Coatings for Biomedical and Healthcare Applications
Room On Demand - Session D2

Bio-corrosion, Bio-tribology and Bio-Tribocorrosion-Additive Manufacturing Impact

D2-1 INVITED TALK: Behavior Of Additively Manufactured 316L Stainless Steel Fabricated By Selective Laser Melting In Comparison To Wrought 316L And 317 L Stainless Steels*, **Mobin Salasi (mobin.salasi@curtin.edu.au)**, K. Wang, E. Hornus,* Curtin University, Australia*; M. Pabbruwe,* Curtin University, Royal Perth Hospital, Australia , Australia*; T. Pojtanabuntoeng,* Curtin University, Australia , Australia*; M. Iannuzzi, Z. Quadir, W. Rickard,* Curtin University, Australia*; M. Salem, P. Lours,* Ecole de Mines Albi, France*; J. Bougoure,* Curtin University, Australia , Australia*; P. Guagliardo,* Curtin University, Australia **INVITED**

Selective laser melting (SLM) is a type of additive manufacturing (AM) with applications in, e.g., the biomedical and aerospace industries. Studies have been carried out on the localised corrosion behavior of SLM fabricated 316L (UNS S31603) stainless steel. Little is known, however, on the effects of tribocorrosive conditions on the response of stainless steels fabricated by SLM. In orthopedics applications, for example, it is known that the alloys often encounter different modes of tribocorrosion. In this research, the effects of abrasive particles on the tribo-electrochemical behavior of AM 316L (UNS S31603) stainless steel produced by SLM was investigated.

Two series of as-printed and solution annealed samples were first characterized using scanning electron microscopy (SEM), and transmission electron microscopy (TEM). Then, the corrosion-only behavior of these samples was investigated by cyclic potentiodynamic polarization in a 0.6 M NaCl electrolyte. The corrosion resistance of SLM fabricated 316L (UNS S31603) was compared to that of wrought UNS S31603 and S31703 stainless steels in the same environment. Three-body tribocorrosion tests were performed with silica sand abrasive particles, delivered to the interface of the sample and a rotating rubber counterface. Additionally, cyclic and potentiostatic polarization methods were used to gain a better understanding of the interaction between corrosion and abrasion. Lastly, the microstructure and the morphology of the tribocorroded regions were characterized using focused ion beam (FIB-SEM).

It was found that presence of Mo had a much more effective role in the tribocorrosion behavior than the manufacturing method. To understand the role of Mo nano-scale secondary ion mass spectroscopy (nanoSIMS) were used to understand the effects of Mo on the passivity. The implication of passivity and tribocorrosion behavior is discussed.

Key words: additive manufacturing, tribocorrosion, polarization

D2-3 Sputtered Thin Film Systems As Anode Materials for Biodegradable Battery*, **Waseem Haider (haide1w@cmich.edu)**,* Central Michigan University, USA

The biodegradable battery is a promising choice to provide power to implantable medical devices. However, the anode material in such batteries, usually Mg or its alloys, suffer from parasitic hydrogen evolution and faster discharge kinetics that limits the lifet ime of these devices. In the pursuit of finding a better anode material, herein, the idea of combinatorial development is employed to fabricate a material having a good combination of corrosion resistance properties and discharge characteristics by exploring a wider $Mg_{100-x}Zn_x$ ($0 < x < 50$ at.%) system. Structural characterization of the Mg-Zn systems via X-Ray Diffraction manifests range of microstructures dictated by percent species and sputtering conditions. The corrosion investigation of the systems is done using potentiodynamic polarization and electrochemical impedance spectroscopy (EIS) in a conventional three-electrode configuration. Additionally, the discharge performance of the Mg-Zn anode systems is investigated, coupled with sputtered iron as the cathode in Phosphate Buffered Saline (PBS) solution as the electrolyte. The EIS and galvanostatic discharge tests reveal that discharge performances of the anode materials can be effectively tailored via a prudent design of alloy composition and microstructure.

D2-4 In Vitro Degradation of ZrO_2 Coated Magnesium Alloys*, **Benjamin Millan (bmillan@ciencias.unam.mx)**,* Instituto de Investigaciones en Materiales, Universidad Nacional Autónoma de México*; O. Depablos-Rivera,* Universidad Nacional Autónoma de México, México*; P. Silva-Bermudez,* Instituto Nacional de Rehabilitación Luis Guillermo Ibarra, Mexico*; S. Rodil,* Instituto de Investigaciones en Materiales, Universidad Nacional Autónoma de México, Mexico

The main limitation of the Mg-based alloys as a biodegradable implant material for bone repair application is

their rapid corrosion rate, especially in solutions containing chloride, including human body fluid and blood plasma. The initial fast degradation lead to the production of H2 bubbles and pH changes that affect the surrounding tissue. The long-term degradation of Mg-based implant materials induces a loss of their mechanical strength and integrity before the recovery of newly formed bone.

Different strategies have been applied to improve the corrosion resistance of Mg-based alloys, and some s urface modifications, such as the use of thick polymeric or ceramic-based coatings, have proven to be effective.

In this work, we evaluated the effect of dense but thin ZrO_2 coatings on optimized MgZnCa alloys. ZrO_2 coatings were chosen due to their excellent biocompatibility, good corrosion resistance and potential to induce osteoblasts differentiation.

The ZrO_2 coatings were deposited on 2 x 2 cm^2 MgZnCa pieces by reactive magnetron sputtering under Ar/O_2 atmosphere, at a deposition pressure of 4 Pa and RF power of 200 W. Thicknesses between 100-300 nm were evaluated. The in vitro corrosion of the uncoated and coated samples was evaluated by measurement of the open circuit potential at long immersion times, potentiodynamic polarization and electrochemical impedance spectroscopy in a 0.89 wt% NaCl solution. A reduction in the corrosion current density of 50% was achieved, without observing significant changes in the corrosion potential. The electrochemical response was compared to the degradation rate measured by immersion tests.

D2-5 In Solution, A New Representation to Link the Corrosion Degradation Consistent with Wear: Smooth and Hard Coatings are Well Discriminated.*, **Jean Geringer (geringer@emse.fr)**, A. Boyer,* Mines Saint-Etienne, France*; H. Ding, V. Fridrici, P. Kapsa,* Ecole Centrale de Lyon, Ecully, France*; T. Tayler, L. Semetse, P. Olubambi,* University of Johannesburg, South Africa

Prosthetic hip joints are nowadays common issues due to people aging. Restoring gait is a heath issue from the patient benefits and the economical one. Due to taper junction manufacturing process some corrosion and fretting corrosion (friction under small displacements, lower than 100 micrometers) issues are appearing concerning the implants lifetime. In this study we are suggesting a not well used representation concerning the efficiency of connections under fretting corrosion solicitations. The usual wear volume vs. Dissipated energy might be investigated but highlighting protective coatings is failing. Wear volume vs. open circuit potential drop (first hundred seconds of fretting) is classifying clearly every coating on metallic material. However another issue is coming related to stick/slip during the fretting process. Finally the wear volume is replaced by the A ratio, dissipated energy over total energy. When some stick, even under high normal load, is occurring, A ratio is decreasing and there is no relative displacement between materials in contact. Various combinations of materials/coatings have been investigated and the evolutions seem evoluate consistently. Some improvements are needed to confirm the tendency.

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