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Targeting Fold Stiffness to Design Enhanced Origami Structures

PHILIP BUSKOHL, GIORGIO BAZZAN, ANDREW ABBOTT, MICHAEL DURSTOCK, RICHARD VAIA, Materials & Manufacturing Directorate, Air Force Research Labs, Wright-Patterson AFB, OH — Structures with adaptive geometry are increasingly of interest for actuation, sensing and packaging applications. Origami structures, by definition, can "shape-shift" between multiple geometric configurations that are predefined by a pattern of folds. Plastic deformation and local failure at the fold lines transform an originally homogenous material into a grid with locally tailored mechanical properties that bias the response of the overall structure to external loading. Typically, origami structures focus on uniformly stiff fold lines with rigid facets. In this study, we discuss how localized variations in stiffness can influence global properties, including energy budget to transition from flat to folded structure, the preferred path through configuration space, and the final mechanical response of the folded architecture. A simple, bi-stable origami fold pattern is laser machined into polypropylene sheets of different compliance and the critical load of the transition is measured. We model the structure as a truss with bar elongation, folding, and facet bending in order to predict ways to enhance or mitigate the critical load. Targeting local folding properties to modify global performance directly extends to the analysis of more complex architectures.

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