Multifunctional Graded Dielectrics Fabricated Using Dry Powder Printing

Austin J Good[(1)], David Roper[(2)], Brandon Good[(2)], Shridhar Yarlagadda[(3)], and Mark S Mirotznik[(1)]
(1) Electrical Engineering, University of Delaware, Newark, DE, 19716
(2) NSWC Carderock Division, Bethesda, MD, 20817
(3) Center for Composite Materials, University of Delaware, Newark, DE, 19716

The ability to fabricate multifunctional devices that combine good structural properties with embedded electromagnetic functionality has many practical applications, including antireflective surfaces for structural radomes, load bearing conformal antennas, integrated RF transmission lines, and passive beam forming networks. We describe here a custom made 3D printer that can print high dielectric constant ceramic powders within a low-loss structural composite substrate to produce mechanically robust parts with integrated graded dielectric properties. We fabricated a number of these parts and evaluated their anisotropic dielectric properties by determining the complete permittivity tensor of the printed samples as a function of local powder weight. This data was then experimentally validated using two practical examples: a Chebyshev antireflective stack and a 2D passive beamsteering network. The results of both electromagnetic systems displayed acceptable agreement between the simulated and measured results. This agreement shows that powder printing is a potential approach for fabricating spatially graded dielectric electromagnetic systems.

The fabricated examples listed above have real world applications in the realm of transmission lines and beamforming systems. The Chebyshev antireflective stack can be utilized for impedance matching to minimize reflections. Therefore, return loss can be greatly improved in transmission systems. The fabricated 2D passive beamsteering network is a cheap and practical alternative to active components in beamforming systems. Also, the materials used in this system are nondispersive in the frequency range of 1 to 18 GHz. The nondispersive characteristics of the materials means the fabricated beamforming network has true time delay (TTD). Therefore, this passive beamforming network has a very large bandwidth when compared to active beamforming systems. Both of these experiments demonstrate that dry powder deposition is a viable alternative to active beamforming systems.