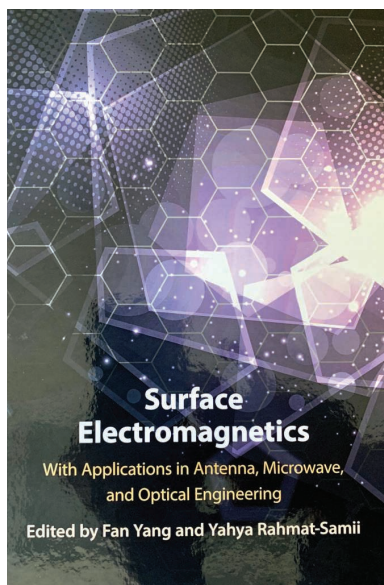


Surface Electromagnetics: With Applications in Antenna, Microwave, and Optical Engineering

Edited by Fan Yang and Yahya Rahmat-Samii
Reviewed by Nader Engheta

This is a fascinating book that presents an exciting and timely set of topics in surface electromagnetics (SEM). With contributions from prominent and pioneering scientists and engineers in this field, the book covers a wide range of subject matter related to electromagnetic field and wave interaction with a variety of structures that are categorized as “surfaces.” The editors, Prof. Fan Yang and Prof. Yahya Rahmat-Samii, who are two of the most outstanding and innovative pioneers in electromagnetics, have compiled a comprehensive set of topics, ranging from fundamental aspects of wave-surface interaction (such as the modeling, analysis, and synthesis of SEM), guided waves, leaky waves, and plane-wave features to various applied areas, (e.g., cloaking and transparency), orbital angular momentum, and microwave, terahertz, and optical applications.

In Chapter 1, Yang and Rahmat-Samii give an informative introduction to and overview of the subject matter. They set the stage by providing the reader with the definition, development, and importance of SEM, and they describe some research frontiers in this topic. They aptly state that the



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electromagnetic surface paradigm is part of the natural progression in the classification of electromagnetic phenomena from zero-dimensional circuits to 1D transmission lines, 2D SEM (the subject of this book), and 3D general electromagnetic problems. This is indeed the

spatial categorization of electromagnetic interaction with matter, analogous to the temporal categorization based on the frequency of operation, such as dc, radio frequency (RF), microwave, terahertz, infrared, visible, ultraviolet, and so on.

Another classification of electromagnetic surfaces, as described in Chapter 1, is based on the nature of a surface in terms of the spatial variation of features, i.e., from uniform surfaces (e.g., flat surfaces and interfaces between different media) and periodic surfaces (e.g., frequency-selective surfaces, soft/hard surfaces, and electromagnetic bandgap surfaces) to quasi-periodic surfaces (e.g., reflectarrays and transmitarrays). One of the important features of electromagnetic surfaces is the possibility of being tailored to achieve specific functionalities. Such specially engineered surfaces, often called *metasurfaces*, can provide platforms for desirable electromagnetic responses. This may include engineered responses based on the magnitude, phase, and/or polarization of incoming waves. Examples such as soft/hard surfaces, high-impedance ground planes, and electromagnetic bandgap surfaces are among the well-known cases.

Chapter 2, by Viktor Asadchy, Ana Diaz-Rubio, Do-Hoon Kwon, and Sergei Tretyakov, discusses analytical models

and tools that are useful for handling wave interaction with electromagnetic surfaces. It describes the polarizability-, susceptibility-, and equivalent-impedance-matrix-based models. Other topics, such as bi-anisotropy, bi-isotropy, and nonreciprocity, along with the functionality of metasurfaces in shaping and controlling waves in transmission and reflection, are presented in this chapter.

Christopher Holloway and Edward F. Kuester describe the techniques of generalized sheet transition conditions (GSTCs) in the analysis of metasurfaces in Chapter 3. This versatile tool provides the necessary boundary conditions for wave interaction with metafilms, metascreens, and metagratings, from which the reflection and transmission coefficients of these surfaces are obtained. From this information, the chapter presents the retrieval expressions and methods to determine surface parameters. Several applications of GSTCs, such as guided waves along a single metasurface, the reduction of the resonator size, and metafilm-based waveguides, are also given in this chapter.

