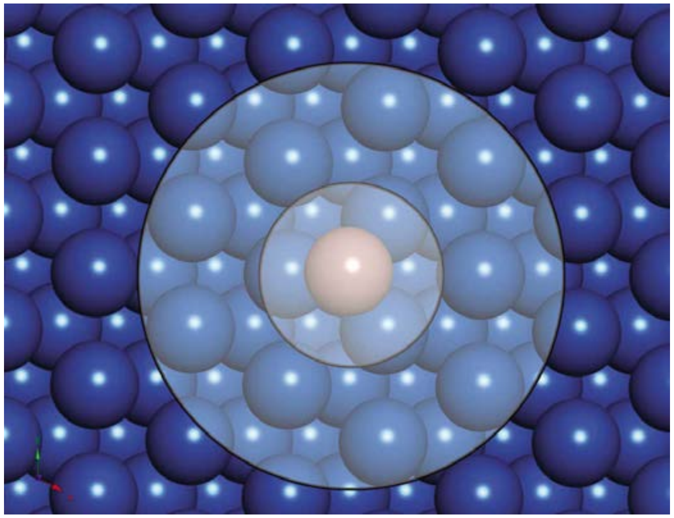

Technological advancements that improve the standards of living, safety, and the quality of life of the citizens of the commonwealth and nation place ever-increasing demands on engineers to provide materials with improved properties that enable these advancements. As materials engineers, our goal is to design materials with suitable properties to meet these demands. Unfortunately, most materials suffer from "time-dependent" degradation phenomena that tend to alter their properties over time. This can cause safety and reliability concerns. One example of time-dependent degradation phenomena is the corrosion of metallic materials. This phenomenon costs the US over $350 billion dollars annually. My research focuses on the mechanisms of corrosion, the prevention and protection against corrosion phenomena, discovery of novel corrosion protection mechanisms, as well as the lifetime prediction of time-dependent corrosion degradation phenomena. Lifetime prediction enables the determination of safe-life, fail-safe, retirement-for-cause materials conditions as well as inspection intervals.

Center for Electrochemical Science and Engineering

John R. Scully

Charles Henderson Professor of
Materials Science and Engineering
jrs8d@virginia.edu
www.virginia.edu/cese/

Dept. of Materials Science and Engineering
University of Virginia
Charlottesville, VA
434.982.5786

"Exploring the phenomena of time-dependent corrosion with the goal of supporting technological advancements which improve standards of living, safety, and quality of life."

University of Virginia Engineering

Corrosion Inquiries by Spectro-electrochemical and Scanning Probe Methods

We study local corrosion processes using spectro-electrochemical methods and scanning methods coupled with surface science and strong materials characterization. For instance, electrochemical impedance spectroscopy, surface enhanced Raman spectroscopy, scanning electrochemical microscopy, scanning Kelvin probe, and confocal scanning laser microscopy are utilized for global as well as locally resolved spatial resolution studies of electrochemical processes. We also seek to understand the effects of many different complex microstructures and compositions on different forms of corrosion such as the mechanisms of under-paint corrosion. Specifically, we strive to establish the effect of the microstructure, composition, and surface treatments on corrosion in the presence of many different functional coatings. Hydrogen embrittlement studies cross many length and time scales are addressed using thermal desorption, permeation, and scanning Kelvin probe mapping of hydrogen to provide precise information on hydrogen content and location. We collaborate with many surface scientists to augment meso-scale corrosion characterizations and computation theory with atomic scale measurements. Techniques used are those than can identify molecular identity, surface chemistry and structure, electronic properties integrated with bulk material characterizations methods.

Lifetime Prediction During Time Dependent Degradation

The life of bridges, steel structures as well as light-weight aerospace and marine vehicles in harsh environments, often within confined spaces, is a major societal challenge. The life of such structural and functional materials is often limited by corrosion. Conventional strategies for suppressing corrosion include organic or metallic coatings, natural passivation, or intrinsic defect tolerant and surface engineering designs. In order to extend lifetimes, improving the inherent corrosion resistance is highly desirable. In order to ascertain the potential benefits of implementing a new material it is often necessary to characterize the corrosion behavior in both the initiation and the propagation stages. We have developed lab techniques to assess these two phases in a shorter time period than accessed in the field. These approaches enable the design of corrosion informed materials.

Nano-engineered Multi-functional Material Design

We have designed amorphous glass alloys and glass-nano crystalline composites that serve as multi-functional "tunable" metallic coatings. Included in the functions are active corrosion inhibition, corrosion barrier properties, and sacrificial cathodic prevention. In recent grant activity our work has been extended towards the Mg based alloy systems where Mg-RE-TM alloys are being replaced with alternatives Mg glass compositions in order to provide functions such as cathodic protection and inhibitor release "on demand" to protect sites where the coating is damage or removed.

RECENT RESEARCH DEVELOPMENTS

- Elucidated the mechanisms of copper and Cu-Sn alloy corrosion, fate of Cu and Sn and origins of high Cu release rates pertinent to the anti-microbial function of these materials
- Developed a new conceptual model to explain the passivation mechanisms of nickel base alloys at the atomistic scale by combining surface science with corrosion electrochemistry

RECENT GRANTS

- Predicting and Controlling the Roles(s) of Minor Alloying Elements in the Passivation of Ni-Cr-X systems – in Understanding Corrosion in Four Dimensions (ONR MURI)
- Localized Corrosion and Stress Corrosion Cracking Behavior of High Strength Stainless Steel Pre-stressing Strand Materials in Marine Atmospheric Highway Environments, (VTRC)
- Understanding Effects of Coatings on IGSCC of Marine Grade Al alloys (ONR)

SEAS Research Information
Pamela M. Norris,
Executive Associate Dean for Research
University of Virginia
Box 400232
Charlottesville, VA 22903
pamela@virginia.edu
434.243.7683

UNIVERSITY of VIRGINIA ENGINEERING