Title: On the maximum self-healing speed of functional materials

Authors: Grady J. Iliff[1,2], Lin Wang[1,2], Alexander J. Myers[1,2], Tak-Sing Wong[1,2,3*]

Affiliations:

[1]Department of Mechanical Engineering, The Pennsylvania State University, University Park, PA, USA

[2]Materials Research Institute, The Pennsylvania State University, University Park, PA, USA

[3]Department of Biomedical Engineering, The Pennsylvania State University, University Park, PA USA

*Corresponding author. Email: tswong@psu.edu

Abstract: Self-healing materials – able to repair themselves upon damages – enable sustainable functioning of biological and synthetic engineered systems. Conventional self-healing materials rely on diffusion-driven mass transport to repair the damaged region, resulting in a self-healing time on the order of minutes to weeks across millimeter to centimeter scale damage. However, the maximum speed of self-healing materials and the associated healing mechanism remain unexplored. Here, we demonstrate that inertial-capillary driven self-healing found in free-standing liquid films enables self-repairing at millisecond scale for centimeter scale damage – a self-healing rate that is three orders of magnitude faster than any conventional self-healing materials. The self-healing rate scales with the intrinsic Taylor-Culick rupture speed of the liquid film, which represents the maximum self-healing rate of any functional materials known to date.

One-Sentence Summary:

The self-healing speed of liquid films scale with their rupture speed, about 1 m/s, representing the limit of self-healing.