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## Experimental and theoretical investigation of magnetorheological elastomers with layered mesostructures

Cao, Changyong, [changyongcao@gmail.com](mailto:changyongcao@gmail.com), Duke University; Lin, Shaoting; Zhao, Xuanhe, MIT, United States

### ABSTRACT

Magnetorheological elastomer (MRE) is a type of smart material which can vary its shear modulus rapidly, continuously and reversibly, by the external magnetic field. MRE has attracted increasing attention and been widely used in various applications. Generally it has been created by dispersing magnetic filler particles in polymer matrices. Most current studies are focusing on the microstructures of MRE such as the alignments of iron-filler particles and their effects on tunable moduli. However, the mesoscale structures of MREs have been rarely investigated by now. In this study, we present a theory on the design of mesostructures of MRE composites consisting of two phases of materials with different permeability. We show that the deformation of elastomers can reorient their mesostructures, which consequently results in variations of their effective permeability. Such variations change the magnetostatic potential energies of the elastomers under applied fields, leading to stiffening, softening, or instabilities. We further fabricate composite MREs by embedding metal-sheets into PDMS matrix to test the feasibility of the concept for MRE. Experimental results show that giant tunable stiffness of MREs can be achieved by carefully designing and optimizing their anisotropic mesostructures. The effect of metal-sheets at mesoscale and carbonyl iron particles at microscale can be superimposed together to increase the MR effect of the composite even if the microsized particles are uniformly distributed.