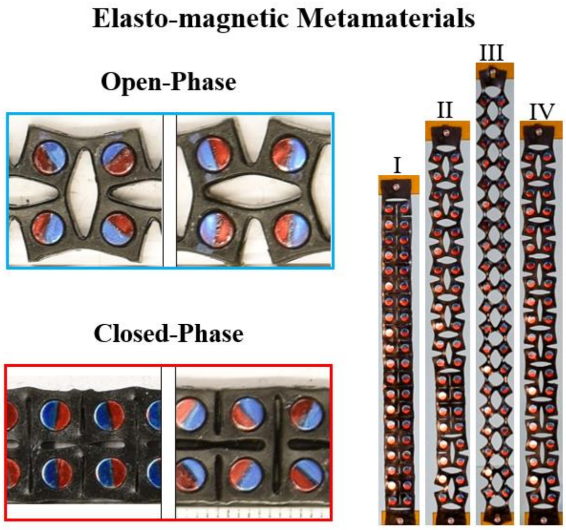
# Phase transforming metamaterial with magnetic interactions

Xudong Liang[a,*], Alfred J. Crosby[b]
[a] School of Science, Harbin Institute of Technology, Shenzhen
[b] Polymer Science and Engineering Department, University of Massachusetts Amherst
Email: liangxudong@hit.edu.cn

Solid-solid phase transformations can affect energy transduction and change material properties. e.g., superelasticity in shape memory alloys and soft elasticity in liquid crystal elastomers. Traditionally, phase transforming materials are based on atomic or molecular level thermodynamic and kinetic mechanisms. Here, we develop elasto-magnetic metamaterials that display phase transformation behaviors due to nonlinear interactions between internal elastic structures and embedded, macroscale magnetic domains. These phase transitions, similar to those in shape memory alloys and liquid crystal elastomers, have beneficial changes in strain state and mechanical properties that can drive actuations and manage overall energy transduction. The constitutive response of the elasto-magnetic metamaterial changes as the phase transitions occur, resulting in a nonmonotonic stress-strain relation that can be harnessed to enhance or mitigate energy storage and release under high-strain-rate events, such as impulsive recoil and impact. Using a Landau free energy-based predictive model, we develop a quantitative phase map that relates the geometry and magnetic interactions to the phase transformation. Our work demonstrates how controllable phase transitions in metamaterials offer new performance capabilities in energy management and programmable material properties for high-rate applications.




**Reference:**
[1] **X. Liang**, H. Fu, A. J. Crosby, Phase Transforming Metamaterial with Magnetic Interactions, *Proc. Natl. Acad. Sci. U.S.A.* **2022**, 119, e2118161119.

**Funding:**
1. National Natural Science Foundation of China (12202120, 12322207)。
2. U. S. Army Research Office, W911NF-15-1-0358.