Nanophase Nickel-Zirconium Alloys for Fuel Cells

Corrosion resistance can be achieved at lower cost.

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Nanophase nickel-zirconium alloys have been investigated for use as electrically conductive coatings and catalyst supports in fuel cells. Heretofore, noble metals have been used because they resist corrosion in the harsh, acidic fuel-cell interior environments. However, the high cost of noble metals has prompted a search for less-costly substitutes.

Nickel-zirconium alloys belong to a class of base metal alloys formed from transition elements of widely different d-electron configurations. These alloys generally exhibit unique physical, chemical, and metallurgical properties that can include corrosion resistance. Inasmuch as corrosion is accelerated by free-energy differences between bulk material and grain boundaries, it was conjectured that amorphous (glassy) and nanophase forms of these alloys could offer the desired corrosion resistance.

For experiments to test the conjecture, thin alloy films containing various proportions of nickel and zirconium were deposited by magnetron and radio-frequency co-sputtering of nickel and zirconium. The results of x-ray diffraction studies of the deposited films suggested that the films had a nanophase and nearly amorphous character.

For tests of corrosion resistance, films of these alloys were deposited on graphite foils to form working electrodes. In each test, the working electrode was immersed in a 2 N sulfuric acid solution and polarized at a succession of potentials in range of 0.05 to 0.75 V versus a normal hydrogen electrode. The steady-state current sustained by the working electrode was monitored at one test, part of a nickel foil was coated with this alloy, then the foil was immersed in sulfuric acid for 48 hours. At the end of the test, the alloy coat remained shiny, while the uncoated part of the foil had become corroded. For another test, a thin film of the alloy was incorporated as a catalyst-support layer in an anode in a fuel cell. The fuel cell was then operated at a temperature of 90 °C for several tens of hours. The fuel cell exhibited stable current densities, indicating that the alloy is stable under fuel-cell operating conditions.

This work was done by Christopher Della-Corte of Glenn Research Center and Malcolm K. Stanford of the University of Dayton. Further information is contained in a TSP (see page 1).

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