Origami assembly of three dimensional metallic structures and their applications

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Abstract

Origami assembly is a topic of growing interest both in the scientific and engineering communities due to the potential applications in a broad range of areas. Recently reported approaches that exploit the controlled, compressive buckling of 2D precursors induced by dimensional change in an underlying elastomer support offer broad versatility in material selection (from polymers to device grade semiconductors), feature sizes (from centimeters to nanometers), topological forms (open frameworks to closed form polyhedra) and shape controllability (dynamic tuning of shape), thereby establishing a promising avenue to autonomic assembly of complex 3D systems. A spatially non-uniform distribution of thickness in the 2D precursors is required in these approaches to induce strain localization at desired folding creases, which, however, complicates the fabrication process and reduces the yield to certain extent. In this paper, an approach to origami assembly of 3D metallic structures with uniform thickness is reported. A set of concepts relying on the use of plasticity and strain localization to achieve reduced bending stiffness at creases are presented through combined experimental measurement and mechanics modeling, for 3D structures formed through either unidirectional or bidirectional folding. Systematic studies of various metallic film structures and the contrastive polymer film structures illustrate the important role of plasticity. Moreover, we demonstrate that the plastic effect can be well leveraged to control the level of residual deformations at the creases, thereby with the capability to construct isolated 3D metallic structures after separation from the elastomer substrate. Finally, we will exploit their functions in sensors and filter capacitors.

Keywords: Buckling; Origami assembly; 3D metallic structures; Plasticity; Isolation