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Fully 3D Printed Deployable Kirigami-Inspired Reflectarray Antenna for 5G+ and mm-Wave Space Applications

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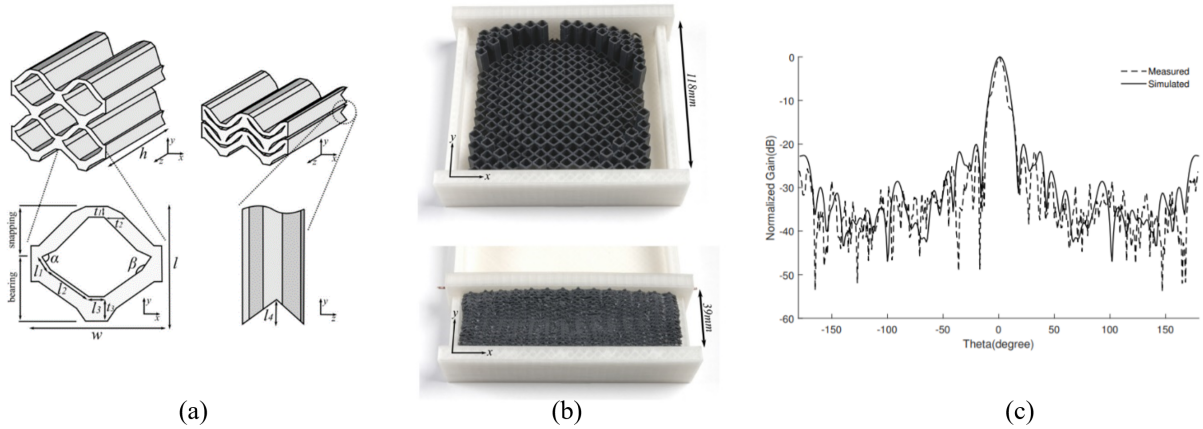
Reflectarray antennas are among the most attractive options for satellite communication systems because they combine the advantages of both parabolic reflectors and phased array antennas featuring planar profile, relatively low-cost, and ease of fabrication. At mm-wave frequencies, conductor losses caused by the metallic phase-shifting elements is one of the performance-limiting factors for reflectarray antennas. To solve this challenge, dielectric reflectarrays with non-metallic phase shifters can be utilized to eliminate conductor losses [1]. However, most of the phase-shifting structures within dielectric reflectarrays are solid and fabricated with rigid materials, preventing them from being able to transform to a deployable design. The lack of deployability and retractability often limits the potential of dielectric reflectarrays being used in future 5G+ and 6G Satcom systems.

In this extended abstract, a deployable dielectric reflectarray is presented with high gain, wide bandwidth, and a novel "kirigami" inspired unit cell structure [2]. The unit cell (Figure 1a) consists of a snapping segment and a bearing segment, where the unique shape of the unit cell structure allows the snapping segment to seamlessly "snap" onto the bearing segment. The phase of the reflected wave can be controlled by changing the height h of the unit cell. The utilized material for an additively manufactured proof-of-concept prototype was Formlabs FLGR02 photopolymer with dielectric constant of 2.82 and loss tangent of 0.0287 at 29GHz. A full 360° phase shift can be obtained by varying the element height h from 9.83mm to 31.10mm. In this work, a 117mm × 118mm array with 14 × 16 element shown in Figure 1b was designed and fabricated. The realized array has a measured gain of 25.5dBi at 29GHz, 1dB bandwidth of 16.34%, 10.5° half power beamwidth (HWBW), and side lobe level (SLL) of -20.54dB (Figure 1c). The fabricated prototype shows 65% volume reduction when retracted.

This work demonstrated the first-of-its-kind deployable dielectric reflectarray antenna inspired by kirigami structures and mechanical metamaterials. The design realized excellent RF and mechanical performance, while featuring a great potential to be used in mm-wave Satcom communication systems.



(a) (b) (c)

Figure 1. Deployable kirigami inspired reflectarray: (a) Unit cell design; (b) Fabricated prototype (deployed and retracted); (c) Simulated and measured radiation pattern [2].

References

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