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Measurement of Electric Field Vector Distribution with a Metasurface Structure

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We have been developing electromagnetic field sensors using metasurface structures for radio-frequency (RF) waves. A thin metasurface absorber was used for monitoring 2-d distributions of RF electric fields incident on the absorber surface, which was constructed with a dense matrix of square metal patches (mushroom cells) on a grounded dielectric substrate, where lumped resistors between the surface patches were used to absorb the incident waves at the resonance frequency [1]. The surface patches worked as a 2-d array of short dipole sensors terminated with the lumped resistors. The voltages on the individual resistors were proportional to the electric field distribution of the incident wave illuminating the absorber surface. The lumped resistors, R_x and R_y, inserted between the square patches in the *x*- and *y*-directions on the absorber surface (the *xy*-plane) were used independently to detect the two (*x*- and *y*-) components of incident electric field polarizations. Measurement accuracy of the technique was evaluated by theoretical (numerical) calculations and electromagnetic simulations as well as by actual measurements for spherical waves incident on the absorber surface [1, 2]. On the other hand, RF magnetic field distributions were measured with another type of metasurface structure, on which a 2-d array of the unit cells with metal loop structures were arranged [3]. Each unit cell consisted of three metal loops orthogonal to each other, to detect the *x*- and *y*-components (on the surface) and the *z*-component (perpendicular to the surface) of a magnetic field vector. The induced voltage on each loop structure was monitored using a resistor inserted in a small gap on the loop, from which the magnetic field vector was calculated. Thus by monitoring the voltages induced on the individual loop structures, the 2-d distribution of magnetic field vectors were measured. Such obtained electromagnetic field distributions should give useful information for in-situ and real-time monitoring and localization of RF noise sources.

In this study, we develop a new metasurface structure which is capable of measuring the 2-d distribution of *electric field vectors* including the *z*-component (perpendicular to the surface), in addition to the *x*- and *y*-components (on the surface) so far developed, of the RF electric field incident on the absorber surface. Using the mushroom-type metasurface sensor, the *z*-component of the electric field is monitored with another lumped resistor, R_z, inserted at the bottom of each of the "vias" connecting the surface patches to the ground plane. Since the voltage on the R_z resistor is generated as the potential difference between the surface patch and the ground plane, the structure works as a short monopole sensor. The voltages on the R_z resistors, as well as on the R_x and R_y resistors, are picked up by RF detectors implemented on the backside of the metasurface structure, to measure the 2-d distributions of RF electric field vectors (a complete set of E_x, E_y and E_z) incident on the surface. This should be useful to monitor the electric field of obliquely incident plane waves, as well as spherical waves in the radiating near-field zone. In the presentation we will discuss the design and performance of the new metasurface using electromagnetic simulations and actual measurements.

References

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