Hybrid Direct Ink Writing/Embedded Three-Dimensional Printing of Smart Hinge from Shape Memory Polymer

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Abstract:
Three-dimensional (3D) printing technology has been widely developed and utilized to make smart structures from shape memory polymers (SMPs). Herein, a smart hinge is fabricated via a hybrid direct ink writing (DIW)/embedded 3D printing (e-3DP) method, in which direct ink writing is used to print a self-supporting ink into a complex 3D structure at an uncured state while e-3DP is then applied to deposit a conductive ink within the structure. This hybrid 3D printing method can only be used if the ink material has the required rheological properties to meet both DIW and e-3DP. Herein, a shape memory photocurable resin, aliphatic urethane diacrylate (AUD), and its chain builder, tert-butyl acrylate (*t*BA), are selected as the main components of the SMP and fumed silica (FS) is used to tune the rheology for printing purposes. It is found that the FS ratio affects the rheological properties, mass loss characterization, filament width, and self-supporting capability significantly. A smart hinge with an embedded circuit from carbon conductive grease to act as a strain sensor was successfully printed. The hinge can be programmed and then recover its shape by controlling the temperature of a resistance wire that was woven through the hinge. The embedded strain sensor can monitor the change in resistance as well, validating the effectiveness of the proposed method for creating functional, smart hinges.