MATERIALS CHARACTERIZATION AND CONFORMAL ANTENNAS FOR 3D PRINTED ANTENNA APPLICATIONS

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The inherent flexibility associated with 3D printing has created demand for both electronics and electromagnetic structures, which leverage potentially complex geometries brought to bear by this layer-by-layer fabrication. In order to design antenna and terahertz structures, the base polymeric materials used by commercial 3D printers must be characterized across the electromagnetic spectrum in printed form. Printing the structures - as opposed to traditional manufacturing – can introduce higher levels of variation in the surface finish and volume porosity. For this reason, a verifiable model that extrapolates the EM characteristics based on print fill factor and other geometric considerations must be created to allow for the next generation of terahertz devices to be designed with anticipated performance across 3D geometries. This work examines five commercially available polymers produced by Stratasys, Ltd. in order to electromagnetically characterize the "as-printed" properties of each material in relation to the "as-printed" polymeric filling factors. The materials: (1) polycarbonate (PC); (2) polycarbonate + acrylonitrile butadiene styrene (PC+ABS); (3) ULTEM 9085; (4) Nylon 12; and (5) an acrylonitrile butadiene styrene electrostatic dissipation material (ABS-ESD7); Additionally, other experimental materials – not currently commercially available were printed and characterized. All materials were examined from 1 GHz to 2 THz using the combination of a microwave vector network analyzer and terahertz time domain spectroscopy. The results were compared to theoretical values predicted through the polymeric filling factors and the Bruggeman model. In order to verify that these prospective material systems could successfully be used to fabricate GHz antenna systems, two conformal cylindrical patch antennas were then modeled and printed using the experimentally determined permittivity and permeability and a Stratasys FDM 400mc 3D printer. These two cylindrical patch antennas were constructed with a polycarbonate base structurally integrated embedded copper mesh or copper foil which acted as both the ground plane and patch surface. The mesh or foil was integrated into the 3D thermoplastic structures with a patent pending process and the resulting antenna demonstrated the largest S11 resonance (-23 dB) with the copper foil based antenna system, and a lower, yet significant resonance (-14 dB) with the copper mesh patch antenna as expected as the foil had no spatial periodicity and better conductive surface finish.