Liquid Metal Patch Arrays with Integrated Feeding Network and 3D Transitions

Vivek Bharambe*[(1)], Dishit P. Parekh[(2)], Collin Ladd[(2)], Michael D. Dickey[(2)] and Jacob J. Adams[(1)]
(1) Department of Electrical and Computer Engineering, North Carolina State University, Raleigh, NC 27695.
(2) Department of Chemical and Biomolecular Engineering, North Carolina State University, Raleigh, NC 27695.

Additive manufacturing (AM) techniques enable the construction of a wide variety of customized geometries – including those that would be impossible using conventional methods. In recent years, AM techniques have been employed to prototype numerous RF devices (waveguides, planar transmission lines, antennas, etc.). A more recent focus of AM research is the development of antenna arrays, in which the antenna elements and feed network can both be fabricated in a single step, thus leveraging the design freedom of a 3D fabrication technique.

In this work, we present an approach to fabricate a C band microstrip patch array and feed network in a single monolithic structure. Our approach uses a vacuum-filling technique to infuse cavities within a 3D printed acrylic mold with gallium-based liquid metal. The embedded hollow cavities constitute four rectangular patch elements arranged in a 2x2 configuration and an integrated coaxial feeding network with 3D transitions. Simulation and measurement indicated reflection coefficients < -25 dB and a gain of 4 -5 dBi for this structure.

By eliminating the need to manually assemble the separate array elements and feeding network, this procedure can be employed to construct an entire array geometry embedded within a single monolithic acrylic structure in a hands free, mask-less manner. While the procedure is not readily adaptable for large scale production, it serves as a convenient approach for rapid prototyping of array designs that exploit the available spatial freedom to enhance their electromagnetic performance. Furthermore, it can enable the fabrication of antenna array designs capable of manipulating their internal liquid-phase conductor geometries, potentially producing reconfigurable frequency response or radiation patterns.