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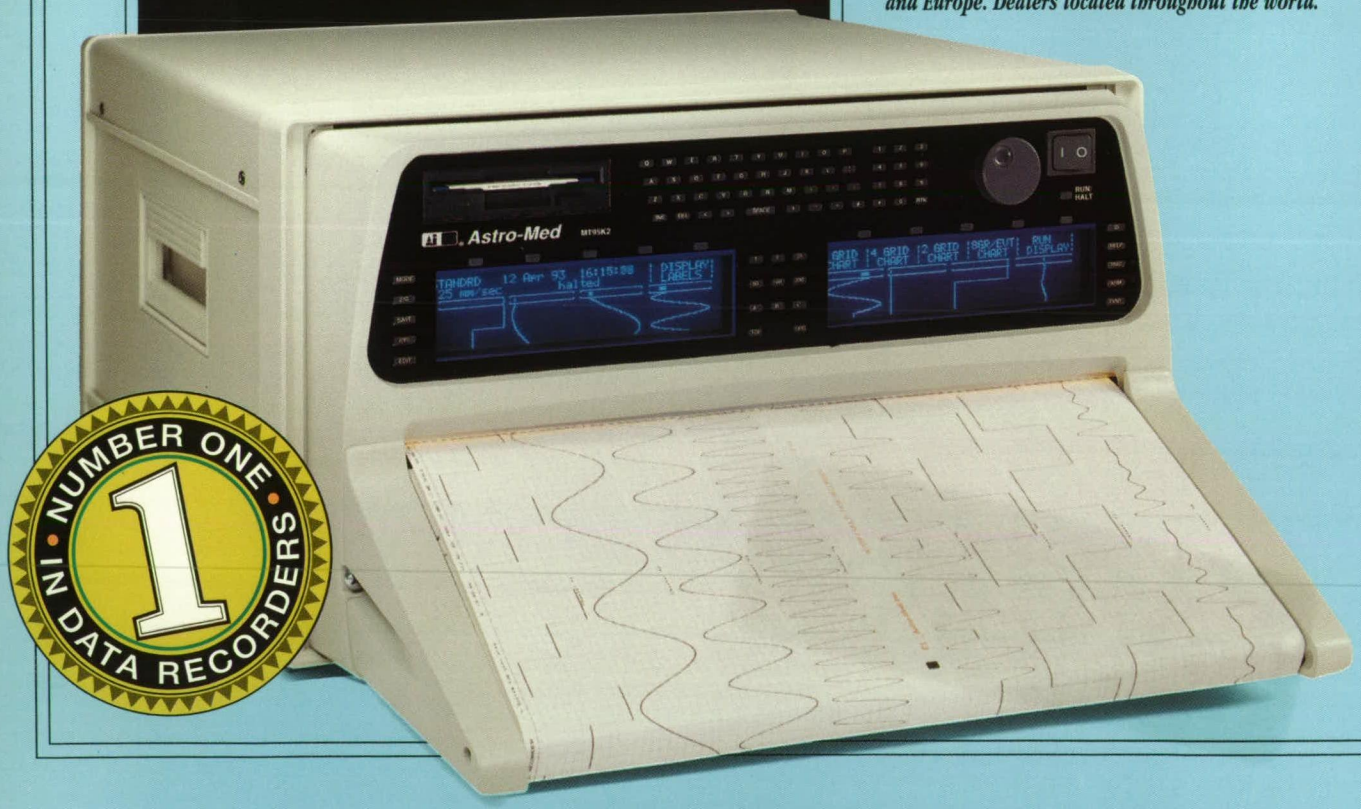

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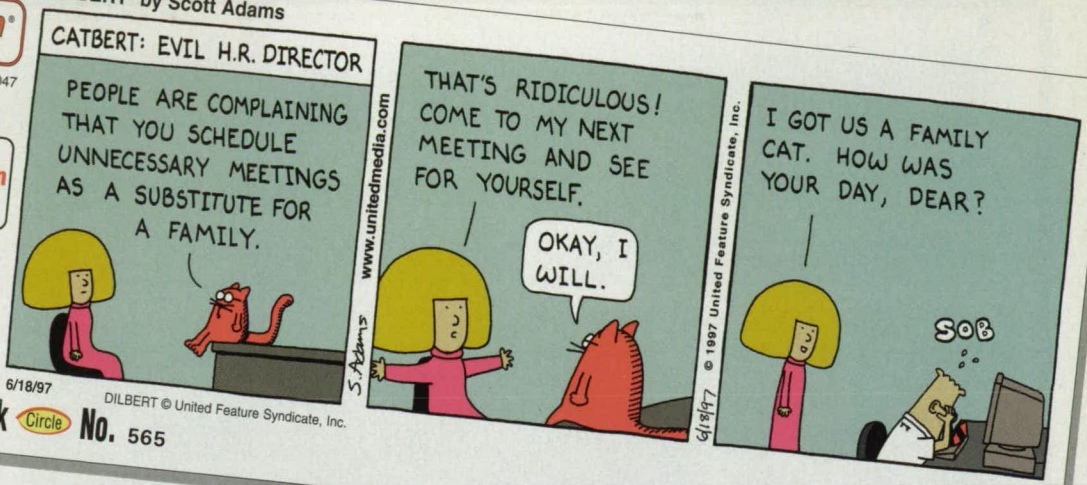

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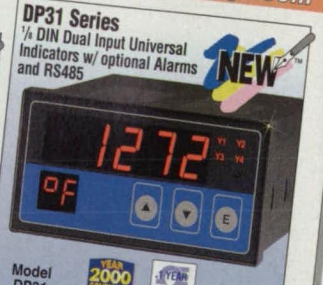

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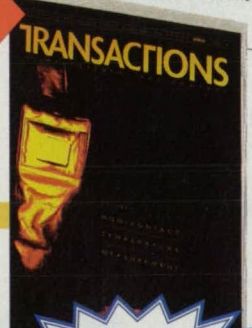

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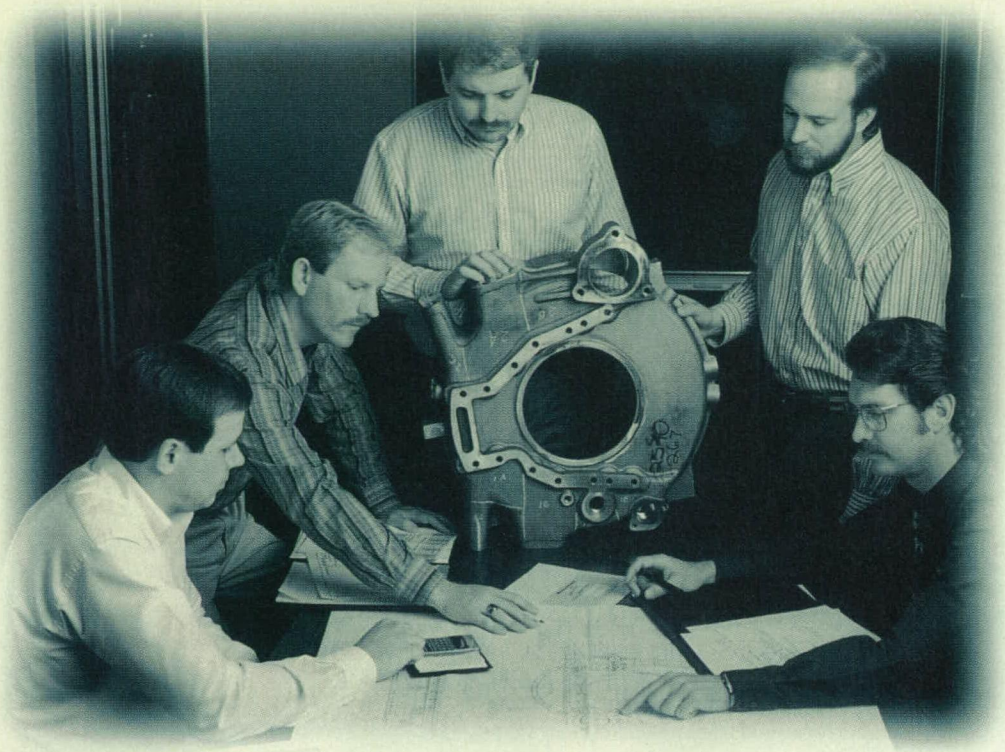

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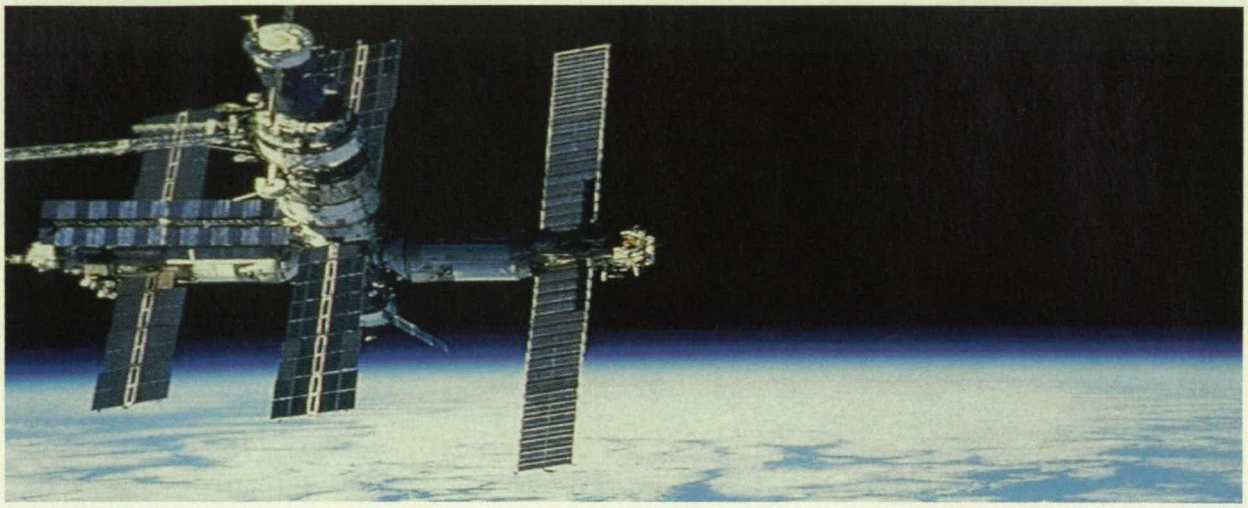
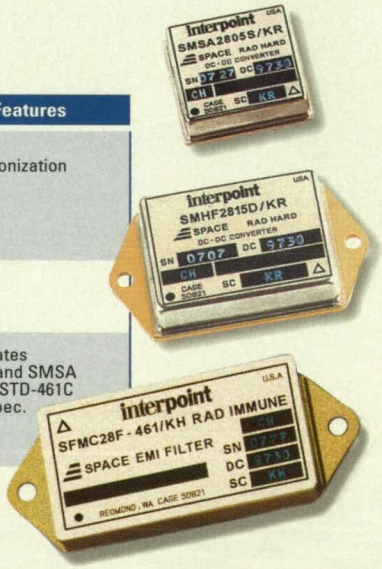


Model	Output	Output (volts)	Size - inches (mm)	Screening Options	Features
Converter SMHF	Power 15 Watts	3.3, 5, 12 or 15 single 12 or 15 dual	1.460 x 1.130 x 0.330 (37.08 x 28.70 x 8.38) Flanged (shown) 2.005 x 1.130 x 0.330 (50.93 x 28.70 x 8.38)	Class H* or K* Rad hard - 3 levels	Inhibit Synchronization
Converter SMSA	Power 5 Watts	5, 12 or 15 single 12 or 15 dual	1.075 x 10.75 x 0.270 (27.31 x 27.31 x 6.86)	Class H* or K* Rad hard - 3 levels	Inhibit
Filter SFMC	Throughput Current 2.7 Amps		2.110 x 1.115 x 0.400 (53.59 x 28.32 x 10.16) Flanged (shown) 2.910 x 1.115 x 0.400 (73.91 x 28.32 x 10.16)	Class H* or K* Rad hard - 2 levels	Attenuates SMHF and SMSA to MIL-STD-461C CE03 spec.

* Per MIL-PRF-38534



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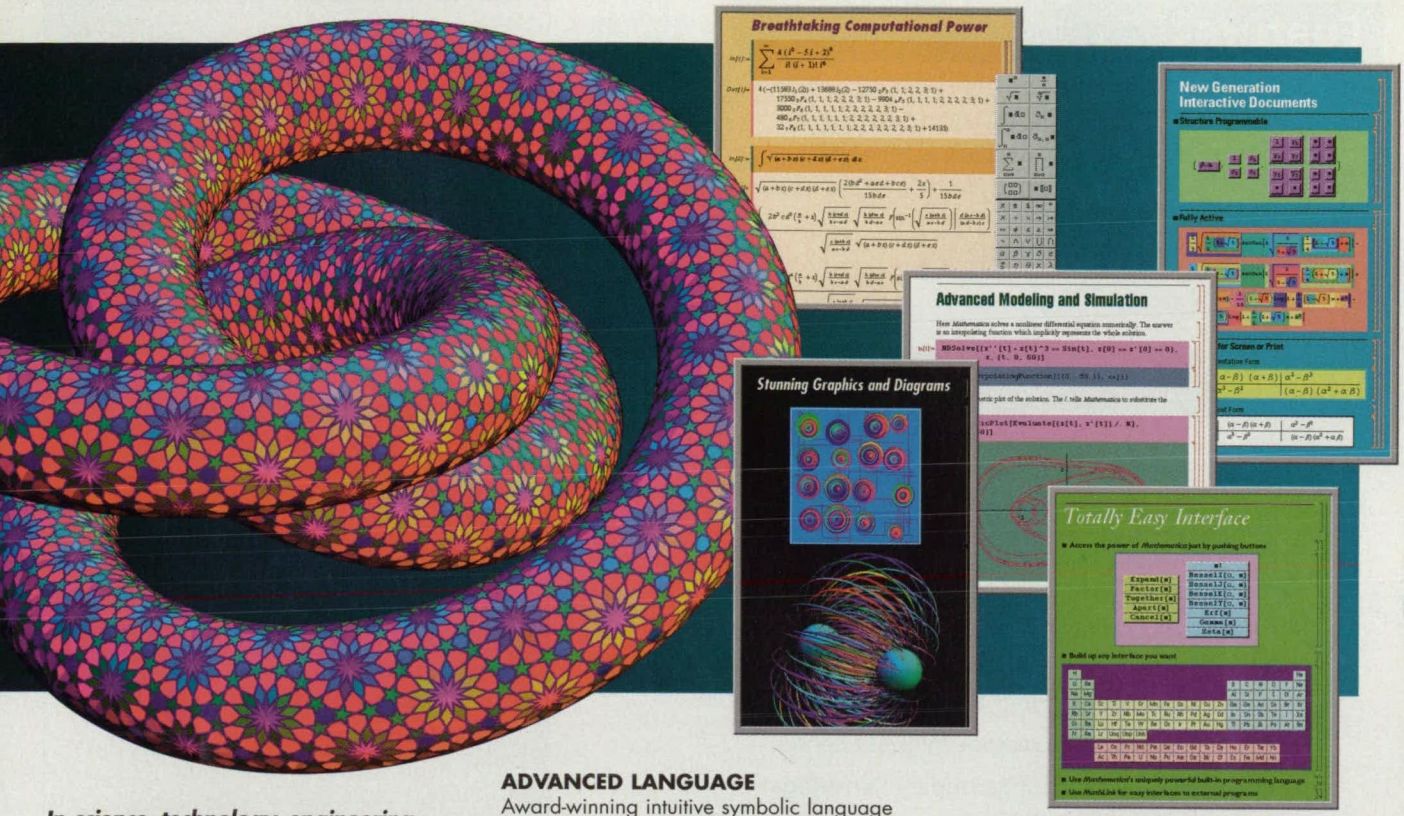

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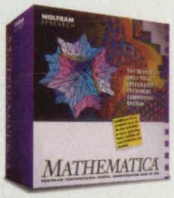

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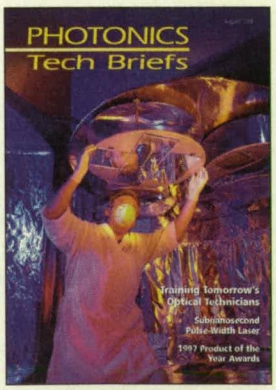
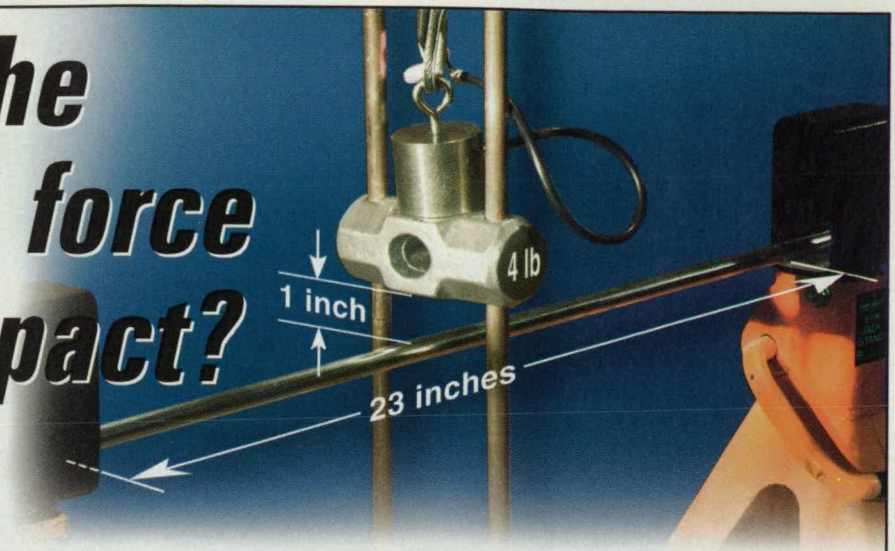
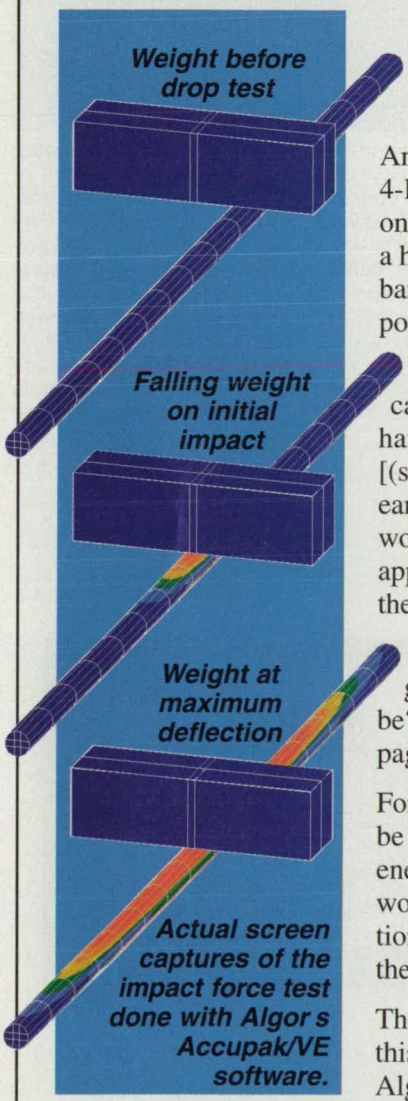


What is the maximum force during impact?





Actual screen captures of the impact force test done with Algor s Accupak/VE software.

An electromagnet suddenly releases a 4-lb hammer head weight which drops onto a 1/2-inch diameter steel bar from a height of 1 inch as shown above. The bar is 23 inches long between the supports.

In the past engineers would try to calculate the maximum stress using handbook calculations such as [(s=Mc/I); (y=WL3)/(48EI)], or a linear static FEA program – but they would have to figure out the force applied to the bar when it is struck by the falling weight.

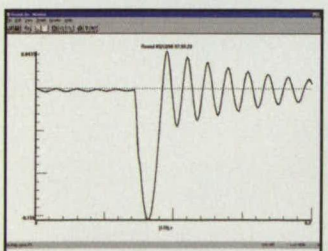
What would you guess the force generated by the falling weight to be? The answer is at the bottom of this page – you may be surprised.

For this simple situation, the force can be approximated by working out an energy balance. This approach will not work, however, for real-world situations due to the difficulty in calculating the stiffness.

The easy way to predict the result of this or any impact problem is to use Algor's Accupak/VE Mechanical Event Simulation software for Virtual Prototyping. Model the bar and hammer head weight with Superdraw III or your CAD system. Apply the dimensions and material properties in Accupak/VE and it will automatically run the virtual experiment and generate a replay showing the stresses and displacements at any or all instants during the time of the event.

Accupak/VE's Monitor virtual instrumentation program shows results graphically during run time. The Monitor program can show displacement, velocity, acceleration, frequency response, reaction forces and maximum stresses versus time as the event unfolds. Also available is an on-board FFT (Fast Fourier Transform) analyzer that converts displacement versus time into frequency versus energy so design engineers can see the energy absorption spectrum of the model during the event.

For more information on Accupak/VE for Mechanical Event Simulation, contact us or visit our website at www.algor.com.



Monitor program showing bar deflection vs. time.

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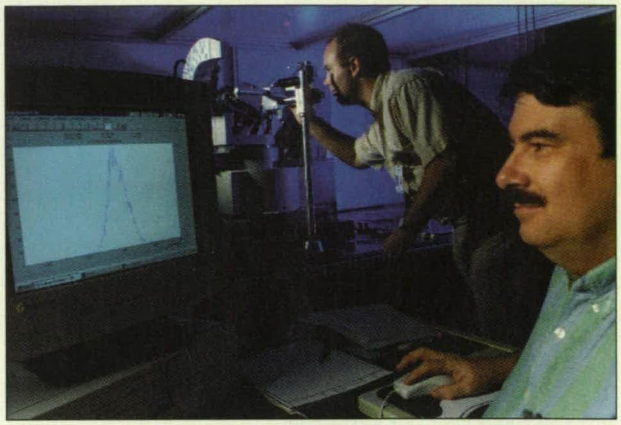
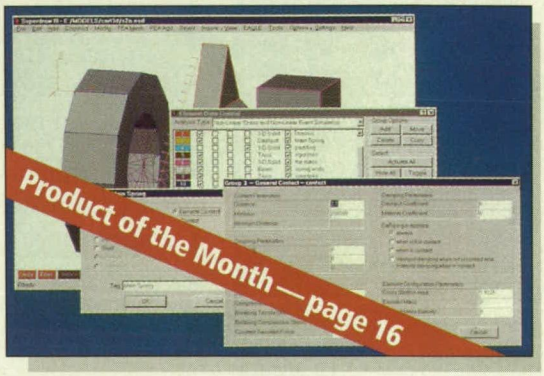


NASA scientist Marc Pusey (foreground) of Marshall Space Flight Center's Space Science Laboratory, and Eddie Snell of the National Research Council prepare to map the microstructure of a crystallized biological module. The team is making the first use of standard x-ray sources to complete the tiny measurement in a lab, rather than traveling to a more complex and busy synchrotron x-ray facility. The first use of this new technique allows researchers growing crystals to design new disease-fighting drugs and vaccines. Marshall researchers are using crystal growth experiments to study insulin and understand diabetes in an effort to develop a new insulin treatment. See UpFront on page 16 for more information on the Marshall research.

(Photo courtesy of Marshall Space Flight Center)



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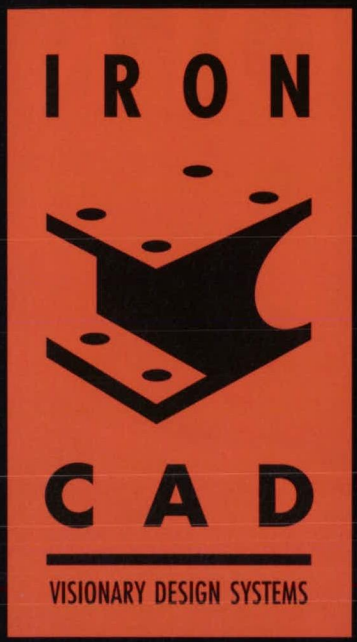

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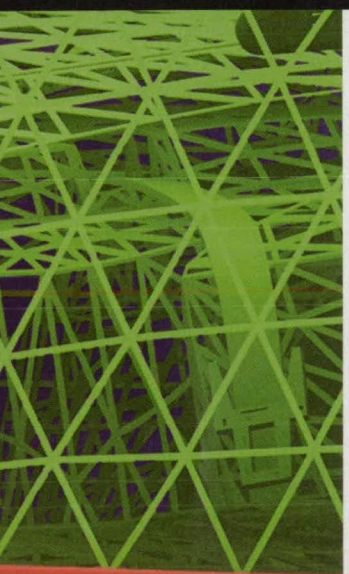

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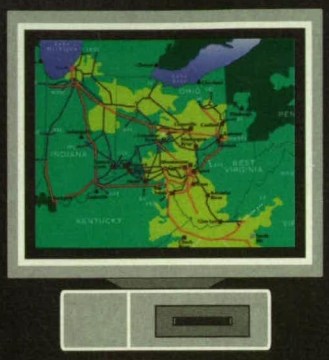

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NASA Commercial Technology Team

NASA's R&D efforts produce a robust supply of promising technologies with applications in many industries. A key mechanism in identifying commercial applications for this technology is NASA's national network of commercial technology organizations. The network includes ten NASA field centers, six Regional Technology Transfer Centers (RTTCs), the National Technology Transfer Center (NTTC), business support organizations, and a full tie-in with the Federal Laboratory Consortium (FLC) for Technology Transfer. Call (206) 683-1005 for the FLC coordinator in your area.

NASA's Technology Sources

If you need further information about new technologies presented in *NASA Tech Briefs*, request the Technical Support Package (TSP) indicated at the end of the brief. If a TSP is not available, the Commercial Technology Office at the NASA field center that sponsored the research can provide you with additional information and, if applicable, refer you to the innovator(s). These centers are the source of all NASA-developed technology.

Ames Research Center
Selected technological strengths: Fluid Dynamics; Life Sciences; Earth and Atmospheric Sciences; Information, Communications, and Intelligent Systems; Human Factors.
Carolina Blake
(650) 604-0893
cblake@mail.arc.nasa.gov

Dryden Flight Research Center
Selected technological strengths: Aerodynamics; Aeronautics Flight Testing; Aeropropulsion; Flight Systems; Thermal Testing; Integrated Systems Test and Validation.
Lee Duke
(805) 258-3802
lee.duke@dfrc.nasa.gov

Goddard Space Flight Center
Selected technological strengths: Earth and Planetary Science Missions; LIDAR; Cryogenic Systems; Tracking; Telemetry; Command.
George Alcorn
(301) 286-5810
galcorn@gsfc.nasa.gov

Jet Propulsion Laboratory
Selected technological strengths: Near/Deep-Space Mission Engineering; Microspacecraft; Space Communications; Information Systems; Remote Sensing; Robotics.
Merle McKenzie
(818) 354-2577
merle.mckenzie@ccmail.jpl.nasa.gov

Johnson Space Center
Selected technological strengths: Artificial Intelligence and Human Computer Interface; Life Sciences; Human Space Flight Operations; Avionics; Sensors; Communications.
Hank Davis
(713) 483-0474
hdavis@gp101.jsc.nasa.gov

Kennedy Space Center
Selected technological strengths: Environmental Monitoring; Sensors; Corrosion Protection; Bio-Sciences; Process Modeling; Work Planning/Control; Meteorology.
Gale Allen
(407) 867-6626
galeallen-1@ksc.nasa.gov

Langley Research Center
Selected technological strengths: Aerodynamics; Flight Systems; Materials; Structures; Sensors; Measurements; Information Sciences.
Dr. Joseph S. Heyman
(804) 864-6006
j.s.heyman@larc.nasa.gov

Lewis Research Center
Selected technological strengths: Aeropropulsion; Communications; Energy Technology; High Temperature Materials Research.
Larry Viterna
(216) 433-3484
cto@lerc.nasa.gov

Marshall Space Flight Center
Selected technological strengths: Materials; Manufacturing; Nondestructive Evaluation; Biotechnology; Space Propulsion; Controls and Dynamics; Structures; Microgravity Processing.
Sally Little
(205) 544-4266
sally.little@msfc.nasa.gov

Stennis Space Center
Selected technological strengths: Propulsion Systems; Test/Monitoring; Remote Sensing; Nonintrusive Instrumentation.
Kirk Sharp
(228) 688-1929
ksharp@ssc.nasa.gov

NASA-Sponsored Commercial Technology Organizations

These organizations were established to provide rapid access to NASA and other federal R&D and foster collaboration between public and private sector organizations. They also can direct you to the appropriate point of contact within the Federal Laboratory Consortium. To reach the Regional Technology Transfer Center nearest you, call (800) 472-6785.

