Bistable Architected Elastomer Beam Unit: Design & Liquid Crystal Elastomer Re-Programming

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Link for virtual participants

Snap-through buckling instabilities are a key driver of multistability in many architected elastomers, which can find applications in fields like energy absorption, vibration isolation, and energy storage. Our research seeks to tune these behaviors by focusing on the unit cell design, taken as a 2D tilted, constrained elastomeric beam. We propose a Fourier series-based beam design parameterization, which covers a large portion of all possible beam designs with a very small number of design variables. This facilitates highly efficient Bayesian optimization, which can be used to tune unit cell energetics and kinematics in few iterations. Moreover, liquid crystal elastomer (LCE) enables a re-programmable stiffness field, which is governed by the applied strain during UV-induced re-programming of mesogen alignment. Therefore a number of mechanical behaviors can be potentially achieved in a single design without requiring alterations of the geometry. By exploring the relationship between applied strain at re-programming and subsequent behavior change, we begin to understand how material properties can be leveraged to modulate mechanical behavior, e.g., buckling mode & post-buckled shape.

David Yoo is a mechanical engineer who often uses computational simulation for engineering analysis. He did his doctorate study in University of Connecticut at Storrs, and his thesis topic was simulation-based design optimization under uncertainty. He did his post-doctorate study at the Air Force Research Lab in Dayton, Ohio, where he did research on designing metamaterials. One of his main research was designing liquid crystal elastomer with programmable stiffness to tune the mechanical behavior. He is currently senior mechanical engineer at Huntington Ingalls Industries in Newport News, Virginia, and his main works have been doing fatigue and shock analyses on aircraft carriers.

Nathan Hertlein began his career as a product development engineer for Fiat Chrysler Automobiles, where he helped release occupant restraint systems for the Jeep Wrangler and Wrangler PHEV programs. There he acted as a connection between Tier 1 suppliers and various teams within the OEM, while ensuring proper prototyping, design validation, and design for assembly activities. He is currently a PhD candidate in mechanical engineering at the University of Cincinnati's Center for Global Design and Manufacturing, where his research focuses on the optimal adoption of additive manufacturing for applications including architected elastomers. Partly resulting from his close collaboration with the Air Force Research Laboratory (AFRL)'s Materials and Manufacturing Directorate, his work using a variety of machine learning techniques has resulted in 7 refereed conference and journal publications to date. He is about to begin a National Research Council post-doctoral fellowship with AFRL in the area of ML-based architected elastomer design.

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