Continuous Analysis within 3D-Printed Structures Using In-Chamber Sensors

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Abstract
We are investigating how to efficiently and accurately measure per-layer chemical composition and build chamber conditions, in situ, for objects manufactured by selective laser sintering (SLS). Our investigation is a first step towards integrating sensors into the powder bed and eventually into parts themselves.

Objective
In-process materials composition sensing for Nylon selective laser sintering (Nylon SLS): To understand whether low-cost sensors provide sufficient accuracy to monitor per-layer build material composition and build chamber properties during the additive manufacturing (AM) process.

The results of the project will make it possible, for the first time, to have a per-object “digital birth certificate” detailing the entire volumetric/per-layer build process and object parameters, for each Nylon SLS AM part produced.

Approach
Monitor build material properties using three complementary sensing modalities: ① 12-band visible/NIR spectrometer in 450 nm–850 nm wavelength range; ② 248-band NIR spectrometer in 900 nm–1700 nm range; ③ Build surface temperature at 64 points.

Monitor build chamber conditions using five sensing modalities: ① temperature, ② humidity, ③ barometric pressure, ④ CO₂, and ⑤ airborne volatile organic compounds.

Planned outcomes
① New methods for using low-cost sensors integrated into AM systems for in-process material characterization and build chamber monitoring.
② Open dataset from materials characterization that captures noise properties of sensors. Potentially useful for machine learning from the data [1].
③ Open platform (hardware and software) that other research groups can use.
④ Concepts for generative documentation and visualization from sensor data.

New research directions which this feasibility study enables
① Monitor powder bed properties (e.g., compaction, flow, temperature distributions) with in-powder sensors. Significant research challenges in energy-efficient signal processing, sensor platform miniaturization, in-situ machine learning on miniature in-powder sensors, and more. Complements existing research on in situ metrology for metal powder bed fusion [3].
② Monitor object properties (e.g., stress concentrations) over lifetime of use, with in-object sensors. Will require fundamental new understanding for in situ sensor signal processing, localization of sensors, and new approaches to extracting in-situ-processed sensor data.

References: