Abstract

Solid-state and non-equilibrium processings are of great interest to researchers due to their ability to control and refine the bulk and/or surface microstructure of metallic alloys and push them to surpass their conventional properties limit. In this dissertation, solid-state processing i.e., Shear Assisted Processing and Extrusion (ShAPE), and non-equilibrium processes i.e., surface mechanical attrition (SMAT) and additive manufacturing (AM) techniques were used to process the magnesium and aluminum alloys respectively. A synergistic investigation of processing-induced microstructural modification and its effect on corrosion resistance was performed using various ex-situ, quasi in-situ, and in-situ electrochemical, microscopy, and spectroscopy characterization techniques. To evaluate the effect of the same processing condition on a range of microstructures, a variety of magnesium alloys such as AZ31B, Mg-3Si, ZK60, and Pure Mg were processed using a novel solid-state processing method, namely ShAPE. It induced a significant grain refinement, homogenized distribution of second phases, and low residual strain in AZ31B alloy, which contributed toward a noble breakdown potential, stable protective film, and hence better corrosion resistance compared to the parent extruded counterpart. However, with variations in composition, volume fraction, and distribution of second phases with Mg-3Si and ZK60 magnesium alloy an opposite response was inferred indicating a strong dependence of corrosion on underlying microstructure compared to a processing condition. Non-equilibrium processes, i.e. SMAT and AM were utilized to process high-strength 7xxx series aluminum alloys. Continuous high energy impacts of hard balls in room temperature (RT SMAT) and liquid nitrogen (LN2 SMAT) flow environment generated a gradient nanocrystalline surface layer with the dissolution of inherent second phase and precipitation of new phases in aluminum 7075 alloys. RT SMAT showed a reduced anodic dissolution rate and improved film resistance, which was attributed to the thicker and composite oxide layer along with new nanoscale precipitates. Lastly, reactive AM was used to process aluminum 7075 and 7050 alloys which resulted in a refined and textureless microstructure. A reduction in corrosion resistance was observed with precipitation of excessive reactive particles (Ti and B4C) in AM alloys compared to wrought counterparts. Overall, this work helps advance the current understanding of corrosion behavior in lightweight alloys processed via novel processing techniques and aids in developing design strategies for engineering corrosion-resistant materials.