

will have its trajectory bent just enough to exit the back slit.

The SDEA units are compact, rectangular, and operate with low voltages. The units can be built up into small arrays. These arrays could be used either to widen the field of view or to sharpen an

existing one. This approach can also be used to obtain angular distributions in two planes simultaneously, thus cutting down the ion source power requirements in half. This geometry has enabled a new mass-spectrometer concept that can provide miniaturized mass spectrometers for

use in industrial plants, air-pollution monitoring, and noxious-gas detection.

*This work was done by Federico A. Herrero of Goddard Space Flight Center. For further information, contact the Goddard Innovative Partnerships Office at (301) 286-5810. GSC-15610-1*

## Polymeric Bladder for Storing Liquid Oxygen

*Lyndon B. Johnson Space Center, Houston, Texas*

A proposed system for storing oxygen in liquid form and dispensing it in gaseous form is based on (1) initial subcooling of the liquid oxygen; (2) containing the liquid oxygen in a flexible vessel; (3) applying a gas spring to the flexible vessel to keep the oxygen compressed above the saturation pressure and, thus, in the liquid state; and (4) using heat leakage into the system for vaporizing the oxygen to be dispensed. In a typical prior system based on these principles, the flexible vessel

is a metal bellows housed in a rigid tank, and the gas spring consists of pressurized helium in the tank volume surrounding the bellows. Unfortunately, the welds in the bellows corrugations are subject to fatigue, and, because bellows have large ullage, a correspondingly large fraction of the oxygen content cannot be expelled.

In the proposed system, the flexible vessel would be a bladder made of a liquid-crystal polymer (LCP). (LCPs are strong and compatible with liquid oxy-

gen.) In comparison with a metal bellows, a polymeric bladder would have less ullage and would weigh less. In experiments involving fatigue cycling at liquid-nitrogen temperatures, two LCPs were found to be suitable for this application.

*This work was done by David H. Walker, Andrew C. Harvey, and William Leary of Foster-Miller, Inc. for Johnson Space Center. For further information, contact the JSC Innovation Partnerships Office at (281) 483-3809. MSC-22943-1*

## Pyrotechnic Simulator/Stray-Voltage Detector

*John F. Kennedy Space Center, Florida*

The concept for a dual test item has been developed for use in simulating live initiators/detonators during ground testing to verify the proper operation of the safing and firing circuitry for ground and flight systems ordnance as well as continuous monitoring for any stray voltages. Previous ordnance simulators have consisted of fuses, flash bulbs, inert

devices with bridge wires, and actual live ordnance items mounted in test chambers. Stray voltage detectors have included devices connected to the firing circuits for continuous monitoring and a final no-voltage test just prior to ordnance connection. The purpose of this combined ordnance simulation and stray-voltage detection is to provide an

improved and comprehensive method to ensure the ordnance circuitry is verified safe and operational.

*This work was done by Terry Greenfield of ASRC Aerospace Corp. for Kennedy Space Center. For further information, contact the Kennedy Innovative Partnerships Program Office at (321) 861-7158. KSC-13282*

## Inventions Utilizing Microfluidics and Colloidal Particles

*Lyndon B. Johnson Space Center, Houston, Texas*

Several related inventions pertain to families of devices that utilize microfluidics and/or colloidal particles to obtain useful physical effects. The families of devices can be summarized as follows:

- Microfluidic pumps and/or valves wherein colloidal-size particles driven by electrical, magnetic, or optical fields serve as the principal moving parts that propel and/or direct the affected flows.
- Devices that are similar to the aforementioned pumps and/or valves ex-

cept that they are used to manipulate light instead of fluids. The colloidal particles in these devices are substantially constrained to move in a plane and are driven to spatially order them into arrays that function, variously, as waveguides, filters, or switches for optical signals.

- Devices wherein the ultra-laminar nature of microfluidic flows is exploited to effect separation, sorting, or filtering of colloidal particles or biological cells in suspension.

• Devices wherein a combination of confinement and applied electrical and/or optical fields forces the colloidal particles to become arranged into three-dimensional crystal lattices. Control of the colloidal crystalline structures could be exploited to control diffraction of light.

- Microfluidic devices, incorporating fluid waveguides, wherein switching of flows among different paths would be accompanied by switching of optical signals.