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National Technology Transfer Center
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Ken Dozier
Far-West Technology Transfer Center
University of Southern California
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Dr. William Gasko
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NASA ON-LINE: Go to NASA's Commercial Technology Network (CTN) on the World Wide Web at **http://nctn.hq.nasa.gov** to search NASA technology resources, find commercialization opportunities, and learn about NASA's national network of programs, organizations, and services dedicated to technology transfer and commercialization.

NASA Program Offices

At NASA Headquarters there are seven major program offices that develop and oversee technology projects of potential interest to industry. The street address for these strategic business units is: NASA Headquarters, 300 E St. SW, Washington, DC 20546.

Carl Ray
Small Business Innovation Research Program (SBIR) & Small Business Technology Transfer Program (STTR)
(202) 358-4652
cray@mail.hq.nasa.gov

Dr. Robert Norwood
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Bill Smith
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Roger Crouch
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rcrouch@hq.nasa.gov

Granville Paules
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gpaules@mtpe.hq.nasa.gov

NASA's Business Facilitators

NASA has established several organizations whose objectives are to establish joint sponsored research agreements and incubate small start-up companies with significant business promise.

Dr. Jill Fabricant
Johnson Technology Commercialization Center
Houston, TX
(713) 335-1250

Wayne P. Zeman
Lewis Incubator for Technology
Cleveland, OH
(216) 586-3888

Joe Boeddeker
Ames Technology Commercialization Center
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Dan Morrison
Mississippi Enterprise for Technology
Stennis Space Center, MS
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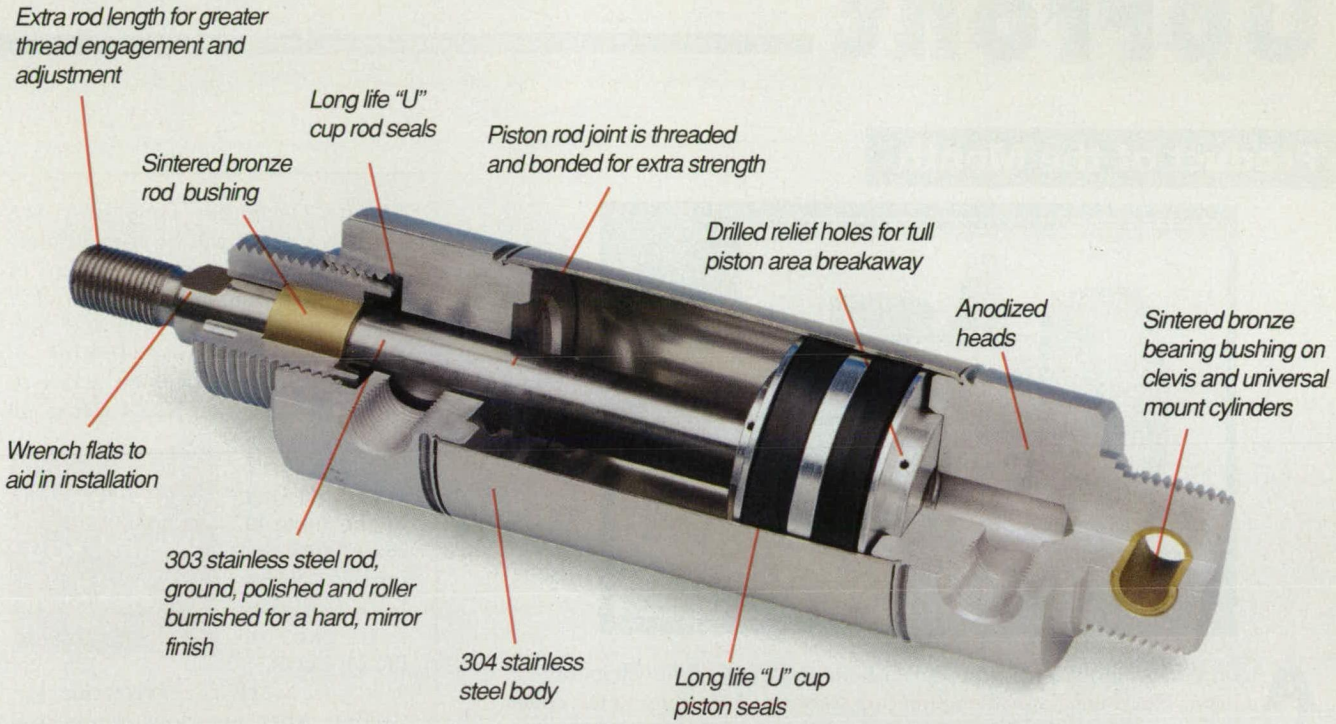
If you are interested in information, applications, and services relating to satellite and aerial data for Earth resources, contact: Dr. Stan Morain, **Earth Analysis Center,** (505) 277-3622. For software developed with NASA funding, contact the **Computer Software Management and Information Center (COSMIC)** at phone: (706) 542-3265; Fax: (706) 542-4807; E-mail: http://www.cosmic.uga.edu or service@cosmic.uga.edu.



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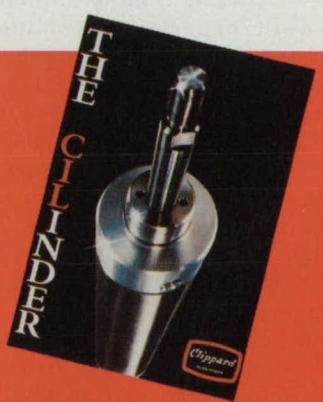

For More Information Circle No. 528

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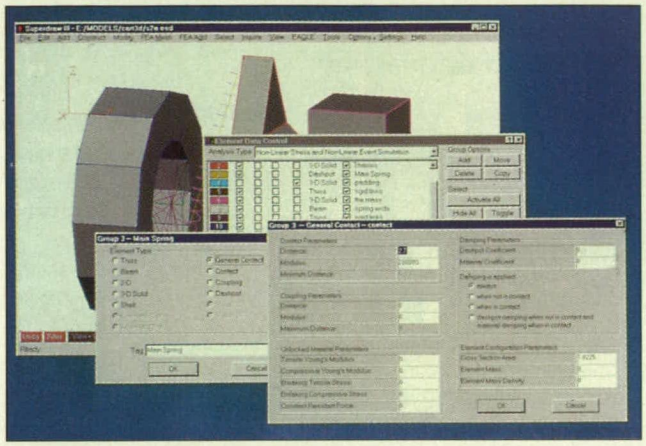
Product of the Month



Algor, Pittsburgh, PA, has announced Release 12 of its finite element analysis based mechanical engineering software. According to the company, the new version is the single most comprehensive release from Algor since 1990. New features of the software include a material data management system that replaces previous methods of storing and applying material data to a model. The system can be interfaced with other information sources for material properties. New Windows-compliant interactive model data input screens allow entering of FEA-specific model data and parameters. Users are not required to complete the entire model geometry before entering the FEA-specific model data. CAD interfacing improvements include the addition of an auto-shaded, solid display that improves mesh refinement capabilities on the visible surface of a model. Each model is organized as a separate database, so a change to a model's input screen is reflected immediately in its database.

For More Information Circle No. 762

What Would You Ask?

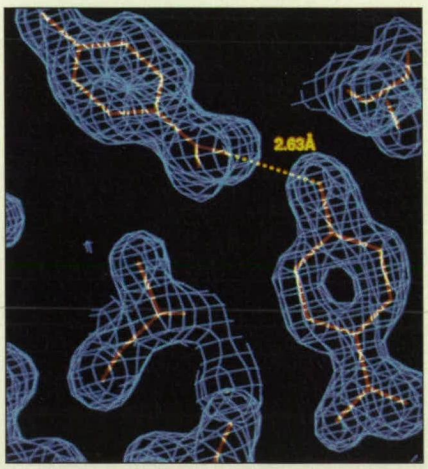
The December issue of *NASA Tech Briefs* will be the culmination of our year-long celebration of NASA's 40th anniversary. Featured in that issue will be an interview with NASA Administrator Daniel S. Goldin, in which he'll be asked to share his views of NASA's first 40 years, where he'd like to see NASA heading in the next 40 years, and the impact NASA technologies have had on life on Earth.

If you were interviewing Mr. Goldin, what questions would you pose regarding NASA's past, present, and future? Let us know. Send your questions for Mr. Goldin to us via e-mail at: linda@abptuf.org, or fax them to Linda Bell, Chief Editor, at 212-986-7864, by September 1. The questions selected for inclusion in the interview will be attributed to the readers who submitted them.

A "Growing" Understanding of Diabetes

Diabetics may be able to reduce their insulin injections and lead more normal lives because of new insights gained through space research in which the largest insulin crystals ever studied were grown on the Space Shuttle. A new understanding of diabetes — a hormone deficiency disease — is resulting from an insulin crystal growth experiment conducted in space in 1994. The research has the potential to significantly reduce expensive treatments, since diabetes treatment accounts for one-seventh of the nation's healthcare costs. Sixteen million Americans suffer from hormone deficiency diseases such as diabetes, hepatic failure, hemophilia, and Parkinson and Huntington diseases.

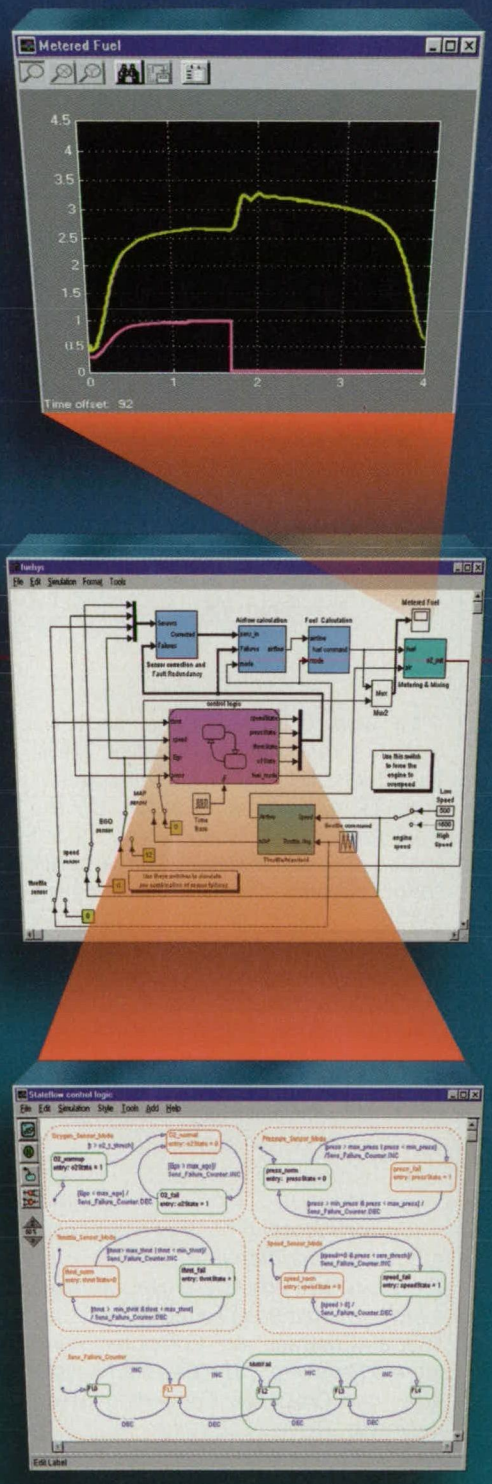
Dr. G. David Smith of Hauptman-Woodward Medical Research Institute in Buffalo, NY, said that the space-grown insulin crystals "have provided us new, never-before-seen information" that is providing a much more detailed picture of insulin. Smith's team is able to study the delicate balance of the insulin molecule because of the increase in crystal size. With some of the new and unexpected findings, researchers may be able to improve how insulin is released from its inactive-stored state to its active state, possibly cutting down on the number of injections diabetics would have to take.



Recent analysis of the molecular structures of insulin crystals grown during Space Shuttle experiments is helping to unlock the mystery of how insulin works.

Hauptman-Woodward is partnering with the Center for Macromolecular Crystallography, a NASA Commercial Space Center in Birmingham, AL. Experiments in crystal growth are being conducted in the near-weightlessness of space. Continuing experiments are planned for the International Space Station.

For more information, contact Steve Roy of NASA's Marshall Space Flight Center at 256-544-6535, or visit the NASA Space Products Development Office web site at: http://microgravity.msfc.nasa.gov



Fault-tolerant fuel injection system

The Simulink diagram (center) models the controller with airflow and fuel mixing. The Stateflow diagram (bottom) shows logic for detecting and responding to sensor failures. The scope (top) shows both a continuous signal and a discrete-event signal, showing the response of the fuel rate to the sensor failure.

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For More Information Circle No. 544

Reader Forum

Reader Forum is devoted to the thoughts, concerns, questions, and comments of our readers. If you have a comment, a question regarding a specific technical problem, or an answer to a question that appeared in a recent issue, send your letter to the address below.

Could you please advise me on how to obtain a copy of NASA's Dynamics Algorithms for Real-Time Simulation (DARTS) software, the NASA Software of the Year for 1997? Thank you.

Irwin Sagalyn
Northampton, MA

*(**Editor's Note:** Irwin, more than 800 software packages originally developed by NASA — such as DARTS — are available from the Computer Software Management and Information Center (COSMIC), NASA's software technology transfer center. You can contact COSMIC at: Tel: 706-542-3265; Fax: 706-542-4807; e-mail: service@cosmic.uga.edu; www.cosmic.uga.edu)*

The April 1998 issue of NASA Tech Briefs *featured a tech brief ("Solar-Powered Aerobots With Power-Surge Capabilities," p. 76) describing the recharging of batteries with atmospheric gases and on-board power fuels in robotics. This technology will prove useful in some designs of our military robotics applications for U.S. Marine Corps contracts.*

Ricky A. Carter Jr.
Texas Robotics Paramedics
Beaumont, TX

My work is in design only, and of a highly esoteric nature. However, NASA Tech Briefs *has helped me with various projects such as a redesign of the Northrop Flying Wing using much lighter, stronger materials and a better control system. Ninety percent of my robotic systems designs have been extrapolated from information, hints, and research presented in* NASA Tech Briefs. *Thanks!*

Tony Max Nance
Decotech/NANCEtech
Laurinburg, NC
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*(**Editor's Note:** A number of you have requested additional information on the CrossPad™ portable digital notepad, which was featured in the June issue's Special Coverage on Computer Hardware & Peripherals. The CrossPad is available from Cross Pen Computing Group in Lincoln, RI. You can call them at 401-333-1200; fax: 401-334-0650; or visit their web site at www.cross-pcg.com)*

Post your letters to **Reader Forum** on-line at: **www.nasatech.com** or send to: Editor, *NASA Tech Briefs*, 317 Madison Ave., New York, NY 10017; Fax: 212-986-7864.
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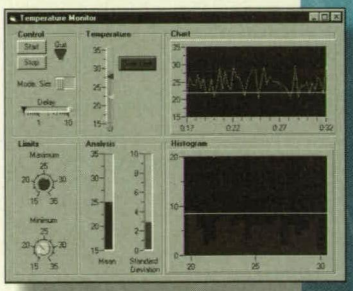

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NASA PATENTS

Over the past three decades, NASA has granted more than 1000 patent licenses in virtually every area of technology. The agency has a portfolio of 3000 patents and pending applications available now for license by businesses and individuals, including these recently patented inventions:

Dual Brushless Resolver Rate Sensor

(U.S. Patent No. 5,644,224)

Inventor: David E. Howard, Marshall Space Flight Center

A need exists for an accurate analog rate sensor that is implemented without mechanical brushes. Prior art devices included resolver or Hall-effect devices used in conjunction with two-phase brushless motors. But a disadvantage of Hall devices is that they do not always produce clean and accurate sinusoidal waveforms. This directly translates into rate error. A disadvantage of differentiating position data from resolvers is that it tends to be very noisy. The present system is a resolver rate sensor in which dual brushless resolvers are mechanically coupled to the same output shaft. Diverse inputs are provided to each resolver by providing the first with a DC input and the second with an AC sinusoidal input. A trigonometric identity in which the sum of the squares of the sine and cosine components equals one is used to advantage in providing a sensor of increased accuracy.

Bevel Gear Driver and Method Having Torque Limit Selection

(U.S. Patent No. 5,647,254)

Inventor: Joseph S. Cook, Jr., Johnson Space Center

Prior methods of applying torque to fasteners, such as nuts, screws, etc., do not provide an uncomplicated mechanism that reliably holds the torque to a selectable limit. This invention provides a method and apparatus for an improved torque-controlled driver. It has a housing with a first shaft, supported by the driver housing, whose axis extends longitudinally through it. A first gear is carried by this shaft for rotation about its axis. The first gear has teeth mounted around a circumferential portion of it. A similar second gear is disposed within the housing for displacement in a direction having a component substantially parallel to the first shaft's axis. This gear moves between an engaged and a disengaged position. A variable bias assembly is disposed substantially within the driver housing to bias the second gear toward the engaged position. In operation, torque is transferred from the first to the second gear and to the fastener. An angled tooth profile on one of the gears produces a separating force between the gears during the transfer of torque. A desired limit for torque to be applied to the fastener is selected from a range provided on the driver. The first gear is rotated to apply torque to the second gear and the fastener until the separating force overcomes the selected bias and separates the gears.

System and Method for Modeling the Flow Performance Features of an Object

(U.S. Patent No. 5,649,064)

Inventors: Charles Jorgensen and James Ross, Ames Research Center

A neural network is used to generate a model of the flow performance features of an object in a wind tunnel from performance data on the object. Initial pairs of test input signals or conditions (flap positions, slat positions, deflection angles, stabilizer position, roll, pitch, and yaw positions) and test output conditions (lift, drag, side-force, pitching moment, yawing moment, and rolling moment) are used to train the neural network. As wind tunnel testing proceeds, the network learns a complete static aerodynamic model of the object. Because the model is generated simultaneously with the testing procedure, it can be immediately used to dynamically adjust the procedure to focus on interesting points. For example, the model can be used to determine optimal geometric configurations of maximum lift, high alpha performance, or other flight performance features. The invention can also be applied in other similar flow-modelling applications in aerodynamics, hydrodynamics, and other such disciplines: for example, the testing of cars, sails, foils, propellers, keels, rudders, and turbines.

For more information on the inventions described here, contact the appropriate NASA Field Center's Commercial Technology Office. See page 14 for a list of office contacts.

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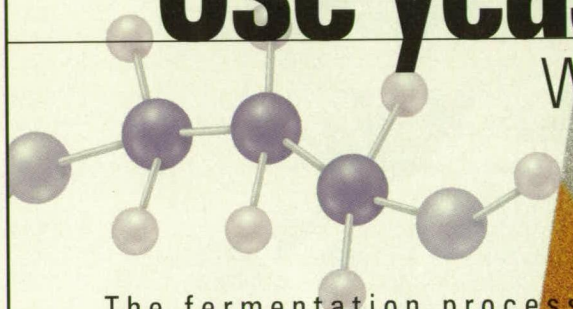
Use yeast to turn sugar

Why not, Egyptians have been



The fermentation process is being redesigned by DuPont scientists to create new chemicals efficiently, precisely and with less environmental impact.

Yeast, grain and water can be used to make really fine beer. Or, for that matter, really fine trimethylene glycol.

© 1996 DuPont

into other molecules?

doing it for 4,000 years.

The transformation of sugars into alcohol by microscopic organisms has been known for a very long time. But only since the advent of genetic engineering is it feasible to think about harnessing the sophistication of biological systems to create molecules that are difficult to synthesize by traditional chemical methods.

For example, the polymer polytrimethylene terephthalate (3GT) has enhanced properties as compared to traditional polyester (2GT). Yet commercialization has been slow to come because of the high cost of making trimethylene glycol (3G), one of 3GT's monomers.

Working the bugs in

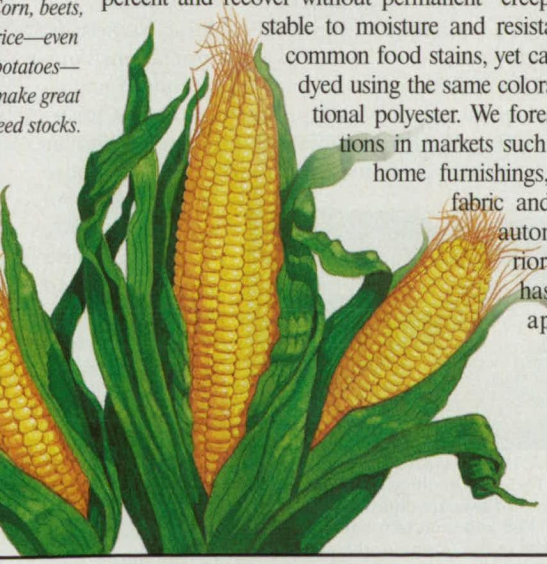
The secret to producing 3G can be found in the cellular machinery of certain unrelated microorganisms. Some naturally occurring yeasts convert sugar to glycerol, while a few bacteria can change glycerol to 3G. The rub is that no single natural organism has been able to do both.

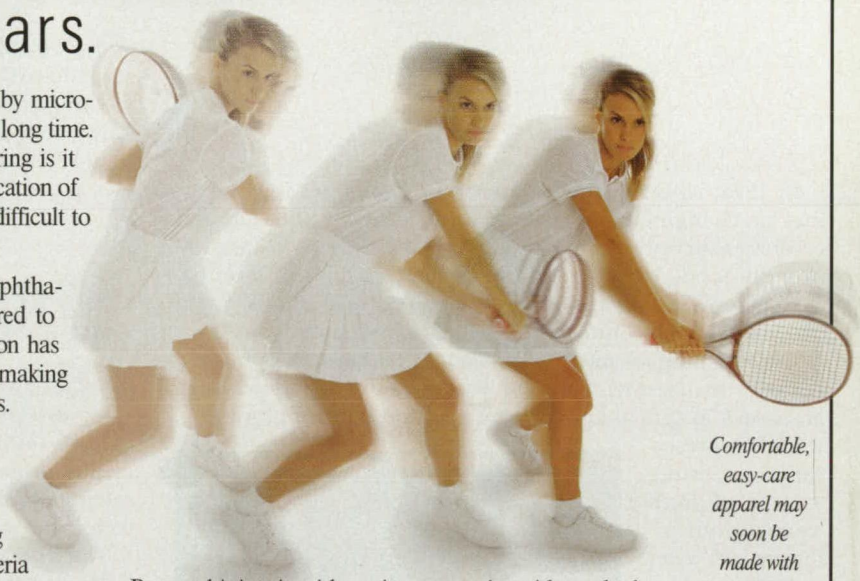
Through recombinant DNA technology, an alliance of scientists from DuPont and Genencor International has created a single microorganism with all of the enzymes required to turn sugar into 3G. This breakthrough is opening the door to low-cost, environmentally sound, large-scale production of 3G. The eventual cost of 3G by this process is expected to approach that of ethylene glycol (2G).

A polymer for your thoughts

The 3GT polymer produced using our biosynthesized monomer has properties that exceed those of normal polyester. It is resilient and can be molded or extruded into fibers. The fibers are heat-settable and can be stretched at least 15 percent and recover without permanent "creep." They are stable to moisture and resistant to most common food stains, yet can be readily dyed using the same colors as conventional polyester. We foresee applications in markets such as apparel, home furnishings, upholstery fabric and carpet for automobile interiors. Even 3G has numerous applications.

is no longer necessary o start with a barrel of l to produce chemicals. Corn, beets, rice—even potatoes—make great eed stocks.





Comfortable, easy-care apparel may soon be made with fibers spun from chemicals that have been fermented from sugar.

By combining it with various organic acids, polyols can be made as precursors to polyurethane elastomers and synthetic leathers.

A break for the environment

The 3G fermentation process requires no heavy metals, petroleum or toxic chemicals. In fact, the primary material comes from agriculture—glucose from cornstarch. Rather than releasing carbon dioxide to the atmosphere, the process actually captures it because corn absorbs CO_2 as it grows. All liquid effluent is easily and harmlessly biodegradable. What's more, 3GT can readily undergo methanolysis, a process that reduces polyesters to their original monomers. Post-consumer polyesters can thus be repolymerized and recycled indefinitely.

Can you play a role?

Throughout DuPont's history, many of our biggest contributions have come to market through collaboration with other companies. Development of 3GT could involve partnering with companies active in traditional polymer processing, separations technologies, recombinant DNA techniques, corn wet-milling and fermentation. If you possess these skills, or have ideas for end-use applications, we'd like to hear from you. Fax us on company letterhead with an indication of your interests to: DuPont, Dept. NT, 302-695-7615. Please limit your correspondence to nonproprietary, public-domain information only.

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Fortieth Anniversary

Environmental Management/Remote Sensing

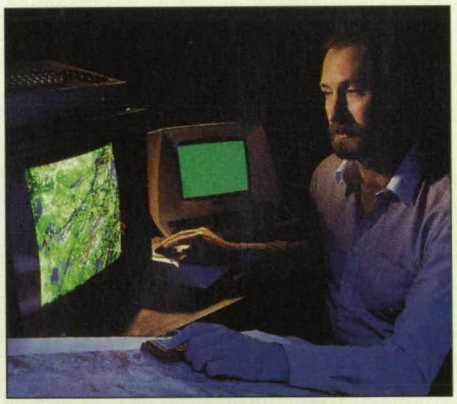
This month, in our year-long celebration of NASA's 40th Anniversary, we take a look at successful spinoff products and new applications of NASA technologies in the areas of Environmental Management and Remote Sensing.

1970s

Landsat Lands Spinoffs

In 1972, NASA introduced a series of satellites for observing the changing conditions of Earth's surface: the Landsat resources survey system. Landsat's remote sensing data, computer-processed into tapes and images, enables differentiation among a variety of Earth features, and allows Earth processes to be monitored for changes over time.

Landsat, now operated on a commercial basis, has provided resource management benefits to thousands of businesses in areas such as agricultural inventory, oil and mineral processing, wildlife preservation, charting sources of fresh water, monitoring air and water pollution, and studying floods. Another benefit is the Landsat-spawned industry devoted to the commercial applications of remote sensing.



A Delta Data Systems technician computer-enhances a Landsat image to include geographic coordinates.

International Imaging Systems (I^2S) of Milpitas, CA, is one of those spinoff companies. A manufacturer of equipment and software for image processing, I^2S developed its initial equipment in 1975, with the help of NASA, to process Landsat data for Earth resources management. The company continued to work with six NASA centers, and has sold thousands of systems for processing Landsat data.

Working with NASA's Goddard Space Flight Center, I^2S developed meteorological analysis systems that led to sales of hardware and software to NASA. In addition, hospitals are using the systems to develop special software for presenting cross-section and 3D body images for diagnostic purposes.

Another company that was spun out of the Landsat program is Delta Data Systems (DDS) of Picayune, MS, formed by a group of former NASA and industry engineers experienced in designing hardware and software for digital image processing systems. The company also adapted a NASA-developed computer program into its ATLAS software system.

