Low-Dielectric Constant Materials in Additive Manufacturing for Improved Air Interface Matching in High Frequency Applications
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In this presentation, we address materials development for multifunctional additive manufacturing specifically targeting high-frequency applications. Low relative permittivity, where $\varepsilon_r \leq 2$, and low dielectric loss tangent, composite filaments were formulated as substrate materials for radio frequency (RF) and microwave applications. Typical thermoplastics used in additive manufacturing include acrylonitrile-styrene-butadiene (ABS), polycarbonate (PC), polylactide (PLA), and nylon. These commercially available materials have approximate dielectric constants in the range from 2 – 4, in addition to the wide range of loss tangents. These material properties make impedance matching potentially difficult to achieve when constructing interfaces for structures that are exposed to air, such as antennas, lenses, and radomes, to minimize reflections. In the additive manufacturing design space, there are techniques utilized that can mitigate these concerns, such as space-filling curves, but reducing the volume fill fraction of polymer can also reduce the mechanical robustness of the part. To mitigate these mechanical concerns, hollow glass spheres, a very low dielectric filler, are added to thermoplastic powders. These materials are processed into a composite material and extruded into flexible filaments with a diameter of 1.75 mm for printing in the nScrypt 3Dn-300. According to effective medium approximations, such as Maxwell-Garnett, these composite materials will have dielectric constants that are between 2 and 1.5, while having an extremely low loss tangent at K-band and above. Combining both strategies of having a low-dielectric, printable filament and space-filling curves will result in devices that have the following attributes 1) improved impedance matching to air, or similar low-dielectric interfaces (i.e., foams), 2) improved mechanical properties, and 3) relative low costs of fabrication. Materials and characterization, such as high-frequency measurements, electron microscopy, rheology, and thermal data are to be presented. Devices using aforementioned strategies with performance data are also to be included.