



## Apparatus for Screening Multiple Oxygen-Reduction Catalysts

Multiple specimens are tested simultaneously at equal potential in the same solution.

NASA's Jet Propulsion Laboratory, Pasadena, California

An apparatus that includes an array of multiple electrodes has been invented as a means of simultaneously testing multiple materials for their utility as oxygen-reduction catalysts in fuel cells. The apparatus ensures comparability of test results by exposing all the catalyst-material specimens to the same electrolytic test solution at the same potential. Heretofore, it has been possible to test only one specimen at a time, using a precise rotating disk electrode that provides a controlled flux of solution to the surface of the specimen.

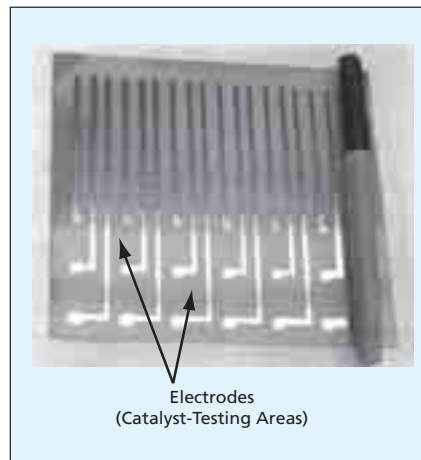
For each set of catalytic materials to be tested, the electrodes and their current collectors (see figure) are fabricated as gold-film patterns on a flexible poly(vinylidene fluoride) substrate that is typically a fraction of a millimeter thick. The electrode areas measure 5 by 5 mm. The electrode areas are coated with thin films of the catalytic materials to be tested. The chemical compositions of these films are established in a combinatorial deposition process: The films are sputter-deposited simultaneously onto all the electrodes from targets made of different materials at different positions relative to the array. Hence, the composition of the deposit on each electrode is unique, dependent on its position. The composition gradi-

ent across the area of the array and, hence, the variations among compositions of deposits on the electrodes, can be tailored by adjusting the target/substrate geometry and the relative target powers.

The resulting flexible electrode fixture is placed on the inside wall of a 20-cm-diameter vertical cylindrical container with the electrodes facing inward. The current collectors are connected to the input terminals of a multichannel potentiostat. The container is filled with electrolyte solution. In operation, oxygen is bubbled through the solution and the solution is stirred rapidly (e.g., by use of a conventional propeller/impeller or a magnetic stirrer) to maintain a laminar flow of consistently oxygenated solution over the electrodes. During operation, the multichannel potentiostat simultaneously measures the currents generated at all the electrodes as functions of an applied bias voltage. Typically, the voltage is varied in a slow potentiodynamic scan.

*This work was done by Jay Whitacre and Sekharipuram Narayanan of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).*

*In accordance with Public Law 96-517, the contractor has elected to retain title to this*



This Array of Eighteen Gold Electrodes and current collectors was fabricated on a 0.5-mm-thick PVDF sheet. Each electrode is coated with a different catalytic material to be tested.

*invention. Inquiries concerning rights for its commercial use should be addressed to:*

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## Determining Aliasing in Isolated Signal Conditioning Modules

Input anti-aliasing filters eliminate rogue frequencies that cause aliasing.

Dataforth Corporation, Tucson, Arizona

Within a digital world, the parameters of real-world information (temperature, voltage, current, speed, flow, pressure, distance, etc.) used for process communications and control are analog in nature. Processing this information is achieved primarily using digital signal processing techniques. The age of microelectronics has made it possible for digital processing power to be extended into the field where sensors are located; thus, much preprocess-

ing can be accomplished outside the main computer or PC.

There are many issues that can create serious problems along the way, such as EMI noise, grounding, accuracy, resolution, aging, drift, isolation, and noisy power supplies. In addition, there is one very subtle problem that often goes unnoticed but can lurk in the background. Known as aliasing, this problem exists in isolated signal conditioning modules

(SCMs) and anywhere an analog-to-digital converter is active.

The basic concept of aliasing is this: Converting analog data into digital data requires sampling the signal at a specific rate, known as the sampling frequency. The result of this conversion process is a new function, which is a sequence of digital samples. This new function has a frequency spectrum, which contains all the frequency com-

ponents of the original signal. The Fourier transform mathematics of this process show that the frequency spectrum of the sequence of digital samples consists of the original signal's frequency spectrum plus the spectrum shifted by all the harmonics of the sampling frequency. If the original analog signal is sampled in the conversion process at a minimum of twice the highest frequency component contained in the analog signal, and if the reconstruction process is limited to the highest frequency of the original signal, then the reconstructed signal accu-

rately duplicates the original analog signal. It is this process that can give birth to aliasing.