DDS President Ferron Risinger is a former systems analyst for the NASA Earth Resources Lab, and former project leader at NASA's Ames Research Center for installations of the NASA-developed software called ELAS (Earth Resources Laboratory Applications Software). ELAS was used as the shell for the company's ATLAS geographic information system, and was used to process satellite and aircraft data, digitize soil and topographic maps, and generate land use maps.

Risinger estimated that the use of the NASA-developed software saved the company an additional four man-years that would have been spent developing the 100 application modules in the ATLAS system.

1980s

It's A Natural

Mayor Harold R. Lee of Haughton, LA, was notified in 1985 that his town's wastewater treatment facility violated environmental protection standards. Add-on modifications to its activated sludge facility would cost $1.2 million. That's when NASA technology came to the rescue.

The mayor had read about research conducted by Dr. Billy C. Wolverton, then head of the Environmental Research Lab at NASA's Stennis Space Center in Mississippi. Wolverton's work involved natural water purification using aquatic plants to remove pollutants from wastewater at a low cost. Haughton officials visited a test site for Wolverton's artificial marsh filtering system, and decided that the NASA technology would allow the town to develop a wastewater treatment facility at less than one-third the cost of improving the old system.

The resulting facility is an 11-acre sewage lagoon with a 70 x 900-foot artificial marsh called a vascular aquatic plant/microbial filter cell in which microorganisms and rooted aquatic plants combine to absorb and digest wastewater pollutants, converting sewage effluents to relatively clean water. The raw wastewater flows from the lagoon over a rock bed populated by microbes that digest nutrients and minerals from the sewage.

The facility went on line in 1987; a year later, the town reduced its sewer user fees by 25 percent. The new facility easily met the more stringent wastewater cleaning standards. Today, a number of southern U.S. towns with populations ranging from 2,000 to 15,000 people employ the Stennis aquaculture techniques as their year-round primary method of wastewater treatment. The Stennis techniques, unlike other similar systems, focus on water hyacinths to absorb and metabolize pollutants from wastewater. Water hyacinths also can be harvested and used as fuel, fertilizer, or as a protein/mineral additive to cattle feed.

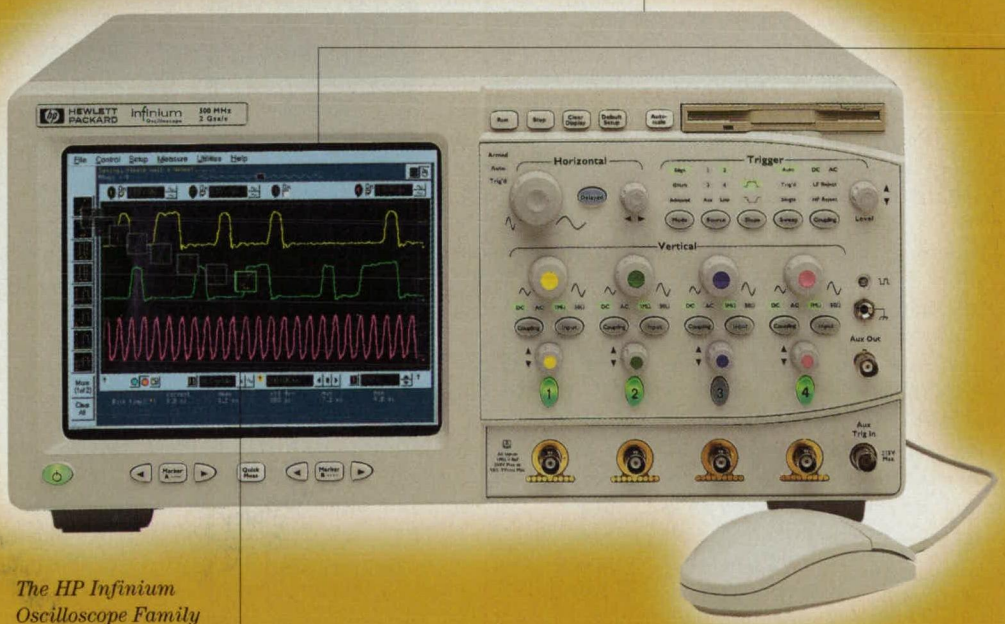
The Haughton, LA, natural wastewater treatment system employs NASA technology. This system uses a combination of sewage-digesting microbes living in a gravel bed and pollutant-absorbing plants — bulrushes in the foreground and canna lilies in the background.

In the meantime, Wolverton's work led to another spinoff for purifying air

Great.

You forgot how to measure that rise time.

Now you've got to waste 10 seconds relearning it.



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Some call it the forgetting curve. The last time you used your scope, you spent a lot of time learning how to measure the rise time of the third edge. But now you can't remember how you did it—and that means you have to waste even more time figuring it out all over again.

Unless you've got the new Infinium oscilloscope from HP.

The HP Infinium oscilloscope's Windows 95–based graphical user interface lets you make those difficult measurements quickly (even if it's been months since you touched a scope). There's a powerful built-in help system that's always there when you have more questions—even tough ones. And with an analog-like front panel, the HP Infinium scope finally makes simple functions simple again.

To find out how you can spend less time fighting your scope, call HP DIRECT at **1-800-452-4844, Ext. 5959**. We'll send you a FREE HP Infinium oscilloscope CD-ROM or brochure and answer questions about our demo program. Or, check out our Web site: **www.hp.com/info/Infinium15**

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and water in indoor environments. His company, Wolverton Environmental Services (WES), provides consulting in areas such as aquaculture and indoor air pollution abatement. Wolverton has developed the first combined indoor wastewater treatment/air purification system employing common houseplants.

The plants absorb harmful gases and chemical compounds to purify home or office air and water. Wastewater from the bathroom and fumes from the kitchen are pumped into a living room filtration system of plants such as ferns, ficus, and philodendrons, that is reinforced by activated carbon filters. The wastewater is used as water fertilizer for the plants. The first public building to use the system is a math and science complex at Northeast Mississippi Community College in Booneville. The system routes ventilation air through a two-story atrium equipped with filter boxes of plants, clay, and charcoal. The plants purify the air and cleanse sewage from the bathrooms, recycling the water for use on campus gardens.

1990s

Minding His Beeswax

Joseph A. Resnick, chief scientist at Petrol Rem, Pittsburgh, PA, developed a new way of cleaning up oil spills by bioremediation. The product — PRP™ (Petroleum Remediation Product) — incorporates technology related to microcapsule fabrication developed by NASA's Marshall Space Flight Center and Jet Propulsion Laboratory.

PRP consists of thousands of microcapsules, which are tiny balls of beeswax with hollow centers. The hollow core houses live microorganisms and nutrients that sustain them. Oil can penetrate the microcapsule shell by osmosis, but water cannot. The encapsulated microorganisms, called lipolytica, degrade hydrocarbons by secreting enzymes that break down oil into base elements of carbon dioxide and water. Oil is consumed and digested by the microorganisms as it passes through the shell. When PRP explodes due to pressure buildup, the enzymes, carbon dioxide, and water are released into the environment. A residue remains that is environmentally safe and can be consumed as food by fish.

Joseph Resnick (l), inventor of the PRP™ confers with a technician in the Petrol Rem production facility.

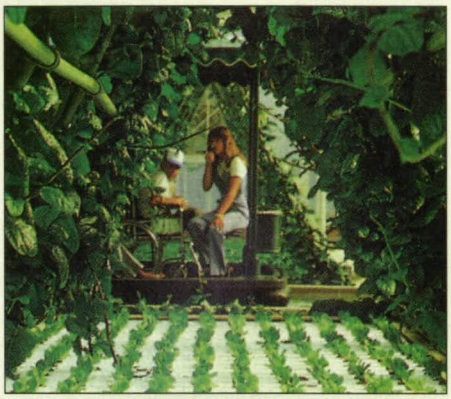
PRP is used with an apparatus also developed by Petrol Rem called the Bio-Boom™ to clean up oil spills. The Bio-Boom is a containment system that has a floatation device to keep the boom on top of the water and prevent contaminated water from spreading into non-contaminated areas. A 10-foot-long cartridge, called a Bio-Sok™, fits into a mesh enclosure on the boom. The cartridge contains an oil-absorbent material and seven pounds of PRP. The absorbent wicks the contaminated water toward the PRP, the oil penetrates the shells of the microcapsules, and is digested by the microorganisms.

Resnick employed technology performed at JPL that demonstrated the feasibility of encapsulating live cells. Technology developed at Marshall for experiments in orbital production of microspheres was incorporated in the basic design of the delivery system that protects the encapsulated cells from water while allowing hydrocarbons to pass through the shell.

Living Off The Land

NASA is conducting research toward developing modules that will recycle wastes produced by human and industrial processes, and provide essential ingredients for growing plants. The plants will provide food, oxygen, and water. This research is in response to the need for life-support resources that will not be naturally occurring in future bases on the Moon or Mars.

At Kennedy Space Center (KSC), NASA continues to develop a Controlled Ecological Life Support System (CELSS) in a government/commercial research partnership with The Land's agricultural team at Walt Disney World's EPCOT Center. The Land team is similarly testing new ways to sustain life in space. Sponsored by Kraft General Foods, The Land is an entertainment, research, and education facility at Walt Disney World in Lake Buena Vista, FL.



At The Land in Walt Disney World, plants are grown on A-frame structures that allow the roots to be sprayed from the inside.

The cooperative effort incorporates plant-growing racks and related KSC-supplied bioregenerative equipment installed in a greenhouse near the end of The Land's boat ride, on which visitors travel through five greenhouses containing more than 30 crops from around the world. The plants are grown on A-frame structures that allow the roots to be sprayed from the inside with a hydroponic nutrient solution.

At KSC, the CELSS research focuses on growing plants in special trays in an atmospherically sealed, environmentally controlled chamber. Scientists monitor parameters such as gases produced in the process. At The Land's facilities, initial research involved testing software and hardware subsystems controlling the plant growing racks, which were developed under the partnership between NASA and Walt Disney World. Additional research studies how microbial contaminants, such as fungi and bacteria, affect plant growth.

Cleaning Up With Crumb and Fluff

Cryopolymers of St. Francisville, LA, has used NASA expertise to improve a process for recycling vehicle tires. The process converts shredded rubber into products that can be used in asphalt road beds, new tires, hoses, and other products. Conducted in conjunction with the Southern Technology Applications Center (NASA's Southeast Regional Technology Transfer Center) and NASA's Stennis Space Center, the project utilized NASA's expertise in cryogenic fuel-handling for launch vehicle and spacecraft operations.

Cryopolymers used NASA advice on types of equipment needed, as well as how to reduce the amount of liquid nitrogen needed in the process. The Cryopolymers process utilizes liquid nitrogen to freeze tire scraps to super-cold temperatures of -200°F,

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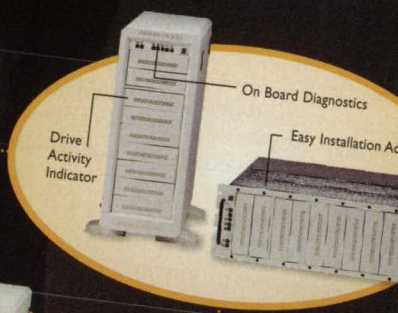

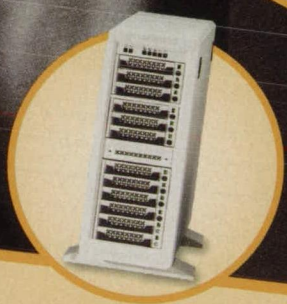

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Cryopolymers used NASA expertise in handling super-cold fluids to recycle shredded tires into these agricultural hoses.

which separates reinforcing steel belts and polyester fibers from the rubber. The material that is left is called "crumb," which can be divided further into various grades, depending on particle size. The larger particles can be used to help improve the wearability of a road surface, or can be reprocessed to mold products that are low in strength, but have high weatherproofing qualities.

The smaller pieces of crumb are used for new tires, agricultural hoses, or for protective mats in pickup-truck beds when mixed with plastics. For each pound of salvaged rubber, nearly 90 percent is reduced into crumb. What remains is called "fluff," a scrap metal and polyester residue that can be used in new products as reinforcing fiber.

Nationwide, more than 300 million tires are produced each year. Cryopolymers expects to reach a production rate of 5,000 pounds of rubber per hour. That translates into more than 5,000 tires recycled each day. Cryopolymers anticipates an annual income of $4 million.

Since 1976, *NASA Spinoff* has featured many down-to-earth applications of NASA technology. To learn more about how NASA technologies affect our everyday lives, visit the *Spinoff* web site at: www.sti.nasa.gov/tto/spinoff.html

To Contact Profiled Companies, Call:

Cryopolymers	504-635-0092
Delta Data Systems	601-799-1813
International Imaging Systems	408-432-3400
Petrol Rem	412-429-0673
Walt Disney World	407-867-3017
Wolverton Environmental Services	601-799-3807

Next Month:

NASA Technologies Used in Automotive Design

Commercial Remote Sensing at NASA Stennis

A unique NASA program headquartered at NASA's Stennis Space Center in Mississippi is the Commercial Remote Sensing Program (CRSP), which works with private and commercial industries to develop remote sensing applications, geographic information systems, and related information technologies.

At its inception, the program provided a new approach to the application of remote sensing, an "old" space technology developed in the civilian sector by the Earth Resources Laboratory (ERL) in the early 1970s. ERL researchers studied ways to apply the new information gained from airborne and space platforms, such as satellites and spacecraft. Through a combined use of techniques and software, the ERL scientists were able to input, study, and identify hundreds of data points of a particular location on Earth.

They assisted users in finding practical applications for the remotely sensed data, including farmers, geologists, city and state planners, environmental monitors, fishermen, firefighters, foresters, law enforcement officers, road builders, and archaeologists. In 1987, a new remote sensing program was put in place at Stennis that better fit the growing trend toward entrepreneurship beginning to blossom in the business community. The program has since evolved into the CRSP.

The Current Program

Stennis was named NASA's lead center for commercial remote sensing in April 1997. The lead center role originally was in support of the Mission to Planet Earth Enterprise, which was renamed Earth Science Enterprise (ESE) in April of this year. One of four strategic enterprises of NASA, ESE focuses on a long-term coordinated research effort to study the total Earth system and the effects of natural and human-induced changes to the global environment. CRSP's lead center role supports the development of a commercial remote sensing industry that can contribute to long-term ESE strategic goals — to expand scientific knowledge of the Earth system using NASA's unique vantage points of space, aircraft, and in situ platforms; creating an international capability to forecast and assess the health of the Earth system; to widely disseminate information about the Earth system; and to enable the productive use of Earth science results and related technology in the public and private sectors.

Many commercial companies already use remotely sensed information to develop their products. These companies can form partnerships with data producers, value-added providers, and remote-sensing customers and submit proposals to the Earth Observations Commercial Applications Program (EOCAP). If chosen, a company and its business partners join with NASA in demonstrating the market effectiveness of new products.

New Opportunities

NASA is extending EOCAP's partnership experience through two recent projects — EOCAP-SAR (Synthetic Aperture Radar) and EOCAP-Hyperspectral. These projects, each structured in a three-phase approach, are designed to demonstrate the commercial viability of specific remote sensing technologies. Participation in either project must involve development teams headed by private-sector companies. All categories or organizations are invited to participate, as long as a for-profit industry partner acts as the principle investigator responsible for commercial development and implementation of the project.

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capability to acquire SAR imagery of the Earth's land and ocean features over broad areas, day or night, and under all weather conditions, has been established. Researchers have shown that SAR data have significant scientific value. At present, however, the commercial potential of SAR data is not well understood. The EOCAP-SAR project seeks to determine the utility of advanced SAR applications and define the commercially viable markets for this technology family.

The science and commercial remote sensing communities are at an early, but varying, degree of awareness, interest, and understanding with respect to the uses and benefits of hyperspectral data. The EOCAP-Hyperspectral project intends to develop a broad portfolio of applications projects as part of a "discovery" process. The first step in the three-step initiative is designed to determine the unique and common requirements of hyperspectral data for science and commercial users, as well as documenting the opportunities for technology improvements associated with acquiring, processing, archiving, and distributing the data.

The V&V Project

Yet another evolution of the CRSP since its lead center designation has been the organization of the Verification and Validation (V&V) Project. CRSP is actioned to provide the remote sensing community with a comprehensive array of man-made and natural targets, measurement systems, and benchmark processes to help test commercial airborne and spaceborne remote sensing systems against performance specifications and customer needs.

A color infrared aerial photograph of completed targets at the V&V site at Stennis Space Center, taken April 20, 1998.

Stennis hosted 60 representatives from NASA and the remote sensing industry last November to develop the requirements for this nationwide network of ground truthing sites. Stennis already has generated at the center a five-acre ground-verification site. Currently, this target supports spatial resolution verification of airborne and spaceborne optical sensors having ground sampling distances of up to four meters.

The V&V team is developing a network of applications-oriented ground truth sites for validating the ability of commercial remote sensor systems to contribute to selected technological, economical, and political decisions. By the end of the century, the Stennis V&V team plans to have the capability to verify performance of the most significant commercial remote sensor systems: electro-optical, radar, hyperspectral, and lidar. The team also plans to regularly conduct validation of commercial data sets, primarily in the areas of precision agriculture and environmental monitoring.

Staci C. Kramer, Stennis Space Center

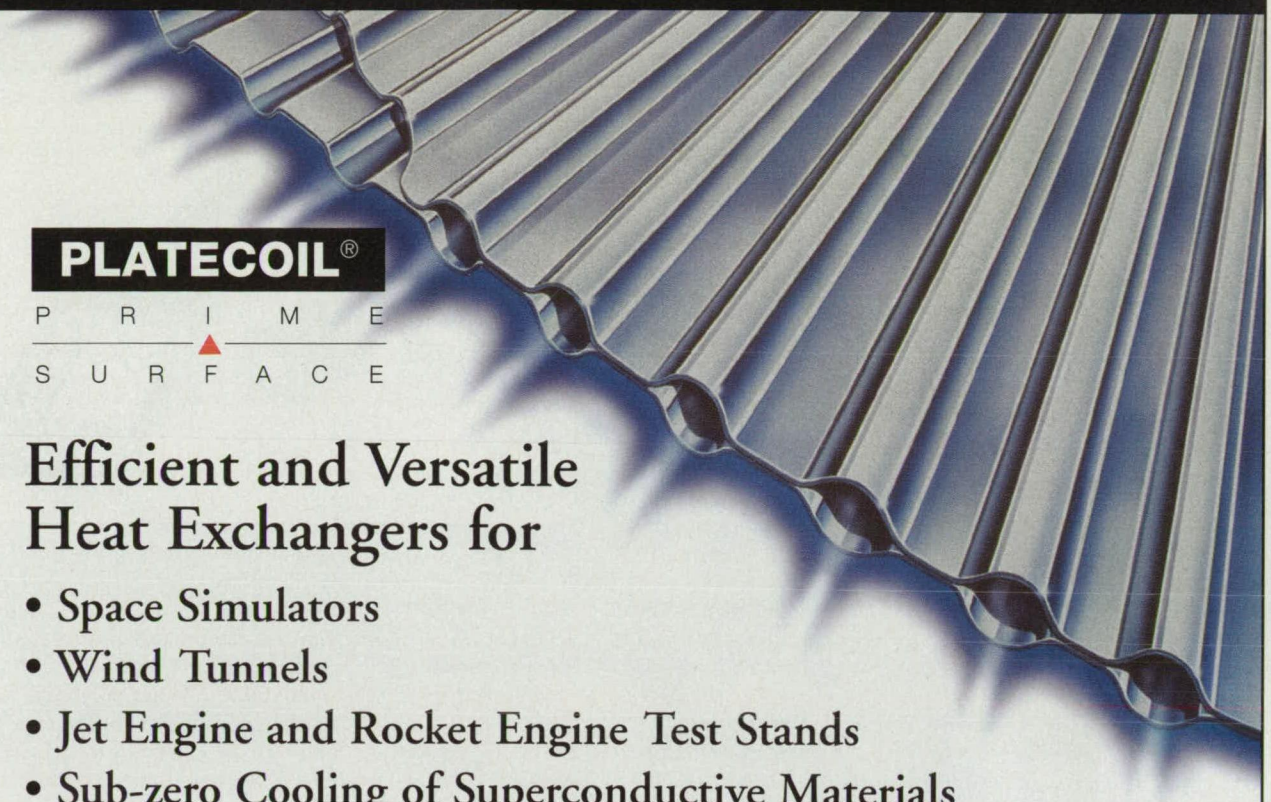
Looking Ahead ...

• Alyeska Pipeline Service, the Anchorage-based operator of the Trans Alaska Pipeline System, has signed an agreement with NASA's Jet Propulsion Laboratory (JPL) to study improved oil spill detection technologies for trans-Alaska pipeline applications. Alyeska operates the 800-mile-long pipeline, through which more than 20% of the United States' domestic oil production flows. Alyeska currently uses a variety of leak detection technologies to identify possible spills at or below the levels required by regulations. The agreement will include the investigation of technologies that can provide remote-sensing detection of oil releases below the present leak detection threshold. Alyeska had launched an initiative last summer that solicited both private and public firms to present available technologies to detect leaks as small as ten gallons. When none of the submitted systems met the company's specifications for the futuristic pipeline monitoring system they envisioned, Alyeska looked at ways of putting one or more of them together to make an operational system. JPL's Joan Horvath, who has been working with the Alaska Technology Transfer Center, thought that "a lot of our instruments for close-up studies of Mars and Europa, a moon of Jupiter, might have some applicability for Alyeska's issues." The two parties came together, resulting in the agreement.

• Transamerica Real Estate Information Companies (TREIC) of Dallas, TX, has created a new business unit, TerraPoint™ LLC, a company combining the business expertise of Transamerica with the technologies of NASA's Goddard Space Flight Center and the Houston Advanced Research Center (HARC). Based in The Woodlands, TX, TerraPoint will provide customers with digital, topographic data generated by laser technology, rather than by microwave and photographic technologies. The laser technology combines Goddard and HARC's laser ranging, global positioning systems, and mapping software into a miniaturized package that can be mounted in a light aircraft. Potential commercial uses include flood plain mapping, pipeline and utility surveys, highway design simulations, shoreline and erosion surveys, river cross-sections for hydrologic modeling, and forest/biodiversity/habitat assessments. The technology can operate in a range of day/night, weather, and vegetation conditions.

• NASA Goddard also is involved in the ongoing Geostationary Operational Environmental Satellite (GOES) system with the National Oceanic and Atmospheric Administration (NOAA). The GOES project satellites carry instruments that provide half-hour or near-continuous observations of Earth. A new generation of satellites, GOES I through GOES M, are now a key element in the modernization of NOAA's National Weather Service. NASA Goddard is responsible for the procurement, development, and verification testing of the spacecraft, instruments, and ground equipment for the project. The GOES I-M system serves the central and eastern Pacific Ocean; North, Central, and South America; and the central and western Atlantic Ocean. This new series of satellites provides half-hourly radiometric observations to fill the need for continuous, dependable, timely, and high-quality observations of Earth and its environment. Processed data are received at the National Weather Service forecast offices across the U.S., and at the National Centers for Environmental Prediction (NCEP) in Camp Springs, MD. The GOES products also are used by universities, the Department of Defense, NASA, and the global research community. The most recent satellite, GOES-K, was launched on April 25, 1997. GOES-L is scheduled for launch in March 1999.

H E A T ▲ E X C H A N G E R S



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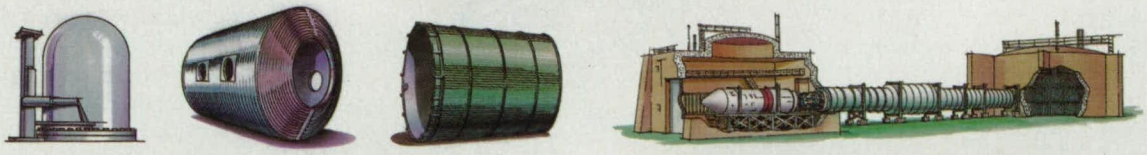

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NASA Loses Weight With PCMCIA Cards

DSP-200/300 PCMCIA card
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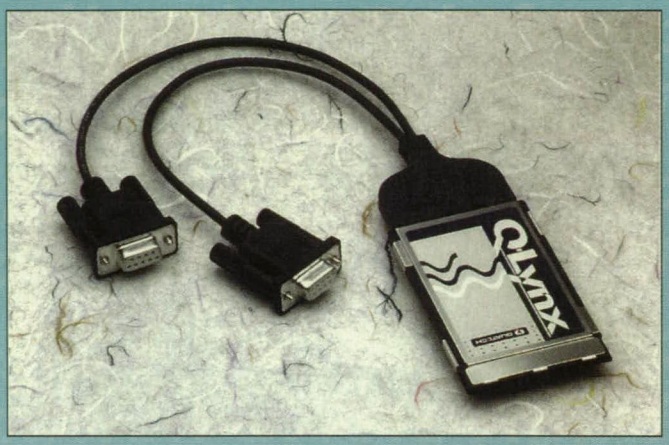
Fax: 330-434-1409
www.quatech.com

In the past, "lunchbox" type portable computers weighing between 20 and 25 pounds were used on the Space Shuttle. Each computer had three open ISA slots that could be used for adding, among other devices, serial ports to the computer. To reduce weight, NASA switched to laptop computers weighing only five or six pounds each. But by doing this, the three ISA expansion slots were lost.

The laptop systems used on the Space Shuttle are integrated by Boeing, which is responsible for ensuring that the systems are flight-ready. Each shuttle is equipped with seven to ten laptop systems.

NASA chose the Quatech DSP-200/300 two-port RS-422/485 serial PCMCIA card to solve the problem of extra serial ports. The card provides two ports on a single PCMCIA card, which can be run in the PCMCIA drives on the laptop computers. The card is Windows-compliant, provides 16-byte transmit and receive FIFOs, and can be used in multi-tasking environments and in applications involving high data rates.



The card is used for several applications on the shuttle. First, it is used as part of the telemetry guidance systems relaying data such as velocity and attitude for navigation. Data is collected from the flight control system, and is displayed on the Payload General Support Computer (PGSC) in the shuttle. As well as being a navigational aid, the serial ports also are used as a payload interface, allowing monitoring of the experiments on-board the shuttle. Finally, it also is slated to be used as the payload interface on the International Space Station to communicate with laptops that will perform experimental control, plant growth, and monitoring of the atmosphere.

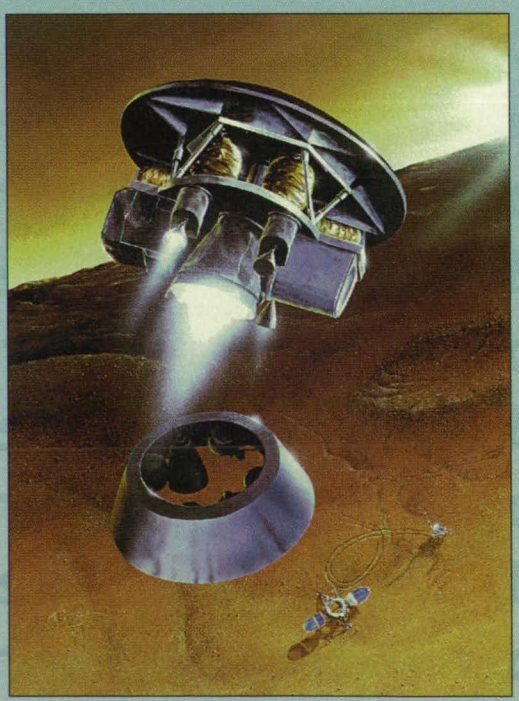
For More Information Circle No. 766

3D Viewing Program Facilitates Mars Sample Return

SolidView 3D viewing software
Solid Concepts
Valencia, CA
805-257-9300
www.solidconcepts.com

The Mars Ascent System (MAS) is designed to carry Mars exploration to a new level by launching the Sample Return Capsule (SRC), carrying Martian atmospheric and soil samples, on its return trip to Earth. Concept designs for the vehicle had to be communicated to a number of people both inside and outside of NASA. Jet Propulsion Laboratory (JPL), which managed the Mars Pathfinder project, chose SolidView to allow engineers and managers who are not CAD users to visualize a rendered 3D model of the MAS and communicate their thoughts and streamline the approval, detailing, and prototyping phases.

