Thermoplastic 3D Printing: The Effect of Particle Interactions and Infill Strategies on the Properties of Zirconia Parts

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Thermoplastic 3D printing (T3DP) is a material-jetting additive manufacturing method that uses wax-based feedstocks with high ceramic solid loading. T3DP deposits micron-sized droplets, which fuse and solidify to create lines and layers. The present study was designed to understand and control the workflow of T3DP, i.e., from tailoring the colloidal particle interactions in thermoplastic ceramic wax-based slurries, to droplet jetting dynamics through which parts can be fabricated using various infill strategies of feedstock deposition.

In the first part of the study, we investigated non-Newtonian slurries with 40 vol% of zirconia (3Y-TZP), with different levels of weak flocculation, provided by varying ratios of surfactants with different chain lengths, i.e., stearic acid (2.4 nm) and Solsperse 3000® (10 nm). The effect of particle interactions on the rheological properties such as viscosity, yield stress, and storage/loss moduli were examined. It was shown viscoelastic properties of the feedstock greatly affect the jetting dynamics, dimensions and shape of deposited droplets as well as homogeneity and surface roughness of the deposited layers.

In the second part, we studied the effect of infill strategy, i.e., the direction of deposition of droplets in the printed part, on the homogeneity of formed 3Y-TZP bending bars, the type of flaw populations (between fused droplets and/or lines), which further influenced the final sintered density, flexural strength, and Weibull moduli. It was shown that the strength and Weibull modulus were not as sensitive to the changes in infill strategy as in fused filament fabrication, for example. This study extends the guidelines for the preparation and processing of feedstocks with T3DP.