*This work was done by David W. M. Marr, Tieying Gong, John Oakey, Alexander V. Ter-ray, and David T. Wu of the Colorado School of Mines for Johnson Space Center. 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:*

*Colorado School of Mines  
Golden, CO 80401  
Refer to MSC-24160-1/1-1/2-1/3-1, volume and number of this NASA Tech Briefs issue, and the page number.*

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## RuO<sub>2</sub> Thermometer for Ultra-Low Temperatures

*Goddard Space Flight Center, Greenbelt, Maryland*

A small, high-resolution, low-power thermometer has been developed for use in ultra-low temperatures that uses multiple RuO<sub>2</sub> chip resistors. The use of commercially available thick-film RuO<sub>2</sub> chip resistors for measuring cryogenic temperatures is well known due to their low cost, long-term stability, and large resistance change.

To measure the resistance, a small excitation is applied across the sensor and the resistance is measured. At increased currents, a greater output signal is achieved, resulting in better sensitivity.

Problems including lowered resolution and sensitivity are found because of self-heating at temperatures below 100 mK when a single chip is used.

A new thermometer design uses multiple RuO<sub>2</sub> chip resistors and off-the-shelf bobbins. The chips would be configured in an array to spread the heat over a greater area during excitation. A technique was developed to connect the chips together, first in a 2×2 array, and finally in a 3×3 array. The 3×3 array configuration of the RuO<sub>2</sub> chips allows better internal heat distribution than a

single chip, thereby reducing self-heating. The uniqueness of this design is in the array configuration, which allows greater sensitivity at ultralow temperatures while keeping a small package footprint [about 0.4 in. (10 mm)]. The device uses a standard round bobbin with a #4 screw through-hole.

*This work was done by Thomas Hait, Peter J. Shirron, and Michael DiPirro of Goddard Space Flight Center. For further information, contact the Goddard Innovative Partnerships Office at (301) 286-5810. GSC-15690-1*

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## Ultra-Compact, High-Resolution LADAR System for 3D Imaging

*Lyndon B. Johnson Space Center, Houston, Texas*

An eye-safe LADAR system weighs under 500 grams and has range resolution of 1 mm at 10 m. This laser uses an adjustable, tiny microelectromechanical system (MEMS) mirror that was made in SiWave to sweep laser frequency. The size of the laser device is small (70×50×13 mm). The LADAR uses all the mature fiber-optic telecommunication technologies in the system, making this innovation an efficient performer. The tiny size and

light weight makes the system useful for commercial and industrial applications including surface damage inspections, range measurements, and 3D imaging.

*This work was done by Jing Xu and Roman Gutierrez of SiWave, Inc. for NASA's Johnson Space Center. For further information, contact the JSC Innovation Partnerships Office at (281) 483-3809.*

*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:*

*SiWave  
400 East Live Oak Avenue  
Arcadia, CA 91006-5619  
Phone No.: (626) 821-0570  
Fax No.: (626) 446-7259  
E-mail: [www.siwaveinc.com](http://www.siwaveinc.com)  
Refer to MSC-23873-1, volume and number of this NASA Tech Briefs issue, and the page number.*

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## Dual-Channel Multi-Purpose Telescope

*Goddard Space Flight Center, Greenbelt, Maryland*

A dual-channel telescope allows for a wide-field telescope design with a good, narrow field channel of fewer surfaces for shorter-wavelength or planet-finding applications. The design starts with a Korsch three-mirror-anastigmat (TMA) telescope that meets the mission criteria for image quality over a wide field of view. The internal image at the Cassegrain focus is typically blurry due to the aberration balancing among the three mirrors. The

Cassegrain focus is then re-optimized on the axis of the system where the narrow field channel instrument is picked off by bending the primary mirror. This now makes the wide-field channel blurry (i.e., the TMA image), and it must be re-optimized while holding the fore-optics fixed. This leaves the tertiary mirror as a variable, as well as a fold mirror strategically placed at the image of the primary mirror (i.e., exit pupil of the telescope). This fold

mirror can then be used to compensate for the departure in primary mirror figure used to optimize the narrow field channel. As such, only an aspheric term is needed for this final optimization on this "corrector" fold mirror.

*This work was done by Joseph M. Howard and David Content of Goddard Space Flight Center. For further information, contact the Goddard Innovative Partnerships Office at (301) 286-5810. GSC-15574-1*