Larry Lee of JPL's Technical Staff sketched out the initial design concepts and presented them to a designer to produce a solid model using a high-end CAD system. The design then had to be communicated to others within the project who had no CAD experience. Lee downloaded a trial copy of SolidView from the company's web site and exported stereolithography (STL) files of the MAS from the CAD system. He then loaded the 3D image in the SolidView viewer, and in five minutes was able to learn the major features of the program. He rendered the image and viewed it as a solid model, identified areas where changes were needed, and sent it back to the designer.



Once the changes were made, Lee created several exploded views, generated 2D detail drawings to illustrate key features, and e-mailed the files and a free viewer program to his manager, who was able to immediately view, rotate, pan, and zoom the 3D drawings. He then sent his changes back to the designer. Once the design was approved, Lee used the program to create a presentation for the management staff that showed the design concept in detail.

For More Information Circle No. 756

August 1998

PHOTONICS Tech Briefs

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Subnanosecond Pulse-Width Laser

1997 Product of the Year Awards

New Photonics Products—see page 31a

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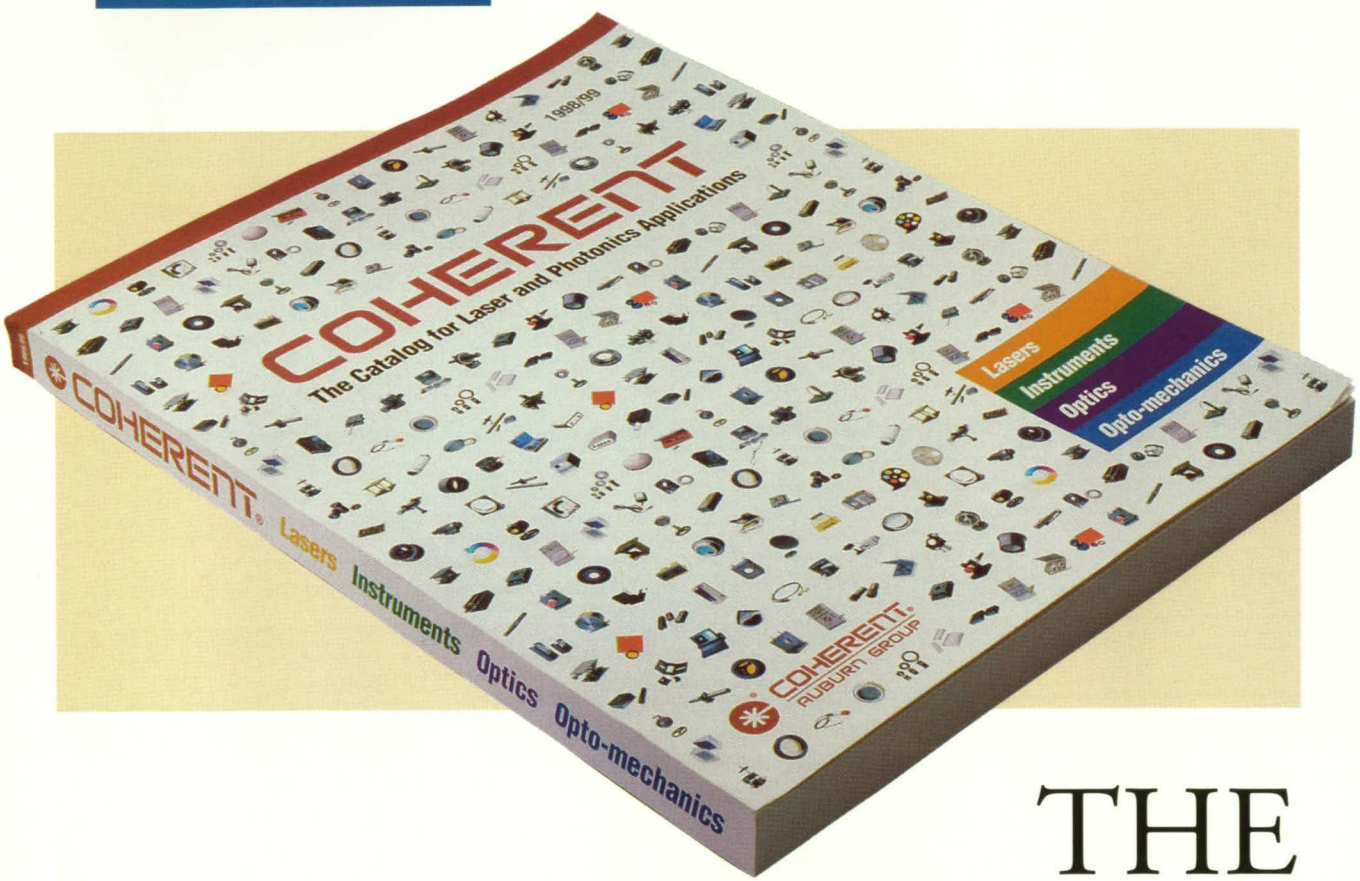

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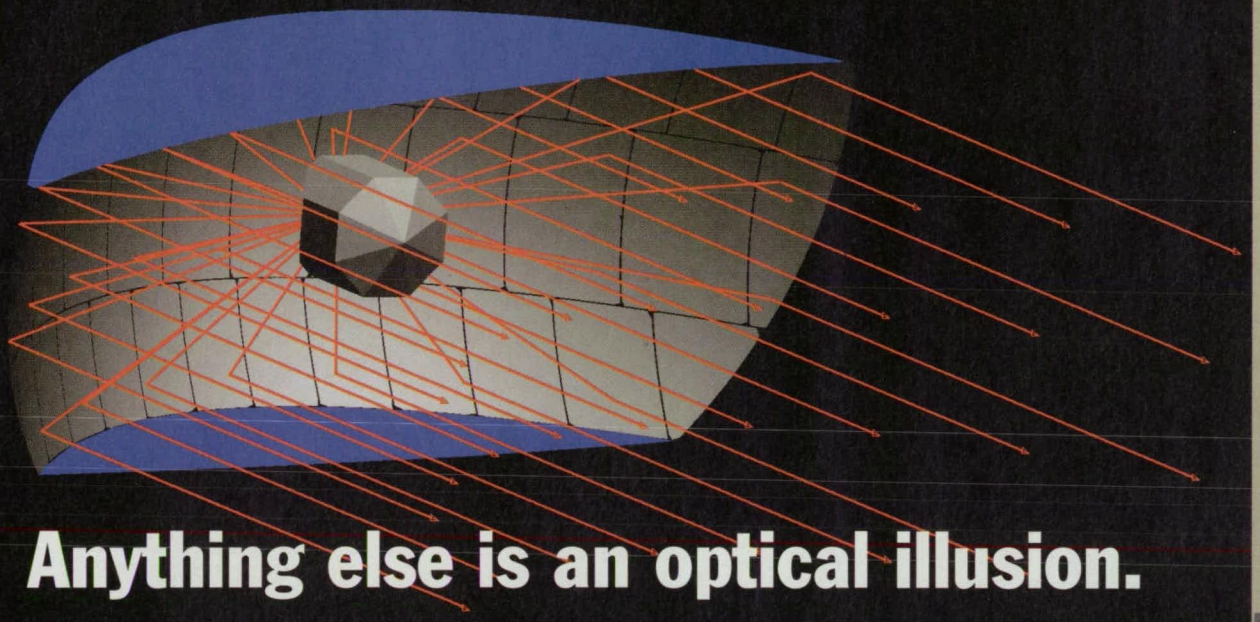
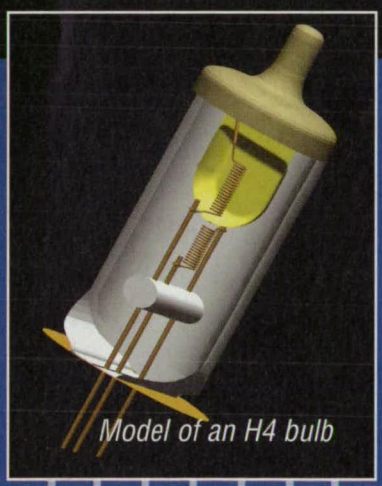


Anything else is an optical illusion.

Segmented reflector



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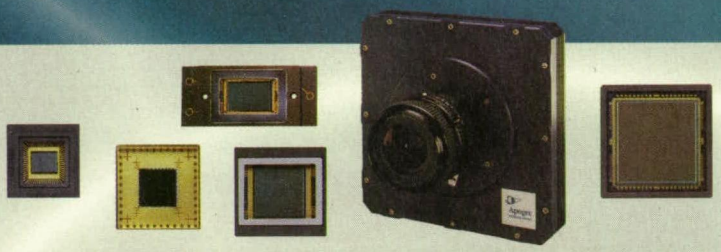

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Photonics Tech Briefs

On the cover: A technician at work in a 64-in. custom-designed coating chamber at ZC&R Coatings for Optics in Carson, CA. The chamber can accommodate coating diameters up to 24 in. *Photo courtesy ZC&R Coatings for Optics.*

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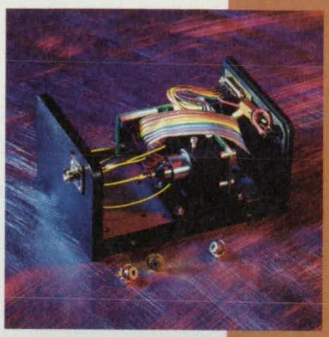

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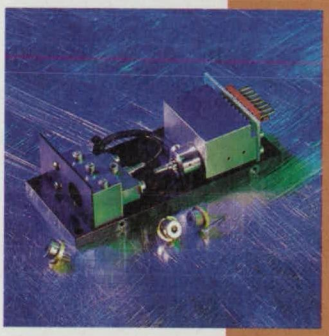

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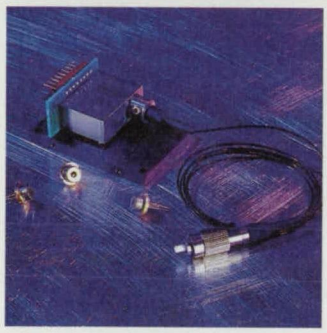

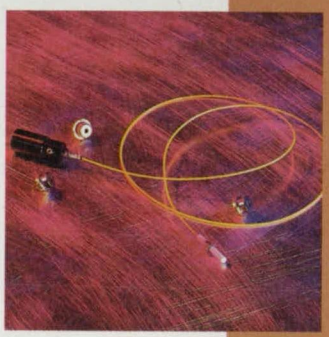

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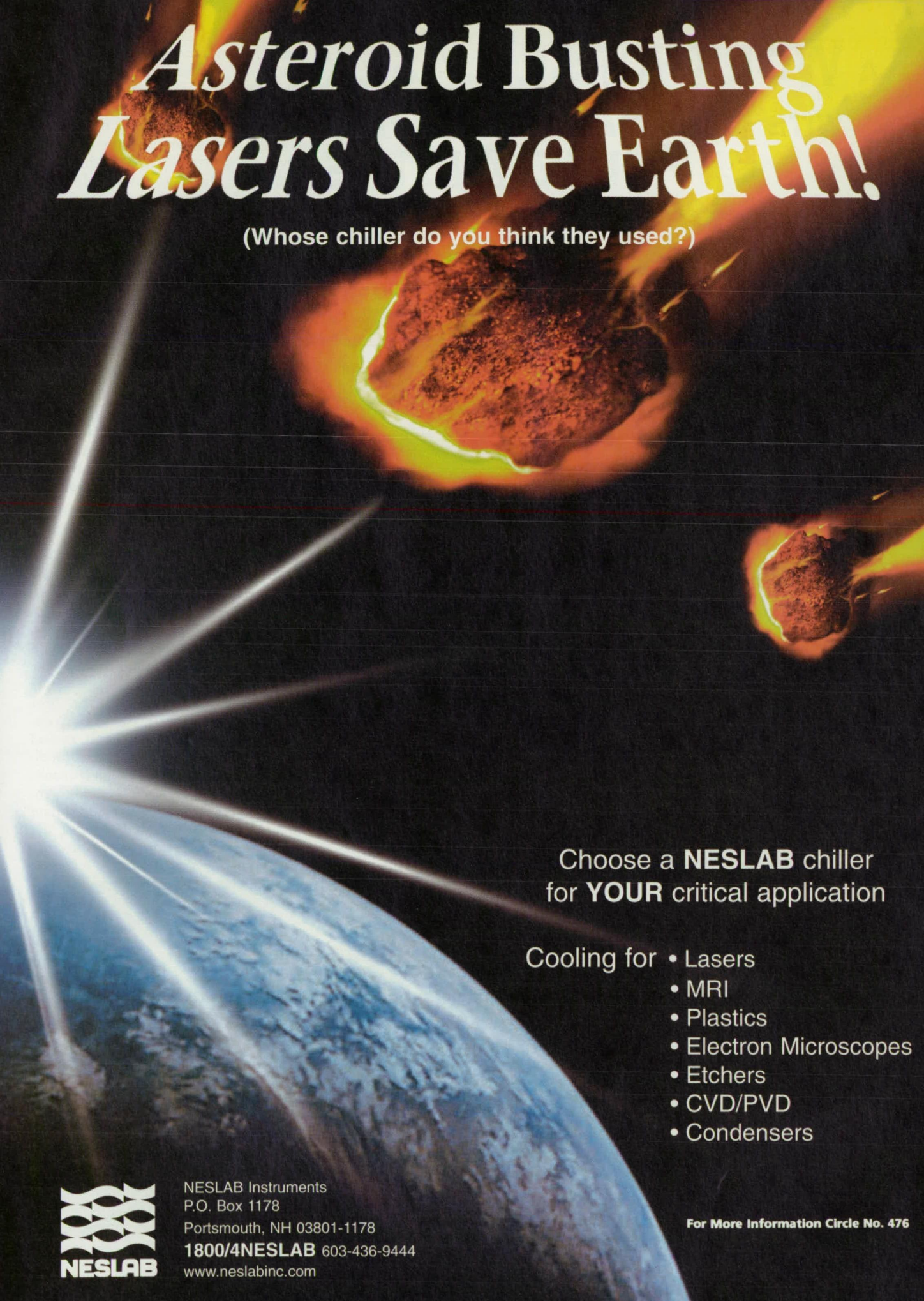
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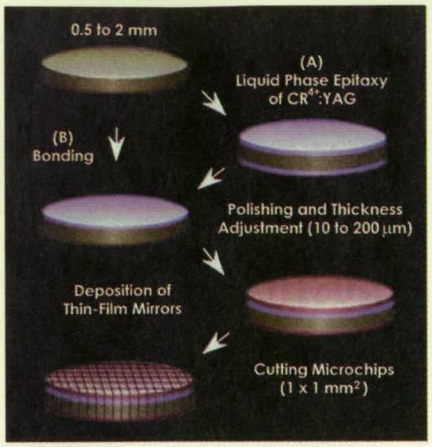

Figure 1. **Steps in the Fabricating Process.**

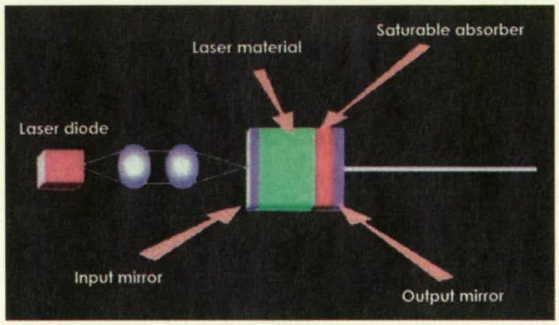

Figure 2. **Basic NanoLaser Configuration.**

Ever since the laser was invented in 1960, large-scale commercial applications for laser technology have been limited by the nature of the lasers themselves. In general, they have not only been large, inefficient, and very expensive, but have also required a high level of maintenance and tender loving care to maintain their performance. As a consequence, only the helium-neon and the diode lasers have experienced sales in excess of a few thousand units per year. But even these lasers have their drawbacks. Helium-neon lasers are low in cost and exhibit excellent beam quality; however, they are inefficient, their size grows dramatically with increasing output power, and they are relatively fragile. Diode lasers are small, inexpensive, and robust but generally exhibit relatively poor beam quality.

Today, NanoLasers™—monolithic diode-pumped, passively Q-switched solid-state microchip lasers—closely approach the ideal. These new devices produce high-intensity, linearly polarized laser light with superb beam quality in a variety of wavelengths ranging from the infrared to the ultraviolet—all from small, extremely rugged, maintenance-free modules that can be manufactured in high volume at very low cost. In 1995 Uniphase Corporation, a leading manufacturer of helium-neon and air-cooled argon-ion lasers for OEM applications, and Daniel Guillot, formerly president of Uniphase Laser Division, formed a joint venture, Nanolase SA, to develop this new technology commercially.

ORIGINS OF THE TECHNOLOGY

The technique of passive Q-switching is well understood. A saturable absorber in a laser cavity prevents lasing until the energy within the cavity reaches a critical value. The onset of lasing produces a high intracavity optical field that quickly bleaches the absorber, increasing the optical quality of the cavity and resulting in a Q-switched optical pulse.

In 1993 John J. Zayhowski and his colleagues at MIT's Lincoln Laboratory bonded a thin, flat wafer of Nd^{3+}:YAG gain medium to a similar saturable absorber wafer of Cr^{4+}:YAG. This composite structure was then coated with dielectric mirrors and diced into laser cavities with approximately a 1×1 mm^2 cross section. Coupling light from a diode laser into the cavity resulted in a train of subnanosecond infrared laser pulses at 1.06 mm. The simplicity of this monolithic passively Q-switched microchip laser and the small amount of material required to make it gave it the potential to be manufactured at low cost and high volume, as well as an inherent robustness and reliability.

At about the same time, a group from CEA/Leti in France developed a method of depositing a saturable absorber on a YAG wafer using liquid-phase epitaxy. In the NanoLaser, these steps are combined, as shown in Figure 1, to make the device shown in Figure 2. The pulse repetition rate of the NanoLaser is determined by the diode pumping power: The higher the pumping power, the faster the absorber saturates and becomes transparent, and the higher the resulting pulse rate.

Since Q-switching is always initiated at exactly the same intracavity energy density, pulse energy is independent of pump power and repetition rate, but is directly proportional to the thickness of the saturable absorber (assuming constant Cr^{4+} doping). Finally, pulse width is determined primarily by the cavity's round-trip time. The shorter the overall laser cavity, the shorter the round-trip time, resulting in pulse widths that are routinely less than a nanosecond.

Pulse energies as high as 100 μJ, pulses as short as 218 ps, average powers as high as 120 mW, and pulse repetition rates as high as 75 kHz have been demonstrated in the laboratory in various laser configurations. At pulse repetition rates below 15 kHz, the laser pulses are extremely uniform, and by carefully controlling the diode pump laser, pulse-to-pulse timing jitter can be kept below 0.5%.

The high peak intensity of the short pulses generated by the NanoLaser, coupled with the extremely short optical cavity geometry, makes it an ideal candidate for harmonic generation. Second, third, and fourth harmonics can be generated simply by sliding the appropriate nonlinear crystals directly against the laser cavity itself (Figure 3). Focusing optics are not needed. *(Continued)*

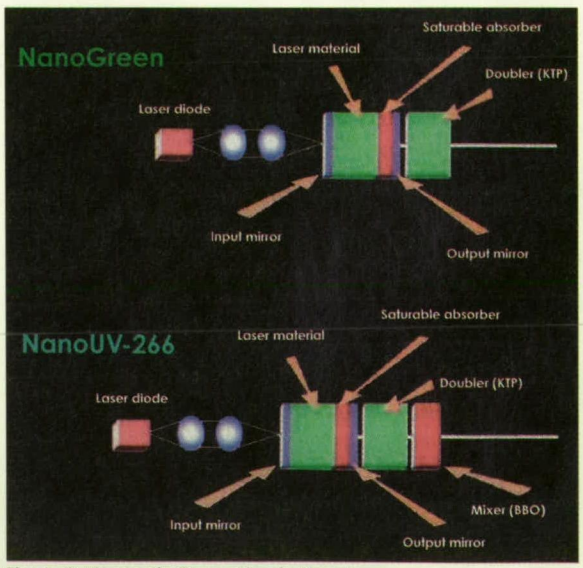

Figure 3. **Harmonic Generation in NanoLasers.**

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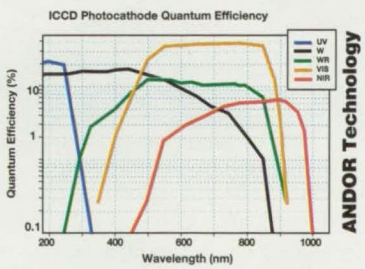

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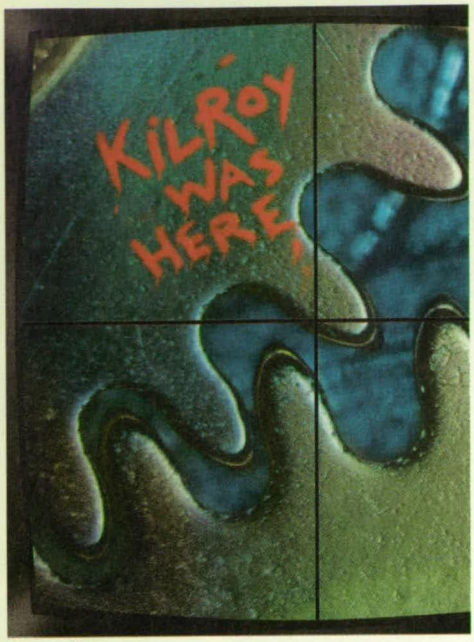

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COMMERCIALIZING THE TECHNOLOGY

Uniphase and Nanolase acquired the rights to the MIT and CEA/Leti patents under license and, in 1996, announced their first products—the NanoPulse™, a 1.06-µm infrared laser optimized for high pulse energy, and the NanoGreen™, a doubled laser operating at 532 nm, optimized for average power. Both units are 10 cm in length and less than 70 cm^3 in volume.

In 1998 these products were followed by two ultraviolet lasers, one operating at 355 nm, the third harmonic of YAG, and one at 266 nm, the fourth harmonic. NanoUV™ systems, like the one shown in Figure 4, are optimized to maximize average output power, and blocking filters substantially reduce residual IR and green wavelengths.

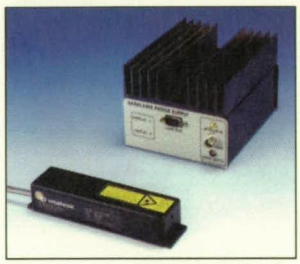

Figure 4. **A NanoUV Laser Head.**

The output beam of all four NanoLasers is linearly polarized and nearly diffraction-limited (TEM_{00}). The beam profile of the NanoGreen system is Gaussian, with an M^2 of <1.2. A thermoelectric cooler in the laser head ensures optimum performance over a wide range of ambient conditions, and the highly regulated OEM power supply tightly controls diode laser current and maintains diode temperature to within a 0.2-°C window for stable long-term operation. Because of its high level of performance and overall robustness, a NanoPulse laser was chosen to fly on NASA's X-33 reusable launch vehicle (see below).

APPLICATIONS APLENTY

NanoLasers, although rapidly pulsed, typically at 10 kHz, may be considered quasi-CW (continuous wave) and thus, with their small size, low cost, and superb beam quality, suitable for many of the existing pulsed and CW applications traditionally filled by air-cooled argon-ion lasers, helium-cadmium lasers, pulsed nitrogen lasers, and actively Q-switched YAG lasers. For example, the visibility of the beam in a NanoGreen laser is five times greater than that of an equivalent red HeNe laser, yet the laser is smaller and more robust and uses less energy—important considerations in field applications. In reasonable volume, the price of the NanoGreen laser is significantly less than argon and helium-cadmium lasers, and much less than

NANOLASERS IN SPACE

A Uniphase NanoPulse laser will be aboard the X-33 Reusable Launch Vehicle on its maiden flight in 1999, helping to monitor the condition of the fuel tanks. The NanoPulse laser is the probe for a critical distributed-temperature-sensing (DTS) system developed by Systems & Processes Engineering Corp. (SPEC) of Austin, Texas, in conjunction with Lockheed Martin and NASA.

An Artist's Rendition of the X-33 Launch Vehicle *(Courtesy NASA)*.

In the DTS system, the laser pulse is injected into a long fiber that is wrapped around the fuel tank. Raman scattering occurs along the entire length of the fiber, and the temperature at a given point along the fiber can be determined by the ratio of the Raman-shifted Stokes and anti-Stokes lines reflected back down the fiber from that point. With sufficiently short laser pulses and very fast electronics, spatial resolution of one foot can be achieved. Due to compromises between speed and power consumption, spatial resolution on the X-33 sensor is limited to one meter.

The NanoPulse laser was selected because of its small size, robustness, and ability to produce subnanosecond laser pulses. In the DTS system, the laser is mounted directly on a VME card that will be exposed to shock and random vibration of 12.5 G and temperature variation of -30 to +80 degrees centigrade. Since the system will be operated in a vacuum, the laser's ability to be fully conduction-cooled is critical.

For more information on distributed-temperature-measurement systems, contact Leif Fredin at (512) 479-7732, E-mail at fredin@spec.com, or visit the SPEC web site at http://www.spec.com. For more information on the X-33, check its website at http://stp.msfc.nasa.gov/stpweb/x33/x33home.html.

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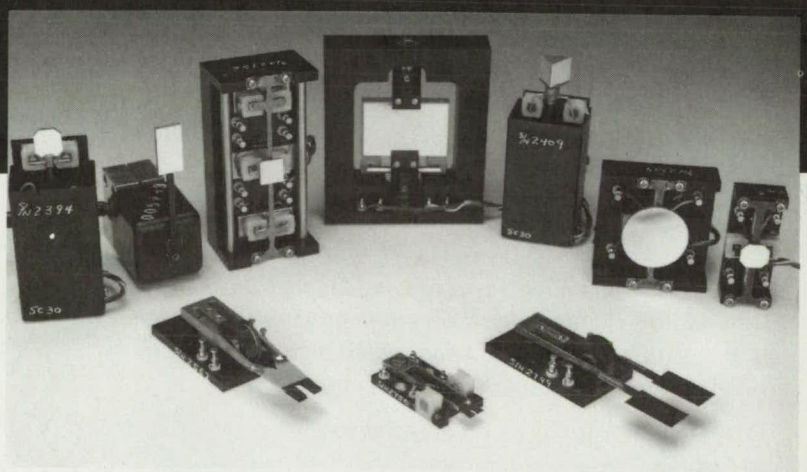

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actively Q-switched devices. Furthermore, the beam quality of a NanoUV system is dramatically better than that of a pulsed nitrogen laser.

Nonetheless, it is the very short pulse width of these lasers that will enable many new and successful commercial applications. Many pulsed laser applications are much more dependent upon peak pulse power than on average power or overall pulse energy. Since most actively Q-switched pulsed lasers exhibit pulse widths of between 10 and 50 ns, the 1-ns pulse of a NanoLaser will have up to 50 times the peak power of a conventional Q-switched laser with the same pulse energy, and it will often do the job of a much larger, more expensive, and less reliable system. Furthermore, because of the short pulse width, the heat-affected zone will be much narrower, reducing collateral damage on the work piece. NanoLasers can photoablate most absorbing materials, including metals, semiconductors, glasses, and biological tissues. At MIT, Zayhowski was able to cut 5-μm lines cleanly in the metallization on semiconductor wafers and to drill holes through the substrate.

As mentioned above, the high peak pulse power facilitates harmonic generation, and the UV output generated by the NanoUV systems enables a broad base of new applications, particularly in the areas of environmental monitoring and remote sensing. Not only is UV light the optimum measurement wavelength for many of these applications, it is also an excellent source for generating time-resolved and UV-Raman spectra for on-line process control, since the fluorescence that plagues most Raman measurements is far removed from the signal.

