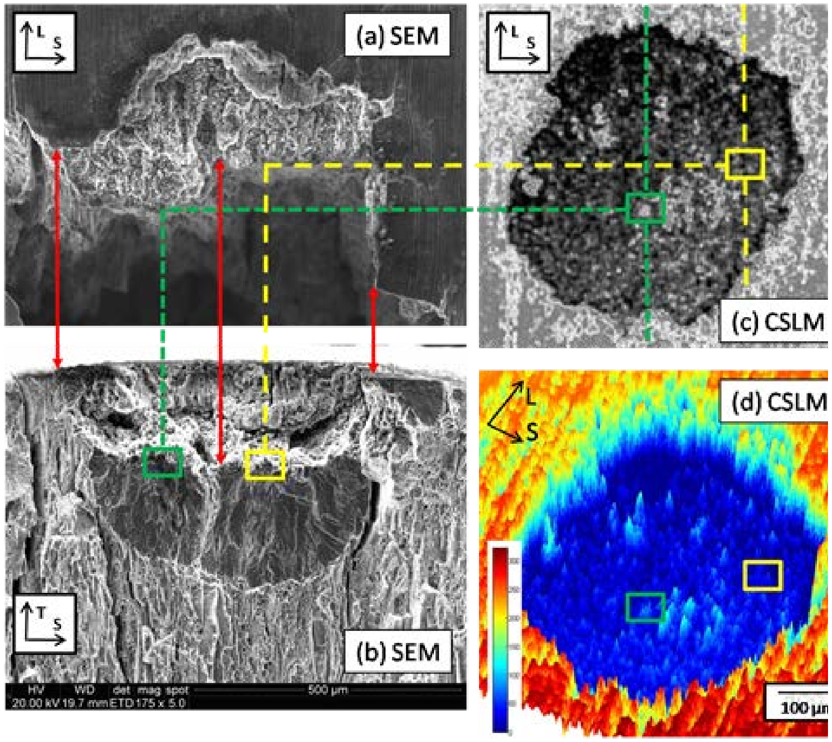
Burns Research Group



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"Evaluating the effects of the loading environment on the mechanical properties of materials."

The overarching research for my group is to develop the scientific foundation for addressing practical engineering issues or technology deficiencies; resulting in improved productivity and performance, heightened safety, and/or cost savings. Our work incorporates three materials science disciplines; metallurgy, solid mechanics, and chemistry; to address problems in fatigues and fracture of metals with environmental influences.

University of Virginia Engineering

Interaction of Localized Stress/Strain with Environmental Conditions

The intersection of metallurgy, solid mechanics and chemistry is currently at the forefront of several important engineering challenges including: prognosis of environmentally degraded airframe and ship components, design of the maintenance protocol for storage and distribution of metal embrittling H_2 for the hydrogen energy economy, and material embrittlement and fatigue issues in the resurgent nuclear power field, and alloy selection and life prediction for bio-medical engineering.

Proper modeling and prediction of the fatigue or fracture behavior of complex metal components necessitates an understanding of the pertinent microstructure and damage physics; specifically the interaction of the mechanical driving force, chemical driving force, and the material response. Such understanding is also critical for alloy development. As such our research focuses on the interaction of localized stress/strain with environment conditions, with a particular emphasis on behavior at the crack tip. In general, experimental data from controlled environmental testing are coupled with high fidelity characterization techniques to gain mechanistic understanding of the damage process; such knowledge is used to inform theoretical and engineering level models.

Current research is centered on aluminum alloys, ultra-high strength stainless steels and nickel-based super-alloys. The effect of water vapor pressures and temperatures typical of airframe operation are being investigated to quantify and better understand the material properties of legacy and next generation aerospace Al; as necessary to maintain structural integrity and safely extend the useful life of airframes. The effect of corrosion damage is also being investigated; mechanistic studies are being used to inform engineering level prognosis techniques. Additionally, the effect of chloride environments (typical of sea coast or marine environments) on fatigue behavior of ultra-high strength stainless steels is being investigated. The use of such steels will enable a reduction in the use of coatings that are both hazardous to personnel and deleterious to the environment. Additionally, stress corrosion cracking of 5xxx-series Al alloys and Ni-based super-alloys aims to understand the mechanistic causes of the high dependence on cathodic polarization and use this knowledge to inform alloy development, preventive actions, and corrective maintenance. Collaboration with industry partners has enabled the development of a novel and unique coupling of a testing method and software package that will enable estimates of the safe operating life for components subject to these aggressive environments.

RECENT RESEARCH DEVELOPMENTS

- Developed a crack initiation life prediction methodology for corroded components: working with Rolls Royce to implement into their structural integrity program.
- Identified order of magnitude decreases in growth rates associated with fatigue of aerospace Al; as pertinent to airframe structural life prediction.
- Began work evaluating coatings that would inhibit a multi-million dollar ship deck cracking problem.

RECENT GRANTS

- Navmar Applied Sciences Corporation – Mechanism-Based Approach to Development of Corrosion and Hydrogen Cracking Resistant Aircraft Alloys
- Safe, Inc. – Managing Environmental Impacts on Time-Cycle Dependent Structural Integrity of High Performance DoD Alloys
- DOD/ONR – EN-MSE Assessing Heat-to-Heat Variations Affecting Mechanism Based Modeling of Hydrogen Environment Cracking (HEAC) in High Strength Alloys for Marine Applications: Monel K-500
- ONR – The Effect of Chloride Concentration on the Corrosion-Fatigue Behavior of Ultra-High Strength Steel

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