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 accurately 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*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^2. 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^2. 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 Cortney 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.

Tunable single-mode WGM resonators would be incorporated into optical spectrum analyzers as shown in the block diagram in Figure 1. The center of the spectral window of the spectrum analyzer will be tuned to the carrier frequency of interest. The rough snapshot of the signal under study will be taken. After that, the WGM filter will be inserted in front of the spectrum analyzer. The internal scanning of the spectrum analyzer will be switched off, while the WGM filter will be scanned through the frequency window. The narrow-band spectral features of the signal will be resolved as the result. In particular, for the purpose of measuring abundances of selected isotopes (e.g., isotopes of carbon) in compounds in outer space and in atmospheres of Earth and other planets, an instrument equipped according to the proposal could measure narrow (width < 10 MHz) optical spectral signatures of compounds (e.g., CO_2) containing such isotopes.

The advantageous spectral characteristics of WGM resonators include high resonance quality factors (see Figure 2) and clean spectra. In addition, relative to other tunable optical resonators that have similar free spectral ranges and Q values, tunable single-mode WGM resonators can be tuned over wider frequency bands and exhibit much greater rejection ratios. A tunable single-mode WGM resonator incorporated into a spectrum analyzer according to the proposal would have a power consumption of no more than a few milliwatts, would have a mass of about 100 g, would have no moving parts, and could be operated autonomously. In addition to being key components of contemplated new high-resolution optical spectrum analyzers, tunable single-mode WGM resonators could be retrofit to current optical spectrum analyzers to improve their performances.

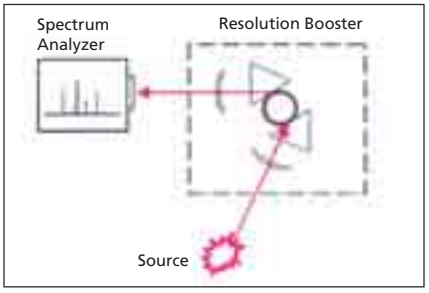

Figure 1. A **Resolution Booster** exploits the advantage of WGM resonators to increase spectral resolution at least three orders of magnitude.

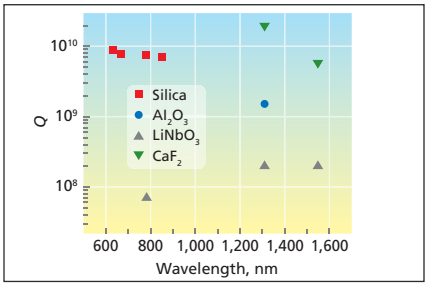

Figure 2. **These Resonance Quality Factors** (Q values) plotted versus wavelength were obtained from measurements on WGM resonators made of the indicated materials.

This work was done by Anatoliy Savchenkov, Andrey Matsko, Dmitry Strekalov, and Lute Maleki 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 invention. Inquiries concerning rights for its commercial use should be addressed to:

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Quantum-Well Thermophotovoltaic Cells

Conversion efficiencies more than twice those of prior thermophotovoltaic cells are expected.

Marshall Space Flight Center, Alabama

Thermophotovoltaic cells containing multiple quantum wells have been invented as improved means of conversion of thermal to electrical energy. The semiconductor bandgaps of the quantum wells can be tailored to be narrower than those of prior thermophotovoltaic cells, thereby enabling the cells to convert energy from longer-wavelength photons that dominate the infrared-rich spectra of typical thermal sources with which these cells would be used. Moreover, in comparison with a conventional single-junction thermophotovoltaic cell, a cell containing multiple narrow-bandgap quantum wells according to the invention can convert energy from a wider range of wavelengths. Hence, the invention increases the achievable thermal-to-electrical energy-conversion efficiency. These thermophotovoltaic cells are expected to be especially useful for extracting electrical energy from combustion, waste-heat, and nuclear sources having temperatures in the approximate range from 1,000 to 1,500 °C.

In its original form, the invention applies to the $In_xGa_{1-x}As$ ($0<x<1$)-and-InP material system. In principle, it is equally applicable to any narrow-bandgap semiconductor material system that is amenable to the growth of lattice-matched multiple quantum wells on suitable substrates. A cell according to the invention is best described with reference to the corresponding conventional $In_xGa_{1-x}As$ thermophotovoltaic cell, which is an electron-acceptor-doped/intrinsic/electron-donor-doped (p/i/n) $In_{0.47}Ga_{0.53}As$ cell lattice-matched to an InP substrate. In the cell according to the invention, instead of the intrinsic (undoped) region, there are multiple strained, lattice-matched, narrow-bandgap quantum wells comprising layers of $In_xGa_{1-x}As$ ($x>0.6$) interspersed with layers of $In_{0.47}Ga_{0.53}As$. It has been estimated that for black-body thermal sources having temperatures between 1,000 and 1,500 °C, the energy-conversion efficiencies of thermophotovoltaic cells according to the invention can be more than twice those of the corresponding conventional $In_xGa_{1-x}As$ thermophotovoltaic cells.

An appropriate choice of the number of quantum wells and the thicknesses of the individual quantum-well layers (typically of the order of a few nanometers) in conjunction with the selection of the quantum-well materials makes it possible to prevent the generation of lattice-mismatch crystal defects in the quantum-well layers. Thus, it is possible to prevent the degradation of crystalline quality and thereby prevent the consequent degradation of electronic performance associated with the fabrication of thicker conventional lattice-mis-