artificially fabricated structures with prescribed electromagnetic properties, the diversity of which is limited only by the ingenuity of the researchers and the sophistication of the fabrication techniques. This new understanding has revolutionized the design paradigm of photonic devices and quickly resulted in the experimental demonstration of several counterintuitive effects with far-reaching breakthrough applications. In particular, it was shown that not only could negative-index metamaterials be fabricated practically, but they can also be used to create super- and hyperlenses with subwavelength optical resolution. Likewise, it is possible to fabricate metamaterials designed using the transformation optics approach and apply them in real invisibility cloaks. Today, scientists and engineers all over the world are combating the fundamental and technological challenges that deter the wide commercial use of these and other exciting functionalities offered by metamaterials.

As is customary with great ideas, the reality of unusual metamaterial properties has been the subject of much controversy. Even now, some experts in optics and electromagnetism argue over this reality in regards to phase advance in evanescent waves, as well as over the existence of a negative refractive index, thus showing that the physics behind these phenomena is more complicated than it may appear at first glance. Interestingly, the analysis of metamaterial critiques may be quite instructive, as it helps one to appreciate the subtleties of the field and gain a deeper insight into it. While leaving such an analysis for future textbooks, we wish to note here that disproving the objections against any metamaterial phenomenon requires the careful consideration of several fundamental principles, including the causality requirement, which makes metamaterials essentially dispersive.

Despite all the differences between the electromagnetic behaviour of ordinary materials and metamaterials, they are both governed by the same set of Maxwell equations. Therefore, it is the new functionalities and design guidelines enabled by the metamaterial paradigm—rather than new physics—that have aroused a relentless interest in metamaterials. This interest remains equally strong from both the physics and engineering communities since the field of metamaterials mediates science and technology. It is therefore not surprising that in recent years we have witnessed a rapidly escalating number of publications on the physics, design, and applications of various types of metamaterials. The focus of theoretical studies shifts from negative-index materials to hyperbolic, tuneable, nonlinear, and nonlocal metamaterials, as well as to media with extreme material parameters. The modern trends in metamaterial applications include superresolution imaging and optical sensing, the advancement of photonic circuitry with metatronics, all-optical and electrooptical dynamic control of light, electromagnetic cloaking, and light harvesting for improved solar-cell technology. This special issue focuses on the advances along these research avenues and on the new photonic devices associated with them.

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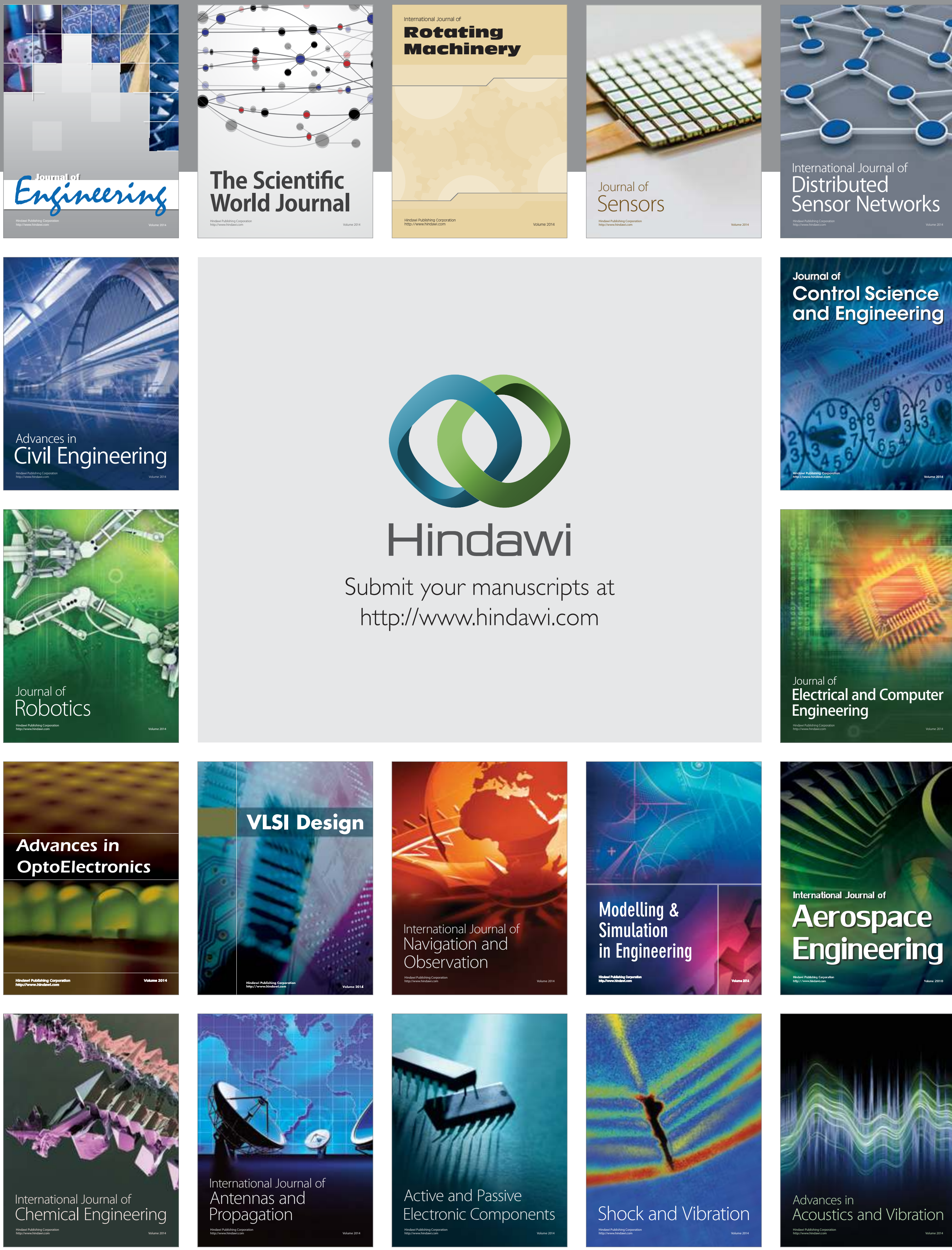
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