

Supplementary Information

A unified understanding of magnetorheological elastomers for rapid and extreme stiffness tuning

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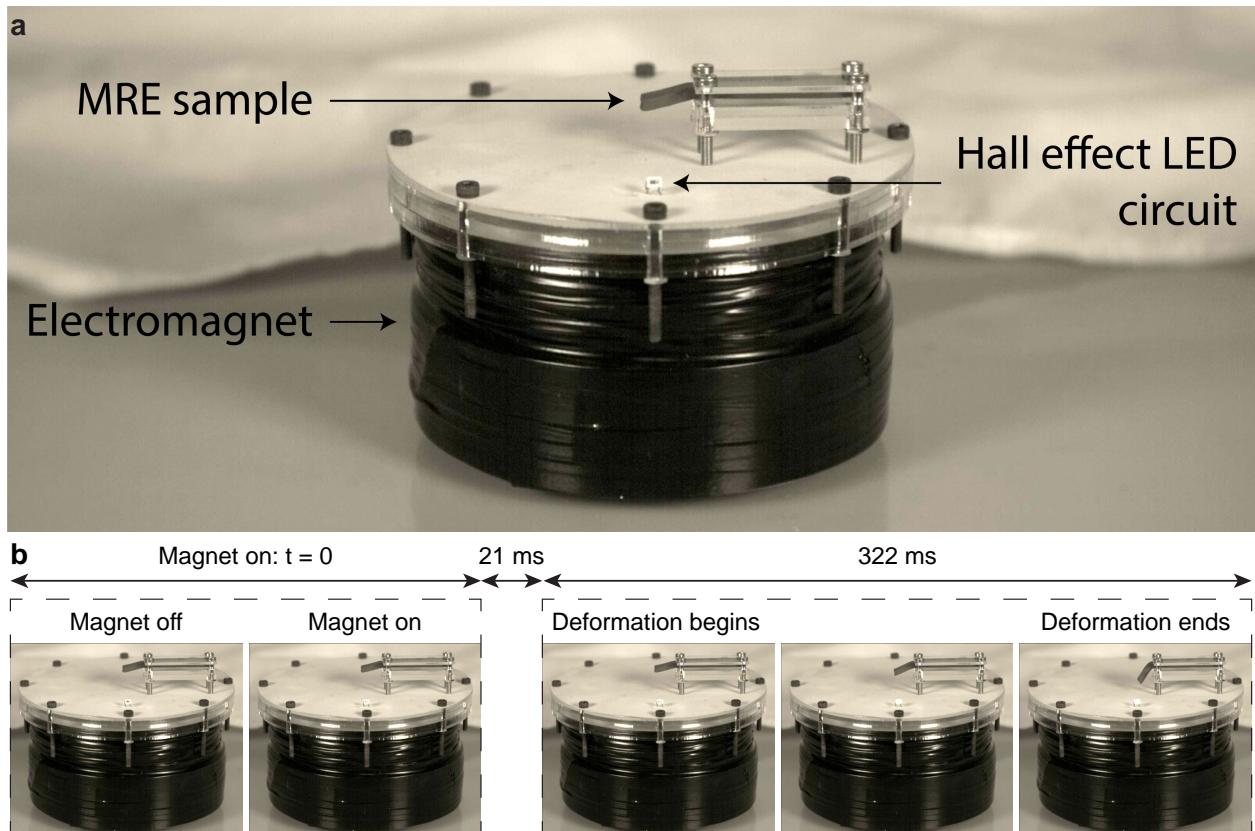


Fig. S1 MRE response time. a) Schematic of magneto-response testing fixture. Hall effect circuit activates LED in response to a magnetic field from the electromagnet. b) Measured response of MRE to applied magnetic field. MRE begins to respond within 21 ms of magnetic field activation. Full actuation of the MRE is measured to be 322 ms.

