All 3-D Printed Dielectric Lens Dual-beam Horn Antenna Based on Phase Control

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A novel concept of combining dielectric lens horn antenna with 3-D printing techniques to achieve excellent performance and symmetrical dual-beam radiation is presented in this study. The proposed dual-beam antenna provides an easy method of transforming the radiation pattern from a single-beam to a dual-beam in a typical circular horn antenna by just inserting the proposed dielectric-engineered lens. Fig. 1 shows the geometry structure of the typical air-filled circular horn antenna with and without a dielectric lens being inserted. The well-designed lens structure with the theories of phase control [1] and wave reflection [2] achieves beam separation by precisely controlling the cancellation of the electromagnetic waves and only takes up the internal space of the basic circular horn. Fig. 2 gives the simulated result of the proposed dual-beam antenna. It shows two clear and pure symmetrical beams existing from 23.7 to 24.4 GHz. At the design frequency of 24 GHz, the front-to-back ratio (FTBR) is $22.8\ dB$; the sidelobe level (SLL) is better than $21\ dB$ in the E-plane and $29\ dB$ in the H-plane. The maximum gain is $13.8\ dB$ at the directions of $\theta = \pm 26°$. For the fabrication process, two different commercial 3-D printing UV resins with relative permittivity of 2.75 and 2.92 at 24 GHz are utilized in this design. All the antenna and dielectric lenses are manufactured using additive manufacturing (AM) technology in hours-time at low cost. The proposed method makes the typical circular horn antenna a good candidate for performing dual-beam radiation and shows good prospects for smaller sizes and simpler feeding systems in dual-beam antenna applications.

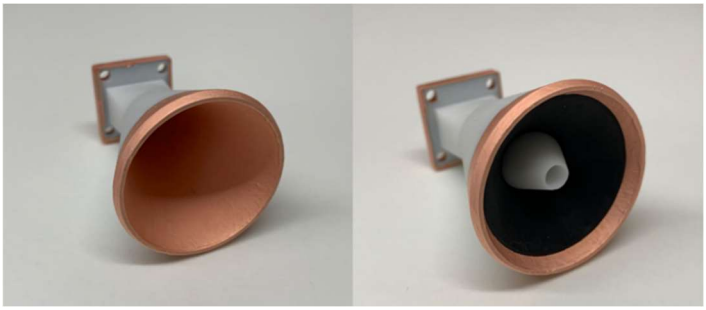

Fig. 1: The SLA-printed prototypes after surface metallization.

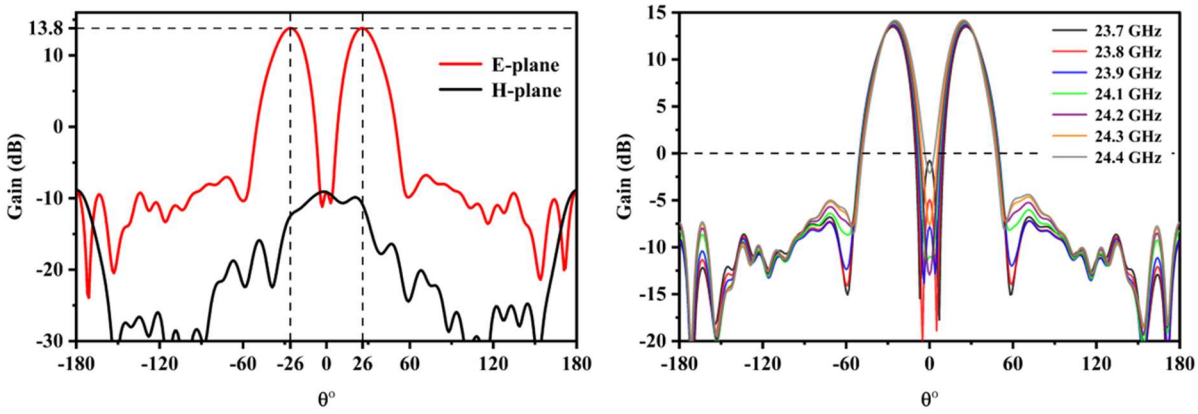

Fig. 2: (a) The simulated radiation pattern of the proposed dual-beam antenna at 24 GHz. (b) E-plane patterns from 23.7 to 24.4 GHz.

[1] S. Huang, K. Y. Chan and R. Ramer, "All 3-D printed antennas based on phase velocity control for beam steering and size reduction with low cost," *IEEE Trans. Antennas Propag.*, vol. 70, no. 3, pp. 1776-1786, Mar. 2022.

[2] R. Reese *et al.*, "A Millimeter-Wave Beam-Steering Lens Antenna With Reconfigurable Aperture Using Liquid Crystal," *IEEE Trans. Antennas Propag.*, vol. 67, no. 8, pp. 5313-5324, Aug. 2019.