Abstract

AA 7XXX alloys are used extensively in aircraft and naval structures due to their excellent strength to weight ratio. These alloys are often exposed to harsh corrosive environments and mechanical stresses that can compromise their reliability in service. They are also coupled with fasteners that are composed of different materials such as Titanium alloys. Such dissimilar metal contact facilitates galvanic and crevice corrosion, which can further reduce their lifetimes. Despite decades of research in the area, the confluence of mechanical, microstructural, and electrochemical aspects of damage is still unclear. Traditionally, 2D and destructive methods have often been employed to study the corrosion and cracking behavior in these systems which can be severely limiting and lead to inaccurate conclusions. This dissertation is aimed at comprehensively studying the corrosion and cracking behavior of these systems using time-dependent 3D microstructural characterization, as well as correlative microscopy. The microstructural evolution of corrosion in AA 7075 was studied using a combination of potentiodynamic polarization, x-ray microtomography (XCT) and Transmission X-ray Microscopy (TXM). In both experiments, a strong emphasis was placed on studying localized corrosion attack at constituent particles and intergranular corrosion. This was achieved through the use of x-ray microtomography and a suite of electron microscopy techniques. With an understanding of the alloy’s corrosion behavior, a dissimilar alloy couple comprising AA 7075 / Ti-6Al-4V was then investigated. Ex situ and in situ x-ray microtomography was used extensively to investigate the evolution of pitting corrosion and corrosion fatigue in AA 7075 plates fastened separately with Ti-6Al-4V screws and rivets. The 4D tomography combined with the extensive fractography yielded valuable information pertaining the preferred sites of pit initiation, crack initiation and growth in these complex geometries. The use of correlative microscopy-based methodologies yielded multimodal characterization results that provided a unique and seminal insight on corrosion mechanisms in these materials.