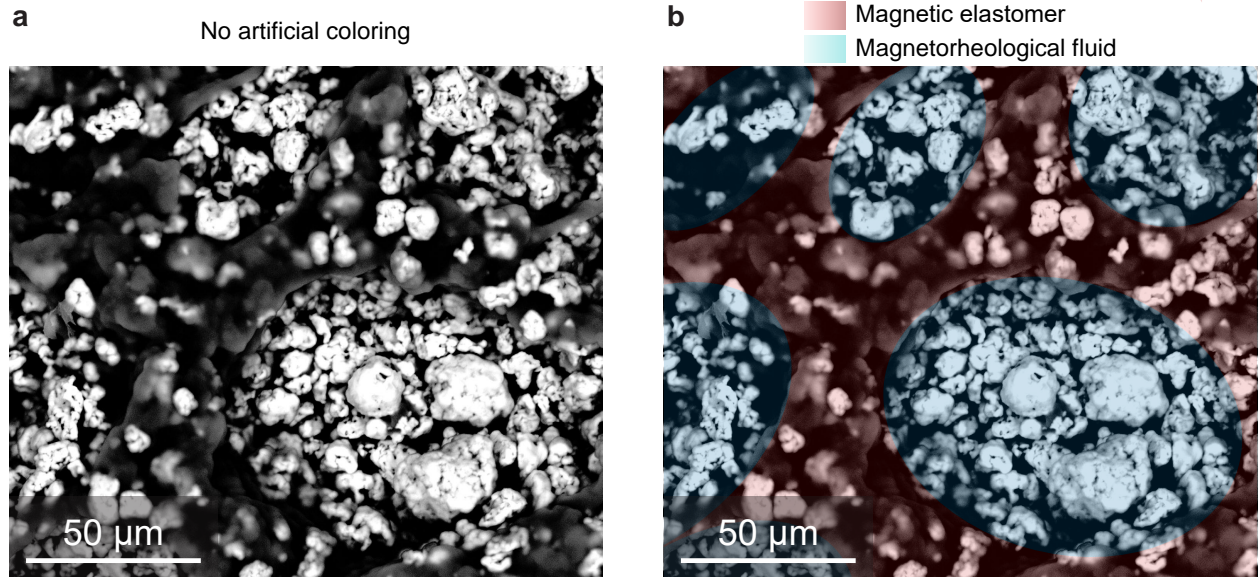


Fig. S2 Hybrid composite MRE microstructure. Scanning electron microscopy (SEM) of hybrid composite MRE cross-section. **a)** Uncolored SEM. **b)** Artificially colored hybrid composite MRE from Figure 1g. The magnetorheological fluid droplets are determined as the regions where elastomer is not visible on the surface.

