



## Fuel Cells Utilizing Oxygen From Air at Low Pressures

Power-to-weight ratios would be higher than in prior fuel cells.

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

A fuel cell stack has been developed to supply power for a high-altitude aircraft with a minimum of air handling. The fuel cell is capable of utilizing oxygen from ambient air at low pressure with no need for compression. For such an application, it is advantageous to take oxygen from the air (in contradistinction to carrying a supply of oxygen onboard), but it is a challenging problem to design a fuel-cell stack of reasonable weight that can generate sufficient power while operating at reduced pressures.

The present fuel-cell design is a response to this challenge. The design features a novel bipolar plate structure in combination with a gas-diffusion structure based on a conductive metal core and a carbon gas-diffusion matrix. This

combination makes it possible for the flow fields in the stack to have a large open fraction (ratio between open volume and total volume) to permit large volumes of air to flow through with exceptionally low backpressure. Operations at reduced pressure require a corresponding increase in the volume of air that must be handled to deliver the same number of moles of oxygen to the anodes. Moreover, the increase in the open fraction, relative to that of a comparable prior fuel-cell design, reduces the mass of the stack.

The fuel cell has been demonstrated to operate at a power density as high as  $105 \text{ W/cm}^2$  at an air pressure as low as 2 psia (absolute pressure  $\approx 14 \text{ kPa}$ ), which is the atmospheric pressure at an altitude

of about 50,000 ft ( $\approx 15.2 \text{ km}$ ). The improvements in the design of this fuel cell could be incorporated into designs of other fuel cells to make them lighter in weight and effective at altitudes higher than those of prior designs. Potential commercial applications for these improvements include most applications now under consideration for fuel cells.

*This work was done by Alan Cisar, Chris Boyer, and Charles Greenwald of Lynntech, Inc., for Glenn Research Center.*

*Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Commercial Technology Office, Attn: Steve Fedor, Mail Stop 4-8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-17284-1.*

## Hybrid Ion-Detector/Data-Acquisition System for a TOF-MS

*John F. Kennedy Space Center, Florida*

A modified ion-detector/data-acquisition system has been devised to increase the dynamic range of a time-of-flight mass spectrometer (TOF-MS) that, previously, included a microchannel-plate detector and a data-acquisition system based on counting pulses and time-tagging them by use of a time-to-digital converter (TDC). The dynamic range of the TOF-MS was limited by saturation of the microchannel-plate detector, which can handle no more than a few million counts per second. The modified system includes (1) a combined microchannel plate/discrete ion multiplier and (2) a hybrid data-acquisition system that simultaneously performs analog

current or voltage measurements and multianode single-ion-pulse-counting time-of-flight measurements to extend the dynamic range of a TDC into the regime in which a mass peak comprises multiple ions arriving simultaneously at the detector. The multianode data are used to determine, in real time, whether the detector is saturated. When saturation is detected, the data-acquisition system selectively enables circuitry that simultaneously determines the ion-peak intensity by measuring the time profile of the analog current or voltage detector-output signal.

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*In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:*

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Refer to KSC-12619, volume and number of this NASA Tech Briefs issue, and the page number.*

## Spontaneous-Desorption Ionizer for a TOF-MS

*John F. Kennedy Space Center, Florida*

A time-of-flight mass spectrometer (TOF-MS) like the one mentioned in the immediately preceding article has been retrofitted with an ionizer based on a surface spontaneous-desorption

process. This ionizer includes an electron multiplier in the form of a microchannel plate (MCP). Relative to an ionizer based on a hot-filament electron source, this ionizer offers ad-

vantages of less power consumption and greater mechanical ruggedness. The current density and stability characteristics of the electron emission of this ionizer are similar to those of a

filament-based ionizer. In tests of various versions of this ionizer in the TOF-MS, electron currents up to 100 nA were registered. Currents of microamperes or more — great enough to satisfy requirements in most TOF-MS applications — could be obtained by use of MCPs different from those used in the tests, albeit at the cost of greater bulk. One drawback of this ionizer is that the gain of the MCP de-

creases as a function of the charge extracted thus far; the total charge that can be extracted over the operational lifetime is about 1 coulomb. An MCP in the ion-detector portion of the TOF-MS is subject to the same limitation.

