Design and Evaluation of a Class of Miniaturized Metal-backed Antenna

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This paper presents a two-layer mushroom-like reactive impedance surface (RIS) and its application to patch antenna miniaturization. RIS, known as meta-substrate, have shown the ability to miniaturize printed antennas with omni-directional radiation pattern, when served as the substrate for the antenna (H. Mosallaei and K. Sarabandi, *IEEE Trans. Antennas Propag.*, 52, 9, 2403–14, 2004). However, the area of conventional RIS substrate usually has to much larger than that of miniaturized antenna, since the cell's dimension is comparable with the antenna, even using a high dielectric constant of 10.2 or 25. The proposed compact two-layer RIS can achieve 76% lower frequency than conventional one-layer RIS with the same size, whose cell dimensions are limited within $\lambda_0/45$ in length and $\lambda_0/100$ in height while the dielectric constant is kept below 3.5. This makes it possible to design a miniaturized antenna over an RIS substrate with the same size as the antenna itself.

The RIS substrate is analyzed by a surface impedance model. A microstrip transmission line over the RIS substrate is studied and shown to have a high propagation constant near the resonant frequencies of the RIS. A model based on simulation results of wide microstrip line over RIS is used to predict the much reduced resonant frequency of patch antennas over the RIS. Applying the two-layer RIS substrate and an optimized miniaturized patch antenna topology, several UHF band patch antenna working around 400MHz has been designed and fabricated. Using this approach a miniaturized antenna with dimensions $\lambda_0/11.4\times \lambda_0/11.4 \times \lambda_0/74$, including the RIS substrate is developed.