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3D-Printed In-Line and Out-of-Plane Layers with Stimuli-Responsive Intelligence

Background

Smart materials and structures with shape memory properties have recently gained attention due to their unique ability to remember their original shape, dimensional flexibility, structural programmability, and multi-material compatibilities. These materials have broad applications in morphing structures, heat storage, flexible electronics, environmental remediation, soft robotics, metamaterials, biomedical platforms, and space missions. Most of these applications require multifunctionality with high precision controls over multi-materials.

Shape memory polymers (SMPs) specifically have unique advantages in that they are lightweight, mechanically robust, thermally manipulable, electrically insulated, chemically stable, biocompatible, and low-cost. However, the shape memory effect of the SMPs relies on the active and passive phases to generate responsive behavior to respective external stimuli. One limitation of current techniques of fabricating SMPs (e.g., copolymerization, manual laminating, or casting of bilayer or trilayer structures) is their difficulty in creating complex shapes of varying chemistry, compositions, dimensions, and topologies, as well as the high cost and long processing times.

Invention Description

Researchers at Arizona State University have developed a novel 3D printing process that uses Multiphase Direct Ink Writing (MDIW) to produce in-line and out-of-plane microlayers. During the manufacturing process, specific sublayers within each printing line for optimized domain size are produced with the stacking of layers along the z-axis to investigate their influences on the stimuli-responsiveness. The mechanical, thermal, and thermomechanical characterizations effectively reveal the time-temperature-dimension relationships in different media (e.g., air and water), showing a precisely controlled actuation phenomenon. This precise characterization and control over stimuli-responsiveness can be used for a broad range of applications.

Potential Applications

- Biomedical platforms (e.g., targeted drug delivery, tissue scaffolding)
- Intelligent devices (e.g., soft robotics)
- Space transportation
- Energy & heat storage

Benefits and Advantages

- High load-bearing capacity
- High shape fixing capability & shape recoverability
- Programmable actuators for broad applications

Related Publication: 3D-Printed In-Line and Out-of-Plane Layers with Stimuli-Responsive Intelligence