# Field-Manipulating Metasheets and Metalayers

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In this review presentation we will discuss electrically thin composite layers, *metasheets and metalayers*, designed to perform desired operations on applied electromagnetic fields. The concept of metasheets or metasurfaces is closely related to the more general notion of *metamaterials*, arrangements of artificial subwavelength structural elements, designed to achieve advantageous and unusual electromagnetic properties. Samples of volumetric metamaterials are designed so that the induced polarization currents in the sample produce desired electromagnetic fields inside and outside of the sample. Possibilities to use negligibly-thin composite sheets instead of volumetric metamaterial objects follow from the Huygens' principle. Here we will show how the generalized Huygens' principle (I. Lindell, S. Tretyakov, K. Nikoskinen, Electromagnetics, 20, 233-242, 2000) can be used to design metasheets and metalayers capable for various operations on the electromagnetic fields.

The composite structure forming the metasurface is assumed to behave as a *material* in the electromagnetic sense, meaning that it can be homogenized on the wavelength scale, and the metasurface can be adequately characterized by its effective, surface-averaged properties. This implies that the unit-cell sizes of composite metasurfaces are reasonably small as compared with the wavelength. Metasurfaces can be considered as effectively two-dimensional structures, which can be designed to ensure the desired relations between the electromagnetic field values on the two sides of the engineered sheet. The generalized Huygens' principle extends this design paradigm to layers of a finite thickness. Possibilities for realizing full control over reflected and transmitted waves using thin layers and sheets makes this area of research exciting and topical, both from the theoretical and practical points of view.

In this presentation we will focus on ultimately thin metasheets formed by single-layer arrays of small inclusions. It appears that properly choosing the inclusion polarizabilities (the relations between the induced electric and magnetic moments and the applied fields) it is possible to design metasheets with rather general properties. In particular, although the array contains only one layer of particles, it is possible to control backward- and forward scattering independently. Furthermore, it is possible to control reflection properties of the two sides of a single-layer array independently. For example, it is possible to design a dipole array which focuses plane waves incident on one side and reflects plane waves incident on its other side into a desired direction. We will discuss the design and performance of several functional metasurfaces, which can shape reflected and transmitted waves at our will.