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550 GHz Scanning Lens Phased Array

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***Abstract*—In this contribution, we present the progress towards developing two submillimeter-wave prototypes of a scanning lens phased array. This recently-proposed array architecture can achieve high-gain, wide-scan radiation patterns with low sidelobes and only a few active elements. Measurements are presented for a prototype lens antenna at 550 GHz.**

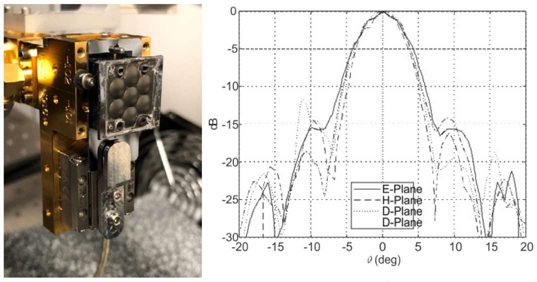
I. INTRODUCTION

FUTURE planetary missions to Mars or Venus require submillimeter-wave heterodyne instruments capable of limb-sounding measurements of atmospheric temperature and gas composition. Current systems at these frequencies scan the field of view mainly using bulky mechanical quasi-optical systems. However, the total volume, mass and power required for this mechanical scanning is impractical for future planetary missions.

Recently, we have proposed [1] a high-gain (>30 dB) antenna array concept which consists of sparse, phase-shifted lenses capable of wide-angle scanning using a low-power piezo-electric motor. The proposed array of silicon lenses can be translated linearly from its central position (i.e. the array factor is steered) and each lens is progressively phased (i.e. the element pattern is steered), resulting in beam steering of the array pattern. The mechanical complexity of the proposed array architecture is low because the required displacement of the lens array is small (in the order of a few millimeters) when compared to a free-standing lens array. Thus, a piezo-electric motor can cover the required lens array displacement [2]. The grating lobes that arise from the array's sparsity are attenuated by the high directivity of the individual lens' element pattern, similar to limited-scan arrays. However, in contrast to limited-scan array antennas, large steering angles can be achieved with this architecture because the element patterns are steered along with the array factor.

The proposed scanning lens phased array must consist of high aperture efficiency lens elements in order to attenuate the sparse array's grating lobes. To achieve this, each lens is fed by a waveguide that excites a pair of nearly-degenerate TM/TE leaky-wave modes in a resonant air cavity [3]. To further improve the lens' aperture efficiency, we propose placing a quarter-wavelength artificial dielectric slab ($\varepsilon_r = 2.5$) between the air cavity and the silicon lens [1].

In this contribution, we present the progress towards the development of two prototypes at 550 GHz. Both array prototypes consist of seven silicon lens elements with a diameter of 5.12 mm ($9.2\lambda_0$) with a quarter-wavelength Parylene AR coating. In the first prototype (Fig. 1a), only the central lens is fed to measure the embedded element. The second prototype is a transmit array, which consists of two lens arrays facing each other, that will show the steering capabilities of the antenna array without the complex integration with active electronics at high frequencies.



(a) (b)

Fig. 1. (a) Photograph of the first prototype and (b) measured radiation patterns of the first prototype at 550 GHz.

The measured radiation patterns of the first prototype (Fig. 1b), show good agreement with the simulated radiation patterns. The scan loss is shown, at various frequencies, in Fig. 2. The scan loss is calculated by measuring the peak power value for each scan angle, and is in good agreement with the simulated scan performance shown in black. Small discrepancies are attributed to power fluctuations, limitations of the measurement setup and increased reflection loss due to the imperfect AR coating. The transmit array prototype is still under development. Overall, the experimental results so far follow the expected performance from simulations, which demonstrates the operability and performance of the proposed antenna architecture.

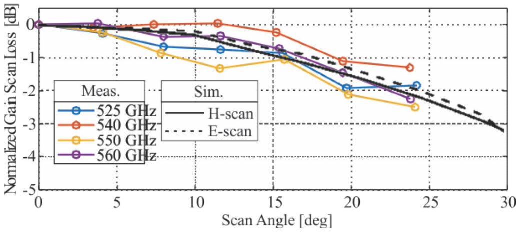


Fig. 2. Measured scan loss of the prototype in Fig. 1a.

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