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Fly's Eye Lens Phased Array for Submillimeter-Wave Space Instruments

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Next planetary missions to Mars or Venus require the development of submillimeter-wave heterodyne instruments to enable limb-sounding measurements that characterize the temperature and composition of gases of their atmosphere. At these frequencies, the main approach to perform such a large field of view is by using bulky mechanical scanners on the quasi-optical system. But the amount of volume, mass and power required for this mechanical scanning is impractical for most of these planetary missions.

In this contribution, we present a sparse phased array based on a fly's eye lens antenna that performs wide angle beam scanning using a piezo-electric motor. An array of silicon lenses is linearly translated from its central position of the antenna creating the steering of the main beam. The required displacement of the lens with this approach is significantly reduced compared to free standing lenses; for subwavelength applications, the maximum translation can be in the order of a few millimeters, which can still be covered by a piezo electric motor. This architecture combines a low mechanical complexity and a greatly reduced number of active elements compared to a fully sampled array. The grating lobes on the sparse array are attenuated by using a very directive element pattern (a lens antenna of a low f-number), an approach similar to limited-scan arrays. However, on the contrary of limited-scan arrays, this architecture can reach large steering angles thanks to the steering of the element pattern and the array factor.

In this work, we have studied the scanning properties of the leaky wave feed and its integration with a piezo-electric motor at 550 GHz in [1]. Furthermore, we have improved the leaky wave feed by removing the iris and adding a dielectric layer in-between the lens and the air cavity to improve the aperture efficiency and the bandwidth [2]

compared to [1]. Simulated results of the array show aperture efficiencies greater than 80% for a bandwidth of 20%. Scanning angles of ± 20 degrees can be achieved with a gain loss lower than 1.5dB.

We are currently developing an array prototype of 36.7dB gain and a scanning range of ± 20 degrees at 550GHz, shown in Figure 1. The fly's eye lens array is fabricated using laser micromachining and is coated with Parylene to minimize the internal reflections of the silicon lenses. The rest of silicon wafers that define the leaky-wave feed and support the lens are processed using the DRIE process developed in [3]. The silicon wafers are sustained on a metal block fixture that integrates the piezo-electric actuator and can integrate the receiver front-end. The piezo-electric actuator is a commercial miniature translation stage based on piezoelectric inertia that is able to achieve a travel range of 12 mm with a 1 nm sensor resolution at 10 mm/s. The details on the design, fabrication and integration of the proposed fly's eye lens antenna array will be presented in the conference.

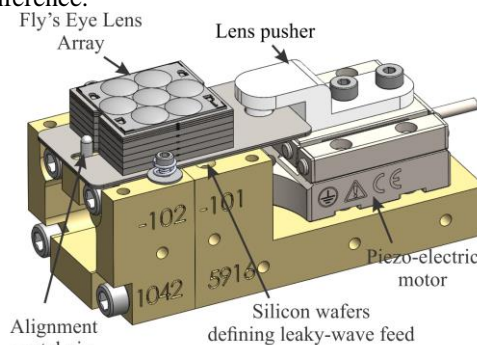


Fig. 1. Sketch of the fly's eye lens phased array prototype at 550 GHz with integrated piezo electric motor. The aperture diameter of each element is around 5.13mm.

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