Real-time volumetric micron-scale monitoring for polymer 3D printing using ultrasound

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As new high-strength materials are being introduced as feedstock for fused deposition modeling (FDM) polymer printers, the need for real-time feedback control increases. Flaws between fused layers, such as voids or delamination, can occur early during printing and can be masked by newly deposited layers. Current techniques rely on line-of-sight inspection through cameras, which have a limited region for inspection, a limited resolution, and cannot evaluate beyond the current deposited layer. Lack of part qualification has inhibited the adoption of FDM components into mission critical roles. In situ nondestructive evaluation using ultrasound can enable volumetric assessment of part quality. Ultrasound is sensitive to microscale defects that can occur during the printing process.

Our approach is based on integrating a piezoelectric element directly within the 3D printer nozzle. Bringing the sensing to the location of the deposition enables sensing at all locations directly beneath the nozzle tip as the filament is being deposited. Large-scale part qualification can be achieved, providing a robust means of certification of components. Ultrasonically sensing over the volume can pinpoint regions where defects are, reducing the time needed for post-build part qualification. Close-loop integration between ultrasonic equipment and software will provide the capability to detect defects and correct them either by altering process parameters on the fly or canceling the print, saving on time, material, and energy consumption.