Hybrid Extrusion 3D Printing of Self-Deployable Smart Solar Panel Hinges

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Shape memory polymers (SMPs) have been applied in the aerospace, biomedical, and automotive fields to make functional devices because they can recover to their original shapes upon exposure to external stimuli, like temperature. Stereolithography (SLA) is the mainstream technique used to fabricate three-dimensional (3D) functional parts from SMPs, but the build material must be both ultraviolet (UV) curable and have a low viscosity, severely constraining the material selection. Complicated post-treatments are needed to add external devices to the fabricated SMP products. As a result, it is necessary to develop a new 3D printing technology for fabricating devices from diverse SMPs.

The deploying actions of solar panels are commonly executed by conventional hinges that lack the capacity of on-demand controlling the unfolding states. Due to their capability to reversibly transition between two shapes, SMPs have become an ideal material category for making smart solar panel hinges. This project aims to investigate and propose a hybrid direct ink writing (DIW)/embedded 3D printing (e-3DP) technique to fabricate self-detected, self-deployable smart solar panel hinges from an SMP. This newly proposed method perfectly aligns with the mission of NASA Innovative Advanced Concepts, a Space Technology Mission Directorate program.

In this work, a self-supporting composite SMP ink was investigated which can maintain the shape at liquid state after DIW to facilitate e-3DP of strain sensor from conductive ink. Using this new composite SMP ink, a complex hinge structure with an embedded strain sensor was successfully printed via the proposed method to validate the effectiveness of the concept of hybrid material extrusion 3D printing. Finally, the hinge was solidified under UV radiation and a resistance wire was used to control the transition from folded to unfolded states of mock solar panels on a mock space shuttle.