New Phase-Field Model of Plastic Deformation for Multiscale Metal Forming Processes Helps to Develop Stronger Metallic Components

Dr. Kasra Momeni
Louisiana Tech University

Award Title:	Consortium for Innovation in Manufacturing and Materials (CIMM): CIMM Seed Award
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What is the outcome or accomplishment? (1-2 short sentences describing it and why it is transformative; 50-word maximum suggested)*

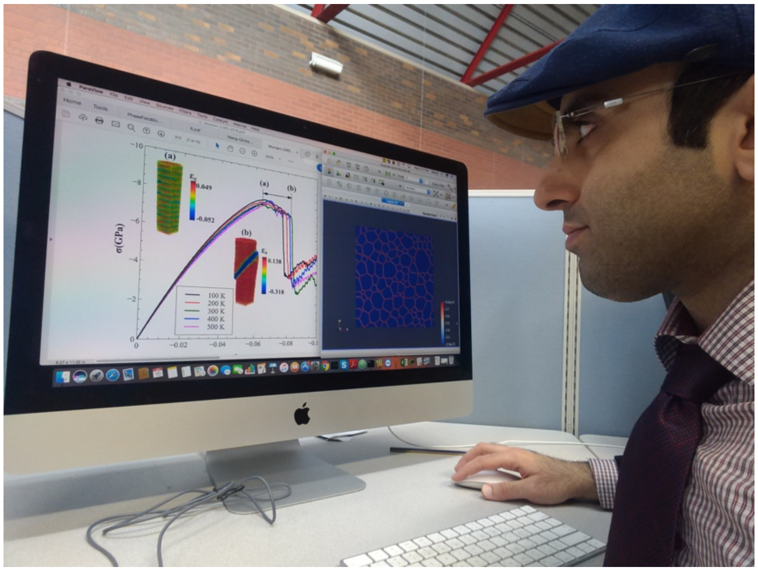
Researchers at Louisiana Tech University have developed a high-fidelity multiscale computer model framework for predicting crack formation in metals. This framework has been verified experimentally during fatigue loading.

What is the impact? (1-2 simple sentences describing the benefits for science, industry, society, the economy, national security, *etc.*; suggested 50-word maximum)

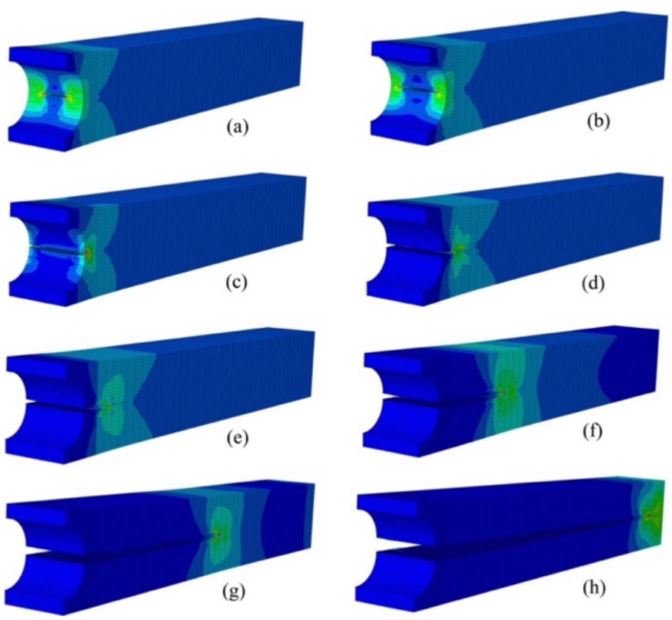
The developed framework paves the way for the design and manufacture of metallic components with extended fatigue life as well as better maintenance of current components.

What explanation/background does the lay reader need to understand the significance of this outcome? (1-2 paragraphs that might include, for example, more on who, when, where; NSF's role; support from multiple directorates/offices; what makes this accomplishment unique; additional intellectual merits; or broader impacts such as education, outreach, or infrastructure improvement that are integral to this outcome; suggested 150-word maximum)

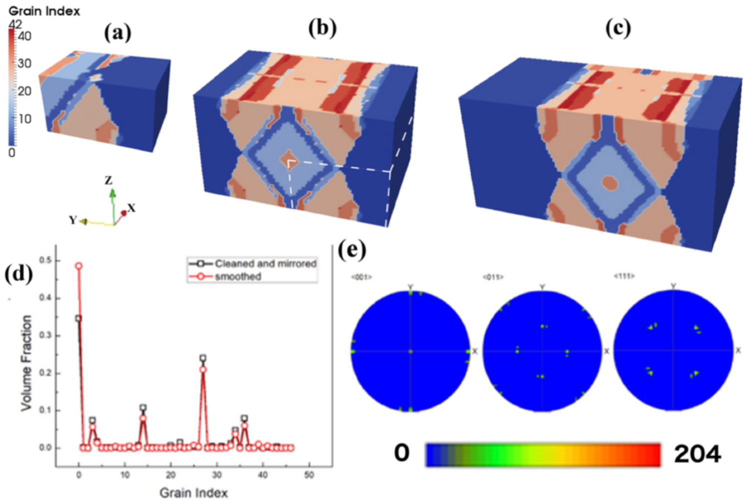
Modeling of fatigue crack initiation and growth requires understanding of the behavior of the crack at the microstructural level. Although linear elastic fracture mechanics (LEFM) has been successfully used for long-crack growth modeling, its application for modeling of the crack initiation and short-crack growth is limited. Employing elastic–plastic fracture mechanics (EPFM) may remedy these limitations, but it still cannot justify the validity of using the homogeneous material solutions. Accurate modeling of the crack initiation and short-crack growth can be achieved through more computationally demanding micro-mechanics-based simulation techniques. Louisiana researchers have developed a multiscale model that couples crystal plasticity, phase-field model of microstructure, and macroscale model of the crack growth using extended finite element method. The developed model captures the effect of microstructure such as grain boundaries on the final fatigue life of the components.



Dr. Kasra Momeni, CIMM researcher at Louisiana Tech University, views a computer simulation for materials research on the strength of 3-D printed metallic components.



Eight crack propagation snapshots of an aluminum plate. The computer model predicts the placement and growth of the crack under loading of the aluminum plate and how the stress evolves as the crack propagates.



Structure of a 3-D printed aluminum alloy. The microstructure of the aluminum alloy is reconstructed (a-c) and analyzed (d-e) by software to calculate its characteristics.