MONTANA STATE UNIVERSITY
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"Investigation into the influence of surface and microstructural characteristics on the corrosion behavior of metallic materials through advanced materials characterizations"

Abstract: Corrosion of metallic materials is a persistent issue that causes industries worldwide to suffer immense financial losses, yet the underlying principles of corrosion are still not fully understood. As a result, predicting and preventing it remains a challenge. This dissertation focuses on how key material properties such as microstructural features, surface topography and surface work function affect the degradation behavior of metallic materials during both abiotic and microbial corrosion. It also aims to develop streamlined strategies to mitigate corrosion by modifying these properties. Three complementary studies were conducted in this regard. The first study examined the effects of varying surface roughness of copper on microbiologically influenced corrosion (MIC) by a model sulfate-reducing bacterium, *Oleisdevibrio alaskensis* G20, under anaerobic conditions using microscopic, spectroscopic, and surface characterization techniques. The second study focused on modifying the microstructure of copper to increase the fraction of special low-energy Σ3 grain boundaries by optimizing heat-treatment parameters and investigating their influence on corrosion behavior. The third study employed a novel characterization method to identify corrosion-susceptible regions on metallic surfaces by mapping work function variations using a state-of-the-art scanning auger nanoprobe.
The studies revealed that a reduction of up to 75% in MIC rate was achieved by modifying the surface roughness of pure copper coupons during anaerobic biotic exposure. Also, microstructural modification by increasing the special grain boundary fraction through annealing reduced the corrosion rate of copper by 32% compared to as-received copper and showed a more stable electrochemical behavior as well as developed a comparatively uniform and protective oxide film. The work function mapping using scanning auger nanoprobe was successfully employed to predict regions of preferential corrosion initiation in both multiphase 1018 carbon steel and single-phase pure copper coupons. By integrating microstructural optimization and surface characteristics, this dissertation provides a framework for corrosion mitigation strategies in metallic materials, spanning both fundamental research and applied materials design.

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