# Materials Science & Engineering Doctoral Defense

## Corrosion and Passivation of Mg-Al and Ni-Cr Alloys

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## abstract

In this dissertation, micro-galvanic corrosion effects and passivation behavior of single-phase binary alloys have been studied in order to formulate new insights towards the development of “stainless-like” lightweight alloys. As a lightweight material of interest, Mg-xAl alloys were studied using aqueous free corrosion, atmospheric corrosion, dissolution rate kinetics, and ionic liquid dissolution. Polarization and “accelerated” free corrosion studies in aqueous chloride were used to characterize the corrosion behavior and morphology of alloys. Atmospheric corrosion experiments revealed surface roughness and pH evolution behavior in aqueous environment. Dissolution in absence of water using choline-chloride:urea ionic liquid allowed for a simpler dissolution mechanism to be observed, providing additional insights regarding surface mobility of Al. These results were compared with commercial alloy (AZ31B, AM60, and AZ91D) behavior to better elucidate effects associated with secondary phases and intermetallic particles often present in Mg alloys. Aqueous free corrosion, “accelerated” free corrosion and ionic liquid dissolution studies have confirmed Al surface enrichment in a variety of morphologies, including Al-rich platelet and Al nanowire formation. This behavior is attributed to the preferential dissolution of Al as the more “noble” element in the matrix. Inductively-coupled mass spectroscopy was used to measure first-order rate reaction constants for elemental Mg and Al dissolution in aqueous chloride environment to be $k_{Mg}=1.653*10^{-6} \pm 1.079*10^{-7}\ s^{-1}$ and $k_{Al}=2.103*10^{-6} \pm 1.9*10^{-7}\ s^{-1}$ for future implementation in kinetic Monte Carlo simulations. To better understand how “stainless-like” passivation may be achieved, Ni-xCr alloys were studied using polarization and potential pulse experiments. The passivation potential, critical current density, and passivation current density were found to decay with increasing Cr composition. The measured average number of monolayers dissolved during passivation was found to be in good agreement with percolation theory, with a fitted 3-D percolation threshold of $p_c^{3D}=0.152 \pm 0.025$ compared with the theoretical value of 0.137. Using these results, possible approaches towards achieving passivation in other systems, including Mg-Al, are discussed.

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