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Dual-band Polarization and Frequency Reconfigurable Antenna Using Double Layer Metasurface

XiaoFeng Chen, YongJiu Zhao

Abstract—In this paper, a polarization and frequency reconfigurable antenna with double layer metasurface, responsible for frequency and polarization reconfiguration respectively, is proposed. This antenna could operate in linear polarization in 4GHz and circular polarization in 5GHz band. By rotating the frequency reconfiguration metasurface, the linear polarization(LP) operating frequency can be continuously changed from 4GHz to 4.35GHz (8.4%) with circular polarization operating frequency around 5GHz unchanged. Moreover, polarization of the whole antenna at 5GHz can be reconfigured to linear polarization(LP), right-hand circular polarization(RHCP) and left-hand circular polarization(LHCP) by rotating polarization reconfiguration metasurface, the 3dB axial ratio bandwidth is 5.0-5.2 GHz (4%). In all states, gain of the antenna achieves 5 dBi.

Index Terms—Metasurface, frequency reconfigurable antenna, polarization reconfigurable antenna, dual-band.

I. INTRODUCTION

Reconfigurable antennas generally fall into three major categories, frequency [1]-[2], radiation pattern [3], and polarization reconfigurable ones [4]-[7]. The reconfiguration of frequency and polarization could be realized mechanically or electrically [2], [8]-[9]. Mechanical reconfiguration is less popular but more convenient comparing to electrical reconfiguration. Several novel structures have been proposed in recent years, including polarization reconfigurations [10]-[12] and frequency reconfigurations [13]-[15].

Metasurface is a surface distribution of electrically small scatters essentially [16]. It has wide applications in the design of planar antennas because of its simple structure and low profile. In [10], which is a significant improvement to the work in [17] a polarization reconfigurable metasurface antenna is proposed which operate in 3.3-3.7GHz band with circular polarization. The realized gain and return-loss bandwidth of the design were significantly improved, as well. In [13], a frequency reconfigurable metasurface antenna was presented. Its operating frequency can be tuned from 4.76 to 5.51 GHz by rotating the metasurface. Radiation efficiency and realized peak gain is more than 80% and 5 dBi, respectively. In literature [18], a novel X-band quad-beam transmitarray using an improved dual-mode metasurface has been realized. The metasurface has a full 360° phase circle. In paper [19], a bifunctional metasurface is proposed which could efficiently and flexibly control the emission beams. There are also many linear polarization converters using metasurface. In [20]-[21], the author proposes two different types of reflective linear polarization converter. Furthermore, in [22], an improved photo-excited switchable broadband reflective linear polarization conversion metasurface for terahertz waves has

been proposed, the PCR is up to 99% at resonances frequency of 0.69THz, 1.01THz and 1.42THz. Metamaterial and metasurface also can be used in antenna for improving some antenna performance. In [23], metamaterial is used in microstrip antenna. And in [24], metamaterial is loaded on microstrip antenna which makes the antenna obtain dual-band and reconfigurable characteristics. In [25], the authors have proposed an especial shape of microstrip antenna based on loop formation with metamaterial load. Metamaterial load can not only provide CP by changing the current distribution but also miniaturize the antenna. In [26], a novel prescription for gain enhancement and layout miniaturization of CP antennas has been proposed using metasurface and meta-resonators, radiation efficiency, BW, and miniaturization of the antennas have been improved. Moreover, metasurface has also been used in focusing, for example, a novel multifunctional microstrip array is proposed in [27] which can be considered as a linear polarizer and focusing metasurface at the same time. To the best knowledge of the authors, in most of the previously published literature, metasurface is used only to improve the performance of planar antennas or realize reconfiguration of antennas. The function of metasurface is relatively simple.

In this paper, a dual-band polarization and frequency reconfigurable antenna using double layer metasurface, that is in charge of frequency and polarization reconfiguration respectively is proposed. The design can be considered as a combination and improvement to the work in [8] and [11]. It is shown that this antenna could operate in linear polarization at 4GHz and circular polarization at 5GHz. For mechanical rotation simplicity, the patch antenna and the MSs are designed circular with the same radius. To validate design, the antenna is fabricated and measured. Good agreement is observed.

II. DESIGN OF METASURFACES

The polarization reconfiguration metasurface(PRMS) is in the uppermost layer with its unit cells on the side face to the middle layer frequency reconfiguration metasurface(FRMS), whose unit cells are etched on the side opposite to the patch antenna as shown in Fig. 1. All layers are fabricated on the substrate RO4350B, with a thickness of 1.524 mm and a dielectric constant of 3.48.

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