Single Antenna Beam Scanning via Reconfigurable Vanadium Dioxide (VO_2) Metasurface

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Beam scanning has a multitude of uses including target tracking, radar, imaging, and more. A typical approach in microwave frequencies consists of individually changing the phase of each element of an antenna array. However, scanning via a single slot radiator is possible and has been previously achieved using a 5×5 metasurface with conductive square rings (T. Hongnara et al., IEEE Access, 6, 9420-9429). By moving the relative positions of the slot and the metasurface, the rings are sequentially excited and effectively act as an antenna array. Compared to electrical reconfiguration, this approach does not require a complex feeding structure to introduce varying phase shifts to individual elements. Mechanical reconfiguration reduces the device footprint and chance of electrical failure in the feeding structure. However, mechanical movement is required. Approaches to achieve mechanical movement may reintroduce complexity and less reliability back into the system as well as increasing the footprint.

To reduce complexity, we propose to achieve beam scanning of 30° in both the E- and H-planes using a single slot radiator covered by a 9×9 metasurface with vanadium dioxide (VO_2) square ring patterns. VO_2 is a phase-change material that acts as a dielectric and conductor below and above 68°C, respectively. Effective movement of the slot radiator and metasurface can be achieved by enlarging the metasurface and heating a select group of elements. Electro-thermal actuation eliminates the need for the complex feeding structures and mechanical movement in the cases of electrical and mechanical reconfiguration, respectively. The only requirement is a method to control the temperature distribution of individual metasurface elements. The result is a smaller system footprint and increased reliability. This approach also lends itself well to an array extension if higher gain is desired. The metasurface can simply be enlarged while multiple slots are placed underneath. Design, simulation, and preliminary fabrication and test results will be presented at the meeting.