In medical and biological applications, these NanoUV lasers have a bright future in diagnostic applications such as capillary cataphoresis and DNA sequencing, drawing on the natural tendency of biological materials to fluoresce in the UV. The short pulses are also well suited to such emerging applications as diffuse optical tomography as well as existing applications in ranging and micro-LIDAR.

Into the Future

NanoLaser technology is still in its infancy, and rapid advances are being made in output power, pulse energy, and packaging. Current NanoLaser models are specified at 3 μJ at 1.06 μm, at 6 mW at 532 nm, or at 1 mW at either 355 nm or 266 nm. Tens of milliwatts of average UV power have been demonstrated in the laboratory, however, and Uniphase plans to offer a product with more than 5 mW of output at 266 nm before the end of the year. Other plans include fiber-coupling the diode laser pump into the laser head to reduce the overall head size to a few cubic centimeters, which will simplify many process-control applications by avoiding the need to transmit UV output through a fiber. Lasers will also be provided with pulse-on-demand for triggered applications. NanoLaser technology is not limited to YAG lasers. Work on other materials, including erbium/glass, is progressing, holding out the promise of an eye-safe 1.5-μm NanoLaser in the near future.

The future of laser technology lies in the development of small, high-power, inexpensive solid-state lasers with beam quality at least equal to that of the traditional gas lasers like helium-neon, helium-cadmium and argon-ion lasers. NanoLaser technology will be a significant part of that future.

For more information, contact the author of this article, Tom Babcock, the Product Manager for NanoLaser Products at Uniphase Corporation in San Jose, CA. He can be reached at (408) 570-2070; E-mail tom.babcock@uniphase.com.

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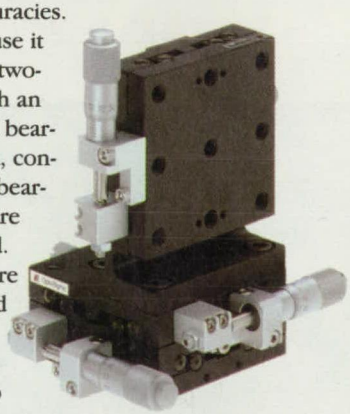

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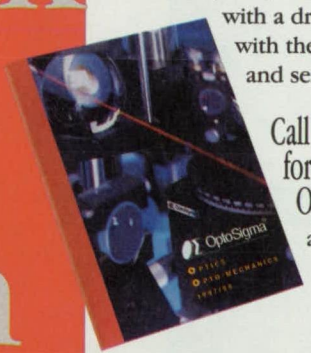

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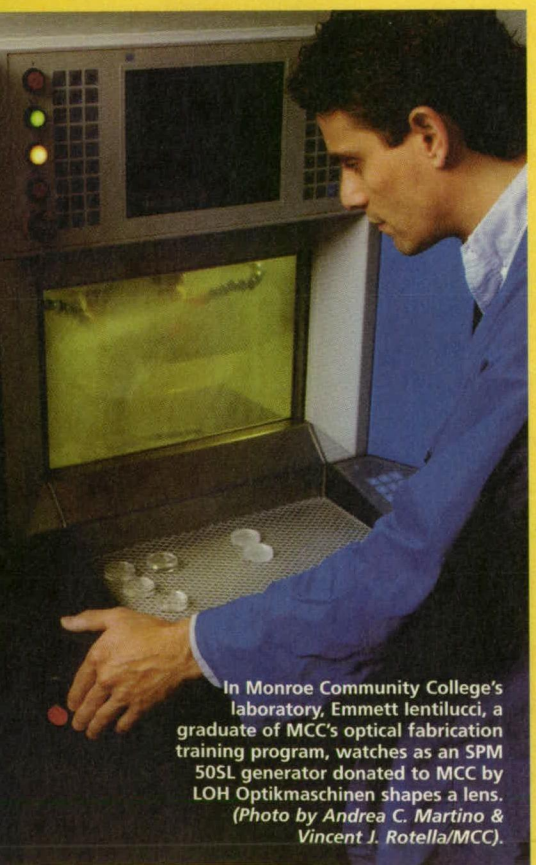
CLOSING *The Optical Technician* GAP

Lawrence Livermore joins Monroe Community College in an innovative program to train more skilled American technicians.



In Monroe Community College's laboratory, Emmett Ientilucci, a graduate of MCC's optical fabrication training program, watches as an SPM 50SL generator donated to MCC by LOH Optikmaschinen shapes a lens. *(Photo by Andrea C. Martino & Vincent J. Rotella/MCC).*

Chalking up the first milestone in what the optics industry looks upon as a pathbreaking effort, Monroe Community College (MCC) in Rochester, NY, has graduated 36 optical technicians from a newly minted certificate training program. Already virtually all have had job offers, some more than one. But offsetting that good news, as Robert Novak, the longtime chairman of the optical systems technology department at MCC, points out, this number will not even satisfy local needs for optical technicians.

The graduating class is the first in a new program spearheaded by Lawrence Livermore National Laboratory (LLNL) in California. Livermore will soon begin construction of the 192-beam $1.2-billion laser for the National Ignition Facility (NIF), the Department of Energy's center for inertial confinement fusion and high-energy-density scientific research. The NIF laser will be the world's largest optical instrument, requiring more than 7000 large—greater than two feet diagonally—optical components and more than 15,000 small ones. Meanwhile optics companies nationwide are suffering from a shortage of trained optical technicians, whether their work is scientific, military, or commercial.

LLNL chose Monroe because of its well-established and highly regarded two-year curriculum in optics technology. MCC agreed to add to that a related single-year course focused on the machinery and methods of optical fabrication. The laboratory is providing MCC with tools and equipment worth hundreds of thousands of dollars for use in the training program. According to David Aikens, an optics manufacturing manager for the NIF, MCC was chosen because of the excellence of its existing facilities and faculty, its close ties to precision optics companies in the Rochester area, and the national reputation of its optics program. LLNL may also supply guest lecturers in photonics disciplines.

"The optics program at MCC has been a leader in delivering training and education to LLNL's industrial partners and to other local and nationally based optics firms for many years," Aikens said. "The close relationship to these companies in the future will be crucial to the success of the program."

LLNL is joined by the 86-member American Precision Optics Manufacturers' Association (APOMA) in supporting the new certificate program: Rochester-area APOMA members have made about $400,000 in in-kind contributions to the program.

Further support came from what might seem an unexpected source. Last November, LOH Optikmaschinen AG of Wetzlar, Germany, donated to the college an SPM/SPS 20 Spheronorm spherical generator and polisher system, so that MCC students could receive hands-on computer-numerical-controlled (CNC) equipment training in the college's optical fabrication laboratory. More recently LOH, an APOMA member, donated a state-of-the-art SPM 50SL generator and SPS 50SL polisher, bringing the total value of the company's gifts to approximately half a million dollars.

MCC's optical science technology faculty still teach students the conventional manual process for producing lenses, but with the LOH equipment students also learn how to use CNC equipment, a key skill for today's technicians. In February, Manfred Hanisch, LOH's manager of process engineering, came to MCC and provided advanced training to the faculty, demonstrating that generating a spherical lens with the SPM/SPS systems would take only five to six minutes.

"We can now provide CNC-trained technicians, and they are a hot commodity," Novak said. "It's extremely difficult to find such well-trained technicians, particularly in CNC technology. Our graduates will have experience on the finest

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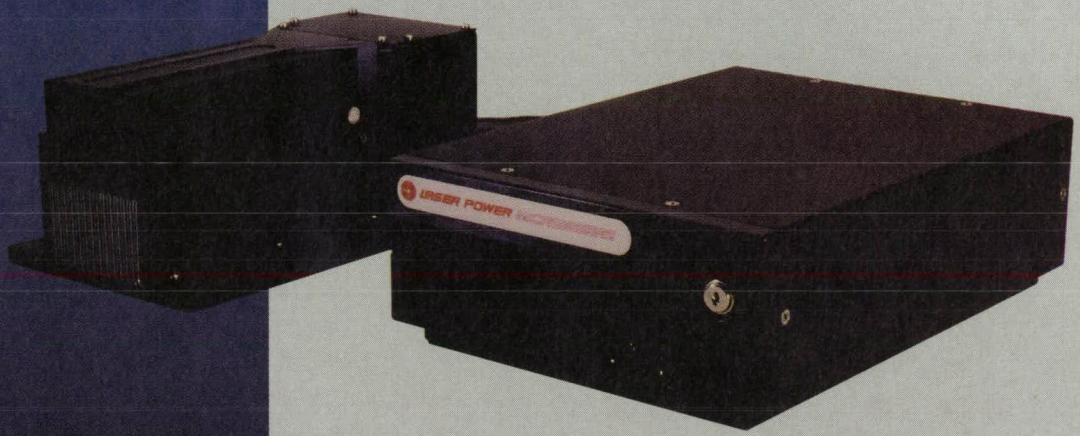

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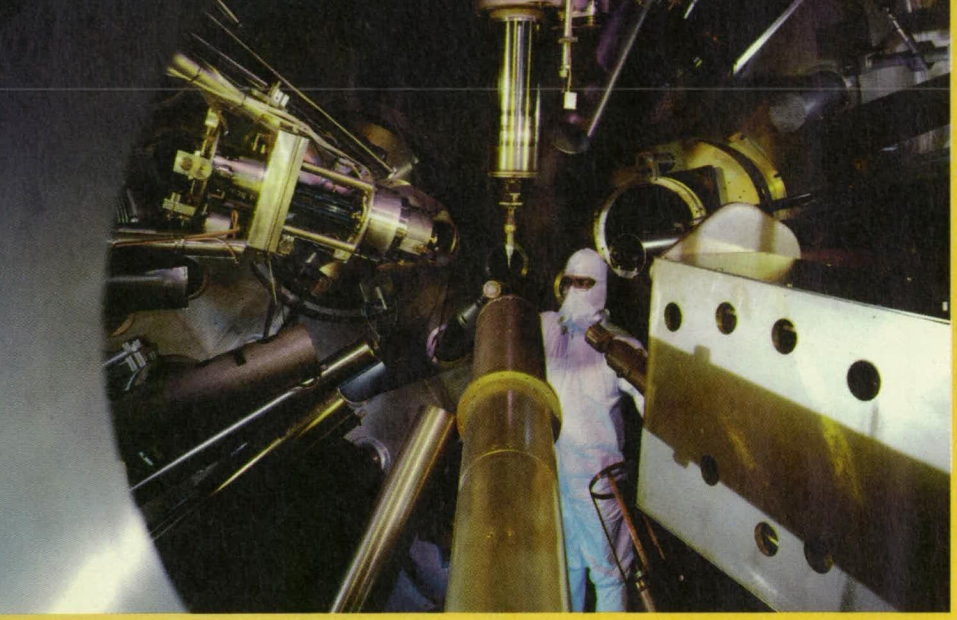


Inside the National Ignition Facility's target chamber, where a tiny fuel target is lowered from above on the vertical stalk. The other instruments pointed at the target will measure its performance at ignition. *(Photo courtesy LLNL)*

precision optical equipment available. That's like learning to drive using a Mercedes-Benz."

MCC's optical technology program was the first of its kind in the United States in 1962, when the college opened. The synergy with local industry was quickly established, what with such leading photonics companies as Eastman Kodak, Xerox, and Bausch & Lomb in the area. Kodak set up the first optics apprenticeship with MCC in 1972. The partnership still stands as the oldest of its kind in the country. MCC training programs in optical fabrication have been developed since and delivered to many other national firms and the military. The new certificate program, designed by Novak, consists of a minimum of 360 lecture hours and 465 laboratory hours, to be completed in a year of full-time study, or more for those already employed in optics companies and attending MCC part-time.

According to Walter Czajkowski, president-elect of APOMA and an engineer in the optical products group at Kodak, "New equipment, coupled with increasingly higher optical performance specifications, requires the optician to have a broad understanding of all the technologies associated with the total manufacturing cycle. This not only includes traditional optical fabrication skills," he continued, "but also an exposure to CNC, metrology, and statistical process control. To date, we have done little in developing training programs that target these needs." Czajkowski is a member of the new program's steering committee, along with Ronald Colavecchia of Melles Griot; James Sydor of Stefan Sydor Optics; Robert Wiederhold of Optimax Systems, Inc.; and Novak, Dustin Swanger, and Andrea Martino, all of MCC.

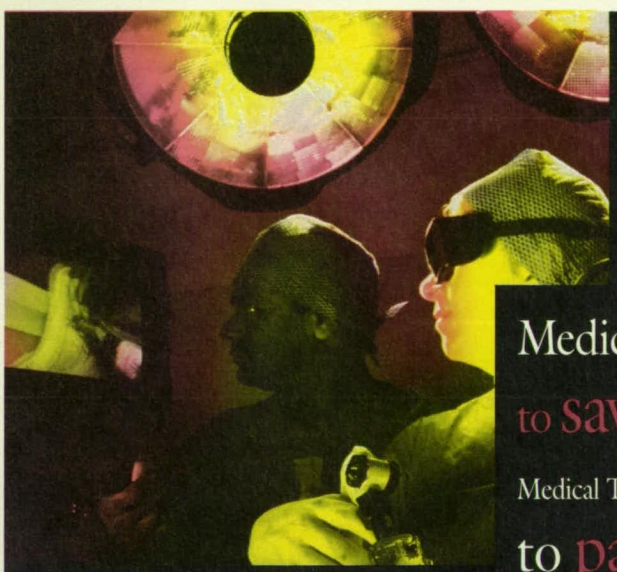
Up to three colleges might ultimately offer the one-year training program by the upcoming school year—"depending on how it goes at Monroe," Aikens said.

William Kutz of K and S Optics in Rochester, NY, head of an APOMA committee to study training of technicians, said, "We recognize there is a serious shortage of trained optical technicians and an even greater lack of training programs. Now, with this deal between Lawrence Livermore and Monroe, we're on our way."

NATIONAL IGNITION FACILITY

The National Ignition Facility (NIF), being built by Lawrence Livermore for the Department of Energy, will integrate civil, commercial, and national security research in a single facility. When NIF's 192-beam laser is operational, LLNL researchers estimate they can achieve inertial confinement fusion ignition within a decade, leading to the production of safe, clean, and abundant energy. Fusion-powered plants are expected to replace fission plants during the next century, thus limiting radioactive inventories by a factor of 1000 and markedly reducing radioactive wastes.

New technologies for NIF's engineering and optics requirements are being developed in coordination with more than 300 team members from science, academia, and 35 U.S. corporations. The NIF laser will be the world's largest optical instrument, its total precision optical surface area measuring three-quarters of an acre, forty times that of what is now the world's largest telescope, the Keck Telescope in Hawaii.



Before the doctor turned to Medical technology to save his patient, Medical Technology turned to page 206.

And to several other pages, where the optical components used in sophisticated medical devices such as blood analyzers, DNA analysis and endoscopes can be found.

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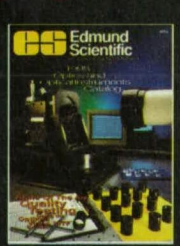

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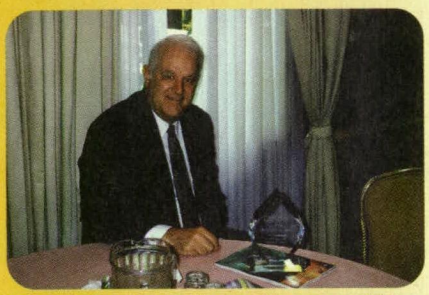
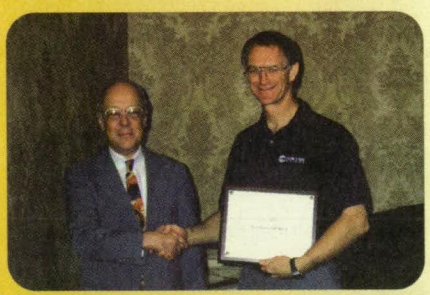
Photonics Tech Briefs 1997 Product of the Year Awards



VLSI Vision Ltd.'s North American General Manager Don Lake with the 1997 *Photonics Tech Briefs* Product of the Year award.

Dr. Heinrich Endert (right), Industrial/Scientific Sales Manager of Lambda Physik Inc., accepts the award plaque for the company's NovaLine 100 excimer laser. Robert S. Clark, editor of *Photonics Tech Briefs*, presented the awards.



Ed North (right), President of New Wave Research Inc., accepted the award for the company's EzLaze micromachining system.

Carlos Roundy (right), President of Spiricon Inc., was presented the award for the company's LBA-300PC laser beam analyzer.

At a breakfast ceremony held in San Francisco during the 1998 Conference on Lasers and Electro-Optics (CLEO) in May, VLSI Vision Limited received Photonics Tech Briefs' *1997 Product of the Year Award for the VV6405 single-chip NTSC color camera. Don Lake, the company's North American general manager, accepted the award on behalf of VLSI Vision, which is headquartered in Edinburgh, Scotland, and has offices in San Jose, CA, and New Jersey.*

The VV6405 single-chip NTSC color camera, using the company's proprietary complementary metal-oxide semiconductor (CMOS) technology, delivers color video with a single external crystal and single-rail 5-V power supply. On one standard CMOS chip, it combines a quarter-inch ColorMOS™ photoplane, video timing controller, 8-bit A/D video converter, 300-MIPS color DSP engine, 5 video line memories, auto exposure control and color balance, and NTSC composite video encoder. The chip draws about 100 mA at 5 V, which VLSI says puts its power consumption at about 20 to 30 percent of that of a CCD.

Each contender for the award had been a Product of the Month in 1997, chosen by the editors for outstanding technical merit and practical value to the magazine's engineering and management readers. The winner was chosen by ballot by Photonics Tech Briefs' *readers at year's end.*

The four other finalists for the award included:

- Hewlett-Packard's LSC2500 1500-nm directly modulated distributed feedback laser, intended for long-haul telecommunications, fiber optic sensors, cable television, and instrumentation, and capable of distances greater than 200 km over single-mode fiber;
- Spiricon's LBA-300PC laser beam analyzer Version 1.2, with the patented Ultracal automatic calibration technique, making it the only commercial-grade system, according to the company, able to make second-moment beamwidth measurements, the new ISO standard;
- New Wave Research's EzLaze™ solid-state laser cutting system designed for semiconductor failure analysis, design verification, LCD repair, and other micromachining applications, and capable of producing uniform cuts ranging from 1 × 1 μm to 50 × 50 μm; and
- Lambda Physik's NovaLine 100, a KrF laser whose 100 W of stabilized output power make it suitable for such industrial microstructuring tasks as high-speed circuit-board via drilling, ink-jet printer nozzle drilling, and wire stripping.

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Voltage-Tunable Surface-Plasmon Band-Pass Optical Filters

Efficiencies would exceed those of previously developed liquid-crystal tunable filters.

NASA's Jet Propulsion Laboratory, Pasadena, California

Voltage-tunable optical band-pass filters based on surface plasmon waves have been proposed. These filters would function at both visible and infrared wavelengths. Whereas liquid-crystal tunable optical filters now on the market exhibit efficiencies of 20 percent or less, theoretical calculations predict that the efficiencies of the proposed tunable surface-plasmon filters could exceed 60 percent in some cases.

Figure 1 schematically illustrates one of two types of the proposed filters. A thin film of a suitable electro-optical material (for example, a liquid crystal) would be sandwiched between two high-index-of-refraction prisms coated with thin metal films at the prism/electro-optical-film interfaces. If p-polarized white light were to impinge on this device at a certain angle (denoted the surface-plasmon angle), then the energies of some of the incident photons would be converted into collective motions of free electrons in the upper metal film. Because of the thinness of the electro-optical film, the optical field would penetrate the film and excite the same collective motion of electrons in the lower metal film. As a result, light would be transmitted in the sense that it would be re-radiated from the bottom. Only the photons at the surface-plasmon resonance frequency could generate surface plasmon waves and could thereby be coupled through the thickness to contribute to the transmitted light; consequently, the transmitted light would be colored.

The surface-plasmon resonance frequency would depend on the indices of refraction of both the metal film and the liquid crystal or other electro-optical material. If a voltage were applied to control the index of refraction of the electro-optical material, then the voltage would control surface-plasmon resonance frequency and thus the spectrum of the transmitted light.

For example, theoretical calculations were performed for a device like that of Figure 1 comprising TiO_2 prisms with 45° angles, silver films 35 nm thick, and a 150-nm-thick electro-optical film made of a recently developed liquid crystal, the index of refraction of which can be made to shift as much as 0.5. According to the calculations, with no voltage applied to the silver films, the device would exhibit peak transmission at a wavelength of 450 nm (blue), with an

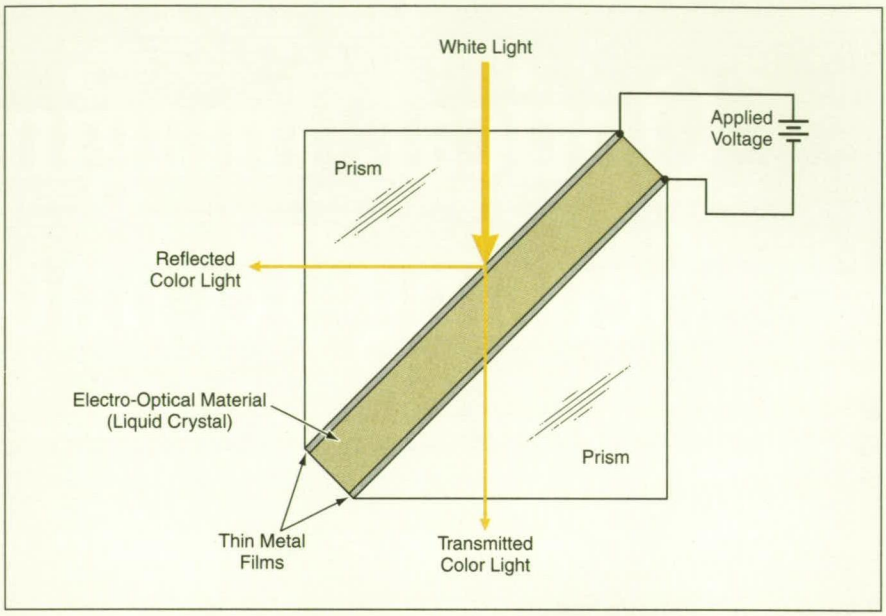

Figure 1. The **Applied Voltage Would Alter the Index of Refraction** of the electro-optical material, thereby altering the surface-plasmon resonance frequency and shifting the spectrum of transmitted light.

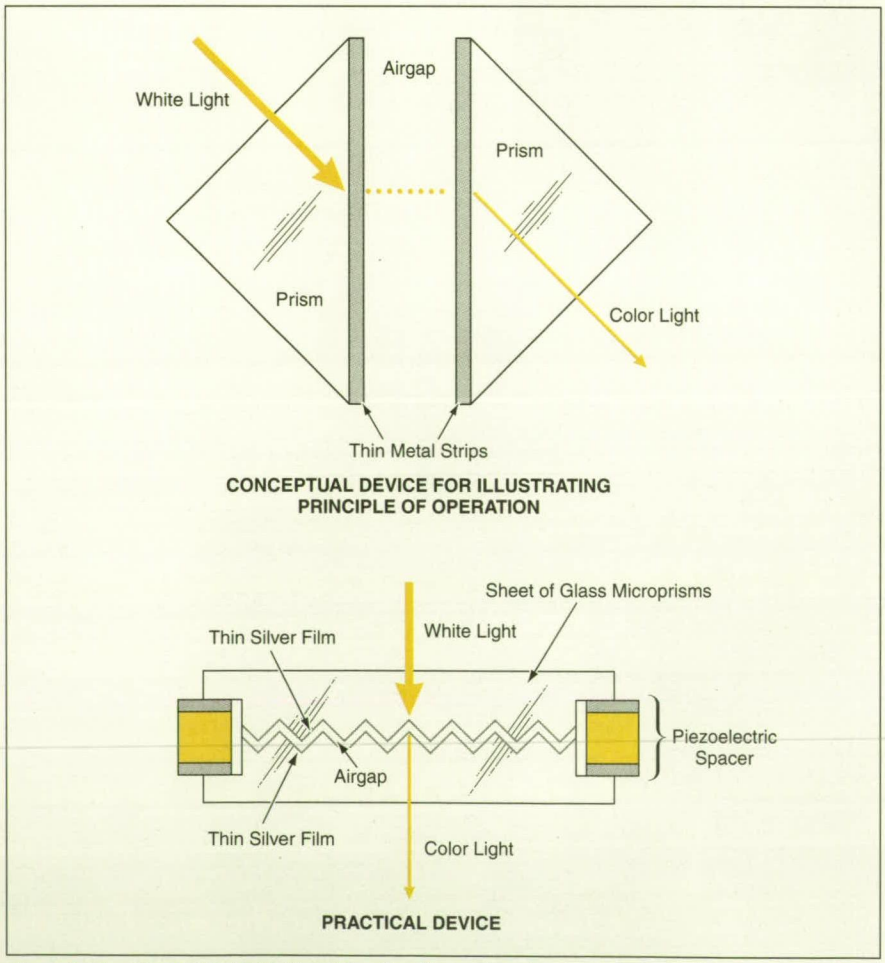

Figure 2. The **Airgap Would Be Varied** to alter the surface-plasmon resonance frequency and thereby shift the spectrum of transmitted light.

efficiency of 62 percent. With enough voltage applied to shift the index of refraction by 0.5, the peak of the transmission spectrum would be shifted to 650 nm (red), and the efficiency would be 70 percent.

If a metal other than silver were used, the device could be made to work in infrared light. For example, if the silver films in the device described in the preceding paragraph were replaced with potassium films, then the wavelength of peak transmission could be made to range from 1,050 to 1,700 nm.

A proposed tunable surface-plasmon optical filter of the second type would also include prisms partly coated with thin metal films (see Figure 2), but there would be no electro-optical film with a voltage applied to control its index of refraction. Instead, an airgap would be left between the metal films, and the distance between the prisms would be varied to vary the airgap and thereby vary the surface-plasmon resonance frequency. A practical device of this type could be made from sheets of microprisms, with piezoelectric spacers for varying the airgap.

This work was done by Yu Wang of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Physical Sciences category.*

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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A Polymeric Optical Correlator for Security Verification

Photorefractive polymer breakthrough enables low-cost optical correlators for security verification.

Optical Sciences Center, University of Arizona, Tucson, Arizona

Rapid technological progress, especially in computers, CCD technology, color printers and scanners makes forgery and counterfeit of identification documents such as credit cards, or other important objects, increasingly simple. Current techniques such as the embossed hologram on credit cards are being defeated, and there is a strong need for a continuous development of new optical methods for security applications to stay ahead of counterfeiters. Optical security features can be inspected by either visual checking without special equipment or with the help of tech-

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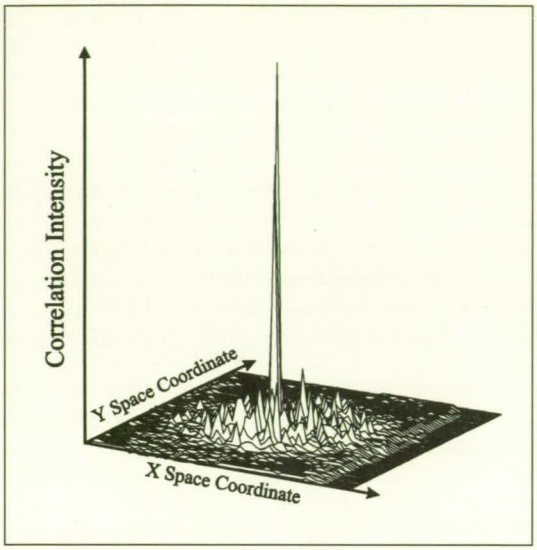
nical facilities for rapid screening. When such an optical system is required for security checking, its low manufacturing cost is a critical issue for its technological viability.

