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Analysis of Pointing Vector Distribution in Metasurface Structures

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Metasurface structures have been used as electromagnetic sensors to measure 2D radio-frequency (RF) field distributions incident on the surface [1]. Electric field distribution is detected by lumped resistors inserted between the surface patches of a mushroom-shaped metasurface, where the resistors act as a short-dipole array and absorb the incident wave power at the resonant frequency of the mushroom structure. The voltages across the resistors are monitored by RF detectors to map 2D amplitude and phase profiles of the RF electric field vectors. The measured distributions can be used for real-time localization of RF noise sources. The accuracy and effectiveness of the measurement for spherical wave illumination were confirmed by a numerical analysis using the plane-wave spectrum (PWS) technique by treating the metasurface as an equivalent impedance surface (an effective medium model). The results of the numerical analysis were in good agreement with electromagnetic simulations and experiments [2].

While the PWS technique accurately reproduced the absorbed and reflected field profiles using the effective medium model, electromagnetic simulations revealed complex 3D field fluctuations due to the dense metallic structure of the metasurface [3]. In this study, the detailed power flow and absorption mechanisms in the metasurface structures are evaluated by electromagnetic analysis and simulation. In a mushroom-shaped metasurface, the incident electric field is scattered to form a semicircular arc around the gaps between the surface patches. Similarly, the scattered magnetic field takes an arc that encircles the RF current on the lumped resistors. These electromagnetic fields cause the Poynting vector to follow a converging path, eventually reaching the resistors. Detailed Poynting vector and electromagnetic field distributions in and around the metasurface structures are presented and discussed from the perspective of the metasurface used as an electromagnetic sensor.

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