Iridium-Doped Ruthenium Oxide Catalyst for Oxygen Evolution

Possible applications of this catalyst include fabrication of water electrolysis units in hydrogen generators.

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NASA requires a durable and efficient catalyst for the electrolysis of water in a polymer-electrolyte-membrane (PEM) cell. Ruthenium oxide in a slightly reduced form is known to be a very efficient catalyst for the anodic oxidation of water to oxygen, but it degrades rapidly, reducing efficiency. To combat this tendency of ruthenium oxide to change oxidation states, it is combined with iridium, which has a tendency to stabilize ruthenium oxide at oxygen evolution potentials. The novel oxygen evolution catalyst was fabricated under flowing argon in order to allow the iridium to...
Dispersion-strengthened molybdenum-rhenium alloys for vacuum plasma spraying (VPS) fabrication of high-temperature-resistant components are undergoing development. In comparison with otherwise equivalent non-dispersion-strengthened Mo-Re alloys, these alloys have improved high-temperature properties. Examples of VPS-fabricated high-temperature-resistant components for which these alloys are expected to be suitable include parts of aircraft and spacecraft engines, furnaces, and nuclear power plants; wear coatings; sputtering targets; x-ray targets; heat pipes in which liquid metals are used as working fluids; and heat exchangers in general. These alloys could also be useful as coating materials in some biomedical applications.

The alloys consist of 60 weight percent Mo with 40 weight percent Re made from (1) blends of elemental Mo and Re powders or (2) Re-coated Mo particles that have been subjected to a proprietary powder-alloying-and-spheroidization process. For most of the dispersion-strengthening experiments performed thus far in this development effort, 0.4 volume percent of transition-metal ceramic dispersoids were mixed into the feedstock powders. For one experiment, the proportion of dispersoid was 1 volume percent. In each case, the dispersoid consisted of either ZrN particles having sizes <45 µm, ZrO₂ particles having sizes <1 µm, HfO₂ particles having sizes of about 1 µm, HfN particles having sizes <45 µm, or HfO₂ particles preferentially react with oxygen from the ruthenium oxide, and not oxygen from the environment.

Nanoparticulate iridium black and anhydrous ruthenium oxide are weighed out and mixed to 5–18 atomic percent. They are then heat treated at 300 °C under flowing argon (in order to create an inert environment) for a minimum of 14 hours. This temperature was chosen because it is approximately the creep temperature of ruthenium oxide, and is below the sintering temperature of both materials. In general, the temperature should always be below the sintering temperature of both materials. The iridium-doped ruthenium oxide catalyst is then fabricated into a PEM-based membrane-electrode assembly (MEA), and then mounted into test cells.

The result is an electrolyzer system that can sustain electrolysis at twice the current density, and at the same efficiency as commercial catalysts in the range of 100–200 mA/cm². At 200 mA/cm², this new system operates at an efficiency of 85 percent, which is 2 percent greater than commercially available catalysts. Testing has shown that this material is as stable as commercially available oxygen evolution catalysts. This means that this new catalyst can be used to regenerate fuel cell systems in space, and as a hydrogen generator on Earth.

This work was done by Thomas I. Valdez, Sri R. Narayan, and Keith J. Billings of Caltech for NASA’s Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).

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