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Polymer Disentanglement during 3D Printing. CLAIRE MCILROY, PETER D. OLMSTED, Georgetown University, Institute for Soft Matter Synthesis and Metrology — Although 3D printing has the potential to transform manufacturing processes, improving the strength of printed parts to rival that of traditionally-manufactured parts remains an underlying issue. The most common method, fused filament fabrication (FFF), involves melting a thermoplastic, followed by layer-by-layer filament extrusion to fabricate a 3D object. The key to ensuring strength at the weld between layers is successful inter-diffusion and re-entanglement of the melt across the interface. Under typical printing conditions the melt experiences high strain rates within the nozzle, which can significantly stretch and orient the polymers. Consequently, inter-diffusion does not occur from an equilibrium state. The printed layer also cools towards the glass transition, which limits inter-diffusion time. We employ a continuum polymer model (Rolie-Poly) that incorporates flow-induced changes in the entanglement density to predict how an amorphous polymer melt is deformed during FFF. The deformation is dominated by the deposition process, which involves a 90 degree turn and transformation from circular to elliptical geometry. Polymers become highly stretched and aligned with the flow direction, which significantly disentangles the melt via convective constraint release.

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