To illustrate, consider a time function signal consisting of two sinusoids, one at 25 Hz, and the other expected to be at 180 Hz. This sampling process uses a sampling frequency of 400 Hz (which is greater than  $2 \times 180$  Hz) and the reconstruction process has a bandwidth limit of 200 Hz. The only frequency components that will appear in the conversion are 25 Hz and 180 Hz. However, if the original signal's highest frequency is not the expected 180 Hz but 213 Hz, a reconstructed signal consisting

of 25 Hz and 187 Hz (400-213) will result. The 213-Hz signal component appears in the output as the 187-Hz component (187 Hz "alias" 213 Hz).

Since all signal conditioning modules that provide isolation typically use some form of analog sampling conversion process to move analog information across an isolation barrier, it is critical for system engineers to examine their application carefully to determine whether aliasing can occur.

*This work was done by Dataforth Corporation. For more information, visit <http://info.hotims.com/22914-122>.*

## Composite Bipolar Plate for Unitized Fuel Cell/Electrolyzer Systems

**A weight-saving design is applicable toward space missions, submarines, and high-altitude aircraft.**

*John H. Glenn Research Center, Cleveland, Ohio*

In a substantial improvement over present alkaline systems, an advanced hybrid bipolar plate for a unitized fuel cell/electrolyzer has been developed. This design, which operates on pure feed streams ( $H_2/O_2$  and water, respectively) consists of a porous metallic foil filled with a polymer that has very high water transport properties. Combined with a second metallic plate, the pore-filled metallic plates form a bipolar plate with an empty cavity in the center.

In electrolyzer mode, this cavity fills with water, which cools the stack, and provides the water for the electrolysis. The water passes through the polymer-filled pores under an RH gradient and feeds the electrolysis reaction. Under fuel-cell mode, the water is vacuumed out of the chamber with vacuum being continuously applied to remove water from the fuel-cell reaction. This evaporative cooling also provides heat removal from the stack.

At 80 °C, electrolyzer performance was superior to that of flowing water in the hydrogen chamber up to 400 mA/cm<sup>2</sup>. Above this current density, the membrane begins to dry out as water cannot be carried to the oxygen electrode fast enough. Similar behavior was seen when operating under fuel-cell mode. The current invention outperformed the traditional flow-through fuel cell up to 300 mA/cm<sup>2</sup>. Above this current density, the oxygen chamber begins to flood.

When operating in electrolyzer mode, the hybrid plate generates  $H_2$  and  $O_2$  at much lower water contents than traditional electrolysis cells. This greatly simplifies drying of the product gases. Because the water is the only product from the reaction, the feed gases can be operated under "dead-ended" conditions; thus, eliminating the need for saturation, recirculation, and water/gas separation systems for fuel-cell operation. In both fuel-cell and electrolyzer mode,

this advanced, unitized cell shows equal or superior performance to discreet systems. This design also allows for simple high-pressure operation with a high differential pressure.

Keeping all feed reactants and products in the vapor phase leads to a system simplification. This eliminates the biggest challenge to unitized systems (water management), allowing the weight savings of a second stack. A study has been carried out and has successfully demonstrated proof-of-concept. More design work has to be done to translate this concept into a full system.

*This work was done by Courtney K. Mittelsteadt and William Braff of Giner Electrochemical Systems, LLC for Glenn Research Center.*

*Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Innovative Partnerships Office, Attn: Steve Fedor, Mail Stop 4-8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-18269-1.*

## Spectrum Analyzers Incorporating Tunable WGM Resonators

**Resolutions would be much greater than those of current spectrum analyzers.**

*NASA's Jet Propulsion Laboratory, Pasadena, California*

A photonic instrument is proposed to boost the resolution for ultraviolet/optical/infrared spectral analysis and spectral imaging allowing the detection of narrow (0.00007-to-0.07-picometer wavelength resolution range) optical

spectral signatures of chemical elements in space and planetary atmospheres. The idea underlying the proposal is to exploit the advantageous spectral characteristics of whispering-gallery-mode (WGM) resonators to obtain spectral

resolutions at least three orders of magnitude greater than those of optical spectrum analyzers now in use. Such high resolutions would enable measurement of spectral features that could not be resolved by prior instruments.