The proposed low-cost security verification system is based on the optical encoding of documents with pseudo-randomly generated phase masks and their inspection by performing all-optical spatial correlation of two phase-encoded images in a real-time optical recording medium and in a four-wave mixing configuration. One phase image is placed on the object to be verified, such as an ID card. The other is made available to the security systems for comparison with the input image. The practically invisible phase mask is permanently placed on the object to be verified, and can be manufactured using a number of techniques such as embossing on plastic films, encoding on photopolymer, etc. With the high resolution of commercially available optical materials, the phase mask can be of the order of a million pixels, and the mask size will be only a few millimeters square.

The recording medium is a key element in this type of all-optical architecture. The limited performance and/or the high cost of existing nonlinear optical materials has severely limited the technological potential of all-optical correlators: inorganic photorefractive crystals have been investigated but their processing and cost has limited their finding widespread applications. Due to limited optical material performance, other correlator designs have been proposed over the years: nonlinear joint-transform correlators, for instance, show good performance for pattern recognition and are capable of real-time operation. However, because these systems use either sophisticated liquid crystal light valves, CCD detectors, and/or a computer to perform Fourier transforms, they do not meet the low-cost requirement.



Correlation Peak detected for identical masks.

The proposed optical correlator uses highly efficient photorefractive polymers developed at the University of Arizona. These materials are at the cutting edge in plastics research and are promising for several applications, including holographic storage, optical processing, phase conjugation, and imaging. In the proposed optical correlation system the phase mask used is a 64-×-64-pixel binary random pattern. To authenticate the document it is compared with a master that is an exact copy. The hologram written by the interference of a reference beam and a laser beam going through the test mask forms a holographic filter for the master mask. If the two phase patterns match, light will be strongly diffracted by the photorefractive polymer. The figure shows the intensity distribution of the signal that is produced by two matching masks. This

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holographic filter is performed in real time with a low-power 675-nm laser diode. The active medium is a 105-micrometer-thick photorefractive polymer film sandwiched between two transparent indium-tin-oxide electrodes.

The security verification system proposed has the following features that make it practical for widespread applications. First of all, the use of a highly efficient photorefractive polymer as active material in an all-optical correlator configuration and its compatibility with semiconductor laser diodes keep the overall manufacturing cost to levels that are significantly lower than that of any previous proposed optical correlator. The system is fast because the processing is implemented optically in parallel. Furthermore, the high resolution of the photorefractive polymers allows the use of lenses with shorter focal lengths in the 4f correlator, thus making its design more compact compared with ones using liquid crystal light valves. In addition, all the components, including the laser source and the nonlinear material, can be manufactured in a very small size and the system can be easily further miniaturized. Finally, because the recording process is based on the photorefractive effect, the stored hologram can be erased and a new hologram written in real time. This reversible real-time recording and processing enables the testing of a variety of different documents encoded with different phase masks and their comparison with a corresponding master mask database.

This work was done by N. Peyghambarian, B. Kippelen, and colleagues at the Optical Sciences Center of the **University of Arizona**, *Tucson, AZ, and by B. Javidi from the University of Connecticut. The project was funded by the Office of Naval Research through the MURI Center CAMP, by AFOSR, and NSF. For more information, call (520) 621-4649 or (520) 621-4341.*

Coherent Gradient Sensing for Measuring Curvature

This is a full-field, real-time, noncontact optical technique.

NASA's Jet Propulsion Laboratory, Pasadena, California

Coherent gradient sensing (CGS) is a diffraction-based, noncontact optical technique for measuring the slight curvature of a nearly flat thin film or specimen surface. CGS is especially useful for measuring curvatures of micromechanical structures and of thin films in electronic devices, to enable the determination of stresses in, and mechanical properties of, such structures and films. CGS

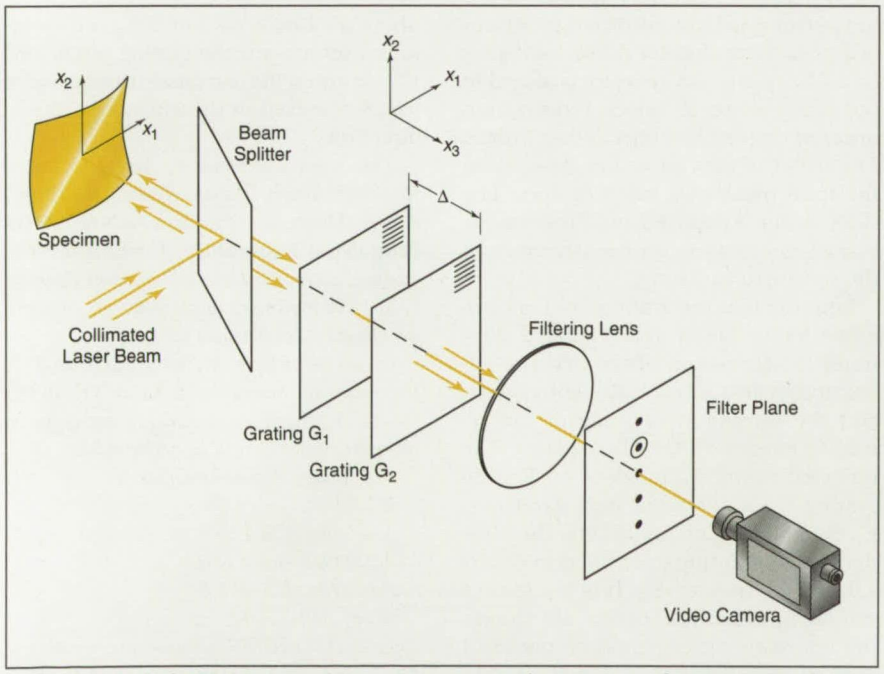

Figure 1. A **Typical CGS Apparatus** is set up to measure the curvature of a specularly reflective specimen.

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is a full-field, real-time technique: Unlike in some other techniques, it is not necessary to acquire images of the specimen surface at different times under different conditions of curvature, nor is it necessary to scan a narrow beam of light over the surface; instead, CGS yields data on curvature over the entire surface area of interest, in as little time as it takes to acquire, digitize, and process a video image. Moreover, CGS is insensitive to rotation or displacement of the specimen.

$E_{1,1}$ through $E_{-1,-1}$, among others. Various sets of parallel diffracted beams are combined by the filtering lens to form diffraction spots D_1, D_0, and D_{-1}, among others.

The net effect of the gratings is a lateral (in this case, along x_2) shift or "shearing" of the incident wavefront, leading to the formation of interference fringes. The fringe pattern has been analyzed theoretically, using the simplifying approximations that the wavefront (and thus the specimen) is nearly flat and that

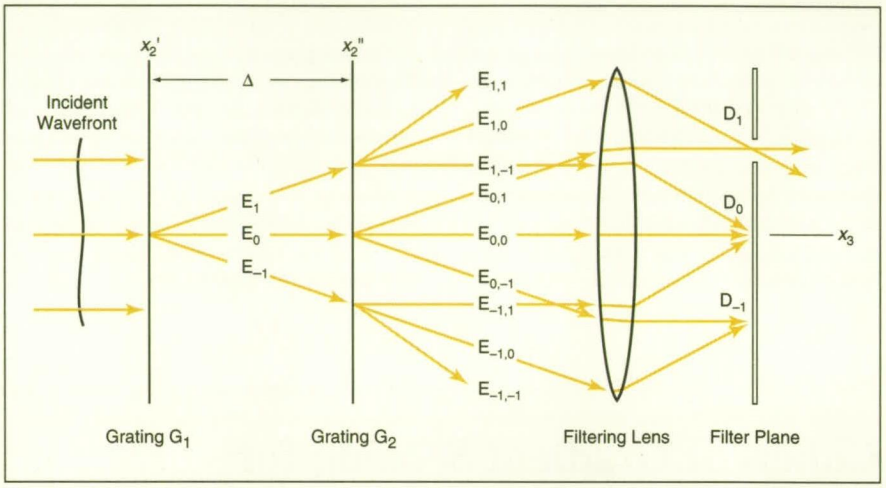

Figure 2. **Diffraction, Interference, and Spatial Filtering** are utilized in CGS to obtain an image containing interference fringes that are indicative of the curvature of the specimen.

Figure 1 schematically illustrates a reflection-mode CGS optical setup. A coherent, collimated laser beam is directed onto a specularly reflective specimen via a beam splitter. The reflected beam passes through the beam splitter, then through two identical high-density (40 lines/mm) Ronchi gratings separated by a distance Δ. A lens spatially filters the portions of light diffracted to various orders to form distinct diffraction spots on a filter plane. An aperture is placed in the filter plane to select a diffraction order of interest and reject other orders. The order of interest is then imaged on the focal plane of a video camera. The video image is digitized and processed to extract information on the curvature of the specimen surface.

Suppose that the grating lines are oriented along the x_1 axis. Figure 2 illustrates the formation of the first few diffraction orders by each Ronchi grating, and the formation of some of the resulting images on the filter plane. The reflected wavefront incident on Ronchi grating G_1 is diffracted into wavefronts E_1, E_0, and E_{-1}, among others, these orders corresponding to diffraction orders 1,0, and –1, respectively. (For the sake of simplicity, only these orders are shown, though many others could be present.) Each of these wavefronts is diffracted by Ronchi grating G_2, yielding wavefronts

diffraction angles are small. The analysis reveals that the curvature of the specimen surface can be obtained from the CGS interference-fringe pattern via the equation

$$\kappa_{\alpha\beta} = \frac{p}{2\Delta}\left(\frac{\partial n^{(\alpha)}(x_1, x_2)}{\partial x_\beta}\right)$$

where $a = 1$ or 2, $b = 1$ or 2, $k_{\alpha\beta}$ is the curvature tensor, p is the grating pitch, and $n^{(\alpha)}$ denotes the cardinal number of a fringe observed in shearing along the x_α direction.

This work was done by Ares J. Rosakis, Raman P. Singh, Elzbieta Kolawa, and Nicholas R. Moore, Jr., of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Physical Sciences category.*

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 NPO-20189, volume and number of this NASA Tech Briefs *issue, and the page number.*

Methods of Manufacturing Fiber Optic Components

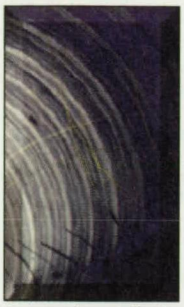
These methods address needs for production of low-cost high-yield optical connections.

The Boeing Company, St. Louis, Missouri

The methods described are used with existing fiber optic technologies, and are based on several patents and on disclosures now before the U.S. Patent and Trademark Office. The patents are No. 4,755,037 ("Fiber Optic Coupler," 1988); No. 4,765,816 ("Method and Apparatus for Making Optical Fiber Couplers," 1988); No. 4,834,493 ("Method of Terminating an Optical Fiber," 1989); and No. 5,381,506 ("Flat to Spiral Polymer Light Waveguide," 1995).

The 1988 patents listed above address methods and manufacturing techniques that can be used to improve coupling between optical fibers by obviating alignment problems. Essentially, two fibers are laid side by side, stretched, and fused into one robust glass conduit. During this process, the optical cores are moved closer together until good optical coupling is achieved.

This technique produces a joint that is more rugged than commonly achieved with well-known alignment and joining methods. The process lends itself to fast, permanent, efficient coupling as may be required in OEM applications and field repairs. Patent 5,381,506 facilitates right-angle couplings. Fibers are gathered from an optical backplane, compacted into a bundle, and prepared for use in a connector or optical subcomponent. Patent 4,834,493 offers a simple, effective method for eliminating unwanted light reflections from an optical fiber lead.



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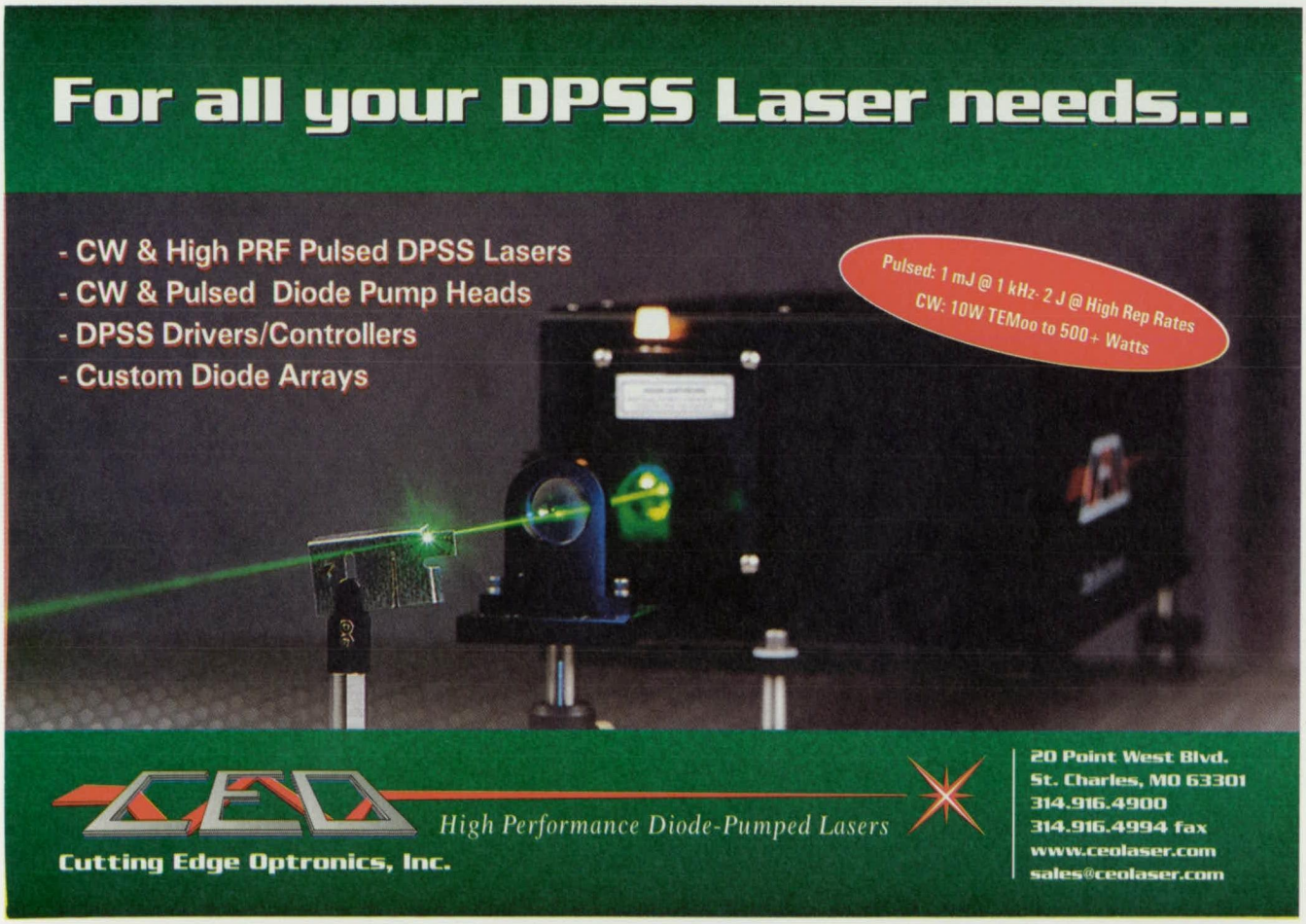
Other methods and components currently being developed and disclosed include a method of soldering fiber optics, a fiber optic holder that assists in the positioning and bonding of multiple single-mode fibers, and a metallized fiber optic feedthrough device used to carry electrical signals along with optical signals. The metallized fiber optic feedthrough enhances current fiber optic systems by reducing the connector parts count and cable weight. Also being developed is a method for coupling fiber optics via machined edge egress. This method eliminates shearing of fibers during milling operations.

The Boeing Company has fully developed the methods based on the above patents. Currently, there are several fiber optic components the company has disclosed to the U.S. Patent and Trademark Office. The methods and components covered by the above patents can be used anywhere to enhance current fiber optic systems. The technology could be applied to existing communication and sensor fiber optic networks.

The Boeing Company *is currently looking for licensing opportunities with companies interested in applying Boeing technologies to their products. If actively interested, please contact Dennis Donahue, Marketing Manager, Licensing; MC 306-1285, PO Box 516, St. Louis, MO 63166; (314) 233-3805; fax (314) 232-4313; http://www.boeing.com/assocproducts/mdip/.*



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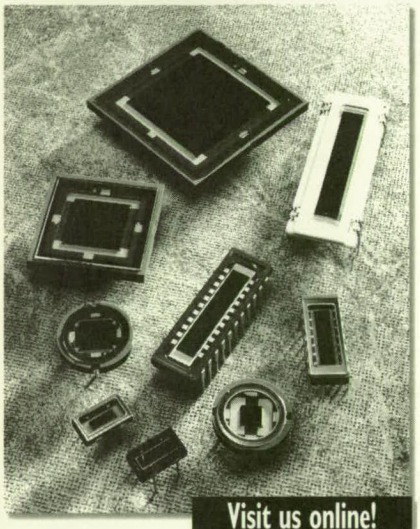

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Photochromic Image-Plane Filter Extends Dynamic Range of CCD

The material of self-adjusting sunglasses enables CCD imaging of high-contrast scenes.

NASA's Jet Propulsion Laboratory, Pasadena, California

A simple technique for extending the dynamic range of a charge-coupled-device (CCD) video camera involves the use of photochromic material — the same material used in self-adjusting sunglasses. The dynamic range of an image is the ratio between the maximum and minimum brightness levels in the image. The dynamic range of a CCD is the ratio between an overexposure brightness level (above which the image becomes saturated or "washed out") and an underexposure level (below which details disappear into the darkness). The dynamic range of a CCD is less than that of the human eye; for example, a human observer can often see both shadowed and unshadowed features in a scene illuminated by sunlight, whereas a CCD cannot capture details simultaneously in both the brightest and darkest parts of the scene (see Figure 1).

The present technique provides for compression of the dynamic range of brightness of an image focused on a CCD so that all or most parts of the image lie within the dynamic range of the CCD. When such compression is effected, the CCD output can be expected to show details in both the brightest and darkest parts of the scene.

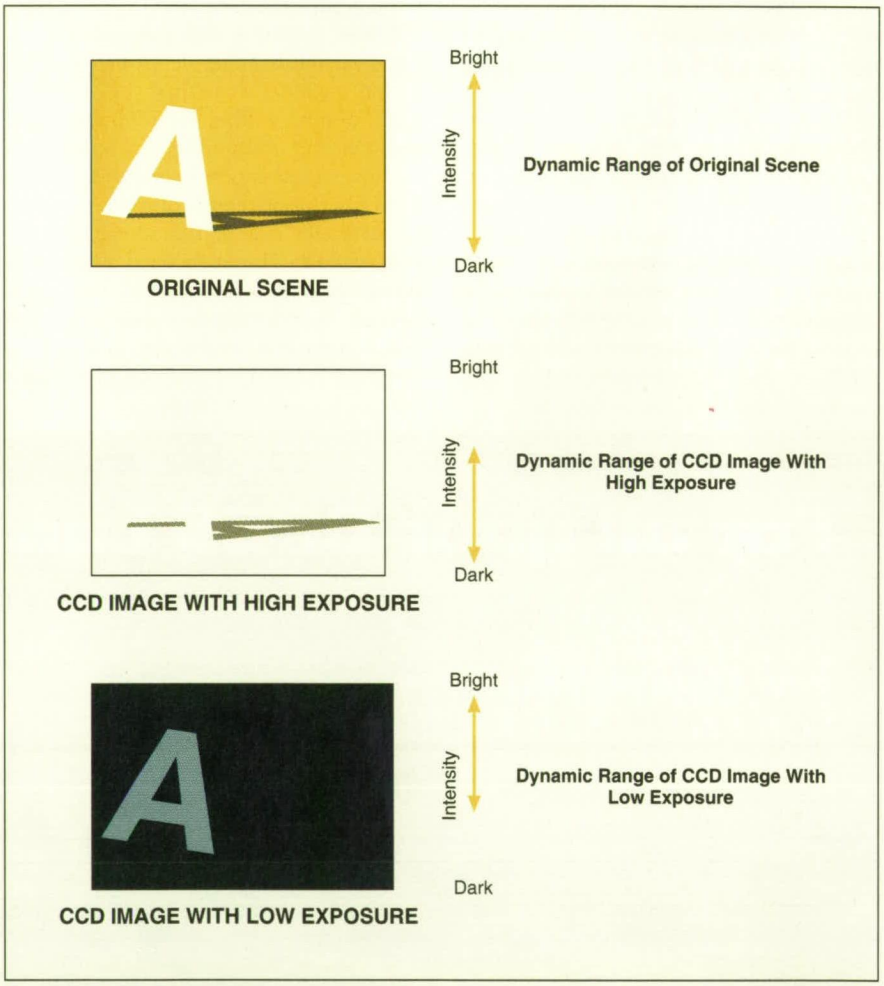

Figure 1. A **High-Contrast Scene** cannot readily be imaged in full detail on a CCD. Depending on the optical and electronic camera settings, the image tends to be either overexposed in the bright areas or underexposed in the dark areas.

In practice, compression of the dynamic range of brightness in an image must be accomplished through local darkening of the image, with greater darkening in brighter locations. Photochromic material exhibits the required greater darkening with exposure to

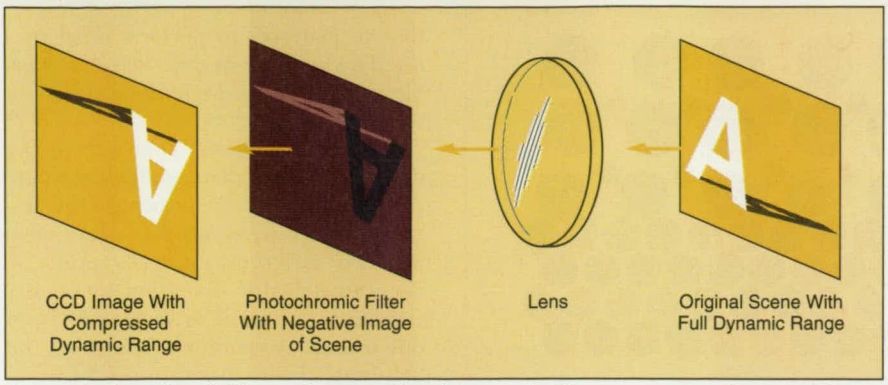

Figure 2. A **Photochromic Filter at the Image Plane** becomes, in effect, a temporary photographic negative with a dynamic range somewhat less than that of the image. Therefore, the net image projected through the filter looks like the original scene, except that it has less dynamic range.

brighter light. In the present technique, a photochromic filter is placed at (or immediately in front of) the CCD image plane, so that it becomes darkened in the bright areas of the image (see Figure 2). As a result, the light that passes through the photochromic filter forms the desired reduced-dynamic-range version of the image.

This work was done by Richard A. Volpe of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Circuits category.*
NPO-20254

Heteroepitaxy with Large Lattice Mismatch

An unconventional approach to semiconductor/insulator multilayer film growth results in heteroepitaxies with unprecedented lattice mismatch.

Naval Surface Warfare Center, Dahlgren, Virginia

A process for the growth of single-crystal (epitaxial) multilayer films has been developed at the Naval Surface Warfare Center, Dahlgren Division. This process is predicated on the preparation of a compliant interfacial "template" layer of atomic dimensions that can overcome large lattice mismatches. The process can be adopted for the fabrication of integrated electro-optic sensors/receivers, and for new thin-film materials such as the III-nitrides.

Single-crystalline thin films are of technological importance in modern electro-optics (E-O) and electronics because they are the real estate upon which circuit elements, detectors, sensors, and emitters such as light-emitting diodes and diode

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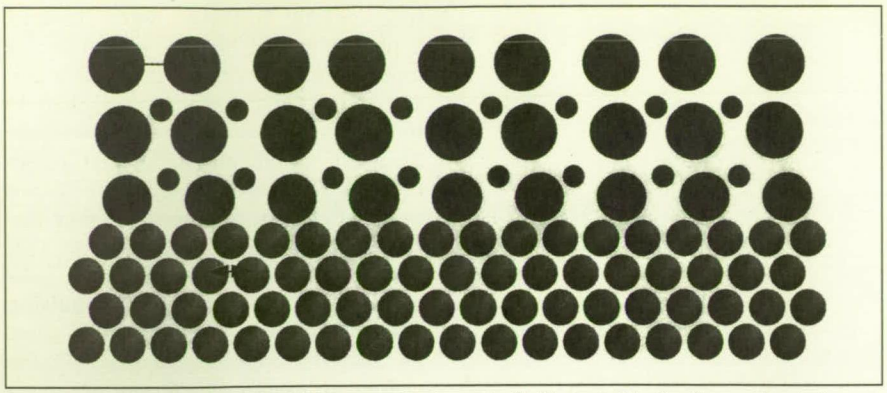

An example of the **Heteroepitaxial Structure** is schematically illustrated in the figure. The circles represent different atoms of various sizes and in different crystalline structures. The bottom four rows represent a silicon substrate, the middle single row an interfacial "template" containing barium atoms, and those at the top a barium fluoride thin film. In this heterostructure, the silicon and the barium fluoride retain their normal crystalline structure. Strains arising from differences (15 percent) in lattice spacing between the BaFl and the Si, exaggerated by the arrows, is taken up by the barium layer at the interface. Without the intervening template layer, lattice mismatches of more than one or two percent will adversely affect the crystal structure of the thin film. The dielectric strength of the BaFl thin film is close to that of the bulk crystal.

lasers are built. These devices are usually built on wafers about 0.015-in. thick. Even so, the materials being actively used occupy only a small thickness near the surface of the substrate. The rest of the wafer is used simply to provide mechanical support. Therefore a successful thin-film technology can provide substantial savings in materials and processing costs.

In addition, a successful thin-film technology will allow rapid development of new electronic and E-O devices by passing over the more expensive approach of bulk crystal development. Furthermore, with a multilayer thin film, the desirable properties of each of the layers can be utilized in a single integrated package. Multifunction devices can be made during the manufacturing process, complete with packaging; assembly of discrete components into functional units can thus be bypassed completely. However, in order for the materials to perform efficiently, the films must be as defect-free as possible, so that device performance will not be degraded.

In the conventional approach to the deposition of multilayer single-crystalline thin films, the lattice spacing—the distance between atoms in a crystal—between different materials must be closely matched so that there is a regular transition in atomic arrangement from one material to another. Otherwise, the bonding between atoms across the interface of the components will be irregular and weak. As a result, the films can peel off, crack, or contain a large density of crystalline defects. With such an approach, multilayer films are limited to cases where the lattice mismatch is on the order of 1 or 2 percent at the maximum. This constraint of close lattice matching limits the combination of materials that can be mated together, and therefore limits the diversity of devices that can be achieved. The ability to fuse together highly lattice-mismatched materials can open up a multitude of possibilities for device engineers.

An important shortcoming in the conventional approach to heteroepitaxial growth is that the chemical interaction, i.e., the bonding between component

materials, is usually ignored. Thus, an important factor in the film deposition process is not exploited to advantage. The Dahlgren group has adopted a contrary approach in which the chemical interaction is taken into account. In addition, this interaction is capitalized on further to create a structure favorable to the subsequent growth of single-crystalline films on the substrates. The basic idea is similar to the use of an "atomic glue," which can bond with a variety of materials. An important criterion for this glue, for applications in the making of multilayer crystalline films, is that it must be compliant. That means it must be easily deformable in the lateral direction so that strains resulting from the mismatch of atomic spacings will be accommodated by the glue, allowing the deposited material to adopt its natural lattice spacing.

