ASM Cleveland Chapter Symposium on Corrosion

Presentations and Speakers

1) The University of Akron Corrosion and Reliability Engineering Program-- Fighting the $400 Billion Annual Costs of Corrosion:

Corrosion adversely affects our daily lives and the U.S. economy. There is a critical national need for better corrosion control. A cornerstone of the UAkron Corrosion and Reliability Engineering program is the BS on Corrosion Engineering degree—the only such degree in the United States. The focus is on the intersection of corrosion science, engineering and management to reduce corrosion costs and to increase reliability and safety. Our technical thrusts and current research include:

- Multi-scale, Multi-level Treatment of Performance Assessment
- Modeling and Prediction of Corrosion Damage Evolution
- Early Stages of Biofilm Formation and Microbiologically Influenced Corrosion
- Corrosion Under Insulation
- Induced AC Corrosion of Pipelines in Shared Right-of-Ways
- Implantable Neuroprosthesis Systems

In order to increase safety and reliability and to reduce costs of corrosion, a combination of policy and management strategies and technical strategies are required. Establishing vibrant industrial partnerships with the UAkron Corrosion and Reliability Engineering program are essential to attain the goals of corrosion workforce development, advanced corrosion mitigation technologies, and enhanced systems health monitoring/performance assessment.

Dr. Joe H. Payer is the Research Director of the UAkron Corrosion and Reliability Engineering program and an internationally recognized expert in corrosion and materials performance. Prior to joining UAkron in July 2009, Dr. Payer directed the U.S. Department of Energy, multi-university, Corrosion and Materials Performance Cooperative at Case Western Reserve University. He is former director of the Yeager Center for Electrochemical Sciences at Case. Dr. Payer is a Fellow of ASM International, a Fellow and past president of NACE International, and received the ASTM Sam Tour Award for Distinguished Contributions to Research, Development and Evaluation of Corrosion Testing Methods. Dr. Payer's expertise includes materials selection, failure analysis, development and verification of corrosion control methods, advances to test methods and monitoring systems and determination of degradation mechanisms.

2) High Temperature Oxidation and Corrosion - A NASA Perspective:

Propulsion systems typically involve combustion of fuels at high temperatures. Thus turbine and rocket engines potentially subject components to high temperatures as well as the gaseous products of combustion. Excess oxygen (air) reacts with component materials, converting surface layers to non-load-bearing oxides. Systems are engineered with intrinsic oxidation resistance, coatings, and control of the surface temperature to enable low oxidation rates and safe, long term performance. Current complex superalloys used in turbine engines typically contain Ni, Co, Cr, Al, Ti, Ta, W, Mo, Re, Hf, C, and B, all of which will react with oxygen. Thermodynamic stability and growth kinetics determine which scales are protective and which are not. In the end, alloys which develop Al_2O_3, Cr_2O_3, or SiO_2 scales are most oxidation resistant. In addition to simple growth kinetics, the ability of the scale to resist cracking and spalling due to cycling and to resist vaporization due to formation of volatile species are also paramount. This presentation will discuss various classes of high temperature engineering materials in the context above. Some attention will also be given to corrosive engine deposits, such as Na_2SO_4 and calcium magnesium aluminosilicate (CMAS) sand.

Dr. James L. Smialek has worked at NASA Glenn (Lewis) for over 40 years in the area of high temperature oxidation and corrosion of aerospace engine materials. These materials typically include superalloys, intermetallics, and ceramics, as well as coatings on each. Some primary research areas involved the microstructure, growth, and adhesion of protective alumina scales, highly oxidation resistant single crystal superalloys, and thermal barrier coating (TBC) durability, cyclic oxidation models, sand deposits on turbine airfoils, and the hot corrosion and recession of SiC-based ceramics in molten salts or water vapor. He is the author of 140 research papers, 6 book chapters, and 14 patents. He was awarded the NASA Medal for Exceptional Scientific Achievement and was promoted to the senior NASA Science and Technology (ST) Corps. He is a Fellow of the American Ceramic Society and the American Society for Materials. He has served as Chairman of the High Temperature Corrosion Gordon Conference and has been on the editorial boards of the *Journal of the American Ceramic Society* and *Oxidation of Metals* for over 20 years.