The synthesis of metasurfaces is presented by Karim Achouri, Yousef Vahabzadeh, and Christophe Caloz in Chapter 4. Metasurface boundary conditions and synthesis procedures are detailed, and examples of negative-refraction metasurfaces; nongyrotropic, nonreciprocal metasurfaces; and time-varying half-wave absorbers are discussed. Some practical realizations are also mentioned. Maokun Li provides the detailed modeling and analysis of quasi-periodic surfaces, with attention to reflectarrays, in Chapter 5. The reduced-basis method is utilized in the numerical analysis of such quasi-periodic structures. Moreover, the comparison between the reflection phase in the quasi- and infinitely periodic cases is explored.

Chapter 6, authored by Eva Rajo-Iglesias, Zvonimir Sipus, and Ashraf Uz Zaman, deals with specialized waveguides, known as *gap waveguides*, in which customized surfaces inside parallel-plate waveguides cause

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desired guided modes along particular paths. Various examples, such as glide-symmetry holey waveguides and bed-of-nails guided-wave structures with ridges, grooves, inverted microstrips, and microstrip ridges, fall into this class of gap waveguides. Gap waveguide antennas are also discussed as an example of the RF applications of such structures. Metasurface antennas, as one of the “metasurfing” applications, are presented by Gabriele Minatti, David Gonzales-Ovejero, Enrica Martini, and Stefano Maci in Chapter 7. In such structures, spatial modulation of the surface features causes the conversion of surface waves into leaky waves. Various parameters can be tailored in the architecture of such antennas, providing useful methods for the design of conformal antennas that have desired properties, such as shaped-beam and multibeam metasurface antennas.

Yang and Shenheng Xu discuss electromagnetic surfaces as transmitarray antennas and transmission surfaces in Chapter 8. The transmission phase is an important quantity that is engineered by such properly designed transmission surfaces. Reconfigurable surfaces are also explored. Chapter 9, by Shuo Liu and Tie Jun Cui, presents another interesting paradigm that benefits from metasurfaces, namely, coding and programmable metasurfaces. Here, the two concepts of coding and metasurfaces have been merged, resulting in the controllable manipulation of electromagnetic waves. Programmable metasurfaces in the presence of the point source and for imaging application are discussed.

In Chapter 10, Giuseppe Labate, Ladislau Matekovits, and Andrea Alu discuss cloaking concepts and applications

that use metamaterials and metasurfaces. Plasmonic cloaking involving volumetric metamaterial coating, mantle cloaking, and parity-time symmetry cloaking are presented. Some fundamental issues, such as the bounds on cloaking, the bandwidth, and directionality, are also given.

Mehdi Veysi, Caner Guclu, Filippo Capolino, and Rahmat-Samii investigate how textured surfaces can be utilized to generate orbital angular momentum (OAM) beams in Chapter 11. They discuss the near- and far-field applications of such OAM beams. They also present reflectarrays that generate phase patterns that are needed to construct Bessel-Gaussian and Laguerre-Gaussian beams. Reflectarrays with cone-shaped patterns are also covered. Finally, in Chapter 12, Daniel Binion, Lei Kang, Zhi Hao Jiang, Shengyuan Chang, Xingjie Ni, and Douglas H. Werner describe a series of applications of metasurfaces in the microwave, terahertz, and optical regimes, some of which include ultrathin absorbers, grounds for low-profile antennas, scattering-signature control, reflectarrays and transmitarrays, terahertz modulators, polarization controllers, metalenses, holography, and optical invisibility cloaks.

The book also has an excellent appendix by Yang, Rahmat-Samii, Xibi Chen, Xingliang Zhang, and Hongling Xu that cites many representative references that are organized based on various topics. This is a highly valuable resource for the reader. In summary, this is a great book to have as a reference for various aspects of electromagnetic surfaces. It is an informative source, and it is inspirational to those interested in entering this exciting field of research. I am confident you will treasure your copy.

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