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Fabrication of composite filaments with high dielectric permittivity for fused deposition 3D printing

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Additive manufacturing of complex structures with spatially varying electromagnetic properties can enable new applications in high-technology sectors such as communications and sensors. This work presents the fabrication method as well as microstructural and dielectric characterization of bespoke composite filaments for fused deposition modeling (FDM) 3D printing of microwave devices with a high relative dielectric permittivity of 11 in the GHz frequency range. The filament is composed of 32 vol% of ferroelectric barium titanate (BaTiO3) micro-particles in a polymeric acrylonitrile butadiene styrene (ABS) matrix. An ionic organic ester surfactant was added during formulation to enhance the compatibility between the polymer and the BaTiO3. To promote reproducible and robust printability of the fabricated filament, and to promote plasticity, dibutyl phthalate was additionally used. The combined effect of 1 wt% surfactant and 5 wt% plasticizer resulted in a uniform, many hundreds of meters, continuous filament of commercial quality capable of many hours of uninterrupted 3D printing. We demonstrate the feasibility of using the high dielectric constant filament for 3D printing through the fabrication of a range of optical devices. The approach herein may be used as a guide for the successful fabrication of many types of composite filament with varying functions for a broad range of applications.

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