3) Qualification of Materials for Plumbing Fixtures:

Moen Incorporated is one of the world's largest producers of residential and commercial plumbing products. Moen is the #1 brand of faucets in North America. The company manufactures a complete line of single and two-handle faucets in a wide assortment of styles and finishes. It is also a leading producer of residential and commercial sinks, a variety of shower accessories, and bathroom accessories.

Moen is known throughout the plumbing industry for its firsts, including single handle faucets. Recently, the company's focus on innovation has led to the introduction of several new products including the launch of Duralast® cartridge with a proprietary ceramic disc design and the introduction of a new Spot Resist™ finish to resist fingerprints and water spots.

The Design Reliability Lab at Moen is an integral part of their commitment to innovation. In these labs, the various environmental and service conditions that influence service of

Moen products are applied to candidate products to ensure that the products will have the desired lifetime. The various functions of coatings are considered in the design process as well as careful selection of materials for use with respect to the various types of corrosion that can occur in plumbing fixtures in the real world. The design reliability lab contains a variety of test capabilities, including mechanical testing, environmental exposure, and failure analysis.

Dr. Brenda Trautman has been head of the Materials Engineering and Analytical laboratories within the Design Reliability Labs at Moen since 1997. She received her doctorate from Case Western Reserve University, where her work focused on corrosion and coatings. She has also worked in the automotive and steel industries. Dr. Trautman is a past-chair of the Cleveland ASM Chapter and was the recipient of the Cleveland Technical Societies Council Technical Achievement Award in 2006.

4) Biocorrosion of Medical Implants - A look at the "Grand Challenge" of Implanted Sensors:

Design issues for implanted medical devices have started to become tractable through extensive material science activity leveraging existing R&D activity in other (ex vivo) harsh environment device material analysis. ISO standards, databases and survey papers have emerged to assist the designer with enclosure strategies (e.g., membranes or coatings) and this information is becoming more readily available for product development projects though publications and conference presentations. A focus on biomedical sensors as a "Grand Challenge" for today's seminar pushes our understanding of the state-of-the-art in implanted medical devices for two simple reasons: (A) sensors are active (not passive) implants, and (B) they must collect and transmit information. Conquering the "sensor challenge" would suggest progress for many implanted devices.

Typical biomedical sensors are devices that detect a physical parameter, say, pressure, and convert the measured signal into another form, most often an electrical signal. The context of anticipated use of a biomedical sensor is important as it has a profound impact on material selection, regulatory clearance, and post-market monitoring for adverse events. Despite the growth in advanced sensor applications for harsh environments, application for implanted devices has emerged a bit more slowly, in which three basic issues have dominated research efforts:

- Transducer materials that combine biocompatibility with an ability to withstand the harsh environment of the body.
- Integrated electronics, amplification and non-invasive transmission of transducer output.
- Transducers selective to biological or molecular activity.

The prospect of corrosion has a direct and "critical path" impact on sensor design, testing, and manufacture. Corrosion, as a process in which the breakdown of material properties occurs through means of electrochemical, oxidation, or dissolution of a material is further complicated where corrosion and erosion might occur simultaneously. Factor in the expectation that implanted devices are expected to last for decades, today's look at corrosion of implanted sensors provide an exciting and encouraging view of materials for implanted devices, with cautionary notes and hopeful ideas for future work.

Dr. Colin K. Drummond is the Director of the Coulter-Case Translational Research Partnership (CCTRP) in the Department of Biomedical Engineering at CWRU. He received his Ph.D. degree in Mechanical Engineering from Syracuse University in 1985 and an MBA in Technology Management from the Weatherhead School of Management in 1997. Dr. Drummond has conducted research in the areas of medical device design, microfabrication packaging, sensor systems, and cross-platform software systems integration. For over two decades Colin has worked in the application of science and technology to the creation of products and services and in the past 5 years has been a co-founder of two medical device start-up companies. Colin co-authored the introductory chapter on "Medical Implant Applications" for the Handbook of Materials for Medical Devices, to be released in 2012.

