Materials Science and Engineering Doctoral Defense

Environmental-Induced Damage in Tin (Sn) and Aluminum (Al) Alloys

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abstract

Sn and Al alloys are widely used in various industries. Environmental-induced damage resulting in whiskering in Sn and corrosion in Al account for numerous failures globally every year. Therefore, for designing materials that can better withstand these failures, a comprehensive study on the characterization of the damage is necessary. This research implements advanced characterization techniques to study the above-mentioned environmental-induced damage Sn and Al alloys.

Tin based films are known to be susceptible to whisker growth resulting in numerous failures. While the mechanisms and factors affecting whisker growth have been studied extensively, not much has been reported on the mechanical properties of tin whiskers themselves. This study focuses on the tensile behavior of tin whiskers. Tensile tests of the whiskers were conducted in situ a dual beam focused ion beam (FIB) with a scanning electron microscope (SEM) using a micro electro-mechanical system (MEMS) tensile testing stage. The deformation mechanisms of whiskers were analyzed using transmission electron microscopy (TEM).

Due to the heterogenous nature of the microstructure of Al 7075, it is susceptible to corrosion forming corrosion products and pits. These can be sites for cracks nucleation and propagation resulting in stress corrosion cracking (SCC). Therefore, complete understanding of the corrosion damaged region and its effect on the strength of the alloy is necessary. Several studies have been performed to visualize pits and understand their effect on the mechanical performance of Al alloys using two-dimensional (2D) approaches which are often inadequate. To get a thorough understanding of the pits, it is necessary for three-dimensional (3D) studies. In this study, Al 7075 alloys were corroded in 3.5 wt.% NaCl solution and X-ray tomography was used to obtain the 3D microstructure of pits enabling the quantification of their dimensions accurately. Furthermore, microstructure and mechanical property correlations helped in a better understanding of the effect of corrosion. Apart from the pits, a surface corrosion layer also forms on Al. A subsurface damage layer has also been identified that forms due to the aggressive nature of NaCl. Energy dispersive X-ray spectroscopy (EDX) and nanoindentation helped in identifying this region and understanding the variation in properties.

April 13, 2017; 12:30PM; ERC 490