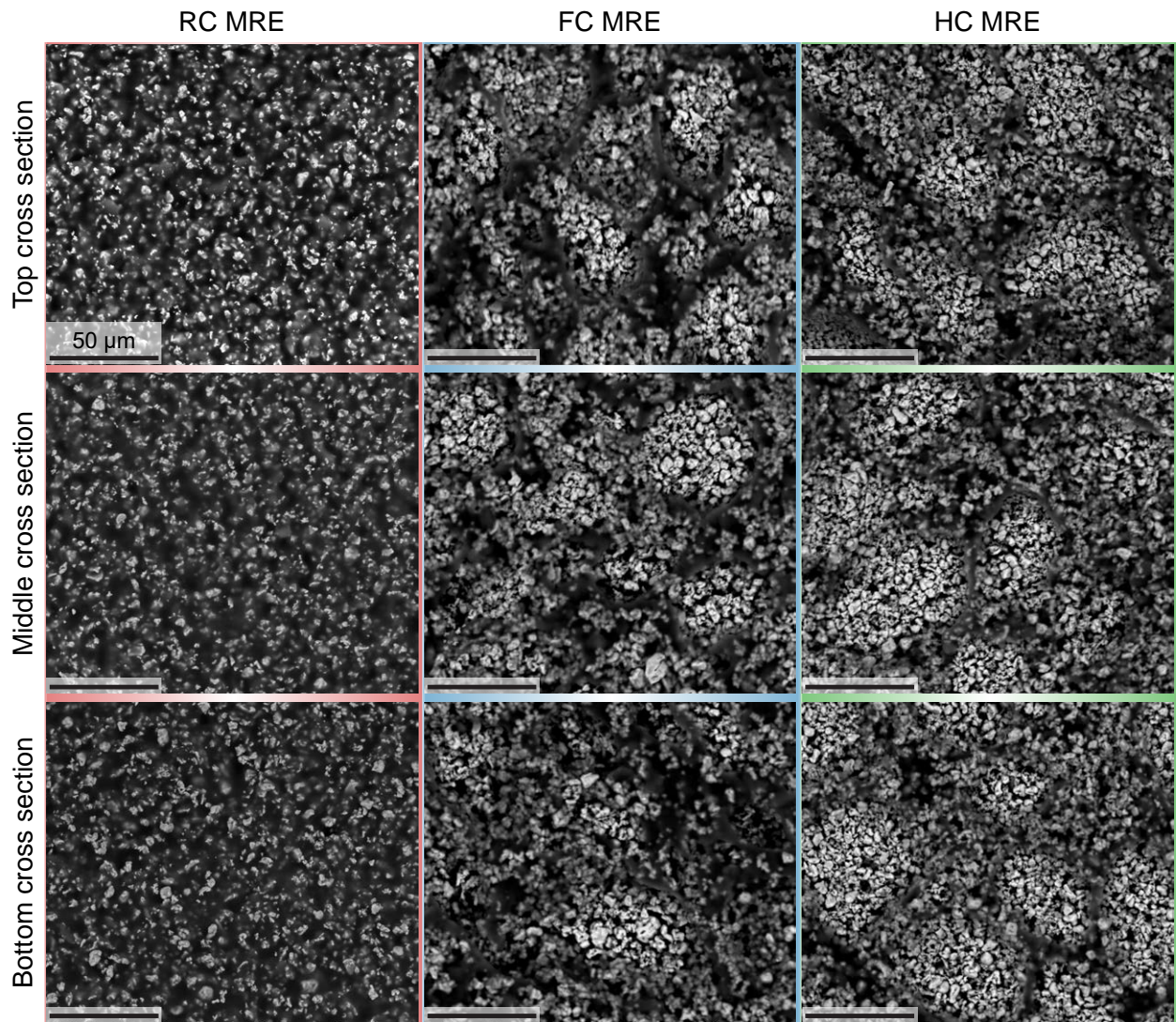


Fig. S3 MREs with diverse microstructure. SEM images of RC, FC, and HC MREs at different depths of the material (magnification = 1500x).

