Polyspectral Volumetric Printing – Reshaping the Future of Precision & Multimaterial Manufacturing

Abstract: Volumetric Additive Manufacturing (VAM) is rapidly redefining the limits of speed, complexity, and functionality in 3D printing. In this talk, I will introduce Polyspectral Tomographic Volumetric Printing (PsTVP)-a new paradigm that expands the capabilities of Tomographic Volumetric Printing (TVP) by enabling unprecedented control over both material properties and fabrication fidelity.

PsTVP exploits wavelength-selective photochemistry to initiate multiple, orthogonal polymerization pathways within a single build volume. By simultaneously employing visible and ultraviolet light, distinct curing mechanisms, free radical and cationic polymerization can be independently activated, allowing true three-dimensional control over material composition and mechanical behavior. This approach enables the fabrication of structures with spatially programmed stiffness gradients for functional grading in 3D printed parts.

Beyond functionality, this work addresses a central challenge in volumetric printing: precision. By extending the contrast in delivered energy doses and introducing a binary photoinhibitory system (BPS), PsTVP overcomes the long-standing non-negativity constraint in tomographic reconstruction. Combined with inhibitor-mediated control using chemical agents such as TEMPO, this strategy significantly enhances printing fidelity, enabling accurate voxel-level polymerization, improved feature resolution, and expanded process windows.

The talk will highlight recent advances demonstrating stiffness gradients with sub-millimeter resolution and rapid fabrication of complex geometries within seconds without support structures and with surface qualities surpassing conventional layer-based techniques. These developments illustrate how PsTVP not only accelerates production but also fundamentally redefines what can be manufactured.

By bridging multispectral chemistry, tomographic computation, and materials engineering, PsTVP represents a transformative step toward high-throughput, multimaterial, and functionally graded manufacturing. I will discuss key findings, current limitations, and future research directions, highlighting the steps required to transition PsTVP from laboratory demonstrations to industrial-scale production, with potential impact in fields ranging from biomedical engineering to advanced micro-manufacturing.