VIRGINIA TECH

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3.30-4.30 pm
113 McBryde Hall

ENHANCING THE TRIBOCORROSION RESISTANCE OF METALS VIA MICROSTRUCTURE DESIGN

Dr. Wenjun (Rebecca) Cai

Abstract

The increasing complexity and severity of service conditions in areas such as aerospace and marine industries, nuclear systems, microelectronics, batteries, and biomedical devices etc., imposes great challenge on the reliable performance of materials exposed to extreme conditions. These conditions include, but are not limited to, high strain and strain rates, irradiation, high surface friction, extreme temperatures/pressures, and corrosive environments. Towards this end, this talk will focus on the development of novel microstructure design strategies for metals to mitigate the combined attack of wear and corrosion (i.e. tribocorrosion) under such extreme conditions. Typically for most engineering metals, there is a trade-off between wear and corrosion resistance. For example, precipitation-hardened aluminum (Al) alloys impart high strength and wear resistance, but few of them have very good resistance against localized corrosion. This is because the precipitation and secondary particles strengthens the material but, at the same time, enhances corrosion by forming unfavorable micro-galvanic couples with the Al matrix. Two design strategies will be discussed to overcome this long-standing dilemma: by forming solid solution alloys and nanostructured multilayers. In the first example, alloying Al with excess manganese (Mn) in solid solution was found to simultaneously enhance the wear and corrosion resistance of Al. Specifically, higher Mn concentration was found to improve the protectiveness of the passive film, increase the hardness via solid-solution strengthening and microstructure refinement, and accelerate the repassivation kinetics during tribocorrosion of Al. In the second example, the effects of chemical heterogeneity on the corrosion resistance of biodegradable Mg alloy will be presented. It was found that the Mg-Zr-(RE) alloy with super saturated solid solution has enhanced corrosion resistance ~ 8 fold by reducing both the anodic and cathodic kinetics compared to traditionally cast alloy. Knowledge gained from these two examples sheds light on the design principles of wear and corrosion resistant metals and coatings, which is of great importance to improve the sustainability of global energy consumption.

Bio-sketch

Wenjun (Rebecca) Cai is an assistant professor of Materials Science and Engineering at Virginia Tech. Prior to coming to VT, Dr. Cai was a faculty member of the Mechanical Engineering department at the University of South Florida (USF). Her current research focuses on understanding the processing-structure-property relationships of metals and coatings under extreme conditions using experiments, analytical theory, and computer simulations. She received

her Bachelor's degree from Fudan University in 2005 and her Ph.D. from the University of Illinois at Urbana-Champaign in 2010, both in Materials Science and Engineering. Her graduate research focused on tribology of metals, with a special emphasis on the relationship between materials' microstructural evolution and their macroscopic tribological and mechanical behavior. She was a postdoc research associate at MIT from 2010-2012, working on the synthesis, characterization, and mechanical testing of lightweight metals. She joined the faculty of Mechanical Engineering at USF in Aug 2012. She received Racheff-Intel award for outstanding graduate research at UIUC in 2010, National Science Foundation CAREER award in 2015, outstanding faculty award from USF in 2016, and TMS young leaders professional development award in 2017.