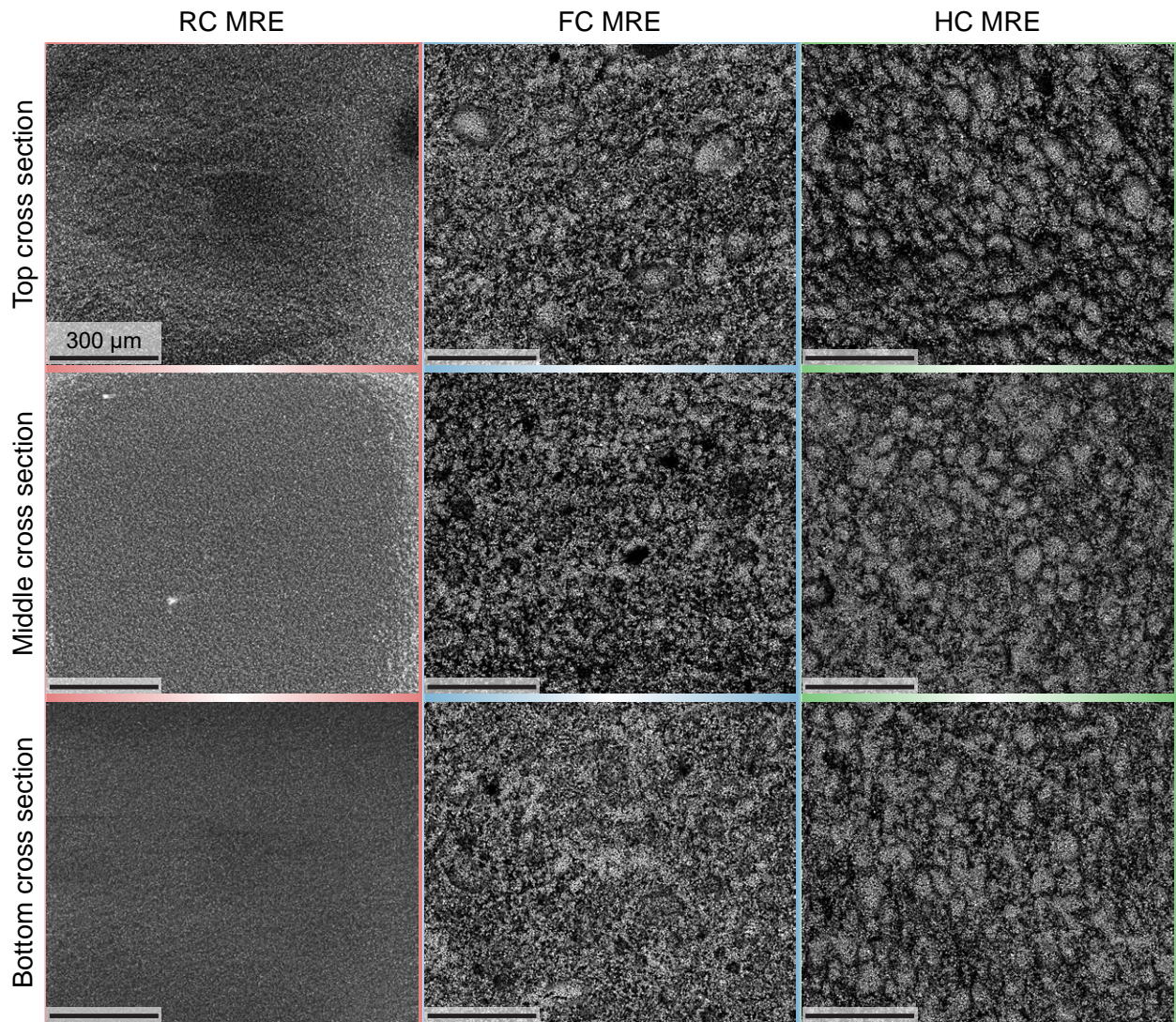


Fig. S4 Microstructural imaging at lower magnification. SEM images of RC, FC, and HC MREs at different depths of the material (magnification = 250x).