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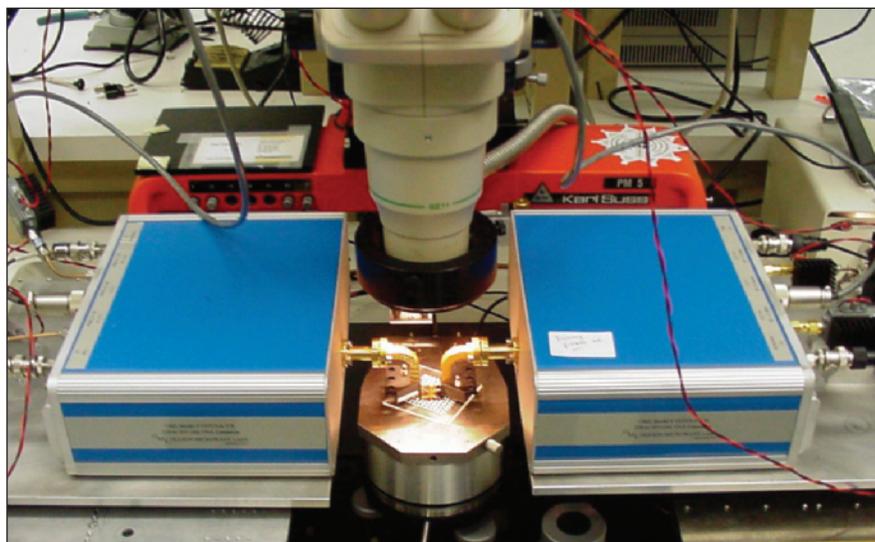
## Equipment for On-Wafer Testing From 220 to 325 GHz

**On-wafer vector network analysis of semiconductors is extended to higher frequencies.**

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A system of electronic instrumentation, constituting the equivalent of a two-port vector network analyzer, has been developed for use in on-wafer measurement of key electrical characteristics of semiconductor devices at frequencies from 220 to 325 GHz. A prior system designed according to similar principles was reported in "Equipment for On-Wafer Testing at Frequencies Up to 220 GHz" (NPO-20760), *NASA Tech Briefs*, Vol. 25, No. 11 (November 2001), page 42. As one would expect, a major source of difficulty in progressing to the present higher-frequency-range system was the need for greater mechanical precision as wavelengths shorten into the millimeter range, approaching the scale of mechanical tolerances of prior systems.

The system (see figure) includes both commercial off-the-shelf and custom equipment. As in the system of the cited prior article, the equipment includes test sets that are extended versions of commercial network analyzers that function in a lower frequency range. The extension to the higher frequency range is accomplished by use of custom frequency-extension modules that contain frequency multipliers and harmonic mixers. On-wafer measurement is made possible by waveguide wafer probes that were custom designed and built for this wavelength range,



**A Probe Station and Test Sets** assembled from commercial-off-the-shelf and custom components enable on-wafer measurement of electrical characteristics of devices in the previously inaccessible frequency range of 220 to 325 GHz.

plus an on-wafer calibration substrate designed for use with these probes. In this case, the calibration substrate was specially fabricated by laser milling. The system was used to make the first on-wafer measurements of a semiconductor device in the frequency range from 220 to 320 GHz. Some of the measurement results showed that the device had gain.

*This work was done by Lorene Samoska, Alejandro Peralta, Douglas Dawson, and Karen Lee of Caltech; Greg Boll of GGB Industries; and Chuck Oleson of Oleson Microwave Labs for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).  
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