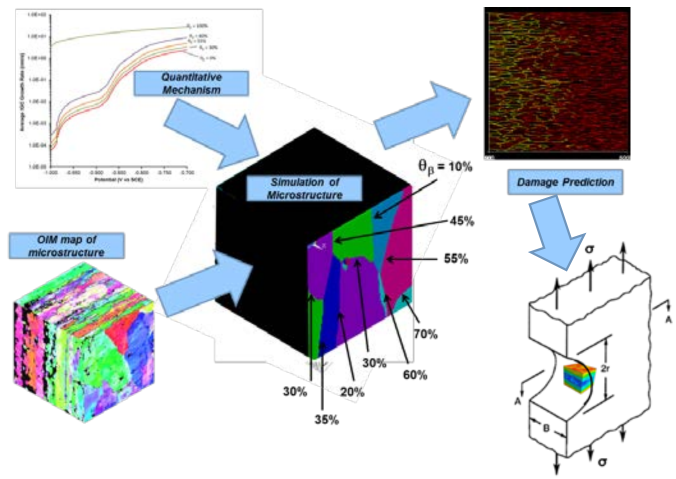
Center for Electrochemical Science & Engineering



Corrosion, the degradation of materials, has a massive economic impact. The estimated annual cost of corrosion to the U.S. economy is on the order of $200 billion. Our current work focuses on moving the field of corrosion science and engineering from one of simply explaining phenomena under controlled laboratory conditions to one of predicting corrosion damage modes and rates for conditions relevant to actual engineering structures. Applications include life prediction of naval structures using advanced aluminum alloys, long-term storage of nuclear waste, compressor blades for jet engines, and high strength aluminum alloys for aerospace structures. In all cases, we combine experimental measurements using state-of-the-art probes with modeling across a wide range of time and length scales. Collaborations are critical to the success of the work, and our group has close interactions with faculty from Chemical Engineering, Systems Engineering, and Environmental Engineering, as well as others in Materials Science and Engineering.

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"Studying the electrochemical and chemical conditions of corrosion in mission critical systems while providing superior research and educational opportunities to student mentees."

Improved Accelerated Corrosion Tests

One of the most challenging aspects of corrosion engineering is need to accelerate the damage in laboratory tests in order to predict damage under less aggressive conditions in the field. Unfortunately, many accelerated corrosion tests lack a strong science basis and are thus not sufficient for life prediction. By combining recent advances in atmospheric science on the chemistry of aerosols with improved means of measuring corrosion under atmospheric conditions, we are developing improved accelerated tests that increase the fidelity of the corrosion morphology while increasing the rate of attack by over 400, allowing tests of 1 week to accurately predict damage that would take nearly 8 years to occur in service. Materials of interest include carbon steel, the most widely used metallic material, as well as advanced aluminum alloys, and stainless steels. Collaborations are ongoing with Prof. Keene in the UVa Department Environmental Science, as well as with colleagues at Ohio State University, University of Hawai'i-Manoa and CSIRO (Australia).

Life Prediction of Naval Al-Mg Alloys

Naval ship structures are increasingly being constructed from Al-Mg alloys in efforts to increase speed and range. Our work involves developing an integrated suite scientific and engineering models to predict the damage evolution for such structures. The damage results from a the development of a metallurgical condition known as sensitization, and the subsequent damage due to combination of intergranular corrosion, stress-corrosion cracking, and fatigue. The model so developed predicts the statistical distribution of the time-to-failure for ship components, which allows for more accurate service life prediction as well as design of maintenance and repair schedules. Collaborations with Profs. Scully, Gangloff and Burns in Materials Science are coupled with ongoing work with the University of Utah.

Localized Corrosion: Measurement & Modeling

Localized corrosion is very common, but understanding and predicting continues to be a challenge. Our recent evaluation of the literature on long-term atmospheric exposures of stainless steels has provided support for the idea that there exists a maximum bound on the size a pit can achieve under these conditions. Understanding the origins and controlling factors behind such a bound would have a profound impact on the ability to assess the likelihood of corrosion failure of these materials. Our current work combines advanced measurements and modeling of localized corrosion in stainless steels and aluminum alloys to develop and validate a means to predict the maximum amount of pitting or intergranular corrosion damage that can occur on a surface of corrosion resistant alloys exposed to atmospheric conditions. Collaborations are ongoing with colleagues at Rolls Royce and Alcoa.

RECENT RESEARCH DEVELOPMENTS

- Developed a computational model for the inhibitor release and transport within and from a hydrotalcite coating system to assist in the design of the multifunctional coating systems with encapsulated inhibitors.
- Developed improved accelerated salt spray laboratory corrosion test.

RECENT GRANTS

- US Air Force Academy – Investigation and Coating Degradation Processes on Modern High-Performance Alloys that Affect Air and Land Vehicle Structural Integrity
- ONR – Development & Validation of an Integrated Intergranular Corrosion/Cracking Model of Al-Mg Alloys for Naval Applications
- OUSD – Investigation of Selected Atmospheric Corrosion Processes on Modern High-Performance Ferrous Alloys that Affect Structural Integrity: Development of Predictive Capabilities and Test Methods
- Rolls Royce – Corrosion Study of Erosion/Corrosion Coating on Compressor Blades

SEAS Research Information

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