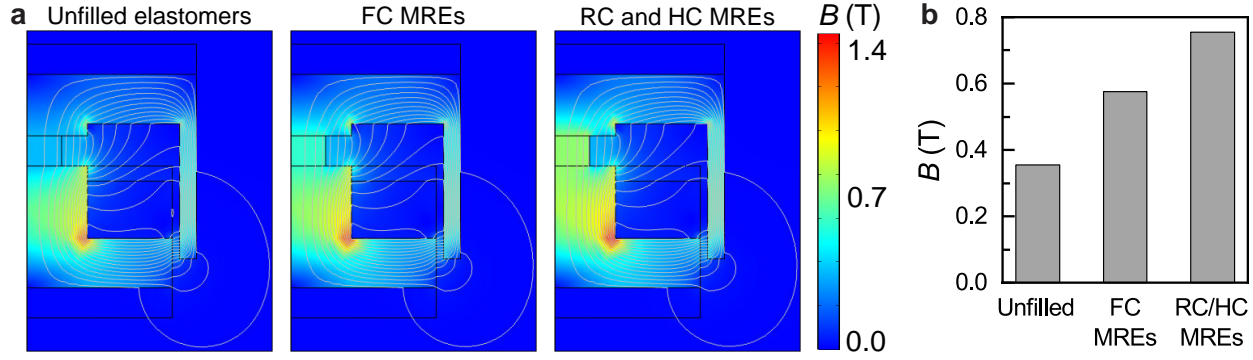


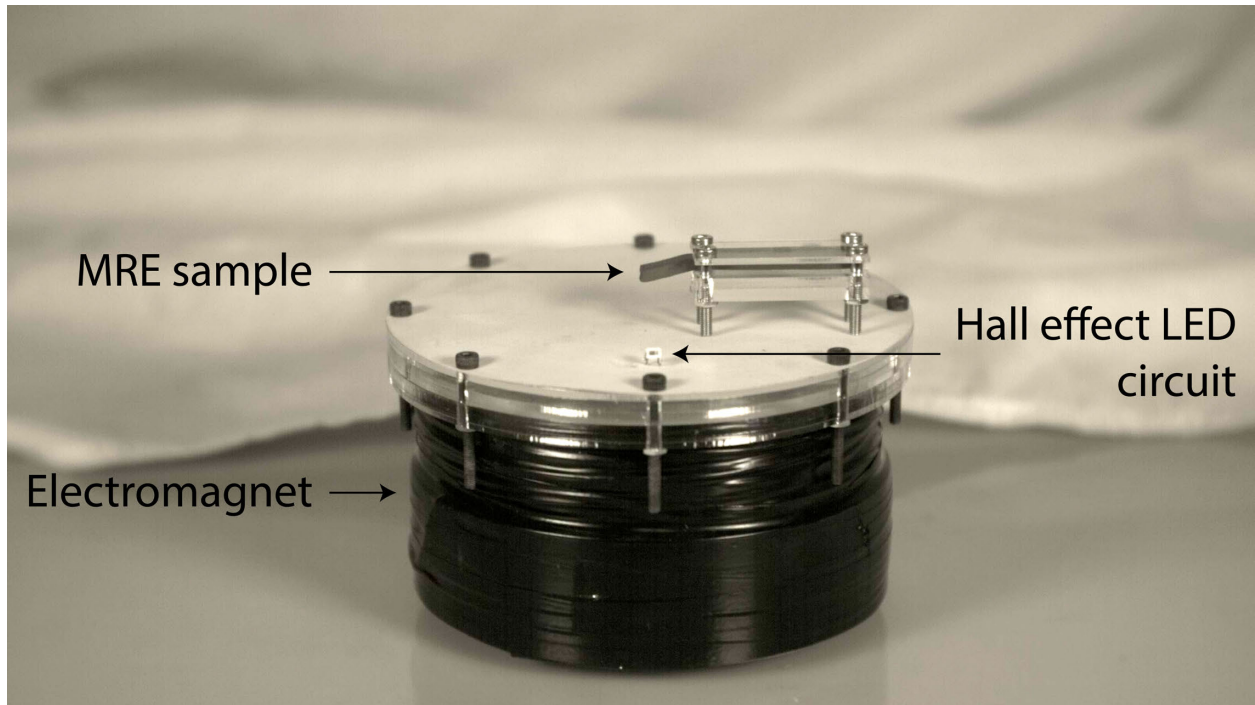
Fig. S5 Magnetic flux density through MRE samples. a) Finite element analysis of MRE testing fixture. b) Average magnetic flux density through compression testing specimens.

