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Microstrip antenna gain enhancement with metamaterial radome

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Abstract In this work, a high gain patch antenna using multilayer FSS radome is proposed for millimeter-wave applications. The antenna operating frequency is 43.5 GHz. The antenna/radome system consists of one, two, three, or four layers of metasurfaces placed in the near-field region of a microstrip patch antenna. The antenna/radome system gain is improved by 9 dBi compared to the patch antenna alone, and the radiation pattern half-power beamwidth is reduces to 20° in both E- and H-planes.

1 Introduction

Frequency selective surfaces (FSSs) are planar infinite array of periodically arranged unit cells on dielectric substrate [1, 2]. Unit cells are constructed from metallic patch or aperture element that exhibits perfect reflection or transmission, respectively, in the neighborhood of the resonant element [3]. FSSs are widely and intensively investigated [4] and the progress in terms of manufacturing of micro- and nanostructures, on the one hand, and the promising properties of the artificial periodic structures, on the other hand, made necessary the use of FSSs very attractive for many applications. Many designs are proposed such as ultra-band or dual-band FSS using multilayer FSSs [5, 6], compact FSS using the fractal configuration [7, 8], and radomes for aeronautical applications [3]. These designs greatly improve the FSSs performances.

Radomes are electromagnetic pass-band filters. Ideally, they have to be electromagnetically transparent, in the operating frequency band. They are essential components that protect radars against physical environment and help to reduce the operational coast [9].

In practical applications, FSS radomes have usually curved shapes and are of finite extent. In addition, when the radome is located close to the antenna, mutual coupling between the antenna and FSS cannot be neglected. These factors will seriously modify the radiation performance of antenna [10, 11]. Another adverse effect of radomes is the presence of water or ice which causes radio signals degradations.

Depending on the operating frequency and physical elements, radomes can significantly deteriorate radar signals especially for higher frequencies [12]. In consequence, millimeter-wave systems introduce a set of particular severe requirements from the antenna point of view. Therefore, high directive antennas are required to overcome the aforementioned degradation. Finally, the antennas must be small, low-profile, lightweight, and low-cost in order to be successfully integrated in a commercial wireless system.

In this paper, an FSS radome is proposed to improve a patch antenna gain and make it more directive. The proposed FSS radome is then used as a superstrate. The FSS radome is placed in the near-field region of the MPA to form an antenna/radome system. The antenna and FSS unit are designed separately.

2 Frequency selective surface design

Up today, the most used FSSs are constituted by cascading several sheets (metasurface), one behind the other and separated by spacer [13]. The addition of a superstrate

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