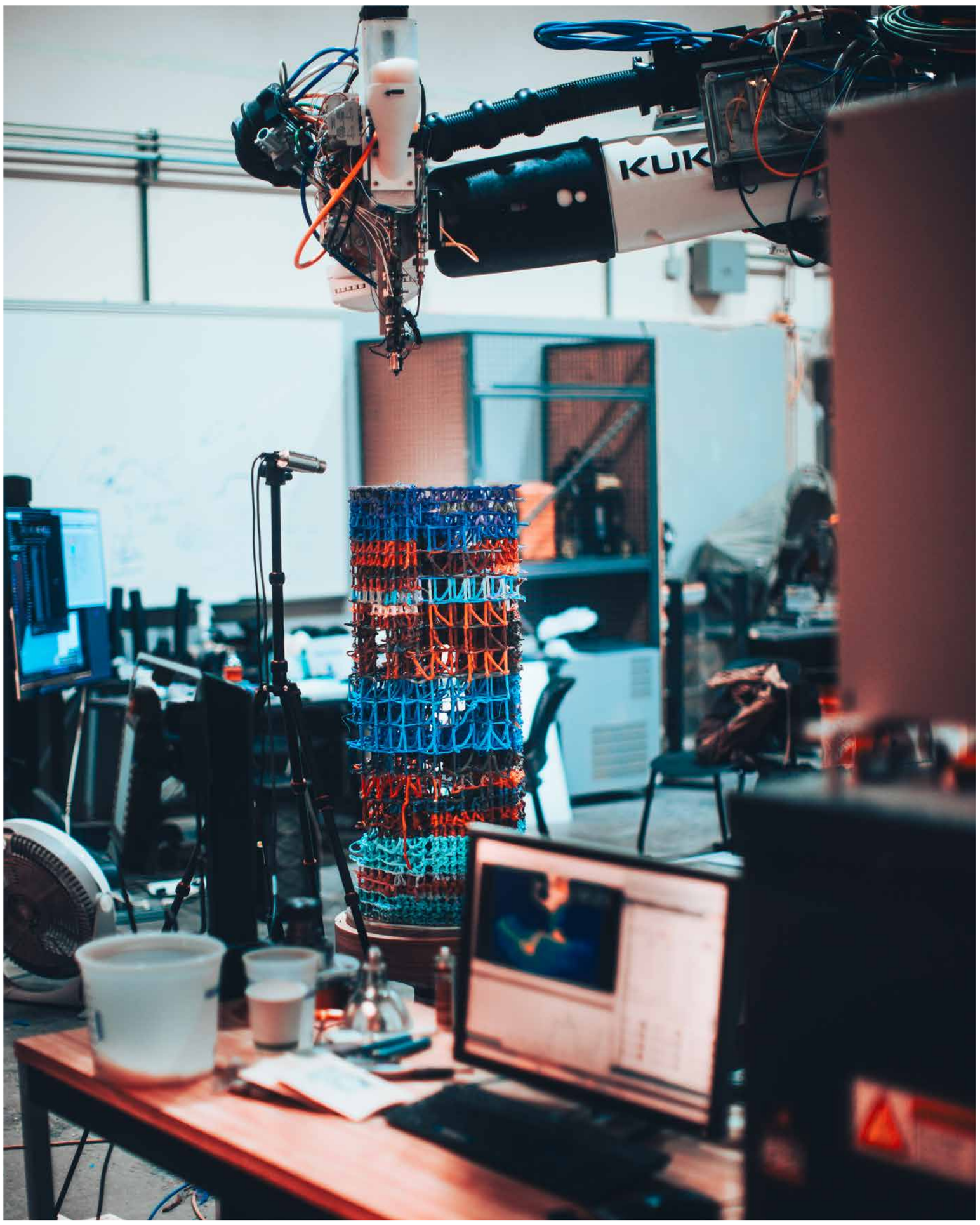

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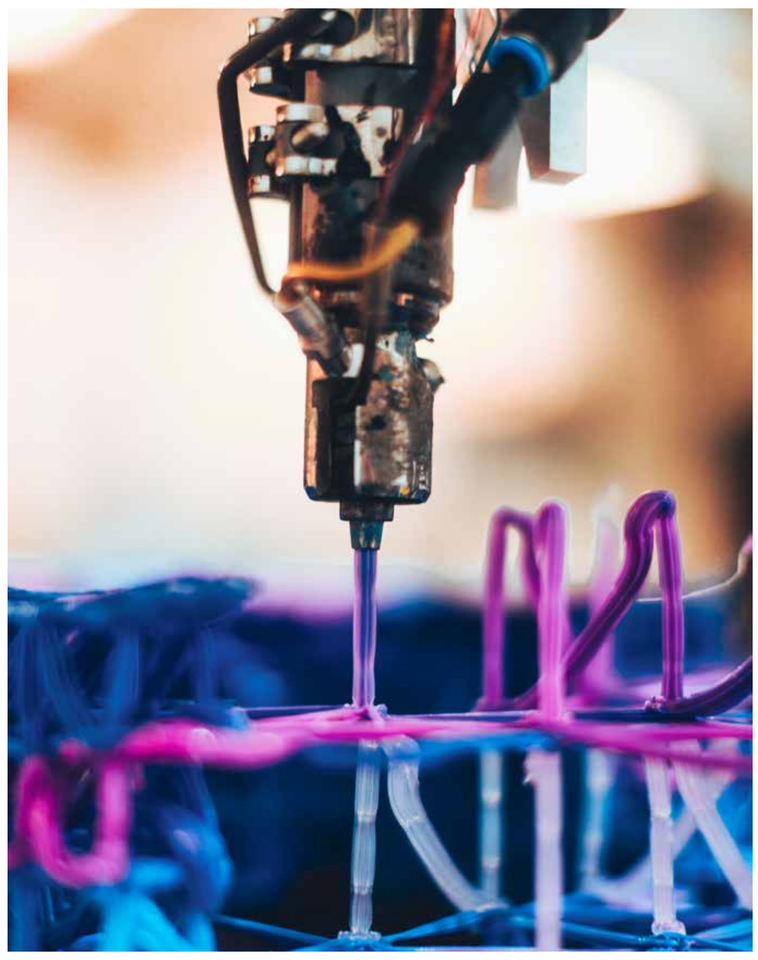

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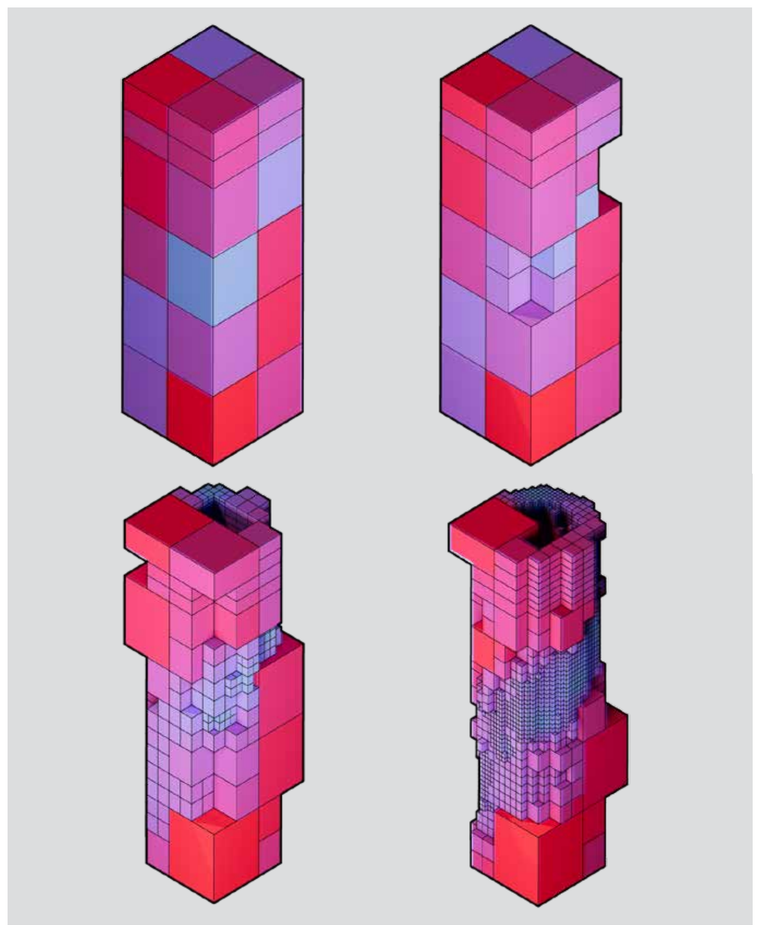

3

FUNCTIONALLY-GRADED DESIGN IN SPATIAL AM

Christopher Voltl
University of Michigan/Dartlab

Additive manufacturing (AM) has introduced unprecedented capabilities for realizing geometrical complexity, enabling large-scale customization and adaptable design strategies. Ongoing advances in AM methodologies have opened new research avenues in architecture and structural engineering, particularly in the analysis, generation, and fabrication of functionally graded cellular materials. Key advantages that functionally graded materials (FGMs) offer are tailored material properties through gradual variation in composition or structure, enabling optimized strength, reduced thermal stresses, and improved bonding between dissimilar materials. Despite clear mechanical benefits, FGMs remain underused at architectural scale, primarily due to (1) the absence of design frameworks that incorporate fabrication constraints, (2) insufficient modeling approaches for optimizing complex three-dimensional structures with numerous design variables, and (3) a lack of experimental protocols for evaluating, calibrating, and validating FGM design and production methods.

1. Robotic work cell for spatial 3D printing with thermal analysis instrumentation (Christopher Voltl, 06/22/2025)
2. Custom 3D printed nozzle with both heated and cooling chambers to control thermoplastic temperature at different points in the process (Christopher Voltl, 06/20/2025)
3. Octree recursive subdivision creating a functionally graded voxelization based on a density field calculation using inverse-distance weighting within a search radius of 10 units at 1,4, 8, and 12 recursions.