Tribology and Corrosion in CoCrMo Alloys and Similar Systems

Emily E. Hoffman

The artificial hip is a rich environment for the tribologist. This research investigated tribology and corrosion in CoCrMo alloy hip implants and extended the characterization methods and analyses to similar systems. The first project examined differences in corrosion behavior in the biomedical CoCrMo alloy using TEM and EDS. At the corroding grain boundaries, we found nanoscale chromium-rich carbides. These carbides caused chromium depleted zones which leads to corrosion, a process commonly referred to as sensitization. The chromium depletion and grain boundary crystallography data were used to develop a model showing nanoscale sensitization initiated grain boundary crevice corrosion. The next area of research looked at nanotribology of solid lubricants and formation of tribolayers. In situ TEM was used to directly observe the sliding interface of nanoflakes of molybdenum disulfide. Investigating low friction mechanisms of the lamellar solid lubricant revealed that the deck-of-cards sliding assumption present in the literature was not true. Instead, we showed sliding and transfer layer formation occurred at one interface only. The in situ sliding tests also revealed that the nanoflakes are unstable during sliding due to rolling, reorientation, flake pull apart, and adhesion changes. The final project analyzed a variety of carbon tribofilms, including the tribolayer found in metal-on-metal hips and the varnish tribofilm that forms in industrial machines. We characterized the carbon varnish film and showed similarities to published work on other graphitic carbon films. By comparing the nanoscale bonding and formation mechanisms, striking similarities were found that could inspire future cross-discipline advancements. Together, this work examined the relationships between wear, corrosion, and tribology to connect nanoscale structure and composition to applied performance.