

4D+ Printing via Metal Additive Manufacturing

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The flexibility brought about by additive manufacturing (AM) goes beyond the ability to produce components of otherwise excessively complex geometries. One of the most attractive capabilities of AM is its potential to produce parts/components with engineered local properties. 4D Printing, for example, enables the fabrication of complex objects—built generally from shape memory polymers and (reversibly-swelling) hydrogels that transform over time when subject to external stimuli. Similarly, research on Functionally Graded Materials focuses on the spatial tailoring of the properties of the fabricated part by controlling feedstock and/or process conditions. However, 4D Printing has never been achieved in metals and alloys to the best of our knowledge. Moreover, combination of 4D printing and functional grading has not been attempted. Recently, we combined these two state-of-the-art techniques to control the voxel level properties in stimuli-responsive materials, and developed, so-called, 4D+ printing technique. In particular, we exploit the extreme sensitivity of the mechanical and functional response of NiTi shape memory alloys (SMAs) to composition and microstructure—facilitated in turn by local process control in AM—to enable the design of new parts with completely different mechanical responses at different locations, and capable of actuating at different temperatures in a single monolithic structure. In this talk, we introduce 4D+ printing and its application to NiTi SMAs and beyond. We further discuss the application of AM NiTi as a sensory material for exploring microstructure-related variability in metallic AM processes.

Finally, we will discuss simultaneous AM of dissimilar materials and functional grading from one material to another without forming detrimental phases.