ABSTRACT

The crystallographic orientation of polycrystalline metallic materials is a well-known structural factor affecting corrosion and other electrochemical properties of many metals and alloys. However, previous investigations have often been limited to the testing of a few crystallographic planes. This practical limitation has led to unclear and often contradictory findings. Modern computational, metallurgical “crystal mapping” and corrosion surface “scanning” methods in combination can provide new insights regarding this phenomenon.

This talk focuses on understanding of the crystallographic controlled dissolution and surface faceting in disordered FCC Fe-Pd alloys. Electrochemical dissolution by congruent oxidation in 1 M HCl solution was strongly controlled by crystallographic orientation. Anodic dissolution was characterized over a wide variety of grain surface plane orientations providing a detailed view of the crystallographic nature of oxidative dissolution and surface facet evolution as a function of grain orientation. Near {100} oriented grains retained low surface roughness after corrosion and low dissolution rates. Grains with orientation within 2° of {111} were also topographically smooth after dissolution and were nearly as corrosion resistant as {100} grains. Overall dissolution depth depended linearly on crystallographic angle within 40° of {100} and within 10° of {111} planes. Post corrosion surface faceting and dissolution were substantially increased at grain orientations near {110} and were highest between 10 and 20° from the {111} plane normal. Grains at these crystallographic angles roughened during oxidative dissolution by forming complex semi-periodic topographies. These finely spaced arrays of terraces and ledges likely consisted of combinations of more corrosion resistant low index planes. Therefore, the overall corrosion depth within a grain possessing an initially irrational crystal orientation was determined by the amount of dissolution required to expose new, slowly dissolving surface facets with low index orientations. Computation of Fe-Pd alloy surface energies as a function of crystal orientation are utilized to help support this explanation.
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