Analytical modeling and applications of periodic metasurfaces

Alexandros I. Dimitriadis[1], Nikolaos V. Kantartzis[1],
Theodoros D. Tsiboukis[1], and Christian Hafner[2]

[1]Department of Electrical and Computer Engineering, Aristotle University of Thessaloniki, GR-54124 Thessaloniki, GREECE
[2]Department of Information Technology and Electrical Engineering, ETH Zurich, Gloriastrasse 35, Zürich 8092, Switzerland

e-mail: aldimitr@ee.auth.gr

Abstract

Metasurfaces typically comprise two-dimensional arrays of electrically-small scatterers or sub-wavelength apertures perforated on a rather impenetrable surface. These structures are usually modeled via a set of effective surface parameters, in order to facilitate the prediction of their scattering properties. In this work, we present a rigorous analytical approach for the characterization of periodic metasurfaces in terms of non-local effective surface susceptibilities. The proposed technique is based on the a priori knowledge of the polarizability matrix for the constituent particles and the exactly computed frequency- and angle-dependent expressions of the interaction coefficients for the corresponding periodic lattice. The universal form of the resulting surface susceptibility matrix is employed for the calculation of generalized Fresnel equations that apply in such surfaces. Extensive comparisons with numerical simulation results as well as the outcomes of alternative modeling approaches validate the proposed methodology and highlight its assets. Finally, an important application of metasurfaces, namely the design and fabrication of the so-called perfect metamaterial absorbers, is discussed and implemented in the realm of the featured algorithm.