E_m (kPa)	Sylgard weight ratio		Ecoflex weight ratio		Total (wt%)	
	Base	Curing agent	Part A	Part B	Sylgard	Ecoflex
8	60	1	0	0	100%	0%
60	45	1	0	0	100%	0%
200	0	0	1	1	0%	100%
900	10	1	1	1	50%	50%
3000	10	1	0	0	100%	0%

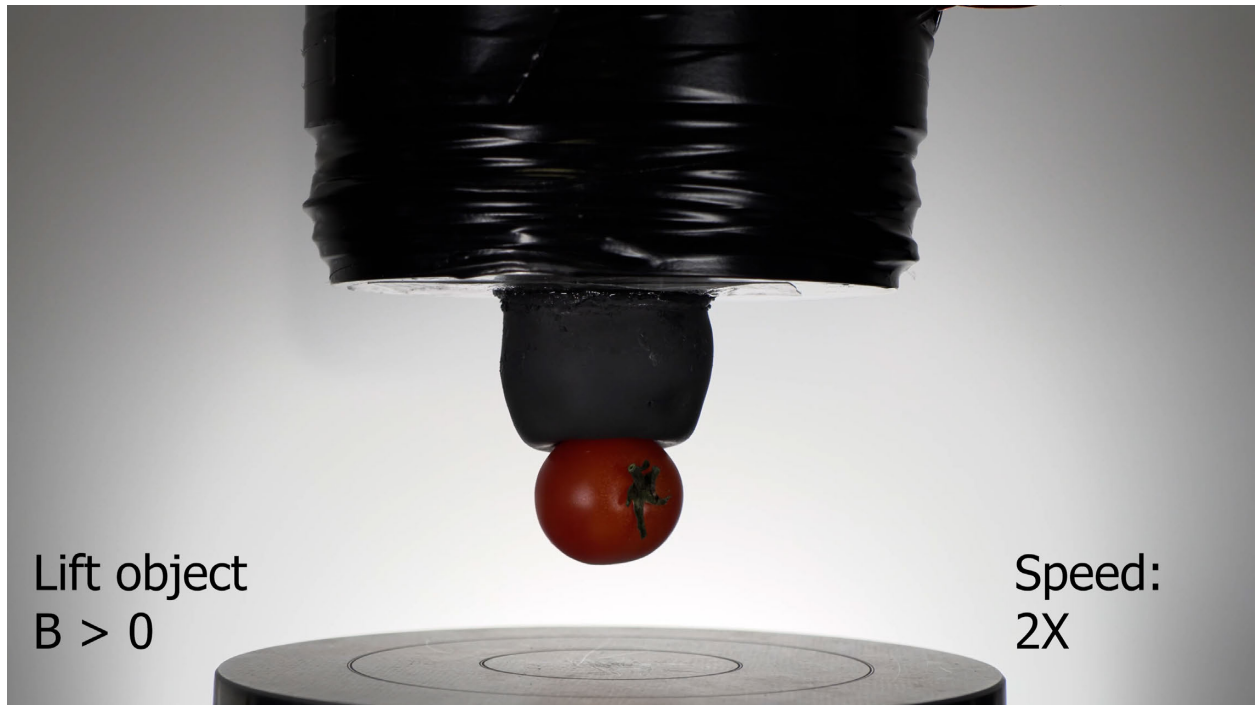
Table S1: Silicone elastomer compositions for control of matrix modulus.

	Elastomer phase (vol%)		MR fluid phase (vol%)		Total (vol%)		
	Iron powder	Elastomer	Iron powder	Propylene glycol	Elastomer phase	MR fluid phase	Magnetic content
RC MRE	25%	75%	0%	0%	100%	0%	25%
FC MRE	0%	100%	35%	65%	50%	50%	17.5%
HC MRE	15%	85%	35%	65%	50%	50%	25%

Table S2: MRE component volume fractions.



Movie S1: MRE rapid response time



Lift object
 $B > 0$

Speed:
2X

Movie S2: Adaptive MRE gripper