Study on the crystallographic orientation dependent electrochemical corrosion rates of aluminum and its binary alloys

Haini Jin[1]

[1]*Author's affiliation and full address: School of Materials Science and Engineering, Kunming University of Science and Technology, 253, Xuefu Road, Kunming 650093, PR China*

Presenter's e-mail address: jinhaini7@163.com

Abstract

This work provides a study for crystallographic orientation dependent electrochemical corrosion rate of aluminum employing an ab initio model with inputs from first-principles calculations. Results show that the sequence of electrochemical corrosion rate is in the order of (111) < (410) < (331) < (221) < (321) < (211) < (110) < (100) < (210) < (320) < (310) < (311) for aluminum under marine environment. The predicted corrosion current densities for (111), (110) and (100) surfaces are in agreement with the previous experimental studies. The lowest corrosion current density of (111) surface is due to its lowest surface energy density and highest free energy of adsorbed hydrogen atom. The electron back-scattered diffraction analysis and atomic force microscope assessment of pure aluminum were carried out to further evaluate the corrosion resistance for surfaces of different crystallographic orientation. The effects of alloying on electrochemical corrosion rate are further investigated employing this model with results validated via the polarization curves of alloyed aluminum. Commonly used alloying additions of Si and Mg were chosen to verify the theoretical prediction. This study could predict the corrosion behavior of different binary Al alloys, provide theoretical guidance for screening effective additive elements to improve the corrosion resistance and is expected to accelerate the design of corrosion-resistant Al alloys.

Keywords

Aluminum; Electrochemical corrosion; Corrosion current density; Corrosion rate; First-principles calculations