

Spore-Polymer Composite Materials

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Principal Investigator(s): Meredith Silberstein

User(s): Ellen van Wijngaarden

Affiliation(s): Sibley School of Mechanical and Aerospace Engineering

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Contact: silbersteinlab.com, mt845@cornell.edu, ewv8@cornell.edu

Research Group Website: silbersteinlab.com

Primary CNF Tools Used: Lyophilizer, PDMS Casting Station

Abstract:

Repeated loading on materials leads to fatigue cracking and eventually, catastrophic failure. Current methods for crack detection, such as visual inspection or ultrasonic testing are expensive, require equipment downtime and do not mitigate cracks that are detected. Living materials achieve novel functionalities through leveraging living organisms to sense and respond to changes in the environment, such as a crack. We designed a bacterial-polymer composite coating capable of detecting fatigue cracking and with the potential to regulate the crack conditions to mitigate cracking in the substrate. This study demonstrates crack detection for various substrate geometries and loading conditions. Ultimately, early crack detection will reduce material waste, increase product lifespan, and improve safety through preventing failure.

Summary of Research:

Fatigue cracking due to repeated loading, eventually leads to failure in all materials. Engineers are continuously looking to develop fatigue resistant materials and early crack detection methods to mitigate the safety risk.[1] Designing living materials presents a novel method of detecting cracks by leveraging living organisms' ability to sense and respond to the environment. Living materials combine conventional synthetic matrices with live organisms to expand the functionality of materials. Extensive progress has been made in developing bacteria-based materials that can self-heal and sense chemicals in the environment.[2,3] However, maintaining a viable living material remains a significant roadblock. Bacterial spores provide a robust option that enables bacteria cells to survive harsh conditions in a dormant, spore, state.[4] Bacterial spores are capable of surviving ultraviolet light exposure, drastic temperature shifts, and lack of nutrients. [5] We have integrated bacterial spores into a material system to produce a functional coating capable of detecting

cracks via fluorescence. Our work explores the material coating design and material selection process. Lastly, we demonstrate the versatility of our coating for different geometries and loading conditions for in situ fatigue crack detection.

The tools and technical expertise provided at the CNF was essential to the rapid testing necessary for biological samples. Future work will investigate different polymer matrix options for obtaining varied material properties. We will also expand on our preliminary tests to include genetically modified spores to respond to specific germinants for sensing applications.

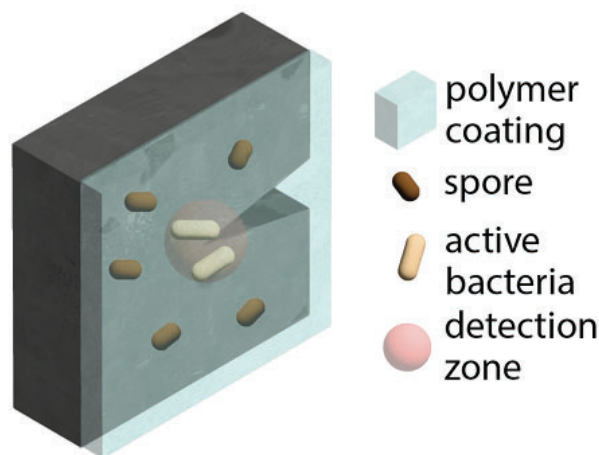


Figure 1: Bacteria-based fatigue crack detection and mitigation concept schematic.

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