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Additively Manufactured Transmission Design for Mesoscale Mechanisms

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Abstract

The design and fabrication of mesoscale mechanisms, on the order of millimeters to centimeters, is a growing area of research, as it occupies the space between traditional macroscale and microelectromechanical systems (MEMS) fabrication methods. Due to the complexity of construction at this scale, the time required to design, fabricate, and assemble mesoscale mechanisms is a challenge for both prototyping and mass production. For actuation at this scale, piezoelectric bending actuators are commonly used, producing a linear displacement in the 0.1-1 millimeter range. This displacement must be amplified before it can be utilized for large scale motion. Through the use of finite element analysis, a compliant transmission mechanism capable of converting small linear displacement to large rotational motion was designed and optimized. Using a monolithic design and flexible materials, multiple design variations were fabricated simultaneously with additive manufacturing (AM). Experimental testing confirmed the critical design parameters identified in the finite element model. The most significant parameter in the transmission to maximize rotation was identified as the thickness of the transmission flexures, followed by the angle between transmission flexures. With a linear displacement of 450 microns, transmission flexures with a thickness of 200 microns resulted in a rotation of +29/-25 degrees, while thicknesses of 300 and 400 microns resulted in rotations of +31/-24 degrees and +22/-28 degrees, respectively. A comparison of the experimental results with the finite element model indicated that the trends and critical parameters from the finite element model are valid for the transmission design.