This new method for making epitaxial films was developed by the molecular beam epitaxy (MBE) process, in conjunction with *in-situ* surface analysis and *ex-situ* film characterization methods. In the MBE process, single-crystal substrates are placed in a vacuum chamber where they are exposed to a beam (or beams) of atoms or molecules evaporated from heated sources. The thin film is formed on the substrate surface when the incident atoms coalesce into crystals. The method developed has yielded highly reproducible results. In fact, recipes have been generated for the preparation of a variety of thin-film combinations. These include barium fluoride on silicon and on gallium arsenide, lead telluride and cadmium telluride on silicon, and a gallium arsenide/barium fluoride/gallium arsenide sandwich. The lattice mismatch in these combinations goes as high as 19 percent. Mismatch of this magnitude was previously considered fatal for epitaxial growth using the conventional approach to heteroepitaxial thin films.

The technology developed here is generic, and thus has wide application potential. The multilayer films are now being used as substrate materials for the making of gallium and aluminum nitride films. This technology is being transitioned to small business to make monolithic low-cost infrared focal plane arrays for applications in surveillance and temperature/fire detection.

This work was carried out at the **Naval Surface Warfare Center, Dahlgren Division**, *Systems Research and Technology Department, Dahlgren, VA 22448. Interested persons should contact Mary Lacey, Department Head, (540) 653-8535; fax (540) 653-4930. Inquiries concerning patent rights should be addressed to the Patent Counsel, NSWCDD, Dahlgren, VA 22448.*

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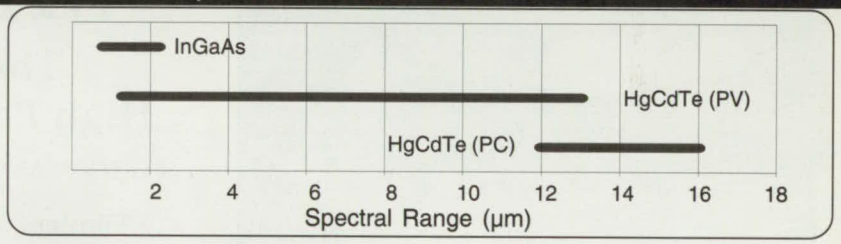
Infrared Detector Selection Chart



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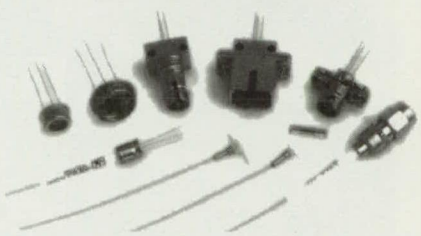

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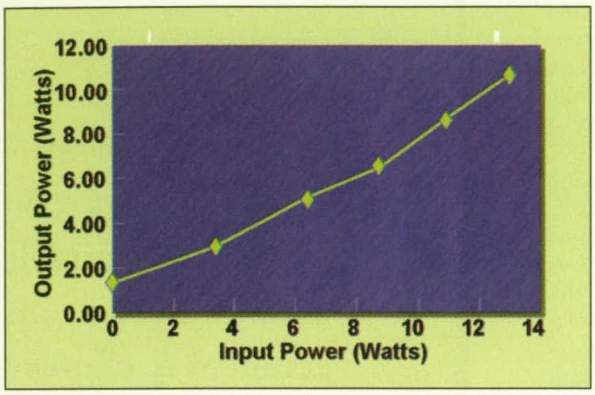
For More Information Circle No. 468

Fiber Laser Amplifiers with Broad Applications

The technology is a proven scaleable architecture capable of power outputs from watts to kilowatts.

The Boeing Company, St. Louis, Missouri

The Boeing Company has developed fiber-laser-amplifier technology representing the latest in diode-laser-pumped systems, providing high output power, high brightness, tunability, frequency-doubled output, multiwavelength amplification, and narrow linewidth operation. The technology is a proven scaleable architecture capable of continuous-wave power output from watts to kilowatts. Using Raman conversion techniques and frequency-doubling techniques, Boeing's technology can meet the needs of many applications by providing access to a wide range of wavelengths. Boeing has been issued two patents on the technology: No. 5,212,707 ("Array of Diffraction-Limited Lasers and Method of Aligning Same," 1993) and No. 5,694,408 ("Fiber Optic Laser System and Associated Lasing Method," 1997).

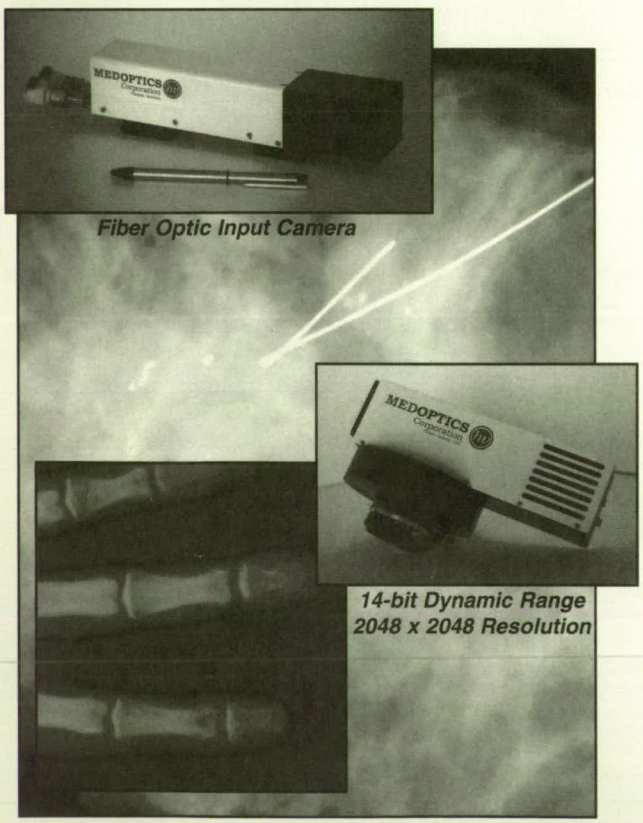


Single-Stage Amplifier Results: High-power amplification.

The industrial, scientific, and military laser markets are all demanding high performance and lower cost. Boeing's fiber laser technology is capable of meeting the demands of these markets by providing a low-cost, high-performance technology that can be ruggedized for use in military systems. Since the fiber laser modules provide usable power at all levels, the same laser modules used in industrial, medical, and scientific instruments can also be used in large-scale military systems.

The Boeing Company has demonstrated amplification of laser sources with linewidths as narrow as 15 kHz, has proven the scaleable system architecture, and is able to convert the wavelength of the primary laser beam via Raman conversion and frequency doubling. Boeing has developed designs for individual laser modules, laser amplifiers, Raman converters, and frequency doublers.

Potential applications include industrial cutting, welding, and soldering; laser surgery; laser printing; uranium isotope separation; laser light shows; remote sensing; noncooperative target identification; personnel detection; ladar; laser countermeasures; guide-star



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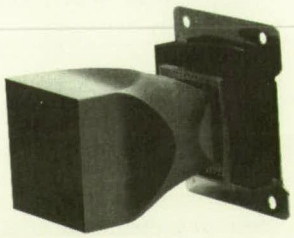

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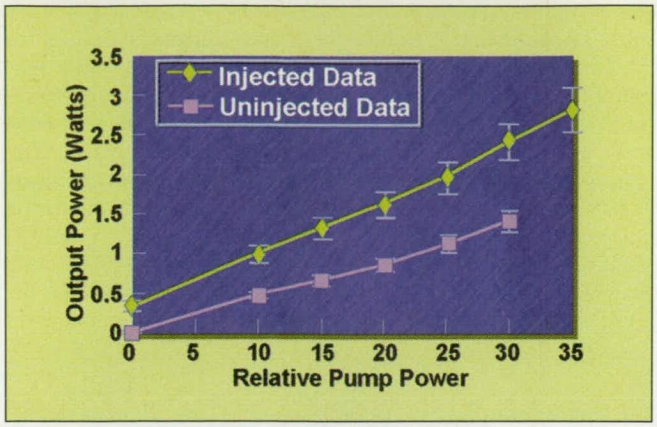
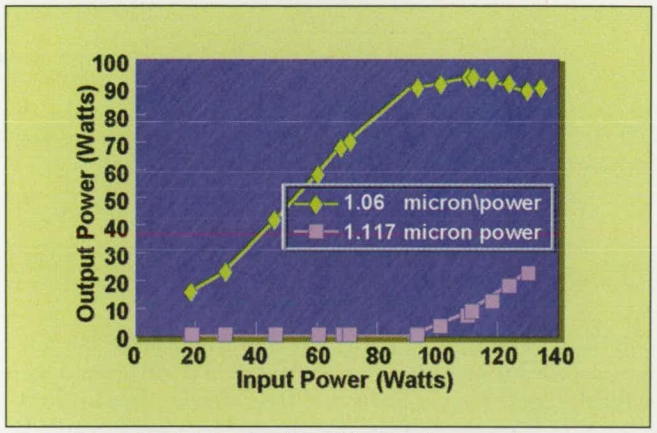


Narrow-Linewidth Amplifier Results: High-power narrow-linewidth amplification.



Raman Conversion in Fiber Amplifier: Wavelength conversion.

for adaptive optics systems; laser communications; repeaterless communications; and a laser video projector.

The Boeing Company *is currently looking for licensing opportunities with companies interested in applying Boeing technologies to their products. If actively interested, please contact Dennis Donahue, Marketing Manager, Licensing; MC 306-1285, PO Box 516, St. Louis, MO 63166; (314) 233-3805; (fax (314) 232-4313; http://www.boeing. com/assocproducts/mdip/.*

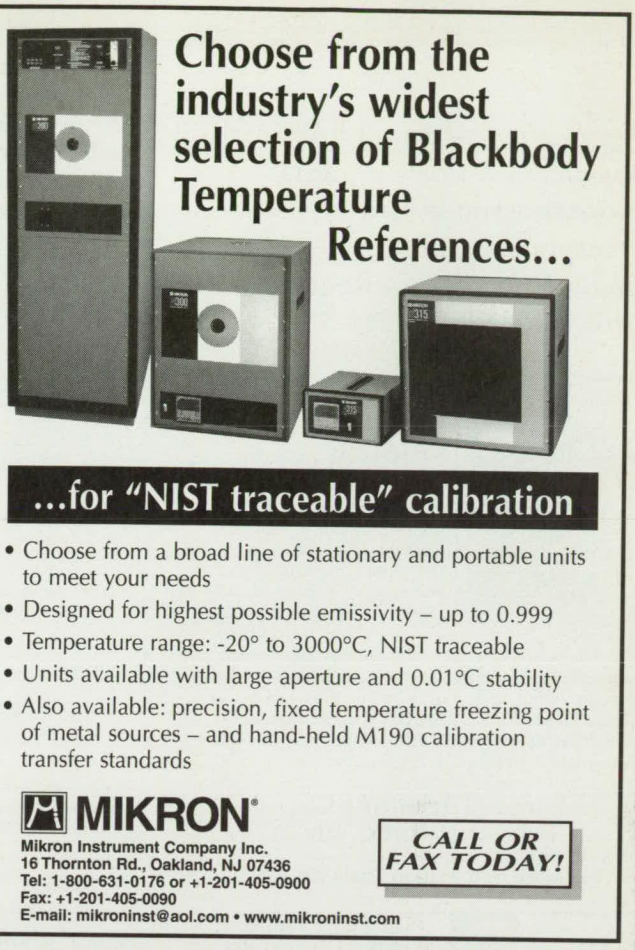
Semimonolithic Cavities for Optical Frequency Conversion

Most advantages of monolithic cavities would be retained and most disadvantages eliminated.

NASA's Jet Propulsion Laboratory, Pasadena, California

Semimonolithic resonant structures external to lasers have been proposed for use in optical frequency-conversion applications — for example, doubling the frequencies of laser beams. These structures would offer most of the advantages, without most of the disadvantages, of monolithic resonant cavities.

In contradistinction with discrete external cavities (that is, external cavities that are assemblies of discrete optical components), monolithic external cavities offer advantages of lower overall intracavity losses, no dispersion-induced mismatches,



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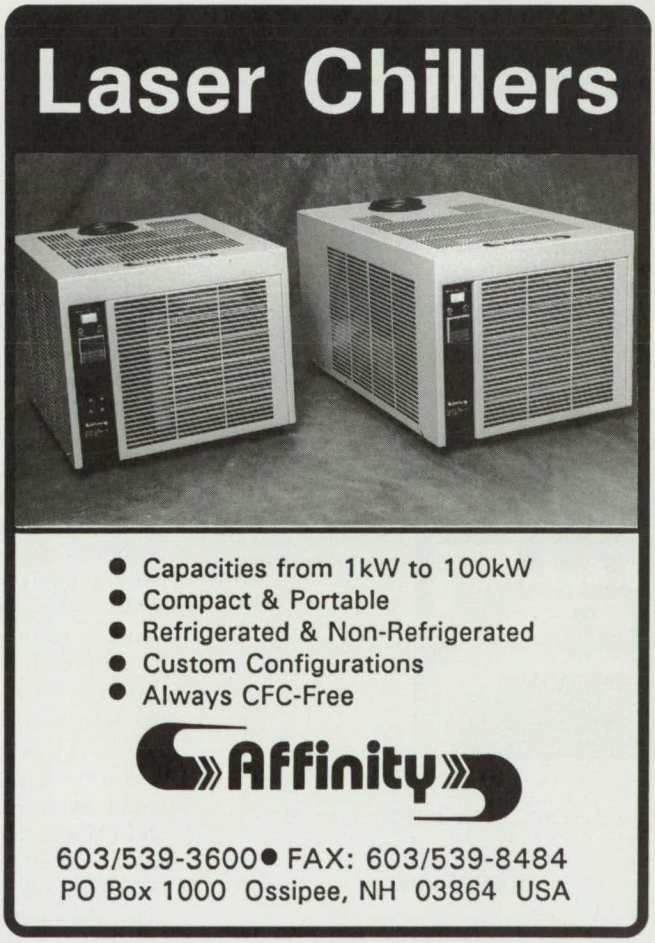

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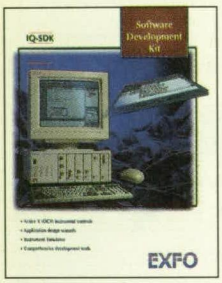


IQ SOFTWARE DEVELOPMENT KIT

EXFO introduces the IQ Software Development Kit (IQ-SDK), a set of programming tools designed to allow programmers to develop fiber optic test applications using the IQ-200 Optical Test System. The SDK is built around custom ActiveX controls (OCXs) and offers extremely efficient programming in Visual Basic™, Delphi™, and Visual C++™ environments. EXFO Electro-Optics Engineering Inc., 465 Godin Ave., Vanier, Quebec, Canada G1M 3G7; (418) 683-0211; 1-800-663-3936; fax: (418) 683-2170; E-mail: info@exfo.com; http://www.exfo.com.

EXFO E-O Engineering Inc.

For More Information Circle No. 491

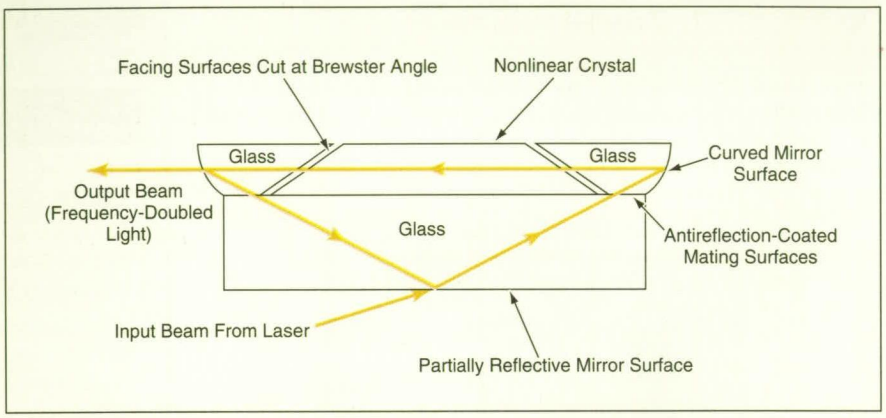
COATINGS FOR OPTICS

ZC&R, Carson, CA, offers precision optical coatings, including high-power laser, antireflection, beam splitters, hot and cold mirrors, bandpass color filters, heat/color control, metal coatings, ITO and IM-ITO, thin-film polarizers, covert and fluorescence filters. Catalog includes specifications and easy-to-read graphs. ZC&R, 1250 E. 223rd St., Suite 111, Carson, CA 90745; (310) 513-6319; 1-800-426-2864; fax: (310) 952-1270.

ZC&R Coatings

For More Information Circle No. 492

mechanical stability with consequent frequency stability, compactness, and lower overall cost. The disadvantages of monolithic cavities include vulnerability to manufacturing errors, lack of any degree of freedom for alignment, potential for difficulty in changing cavity lengths for resonance frequency locking, and, in some applications, unavailability of nonlinear crystals that are large enough.



A **Semimonolithic Cavity** would cost less than does a monolithic cavity of equal capability. Unlike a monolithic cavity, it would be somewhat adjustable.

A typical semimonolithic structure ("cavity") of the proposed type would include a nonlinear optical crystal fitted with optical components of glass or other suitable linear optical material on both ends (see figure). The glass chosen for this application must have an index of refraction as close as possible to that of the nonlinear crystal. The curved end mirrors of the cavity ("cavity mirrors," for short) would not be fabricated on the nonlinear crystal as in a monolithic cavity; instead, the cavity mirrors would be fabricated on the glass endpieces. The second-harmonic output could be extracted from the cavity through one of the cavity mirrors or through a dichroic beam splitter.

In a monolithic cavity, if any error occurs in fabrication of the cavity-mirror surfaces, or if the apices of these curved surfaces are not exactly coaligned, then the entire piece of nonlinear material must be discarded or completely reworked. In a semimonolithic cavity like the one proposed here, one could replace the glass endpieces or make small corrections on them. The polishing and coating characteristics of optical glasses and the techniques for fabricating mirror surfaces on them are well known. Thus, the fabrication of cavity mirrors on glass for the proposed cavity could be accomplished more reliably and cheaply than can fabrication of the same mirrors on an exotic nonlinear crystal for a monolithic cavity.

In the semimonolithic cavity, there would be some limited freedom to adjust the alignment of the cavity mirrors by slightly adjusting the positions and orientations of the glass endpieces before bonding them in place. The effective optical length of the cavity could be adjusted by applying an electric field to the nonlinear material, provided that the material was accessible in the position and orientation suitable for that purpose. Alternatively, prior to entering the resonant cavity, the laser beam could be bounced off a translation mirror that was piezoelectrically or otherwise adjustable. In thus freeing the cavity designer from limitations on the available size of the nonlinear crystal, the semimonolithic cavity would offer a major advantage.

One disadvantage of the semimonolithic cavity would lie in the potential for optical losses that occur at the multiple surfaces traversed by the laser beam. Some of these surfaces could be antireflection-coated to reduce losses. The polished surfaces at the ends of the nonlinear crystal and the facing surfaces of the glass blocks could be formed at the Brewster angle to reduce losses further.

This work was done by Hamid Hemmati of Caltech for **NASA's Jet Propulsion Laboratory** *and funded under the AITP Program. For further information, access the Technical Support Package (TSP)* ***free online at www.nasatech.com*** *under the Physical Sciences category.*

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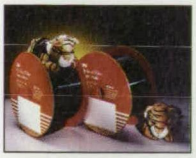
NEW PRODUCTS

PRODUCT OF THE MONTH

Goniometric Radiometer for Laser Diodes

Photon Inc., Santa Clara, CA, says its Model LD 8800 goniometric radiometer is specifically designed for measuring the radiation pattern emitted from a highly divergent source such as a laser diode or an LED. The company says the instrument, which precisely measures angular divergence and intensity distribution, is based on a proprietary patent-pending rapid scanning pinhole technique invented by Photon. This, the company asserts, makes possible measurements in a few seconds that previously could take hours. Single goniometric scans are done at 10 Hz and a full 3D characterization is completed in about one minute. Sampling resolution in the angular direction is 0.05° and in the azimuthal direction less than a degree. The Model LD 8800 provides a set of measured intensity parameters as well as statistical data; the software also provides a graphical depiction of the measured data.

For More Information Circle No. 750



1550-nm Polarization-Maintaining Fiber

3M Specialty Optical Fibers, West Haven, CT, adds Tiger PM fiber, operating at 1550 nm, to its line of polarization-maintaining fibers. Designed specifically for telecommunications applications, it meets or exceeds, the company says, the performance, optical, and mechanical specifications of the most commonly used polarization-maintaining fibers. 3M calls Tiger PM ideal for pigtailing lasers, external modulators, and other devices. It has better than 35 dB extinction over a typical pigtail length; core-to-clad concentricity offset is specified at less than 0.8 micron, and cladding ovality at less than 1 percent. Tiger PM fiber has a 200-kpsi proof test level.

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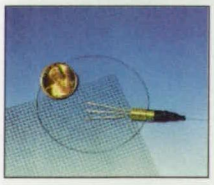
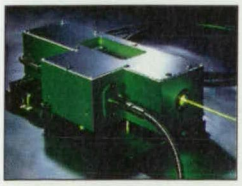


Integrated Power Monitor Module

E-TEK Dynamics Inc., San Jose, CA, announces an Integrated Power Monitor Module (IPMM) that it calls a free-space integration of a wideband optical tap coupler and a photodiode for stable power monitoring in any optical fiber system. It measures 6.3 mm in diameter and 51 mm in length; typical polarization-dependent loss is 0.03 dB and PIN linearity less than 10 percent. The PIN photodetector in a TO-can package is hermetically sealed inside the hybrid device for reliability. The IPMM can be used in erbium-doped fiber amplifier, transmitter, add-drop, and WDM systems for monitoring.

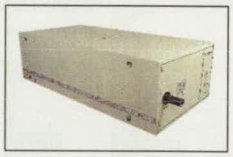
For More Information Circle No. 755



Industrial Diode-Pumped Solid-State Lasers

The Millennia *i* Series™ from Spectra-Physics Lasers Inc., Mountain View, CA, comprises a pair of industrial high-power diode-pumped solid-state lasers. The Millennia V*i* is available with 5 W of CW TEM_{00} 532-nm output power, and the Millennia II*i* provides 2 W of the same. The series utilizes the company's patented QMAD intracavity doubling technology to provide low optical noise of less than 0.1 percent rms. The simple linear cavity is pumped with the output from a fiber-coupled diode bar. These Millennia lasers require only 110 V or 220 V single-phase power.

For More Information Circle No. 758



High-Power Industrial Excimer Laser

Lumonics, Kanata, Ontario, Canada, introduces the IPEX™-800 series of high-power industrial excimer lasers. Incorporating Lumonics' new Integrated Ceramic On Nickel (ICON™) laser tube technology, the IPEX series more than doubles the gas lifetime of its predecessors, according to the company. IPEX-848 offers 80 W average power with KrF and 50 W with XeCl; IPEX-846 offers 40 W with KrF and 25 W with XeCl. Lumonics says that because the 800 series' footprint is smaller than that of most industrial excimer lasers, it is well suited for integration into micromachining, test, and marking equipment.

For More Information Circle No. 753

Open Heatsink Diode Laser

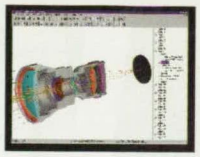
Opto Power Corp., Tucson, AZ, adds the H02-A060-915-CS 60-W diode laser to its family of high-power open heatsink components. The monolithic laser, designed for medical, industrial, and other direct thermal and illumination applications, emits continuous-wave output at a wavelength of 915 nm. The laser serves as the engine for Opto Power's high-power fiber-coupled diode laser units. For thermal applications, the company offers fiber-coupled versions. Other accessories include transient-protected power supplies, and active air- or water-cooled heatsinks for optimum thermal management.

For More Information Circle No. 765

Internal-Mirror Argon-Ion Lasers

A new line of internal-mirror argon-ion lasers is available from Melles Griot, Carlsbad, CA, in violet, blue, green, multiline, or all-line wavelengths, with output powers to 200 mW. The company says the integrated hard-sealed mirror design does not require maintenance, increasing long-term reliability and output-power stability. The CE-approved air-cooled laserhead designs are either rectangular or cylindrical. Melles Griot recommends the line for laser-induced analysis, testing, recording, and measuring in biotechnology, spectroscopy, and other critical applications.

For More Information Circle No. 759



Optomechanical Prototyping Software

Lambda Research Corp., Littleton, MA, offers TracePro™ version 1.3, the first optical and illumination analysis program to have the industry-standard solid-modelling engine, ACIS® 3.0, at its core. Calling TracePro the virtual prototyping software widely used in analyzing and designing optical, illumination, display, and lighting systems, the company says its new features include: aperture diffraction using an asymptotic model; bulk absorption; new macro commands; light-source input using measured data from Radiant Imaging, Inc.; polychromatic ray-traces and unlimited wavelengths; and polarization ray-trace, among others.

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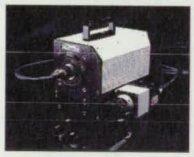

High-Speed Video System

The Memrecam Ci/RX-2 camcorder system from NAC Image Technology, Canyon Country, CA, features a small separable camera head that weighs less than 1-1/2 lb. and measures 2.4 × 2.2 × 4 in. NAC points out that the camera head fits easily into confined spaces such as engine compartments and under dashboards. Its compact profile and high G rating also make it suitable for use on the wing of an aircraft and other high-acceleration high-vibration environments. Tested to accelerations of 150 Gs at over 1000 repetitions, the Memrecam Ci/RX-2 captures 500 fps of high-resolution color digital images. The entire system weighs only 11 lb.

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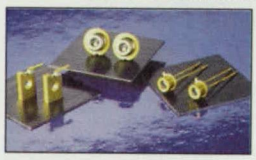

Infrared Laser Diodes

Hamamatsu Corp., Bridgewater, NJ, announces a series of infrared pulsed diode lasers for varying industrial and scientific applications. The L7055-04 has output power of more than 20 W, peak emission wavelength of 870 nm, and beam spread of 8° FWHM along one axis and 32° along the other. The L7060-02 delivers more than 30 W at 870 nm, with beam spread of 9° along one axis and 30° along the other. The L6690 has a peak emission wavelength of 860 nm and radiant power of 3 W, with a beam spread of 8° along one axis and 32° along the other. Rise time for all three is less than 0.5 ns.

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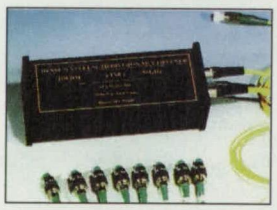

Dense Wavelength Division Multiplexers

APA Optics Inc., Blaine, MN, offers a dense wavelength division multiplexer with either 4 or 8 channels, with 100-GHz channel spacing and 35-dB channel isolation, and an ultra-dense wavelength division multiplexer with 50-GHz channel spacing and 30-dB channel isolation with 4 or 8 channels. Designed for lasers centered on the ITU grid, these products have low insertion loss and can be used either as multiplexers or demultiplexers. Applications include CATV and long-haul communications.

For More Information Circle No. 760

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441	442	443	444	445	446	447	448	449	450	451	452	453	454	455	456	457	458	459	460
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Commercialization Opportunities

Snakelike Robots Would Maneuver in Tight Spaces

Robots with multiple-link arms are being developed to move through tight spaces in a slithering motion. Inspection, maintenance, and repair of complex machines like aircraft engines could become possible without expensive, time-consuming steps of disassembly and reassembly.

(See page 36.)

Miniature Electron Microscopes Without Vacuum Pumps

The proposed microscope would work without external vacuum pumps and would thus be much smaller, lighter, and less power hungry than conventional electron microscopes. Potential market is anticipated in physical and biological sciences, engineering, medicine, and chemistry.

(See page 38.)

Jewellike Bearings for Blood Pumps

These bearings enhance the performance and safety of small rotary pumps that are used to increase or sustain blood flows in cardiac patients. The risk of clots is reduced because blood is not forced through small clearances.

(See page 42.)

