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Development and Characterization of Ceramic-Filled Composite Filaments and Functional Structures for Fused Deposition Modeling

Authors : B. Khatri, K. Lappe, M. Habedank, T. Müller, C. Megnin, T. Hanemann

Abstract : We present a process flow for the development of ceramic-filled polymer composite filaments compatible with the fused deposition modeling (FDM) 3D printing process. Thermoplastic-ceramic composites were developed using acrylonitrile butadiene styrene (ABS) and 10- and 20 vol.% barium titanate (BaTiO3) powder (corresponding to 39.47- and 58.23 wt.% respectively) and characterized for their flow properties. To make them compatible with the existing FDM process, the composites were extruded into filaments. These composite filaments were subsequently structured into tensile stress specimens using a commercially available FDM 3D printer and characterized for their mechanical properties. Rheometric characterization of the material composites revealed non-Newtonian behavior with the viscosity logarithmically decreasing over increasing shear rates, as well as higher viscosities for samples with higher BaTiO3 filler content for a given shear rate (with the ABS+20vol.% BaTiO3 composite being over 50% more viscous compared to pure ABS at a shear rate of 1x□10□^3 s^(-1)). Mechanical characterization of the tensile stress specimens exhibited increasingly brittle behavior as well as a linearly decreasing ultimate tensile strength of the material composites with increasing volumetric ratio of BaTiO3 (from σ_max=32.4MPa for pure ABS to σ_max=21.3MPa for ABS+20vol.% BaTiO3). Further studies being undertaken include the development of composites with higher filler concentrations, sintering of the printed composites to yield pure dielectric structures and the determination of the dielectric characteristics of the composites.

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