Design of a Metasurface-Based Beam-Steering System

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In this paper, we report a compact beam-steering system with high efficiency. Different from the conventional beam-steering systems consisting of complicated feeding networks, phase shifters and control circuits, the proposed beam-steering system is constructed by metasurface cells with low-profile and flexible performance (e.g. dynamic phase control). In this way, a highly integrated beam-steering system with good performance and low implementation cost is achieved. The resulting beam-steering system can find applications in radar, navigation, telecommunication and security.

Metasurface is an artificial two-dimensional metamaterial structure composed of planar electromagnetic units in subwavelength scales. It features the capability of introducing abrupt phase change to the incident electromagnetic wave with an ultra-thin aperture, which has enabled it to manipulate wave propagation across the entire electromagnetic spectrum (e.g. from radio-frequency (RF) to visible). So far, there are a lot of metasurface-based applications that have been demonstrated including ultra-thin lens, holography, vector beam generation [H. T. Chen et al., arXiv:1605.07672, May 2016]. However, there are no metasurface-based beam-steering systems reported, which is partly due to the lacking of high performance tunable/reconfigurable metasurface cells [H. Ren et al., URSI 2016, July 2016]. In this paper, a new tunable transmission-type metasurface cell is proposed. The general schematic of it is shown in Fig. 1. It is formed by a few-layer metasurface structure. To achieve high transmission efficiency with broad bandwidth, it is designed to operate in the non-resonant frequency region. Equivalent circuit models are applied to analyze the performance of the metasurface structures and facilitate the design. Numerical simulation results of the designed metasurface cell show that it can achieve a large range of phase coverage with high transmission efficiency (>80%). Enabled by the proposed metasurface cell, a 6x6 beam-steering array has been designed with a total size of around 1.44 wavelength x 1.44 wavelength. It is found that the new beam-steering system can realize a beam scanning within a scanning window of [-60°, +60°] and a gain of 11.7 dBi.

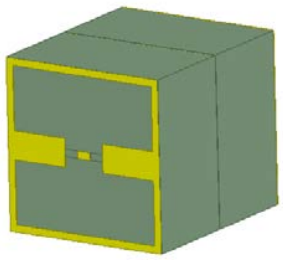

Figure 1. The general schematic of the proposed metasurface cell.