V.B.2 Nitrided Metallic Bipolar Plates

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- ATI Allegheny Ludlum, Brackenridge, PA
- GenCell Corporation, Southbury, CT

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Objectives

- Optimize stainless steel alloys amenable to formation of a protective Cr-nitride surface by gas nitridation, at a sufficiently low cost to meet DOE targets and with sufficient ductility to permit manufacture by stamping.
- Demonstrate capability of nitridation to yield high-quality stainless steel bipolar plates from thin stamped alloy foils.
- Demonstrate single-cell fuel cell behavior of stamped and nitrided metallic bipolar plates equivalent to that of graphite.
- Complete testing of a 10-cell, 250 cm^2 active area fuel cell stack utilizing stamped and nitrided metallic bipolar plates.

Technical Barriers

This project addresses the following technical barriers from the Fuel Cells section of the Hydrogen, Fuel Cells and Infrastructure Technologies Program Multi-Year Research, Development and Demonstration Plan:

(A) Durability
(B) Cost
(C) Performance

Technical Targets Relevant for Metallic Bipolar Plates

Characteristic	2010 Goal	Status
Corrosion Current Density	$<1\ \mu A/cm^2$	[1]Met in pH3 H_2SO_4, 80°C, ~0.9 V vs. SHE
Contact Resistance	$<10\ m\Omega cm^2$	[1]Met at ~100-150 N/cm^2
Durability	>5,000-hour stack lifetime under drive cycle conditions	[2]Successful 1,160-hour single-cell test under drive cycle conditions (model nitrided Ni-Cr base alloy)
Cost	\$5/kW: Translates to metal plate ~\$5-7/lb alloy, 0.1 mm thick, 500 cm^2 total plate area and 0.05 mm cooling foil	In progress for low cost, ductile Fe-Cr-V base alloys amenable to stamping.

[1] Met with model Fe-27Cr-6V wt% alloy. Lower Cr and V levels needed to meet cost and manufacturability goals
[2] Met with model Ni-Cr base alloy

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Approach

The goal of this 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. Proper selection of bipolar plate alloy composition and nitridation conditions can yield a pin-hole free, electrically conductive and corrosion resistant Cr-nitride-based protective surface layer. Testing to date for nitrided model alloys indicates that thermally grown Cr-nitride base surfaces exhibit excellent corrosion resistance and maintain low contact resistance in proton exchange membrane fuel cell environments, and have the potential to meet the DOE 5000-hour durability goals for automotive applications [1]. The effort will focus on Fe-base stainless steel alloys with Cr levels of 15-25 wt% (weight percent) and V levels of 0.5-4 wt% to help form the protective Cr-nitride surface layer.

Ferritic, austenitic, and duplex stainless steel alloy bases will be investigated in order to co-optimize alloy ductility (to increase suitability for stamping) and cost.

Planned Activities

Oak Ridge National Laboratory will lead efforts for optimization of an inexpensive and ductile Fe-Cr base 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 the National Renewable Energy Laboratory and Arizona State University. Fuel cell stack testing will be conducted by Los Alamos National Laboratory. A stainless steel alloy producer, ATI 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 (Figure 1). By teaming with an alloy manufacturer and a metallic bipolar plate component supplier, the basis will be established to make the technology developed under this project commercially available to all interested fuel cell developers and end users.

FIGURE 1. Stamped Metallic Bipolar Plate (After Reference 1, Courtesy of GenCell Corp.)

References

1. M.P. Brady, B.Yang, H. Wang, J.A. Turner, K.L. More, M. Wilson, and F. Garzon, “Formation of Protective Nitride Surfaces for PEM Fuel Cell Metallic Bipolar Plates”, JOM, pp. 50-57, August 2006.