Dr. Drummond is an adjunct faculty in The Institute for Management and Engineering (TiME), with a focus on Accounting, Finance, and Entrepreneurship. In the spirit of entrepreneurship, Colin co-founded the "Regional Roundtable for Allied Health – Biomedical Engineering Collaboration" between Case Western Reserve University, Cleveland State University, and Lorain County Community College; this quarterly meeting explores collaborative research and teaching interests in the biomedical sciences. Colin is also the co-director of the Electronic Materials Reliability Institute.

During 2004-2007, Colin was the Director of Clinical Research for non-acute medical products at the Invacare Corporation, specializing in respiratory therapy (primarily oxygen therapy), sleep disorder research, and establishing a new clinical research program strategy. Prior to joining Invacare in 2000, Colin was the Manager of Marketing and Business Development for the Powder Systems Group at the Nordson Corporation, focusing on product development, international high-technology manufacturing coating system start-ups, and eBusiness initiatives. Earlier, Colin spent 8 years at the NASA Lewis Research Center developing programming techniques for complex aircraft system analysis and turbomachinery stability. He holds three product patents and has a fourth pending. Colin is very active in the Cleveland area and serves in a variety of capacities for several non-profit organizations.

5) Corrosion in Mechatronic Industries Due to the Influence of Scaling in Microsystem Technology:

Corrosion in electronic components manifests itself in several ways. One of the most common reasons for electronic failure is environmental contaminants and conditions. The trend towards miniaturization of technology makes integrated circuits and microsystems an integral part of industry based applications ranging from aerospace and automotive to medical equipment and consumer products. Electronics circuits with submicron dimensions, high voltage gradients and extreme sensitivity to corrosion, when exposed to a variety of environmental conditions, present a unique set of corrosion-related issues—the mechanisms leading to corrosion problems are not easily defined, therefore failure occurs. Failure to control corrosion can lead to increased cost, reduced safety and negative environmental impact. This paper briefly discusses the effects of wire bond and surface mount corrosion in electronics, medical device and microelectronics mechanical system (MEMS) industries. The application of standard methodology to reduce corrosion-based degradation of electronic components can have a positive economic impact.

Matthew Apanius is a microelectronic mechanical systems (MEMS) technology specialist who was instrumental in developing the concept for the SMART Commercialization Center for Microsystems and Director of Operations for the Center at Lorain County Community College. The SMART Center will be a regional core facility that supports the commercialization of novel microsystems by offering access to process capability needed for optimizing device packaging for application specific requirements. Matthew owns a successful MEMS prototyping company, Microfabrication Solutions, Inc., that has been doing business in Cleveland, Ohio since 2003. Over the last eleven years, Matthew has worked on numerous MEMS applications for industry in varied areas, including: telecommunications, life science, aerospace, drug delivery, automotive, biomedical, optical display, machine health monitoring, and microelectronic/wafer-level packaging.

Sweata Lal is a microelectronics mechanical system (MEMS) Packaging and Test Engineer for the SMART Commercialization Center for Microsystems at Lorain County Community College. She has recently joined the SMART Center team and, for the past 9 years, has worked on numerous MEMS wafer-level, board-level and chip-level applications with companies such as Cypress Semiconductor, Micron, and Texas Instruments. Her experiences in semiconductor and manufacturing industries include computing, networking applications, as well as, mobile, embedded, consumer, automotive, and industrial electronic designs. Sweata has a Master of Science in Electrical and Computer Engineering from New Mexico State University.

6) Accelerated Corrosion in Duluth-Superior Harbor:

The Detroit District of the U.S. Army Corps of Engineers (Corps) was asked to investigate the corrosion of steel structures in the Duluth-Superior Harbor. During 2004 the Corps convened an expert panel to review existing data for the harbor and make recommendations about potential causes to investigate. The expert panel recommended evaluating several water quality parameters, stray electrical currents, and the potential for microbially influenced corrosion, as possible causes of accelerated corrosion. The Corps and Port Authorities conducted diver surveys of the structures in the harbor and conducted water quality monitoring. They also placed steel coupons in the harbor to allow measurement of corrosion rates. The impacts of accelerated corrosion became even more apparent when Lake Superior water levels dropped in 2007, exposing infrastructure that had been skeletonized by corrosion.

