

Abstract Submitted  
for the MAR17 Meeting of  
The American Physical Society

**High thermal conductivity in soft elastomers with elongated liquid metal inclusions.**<sup>1</sup> NAVID KAZEM, Carnegie Mellon University, MICHAEL D. BARTLETT, Iowa State University, MATTHEW J. POWELL-PALM, XIAONAN HUANG, WENHUAN SUN, JONATHAN A. MALEN, CARMEL MAJIDI, Carnegie Mellon University — Soft dielectric materials typically exhibit poor heat transfer properties due to the dynamics of phonon transport, which constrains thermal conductivity ( $k$ ) to decrease monotonically with decreasing elastic modulus ( $E$ ). This is limiting for wearable computing, soft robotics, and other emerging applications that require materials with both high thermal conductivity and low mechanical stiffness. Here, we overcome this constraint with a dielectric composite that exhibits an unprecedented combination of metal-like thermal conductivity, an elastic compliance similar to soft biological tissue ( $E < 100\text{kPa}$ ), and extreme deformations capability ( $>600\%$  strain). By incorporating liquid metal (LM) microdroplets into a soft elastomer, we achieve a  $\sim 25\text{x}$  increase in thermal conductivity ( $4.7 \pm 0.2 \text{ W/m}\cdot\text{K}$ ) over the base polymer ( $0.20 \pm 0.01 \text{ W/m}\cdot\text{K}$ ) under stress-free conditions and a  $\sim 50\text{x}$  increase ( $9.8 \pm 0.8 \text{ W/m}\cdot\text{K}$ ) when strained. This exceptional combination of thermal and mechanical properties is through the deformation of the LM inclusions to create thermally conductive pathways in situ. Moreover, these materials offer new possibilities for passive heat exchange in stretchable electronics and bio-inspired robotics, which we demonstrate through the rapid heat dissipation of an elastomer-mounted extreme high power LED lamp and a swimming soft robot.

<sup>1</sup>AFOSR Young Investigator Program (Mechanics of Multifunctional Materials and Microsystems; Dr. Les Lee; FA9550-13-1-0123), NASA Early Career Faculty Award (NNX14AO49G), Army Research Office Grant W911NF-14-0350

Navid Kazem  
Carnegie Mellon University

Date submitted: 08 Nov 2016

Electronic form version 1.4