Extraordinary Transmission Through Dielectric-Loaded Metascreens

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A conducting metal plate with periodically spaced electrically small apertures forms what has been called a metascreen—a particular example of a metasurface. Under ordinary conditions, such a metascreen merely functions as a bandstop filter for waves of sufficiently low frequency. It has been found that at optical frequencies where a metal has electromagnetic properties vastly different from those of a perfect conductor and a thickness different from zero, abnormally large transmission can occur when the size of the apertures is significantly smaller than a wavelength (T. W. Ebbesen *et al.*, *Nature*, 391, 667-669, 1998). In this case, the mechanism responsible for this "extraordinary transmission" was found to be the coupling of the electromagnetic wave with surface plasmons on the nonideal metal.

In this paper we will demonstrate the occurrence of extraordinary transmission when the metal plate is perfectly conducting and has zero thickness. The effect in our case is created by loading each aperture with a high-permittivity dielectric resonator that possesses Mie-type resonances in a frequency range where the corresponding unloaded metascreen would have very low transmission. Plane-wave reflection and transmission coefficients were calculated from numerical simulations using finite-element software. If a generalized sheet transition (GSTC) model can be assumed to be adequate for the macroscopic field behavior of this loaded metascreen, then the parameters in the GSTC (the surface susceptibilities and surface porosities) can be extracted by suitably processing the numerical simulation results for S_{11} and S_{21}. The self-consistency of the extracted parameters is tested by comparing results of simulations for plane waves incident at different angles to the metascreen, and checking whether the same values of surface susceptibility and surface porosity are found. Agreement is found to be very good except just at the resonance peaks, and this discrepancy can be attributed to the effects of spatial dispersion, which have only been included to a low-order approximation in the GSTCs.