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Rheology, thermography, and interlayer welding in polymer extrusion 3D printing JONATHAN SEPPALA, CHELSEA DAVIS, KALMAN MIGLER, NIST — In polymer extrusion 3D printing, thermoplastic filament is extruded though a rastering nozzle onto previously deposited layers. The resulting strength of the 3D produced part is limited by the strength of the weld between each layer. During this thermal processing, the temperature of the interface between layers dictates the chain mobility, interdiffusion, entanglement, and thus weld strength. In quiescent welding experiments, it has been found that the weld strength in symmetric linear polymer systems scales with t 0.25, where t is the isothermal annealing time, before plateauing to the bulk strength. However, 3D printing is highly non isothermal and we calculated an equivalent isothermal annealing time using a combination of in situ infrared thermography and horizontal shift factors from offline rheological measurements of the neat polymer. Interlayer adhesion energy was measured directly by mode III fracture using a simplified geometry limiting the measurement to a single interlayer. Since the processing conditions are known a prioi this approach provides the data needed to estimate the final build strength at time of design. The resulting agreement between annealing time and adhesion energy for a range of printing conditions and thermoplastics are discussed.

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