In addition to the causes of corrosion, the team also undertook to identify methods to protect the existing steel in the harbor as well as steel being installed. The Corps recommend coatings that could be applied to the steel for protection and an initial set of coupons was placed at a depth of four feet (zone of most accelerated corrosion). A second set was placed in the ice scour zone to assess impacts.

Localized corrosion on DSH pilings is characterized by tubercles, varying in diameter from a few millimeters to several centimeters, and when removed, large and often deep pits are exposed. The tubercles, made up of intact and/or partly degraded bacterial stalks mixed with amorphous hydrous ferric oxides, create reducing conditions beneath the tubercles that cause copper, dissolved in the water, to precipitate. A galvanic couple established between the copper layer and the iron substratum produces aggressive localized corrosion. Pit depth and weight loss have been measured at multiple locations over a 4-year period. Linear polarization resistance (LPR) measurements were made at the start of the study. Corrosion rates, calculated from the three independent techniques, vary with location. There are no obvious relationships between predicted corrosion rates derived from the three techniques. However, the presence of zebra mussels appears to stifle pitting.

Mr. David W. Bowman is a Physical Scientist with the Detroit District of the U.S. Army Corps of Engineers. He has worked for the Corps for 25 years, first as a sediment testing and water quality specialist, and more recently as a project manager.

He received a Bachelor of Science degree in Fisheries/Limnology from Michigan State University in 1978, a Master of Science degree in Biology from Central Michigan University in 1983.

Mr. Bowman has authored several publications for the Corps of Engineers and has made numerous presentations on the treatment and handling of dredged material. His principal research interest is in release pathways from dredged material disposal facilities and in the development of beneficial use alternatives for dredged material. To that end he has worked with dredged material on some of the District's most troubling sediments, including projects at Green Bay, Wisconsin; Milwaukee, Wisconsin; and Duluth, Minnesota. This research has often been jointly funded by the Corps and the U.S. Environmental Protection Agency.

Mr. Bowman led the team that designed the dredging and disposal plans for the Black Lagoon project, the first Great Lakes Legacy Act project to be completed. This was followed by providing design and construction assistance for other Legacy Act projects at Ruddiman Creek in Michigan and the Kinnickinnic River site in Milwaukee. The Black Lagoon Team won the Detroit District's 2006 Project Delivery Team of the Year Award and the Ruddiman Creek project won a State of the Lakes Ecosystem Conference (SOLEC) Award in 2006. In 2009 Mr. Bowman received the Bronze Medal for Commendable Service from the EPA's Great Lakes National Program Office for the Kinnickinnic River project.

Dr. Brenda J. Little is a Senior Scientist for the Marine Molecular Processes in the Ocean Sciences Branch, Naval Research Laboratory. She is active in NACE as a fellow, a member of the research committee, chair of the awards committee, and on the Board of Directors. Brenda is also the assistant editor for *Biofouling*, The Journal of Bioadhesion and Biofilm Research. Dr. Little has a B.S. in biology/chemistry from Baylor University, and a Ph.D. in chemistry from Tulane University.

7) The Corrosion Analysis Network™:

The Corrosion Analysis Network is a joint project between founding partners ASM International and NACE International. ASM is Everything Material, the society dedicated to serving the materials science and engineering profession. Through our network of 36,000 members worldwide, ASM provides authoritative information and knowledge on materials and processes, from the structural to the nanoscale.

The Corrosion Analysis Network is the most comprehensive and authoritative online source for researching, understanding, preventing and solving corrosion-related problems. This collaborative effort combines every corrosion mitigation solution from the partner organizations, into one, all-inclusive, easy-to-access database.

The Corrosion Analysis Network is made up of three dynamic portals that include:

- Corrosion information
- Environment specific analysis tools
- Collaboration – connection to the world's corrosion network

The Corrosion Analysis Network features:

- More than 9,000 conference papers from leading industry events
- Nearly 2,000 journal articles from NACE and other publications
- More than 1,300 technical papers from ASTM Publications
- Nearly 500 handbook articles from the ASM Handbook
- More than 350 book articles from ASM and NACE
- 250 standards from ASTM and NACE

Scott Flowers, the Materials Solutions Sales Manager for ASM and an Electrical Engineering graduate of Purdue University, will be demonstrating how the Corrosion Analysis Network can be used in real world applications to solve corrosion-related problems.