

High Efficiency Terahertz Beam Steering Metasurfaces Using Vanadium Dioxide-Based Cross-Polarization Converters

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Terahertz (THz) metasurfaces are crucial for the rapidly advancing 6G communication technologies. However, the wavefront manipulation of THz waves to redirect is still a great challenge. In this work, a 3-bits beam-steering THz metasurface based on cross-polarization conversion is proposed. The proposed design has the advantages of broadened operating bandwidth, high efficiency, and high stability making it suitable for next-generation communication systems.

The abrupt insulator-to-metal phase transition characteristic of vanadium dioxide (VO_2) provides the switchable capability of VO_2 -based metasurfaces. A VO_2 -based cross-polarization converter is proposed first. In the VO_2 insulating state, it can convert the co-polarized reflection to cross-polarized reflection with a high magnitude. Additionally, by rotating the polarizer by 90° without changing its dimensions, the reflected electric field is rotated in the opposite direction, inherently creating a 180° cross-polarized reflection phase difference between these two kinds of elements. Then, by varying the size of the polarizers, 8 elements with 3-bits phase response and high reflection magnitude are obtained, as shown in Fig.1.

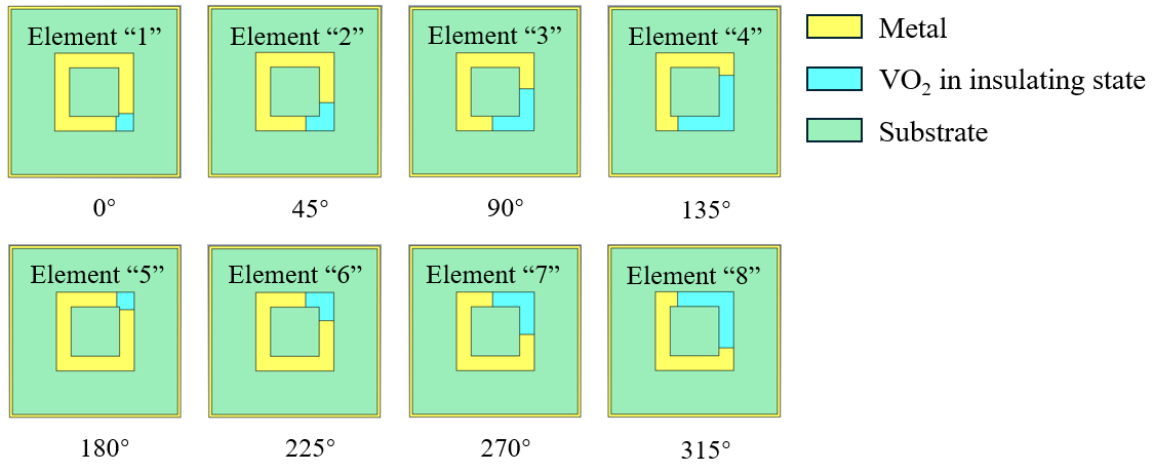


Figure 1. The proposed eight elements have high cross-polarization reflection magnitude and 360° reflection phase coverage at 0.46 THz.

Metasurfaces composed of the proposed 8 elements under normal incidence with electrically switchable beam steering of 30° , 45° , and 60° at 0.46 THz are designed to verify the design concept. When the VO_2 transits to the metal state with increased temperature, the incident wave will be totally reflected in co-polarization without beam steering. In addition, the achieved phase differences of the elements are stable, and the cross-polarized reflection magnitudes remain high within a relatively wide frequency range. Therefore, the beam-steering characteristic can be achieved in a wide band instead of only one frequency point.

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