Abstract

Total hip replacement surgery is currently one of the fastest growing medical procedures in the United States and around the world. The permanent nature and long lifetimes of hip replacements require materials with excellent mechanical properties and biocompatibility. Cobalt-chromium-molybdenum (CoCrMo) alloys with the addition of carbon were previously determined to be suitable for hip replacements. However, this material is susceptible to corrosion due to tribological events such as joint movements and their constant exposure to corrosive body fluids. These degradation processes, which release nanoscale metallic debris particles and toxic ions into the body, do not only pose health complications but also reduce the lifetime of implants. Since there is currently a large number of patients with CoCrMo implants installed, it is critical to gain a fundamental understanding of corrosion in CoCrMo alloys, which would in turn improve their applications.

In this work, electrochemically corroded CoCrMo alloy samples were analyzed from the millimeter to nanometer scale in order to understand how different grain boundary properties impact the *in vivo* performance of the alloy. This was achieved by correlating coincidence site lattice geometry and chemical composition to localized corrosion properties. Using high-resolution transmission electron microscopy and energy dispersive X-ray spectroscopy, it is shown that higher magnitudes of chromium depletion and larger carbide precipitates are observed with increasing grain boundary interfacial energy. Additionally, the microscale morphology of corrosion crevices reveals that crevice corrosion had occurred at the crevices initiated by grain boundary sensitization. The conclusions presented can help refine the processing procedures in order to engineer higher performance CoCrMo alloys for biomedical applications.