DOE Hydrogen Program

Nitrided Metallic Bipolar Plates

Cost-Effective Metallic Bipolar Plates Through Innovative Control of Surface Chemistry

Background

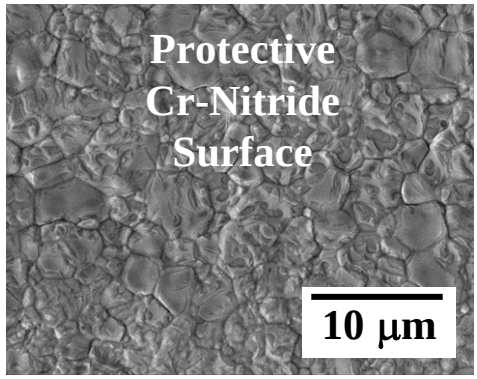
The goal of the effort is to scale up and demonstrate the technological and economic viability of thin (≤ 0.1 mm) stamped metallic bipolar plates protected by a thermal (gas) nitridation surface treatment. In this approach, an electrically-conductive and corrosion-resistant Cr-nitride surface layer is formed on the bipolar plate component by heating a specially designed bipolar plate alloy to high temperatures in a nitrogen-containing environment. The alloy compositions of interest are in the range of Fe-(15-27)Cr-(0.5-6)V wt.%.

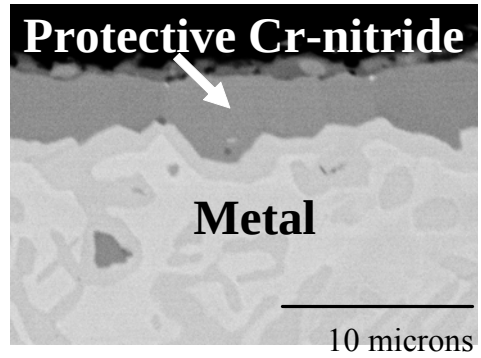
To accomplish this, a multi-organization national laboratory-university-industry team has been assembled. Oak Ridge National Laboratory (ORNL) will lead efforts for optimization of alloy composition and nitridation conditions to meet DOE bipolar plate performance and cost goals, with supporting characterization studies of corrosion resistance, electrical properties, and single cell behavior performed by National Renewable Energy Laboratory (NREL) and Arizona State University (ASU). Fuel cell stack testing will be conducted by Los Alamos National Laboratory (LANL). To establish the basis for commercial viability and availability, an alloy producer, Allegheny Ludlum Corp. will cast and manufacture developmental alloys into light gage alloy foil suitable for stamping. A metal bipolar plate manufacturer, GenCell Corp, will stamp the alloy foil into bipolar plates for subsequent nitridation and fuel cell stack testing.

Technology

Proof of principle for the nitridation approach was established with model Ni-Cr base alloys readily amenable to Cr-nitride surface layer formation. Nitrided model alloy plates were subjected to cyclic single-cell fuel cell testing at LANL (~1100 h, using a cycle of 0.94 V for 1 min, 0.60 V for 30 min, 0.70 V for 20 min, and 0.50 V for 20 min).

Stamped metallic bipolar plate (courtesy of GenCell Corporation, Southbury, CT)





Surface and cross-section views showing thermally nitrided surface of Ni-50Cr

An additional 24 full shutdowns (cell cooled off, gases removed, opened to air at connections) were superimposed in an attempt to induce even more aggressive conditions. No loss of performance was observed; in fact, performance slightly increased during testing. Nickel-base alloys are too expensive for many PEMFC applications. The current effort is therefore focused on nitridation of Fe-Cr base stainless steels, which have the potential to meet bipolar plate cost targets.

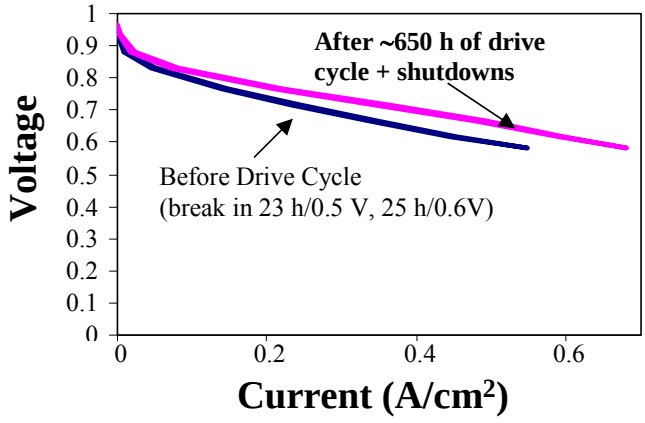


Plate performance increases after cycling

Benefits

- Nitridation forms protective, pin-hole defect free nitride surface coatings
- Stamping and nitriding are industrially established manufacturing techniques
- Thin metallic bipolar plates translate into high power density fuel cell stacks of interest for automotive applications
- Materials and manufacturing methods are low cost and can deliver power at Program goal of $11/kW

Points of Contact
Michael P. Brady, 865-574-5153, bradymp@ornl.gov
T. Armstrong, 865-574-7996, armstrongt@ornl.gov