Insight into the influence of cold deformation on microstructural evolution and corrosion behavior of novel Zr-based alloys in a proton exchange membrane water electrolysis environment

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Abstract This study investigated the impact of cold deformation reduction on the corrosion behavior of $Zr_{50}Ti_{25}Nb_{25}$ alloys in a simulated proton exchange membrane water electrolysis environment. The result indicated that cold deformation did not alter the phase structure of alloys, but increased dislocation density proportional to the deformation degree. The geometrically necessary dislocations reached approximately 1.194×10^{16} m^{-2} at a 70% cold deformation reduction. The presence of high-density low-angle grain boundaries within heavily deformed grains suggested incomplete recrystallization. Electrochemical tests confirmed that cold deformation negatively affected the corrosion resistance of $Zr_{50}Ti_{25}Nb_{25}$ alloys in the simulated proton exchange membrane water electrolysis environment. At a maximum reduction in cold deformation, the passive current density was about 2.971×10^{-5} A/cm^2. The donor concentration of the passive films behaved as n-type were on the order of 10^{20} cm^{-3} and increased with the enhancement of cold deformation reduction. X-ray photoelectron spectroscopy analysis indicated that the reduced resistance of the passive film to corrosion could be attributed to a decrease in oxide content, particularly ZrO_2, which fell below 50% after deformation. Cold deformation increased dislocation density, creating potential initiation sites for pitting corrosion. This heightened dislocation density hindered the formation of a stable passive film, resulting in diminished corrosion resistance.

Keywords Cold deformation, Microstructure, Zr-based alloys, Electrochemical corrosion behavior

Reference

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