3D Printable Multilayer Phased Array Design

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To achieve high gain and electronic beam steering, phased array systems are commonly used. The phased array technique plays an important role in sensing and communication systems. Practical phased array system usually consists of many components including RF power feeding networks, antennas, and active parts such as phase shifters and amplifiers. Single-layer implementation of phased arrays usually leads to large system size and limited applicability as the functionality becomes more complex. Multilayer structure is useful to make the system compact. In addition, it increases the flexibility to add more functions by increasing the total structure thickness without increasing the footprint size. However, it is more challenging to design and fabricate multilayer phased array. The vertical transitions between layers require careful design to have low loss and conventional fabrication technique may not be cost effective. Additive manufacturing (AM), which enables 3D objects of arbitrary shape to be printed automatically layer by layer, is a potentially promising technique to manufacture multilayer phased array that has reduced size and cost but still possesses good electromagnetic performance.

In this work, a 3D printable multilayer phased array system that fully utilizes 3D space is proposed. The phased array (operating at 3.5 GHz) is designed as shown in Fig. 1. It consists of three layers. The bottom layer is a 1 to 4 Wilkinson divider. The center layer is for four voltage controlled phase shifters and the top layer consists of four patch antennas. The substrate of each layer is made of printable polymer that has dielectric constant of 2.7 and loss tangent 0.005. The layer to layer vertical interconnections (coax to microstrip and microstrip to CPW vertical transitions) are designed to ensure good transmission between layers. Good impedance matching around 3.5 GHz is obtained from the simulated results. The radiation pattern with four channels equally phased has been simulated and the results show a high directive beam in broadside as expected. This multilayer phased array structure will finally be fabricated by integrating ultrasonic wire mesh embedding (for metal), fused deposition modeling technique (for dielectric), and laser welding approach (for phase shifters). The beam steering capability of this array will be also tested.

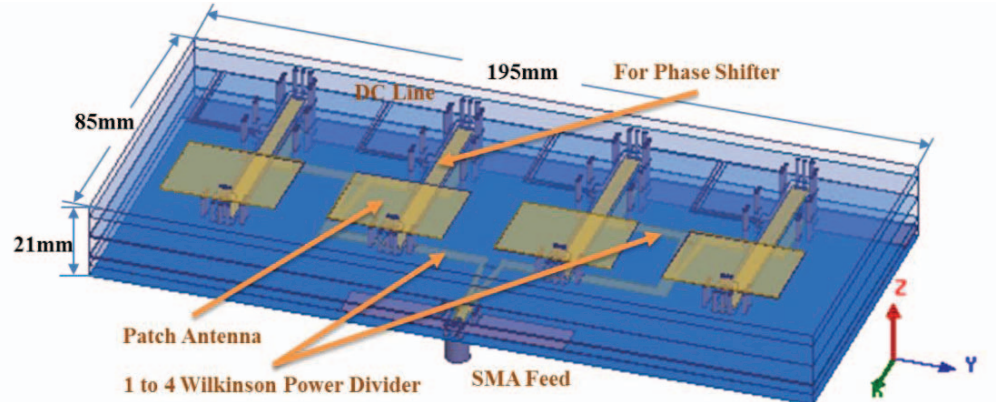

Fig. 1. 3D printable three-layer phased array system design.