Miniature Microscope Without Lenses

The focusing optics of a conventional microscope would be supplanted by a combination of a microchannel filter and an advanced electronic image sensor. Without the focusing optics, the instrument is smaller and lighter and can be used to examine specimens in faster succession.

(See page 43.)

Wavy Blades for Secondary Centrifugal Blood-Pump Impeller

Wavy instead of rectangular cross-section blades in a ventricular-assist blood pump would reduce the tendency toward blood clotting.

(See page 44.)

Doped ZnTe: A Developmental Photorefractive Material

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(See page 72.)

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For More Information Circle No. 573

Snakelike Robots Would Maneuver in Tight Spaces

Potential applications include inspection, maintenance, and surgery.

NASA's Jet Propulsion Laboratory, Pasadena, California

Robots with multiple-link arms that could reach through narrow openings into hidden cavities are undergoing development. Called "multifunction dexterous boro-robots" (MDBRs), these robots would resemble snakes (see Figure 1), in both general appearance and in the slithering motion with which they would negotiate narrow passages. Robots like these could make it possible to inspect, maintain, and repair critical parts in the interiors of complex machines like aircraft engines, without having to take the machines apart and then putting them back together at great expense. Such robots could also prove useful as surgical endoscopic tools. In comparison with currently available borescopes and endoscopes, MDBRs would be more versatile, more controllable, and better able to maneuver around obstacles. The MDBRs would differ from the serpentine inspection robots reported previously in *NASA Tech Briefs* [see "Small, Lightweight Inspection Robot With 12 Degrees of Freedom" (NPO-19367) Vol. 20, No. 2 (February 1996), page 73 and "Control of a Serpentine Robot for Inspection Tasks" (NPO-19506) Vol. 20, No. 3 (March 1996), page 1b.]

Each link in an MDBR contains linear actuators that are part of a kinematic linkage for controlling the relative orientations of the adjacent links. The kinematic linkage (see Figure 2) includes a base plate at one end and an articulation plate at the other end. The base and articulation plates also serve as the articulation and base plates, respectively, of the preceding and following links. The base and articulation plates are connected by six struts with compensated universal joints at their ends.

Three of the struts are of fixed length and are crossed; three of the struts are the linear actuators and are not crossed. Together, the six struts and the base and articulation plates constitute a truss with a unique configuration and a high strength-to-weight ratio. The configuration of the truss (and thus the position and orientation of the articulation plate relative to the base plate) can

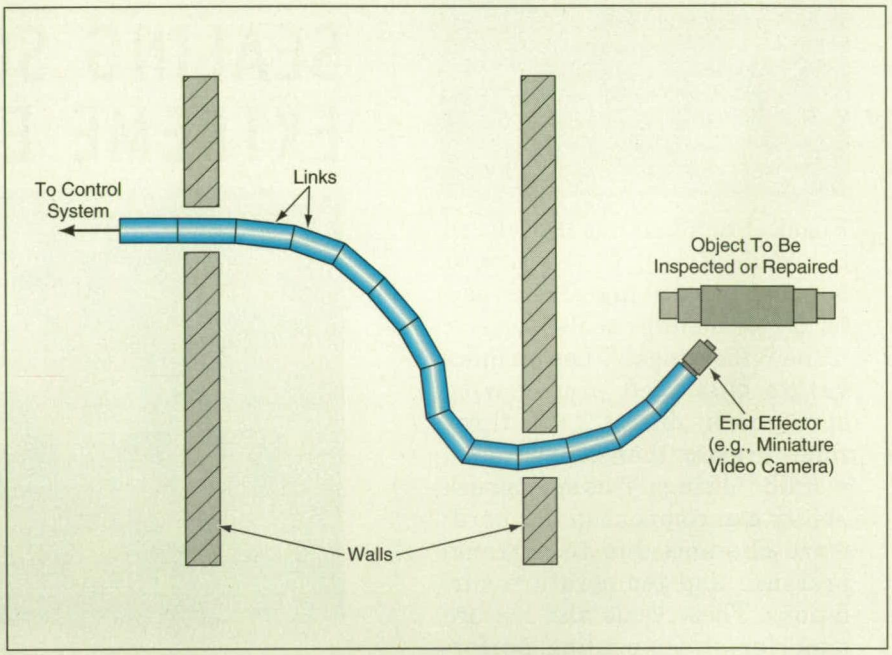

Figure 1. A **Serpentine Robot Arm** comprising many lightweight, rigid links could be maneuvered through narrow openings to reach objects that would otherwise be inaccessible. Each link could be made less than 1 cm in diameter and would typically be several centimeters long. The robot arm would be covered by a sheath of flexible material to protect the mechanisms in the links.

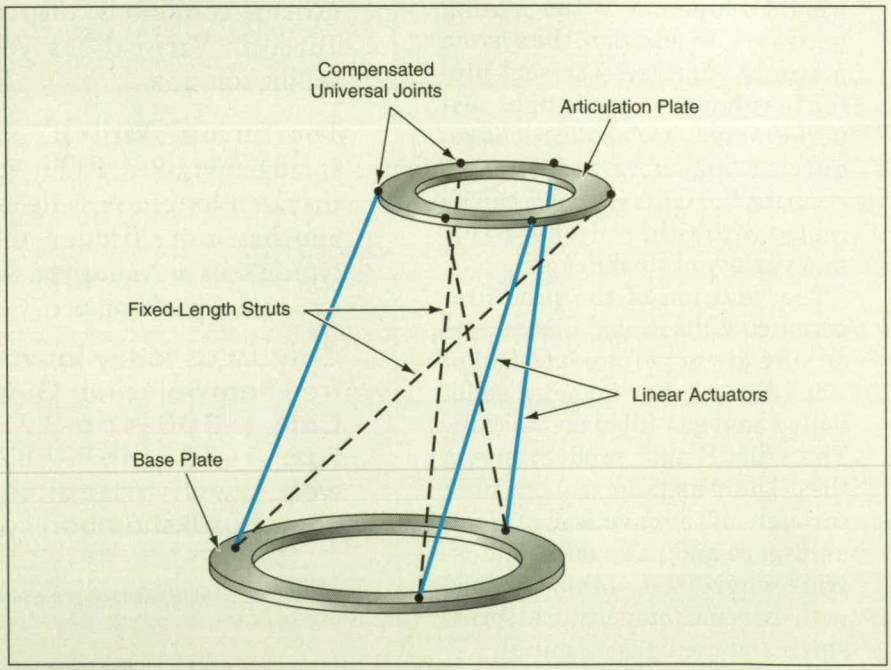

Figure 2. The **Kinematic Linkage** in each link provides control of the position and orientation of the articulation plate relative to the base plate. The base and articulation plates are shown here as circular disks, but they could just as well have triangular or any other suitable shape.

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For More Information Circle No. 517

be altered by commanding the linear actuators to change their lengths according to the kinematical requirements. The linear actuators could be of any of several types; miniature piezoelectric "inchworm" actuators are particularly suitable.

The individual actuator commands to obtain the overall desired pose and snakelike motion of the arm are generated by a computer that solves the equations for both the forward and the inverse kinematics of the links and of the whole arm. An MDBR is modular in the sense that in principle, any number of links [with the same or different diameter(s) and length(s)] can be added to extend its reach or increase its dexterity. A two-link prototype has been demonstrated. In a practical application, the benefits of increased dexterity and reach would have to be traded off against the increase in the amount of computation needed to solve the inverse kinematical equations for a greater number of links.

This work was done by Yoseph Bar-Cohen and Mohsen Shahinpoor of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Machinery/Automation category.*

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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Miniature Electron Microscopes Without Vacuum Pumps

Self-contained, microfabricated devices with short working distances, enable operation in air.

NASA's Jet Propulsion Laboratory, Pasadena, California

The proposed electron microscope would function without the need for external vacuum pumps and thus have a significant reduction in size, mass, and power consumption, as compared to conventional (vacuum-pump-equipped) electron microscopes now used in many laboratories. These devices could be used for both imaging as well as chemical-composition determination, in laboratory and field applications. There may be a significant potential market for these devices in applications now served by conventional scanning and transmission electron microscopes in physical and biological sciences, engineering, medicine, and chemistry.

Because the proposed devices could operate in air, it would not be necessary to prepare specimens for examination in vacuum; this is a decisive advantage in situations in which vacuum or the preparation process could damage specimens (e.g. biological specimens). Vacuum pumps are used in conventional electron microscopes because vacuum enables the lossless propagation of electrons over required distances. In the presence of a gas (e.g., air), electrons propagate over short distances, with loss of kinetic energy. In

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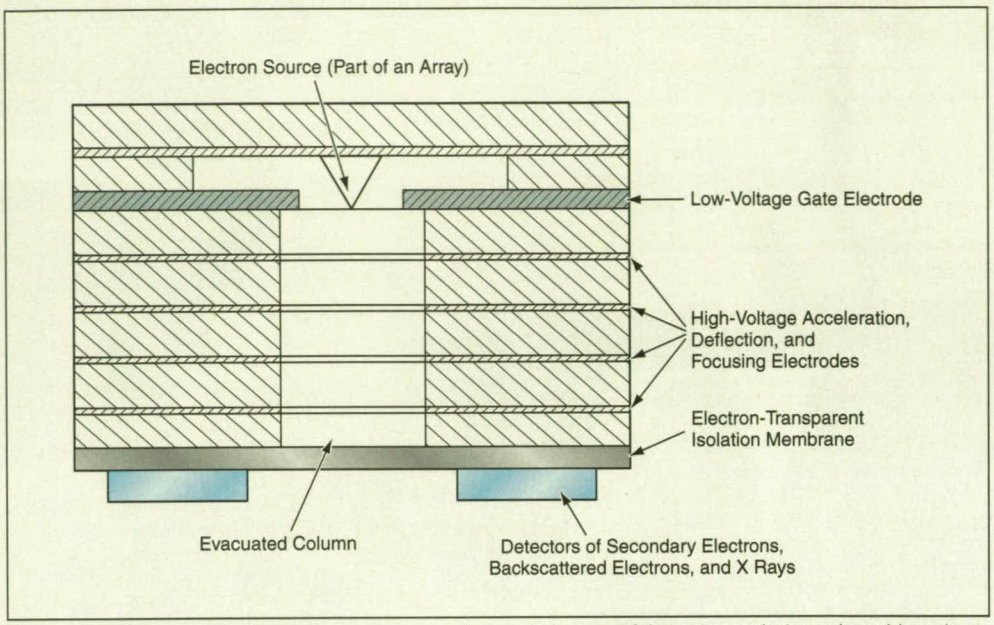
the operation of the proposed devices, working distances to specimens would be made small enough to limit attenuation of electrons to acceptable levels. The spatial resolution is determined primarily by the properties of the electron-transparent, atmosphere isolation membrane that encapsulates the electron column. The best achievable spatial resolution is expected to be at the micron level, whereas conventional electron microscopes give nanometer resolutions. Nevertheless, the advantages may outweigh the loss of resolution in many applications.

In addition to the advantages mentioned above, the proposed electron microscopes offer the great advantage of mass-producibility at relatively low cost by microfabrication techniques established for silicon micromachining. The fabrication process for the proposed electron microscopes would also exploit the recent development of low-voltage, low-power arrays of field-emission electron sources, the miniaturization of high-voltage electronics, and the development of devices that can detect secondary electron emission in the presence of gases.

A typical microfabricated electron microscope column is expected to be a few millimeters thick and about a centimeter square. The evacuated column will consist of a stack of microfabricated chips with metal-film apertures that will serve as electrodes for acceleration, deflection, and focusing of the electrons (see figure). The electron sources will either be an array of thermionic or field emitters, depending on the vacuum level maintained by an integral ion pump (not shown). Although typical field-emission sources require ultra-high vacuum [~10^{-10} torr] for operation, the development of diamond-based field emitters promises much less stringent vacuum requirements [as low as 10^{-4} torr] for operation.



A **Pumpless Miniature Electron Microscope** would be made by microfabrication techniques based largely on micromachining of silicon. The stacked parts would be assembled in vacuum, following a wafer-to-wafer-bonding approach.

The key to the self-contained, atmospheric operation is the electron-transparent membrane that encapsulates the electron column. Recently, high-quality thin films of materials such as silicon nitride, boron nitride, and diamond have been developed. These materials have a low average atomic number and are mechanically very robust. Thus, extremely thin films of these materials offer low electron attenuation with the ability to withstand over one atmosphere of differential pressure.

The detectors for the electron microscope will be mounted outside the encapsulating membrane. These detectors will measure fluxes of characteristic x-rays, backscattered electrons and secondary electrons via gas ionization, emitted by the sample in response to the primary electron irradiation.

This work was done by Thomas George of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free online at www.nasatech.com*** *under the Physical Sciences category.*

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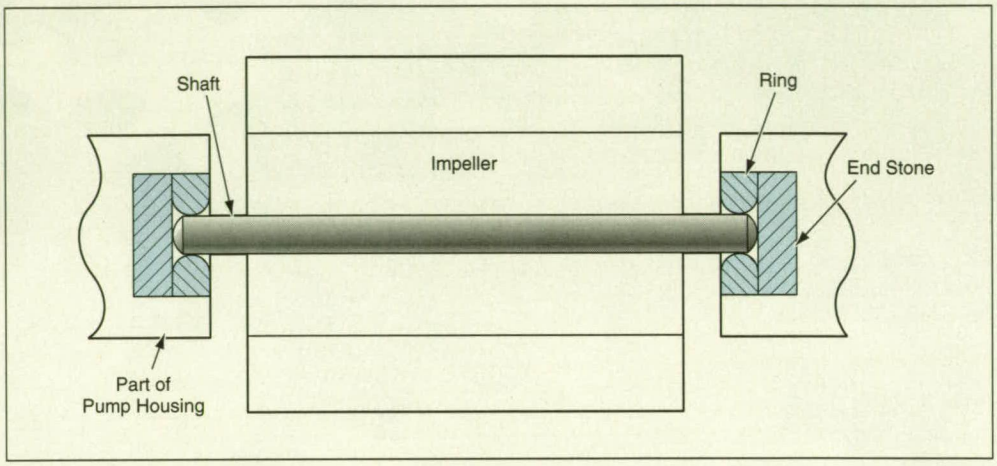
Jewellike Bearings for Blood Pumps

Clots are reduced because blood is not forced through small clearances.

Lyndon B. Johnson Space Center, Houston, Texas

Jewellike bearings have been devised to enhance the performance and safety of small rotary pumps that are used to increase or sustain flows of blood in cardiac patients. A pump of this type includes a spinning impeller in an axial- or radial-flow configuration. The impeller shaft is supported at its ends by the jewellike bearings. Similar bearings could be used in other small pumps that are required to operate for long times without need for maintenance.



The **Jewellike Bearings** at the ends of the impeller shaft offer advantages over rolling-element, pivot, and journal bearings.

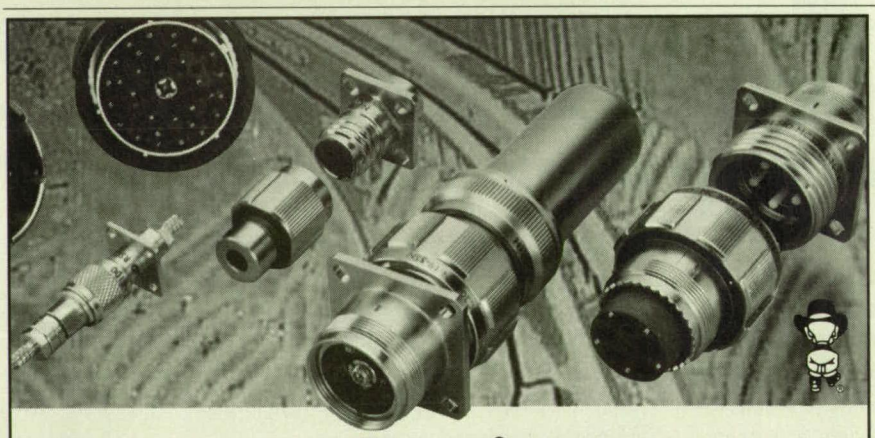
The jewellike bearings are designed to overcome the deficiencies of older rolling-element, pivot, and journal bearings. One of the chief deficiencies is susceptibility to pump seizure caused by the accumulation of coagulated blood in narrow flow passages and in voids within bearings. In the case of journal bearings, another notable deficiency is damage to red blood cells and generation of microclots in high-shear flows of blood through the narrow journal gaps.

In a pump, the jewellike bearings at both ends of the impeller shaft are identical. Each bearing (see figure) includes the end portion of the shaft, a ring, and an end stone. The rings support the shaft radially, while the end stones sustain thrust (axial) loads and limit axial movement of the shaft. The inner surface of the ring facing the shaft is rounded for line contact with the shaft, and the tips of the shaft are rounded for point contact with the end stones; these line- and point-contact features reduce bearing friction and thereby reduce the power needed to drive the pump.

The radial clearance between the shaft and ring is typically 0.0001 to 0.0002 in. (0.0025 to 0.005 mm). The shaft end play (axial clearance) is typically 0.005 to 0.010 in. (0.13 to 0.25 mm). The bearing components can be made of ceramics or hardened metals.

The jewellike bearings offer several advantages:

- Unlike rolling-element bearings in which shaft seals are used to keep blood from entering voids, these bearings can function without shaft seals. Any blood that enters the small void in either bearing coagulates quickly, but in so doing, it forms a smooth surface that conforms to the end of the shaft and thus does not interfere with the rotation of the shaft. Moreover, the diameter of the shaft can be made very small so that any increase in friction caused by the coagulated blood results in only a small increase in frictional torque.
- The configuration of the rounded inner ring surface and the mating cylindrical lateral shaft surface provides the precise clearance fit needed for precise rotation of the shaft, yet accommodates misalignment of the shaft.
- No axial-preload mechanism is needed because the pump is designed to operate with shaft end play.



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- Because the bearing surfaces are in contact with each other, there is no need for the additional pump, reservoir, and/or complex plumbing that would be needed if the design relied on fluid pressure (as in some journal bearings) to carry the bearing loads.
- Blood trauma and potential clotting are reduced in that blood is not forced through narrow gaps.

This work was done by Greg S. Aber of **Johnson Space Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Machinery/Automation category.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Johnson Space Center, (281) 483-0837. Refer to MSC-22721.

Miniature Microscope Without Lenses

Focusing optics would be supplanted by a microchannel filter and electronic image sensor.

NASA's Jet Propulsion Laboratory, Pasadena, California

In a proposed optical microscope, the focusing optics of a conventional microscope would be supplanted by a combination of a microchannel filter and an advanced electronic image sensor. Elimination of focusing optics would eliminate the need for the time-consuming focusing operation, making it possible to examine different specimens in faster succession. Elimination of the focusing optics would also result in a smaller, lighter instrument.

Electronic image sensors with pixel sizes of several microns have been developed. During the next few years, pixel sizes in advanced image sensors may be reduced to < 1 μm — close to the limit of resolution of a conventional microscope with focusing optics. In that case, and if it were possible to effect a one-to-one mapping from a point on a specimen to a pixel in such an image sensor, then the electronic output of the sensor would contain image information equivalent to that from a microscope.

The desired one-to-one mapping could be obtained by use of conventional optics to focus an image of the specimen onto the image sensor, but in this case, one seeks to avoid the use of focusing optics. Instead, according to the proposal, the following would be done: The specimen would be illuminated with highly collimated light (e.g., laser light) aimed through the specimen and toward the image sensor (see figure). Assuming that the specimen were thin enough to be partially transparent but were also highly scattering, the unscattered portion of the incident light would continue to travel along the di-

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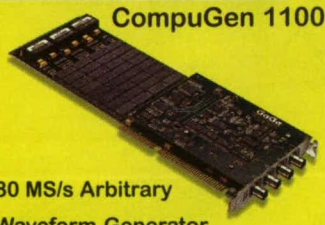

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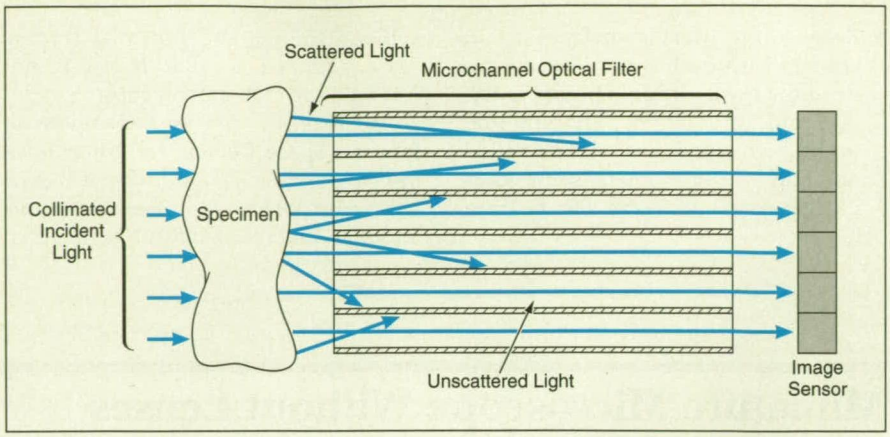

This **Miniature Microscope** would not contain any lenses or other focusing optics. Focusing would not be necessary because the specimen would be imaged in collimated light on an electronic image sensor with microscopic pixels.

rection of incidence, and some would be scattered in other directions.

A narrow-angle filter — a filter capable of absorbing the scattered light — would be placed between the specimen and the sensor. Such a filter could be constructed as a plate or block of opaque material with straight microchannels; more specifically, parallel microscopic-cross-section holes much longer than they are wide. The microchannels should be positioned and dimensioned so that each one is registered with a pixel on the image sensor.

The scattered light would be absorbed on the walls of the holes, and only the unscattered light would pass through. Therefore, the light arriving at each pixel on the sensor would have traveled along a straight line from a corresponding location on the specimen. Given the parallelarity of the holes and of all the optical paths in a collimated beam of light, the geometric relationship among the pixels would match that of the corresponding location in the specimen. Thus, the desired one-to-one mapping would have been effected.

This work was done by Yu Wang of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Physical Sciences category.*

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 NPO-20218, volume and number of this NASA Tech Briefs *issue, and the page number.*

Wavy Blades for Secondary Centrifugal Blood-Pump Impeller

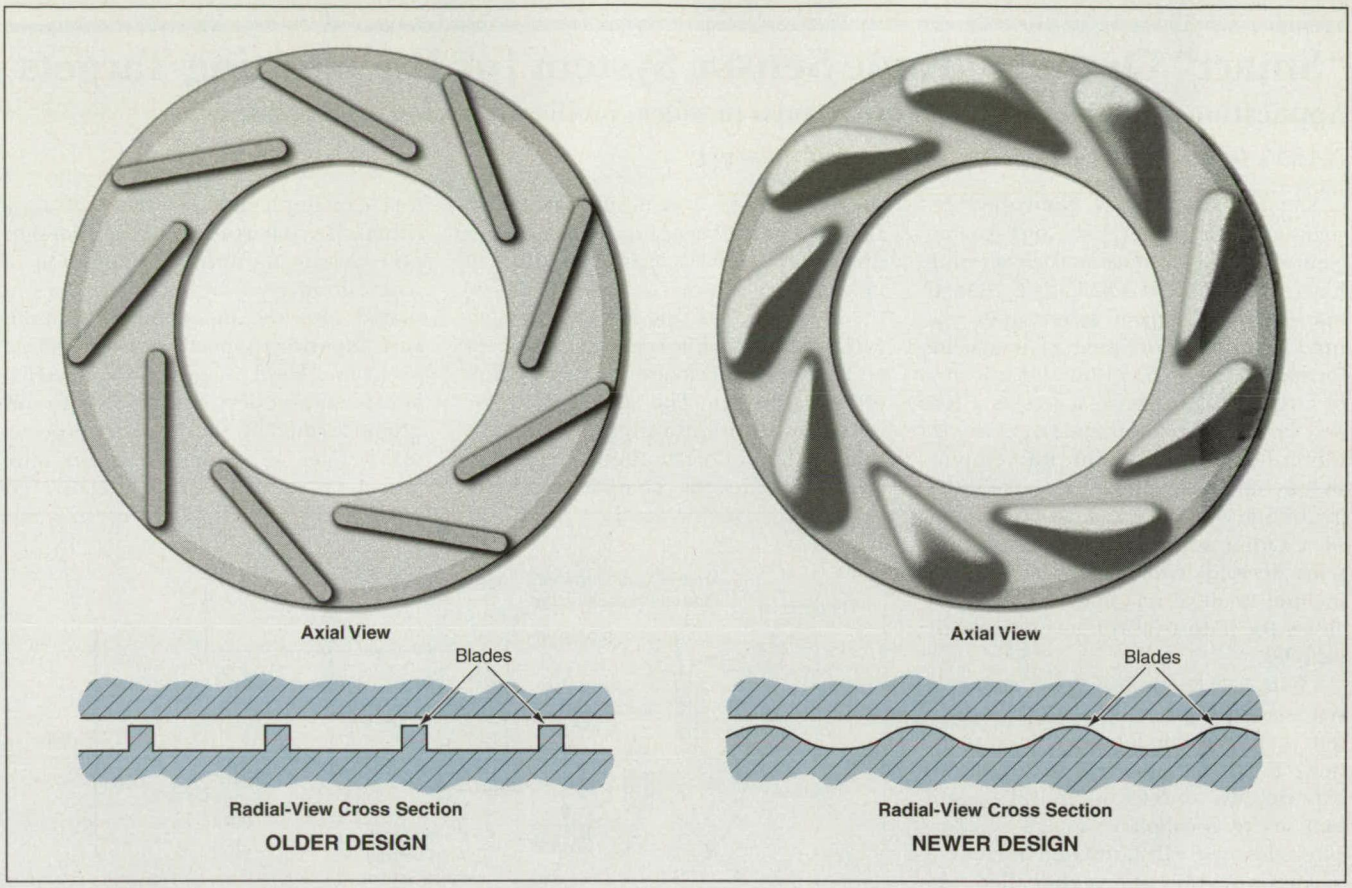
The flow pattern would be modified to reduce the tendency toward clotting.

Lewis Research Center, Cleveland, Ohio

The rectangular-cross-section blades of a centrifugal secondary impeller in a ventricular-assist blood pump would be replaced with blades of wavy cross section, according to a proposal. As explained below, the resulting modification in the flow pattern would reduce the tendency toward clotting.

The function of the secondary impeller in a centrifugal-assist blood pump is to deliver a flow of ≤0.1 liter per minute through a fluid film bearing. The wavy-blade concept would be primarily advantageous at flow rates ≤0.1 liter per minute, but could also be applied, if necessary, to blood-pump impellers with nominal flow rates as large as 5 liters per minute, in cases in which blood would otherwise coagulate on blades, forming deposits that would eventually grow to block flow passages.

The figure illustrates the older and the proposed newer designs. In the older design, the square corner regions of the passages between the blades accommodate the formation of pockets of recir-



The **Wavy-Blade Design** would eliminate the square corner regions where recirculation tends to occur, and would reduce the flow cross section, thereby reducing residence time.

culation, which can cause coagulation and deposition of blood on the blades. Recirculation also gives rise to long residence times within the passages, thereby triggering the onset of coagulation within the blood and increasing the deposition on the blades.

The adoption of the proposed wavy (nearly sinusoidal) cross sections of the proposed impeller blades would effectively reduce the sizes of the corner regions, reducing the tendency for pockets of recirculation to form. The average thicknesses of the wavy blades would be greater than those of the rectangular blades; in other words, the cross-sectional areas of the passages between blades would be reduced. As a result, the residence time for a given flow rate would be reduced.

This work was done by Joseph P. Veres of **Lewis Research Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Machinery/Automation category.*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Lewis Research Center, Commercial Technology Office, Attn: Tech Brief Patent Status, Mail Stop 7–3, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-16447.

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For More Information Circle No. 419

"Smart" Optoelectronic Sensor System for Recognizing Targets

Applications could include defense against missiles, medical imaging, and robotics.

NASA's Jet Propulsion Laboratory, Pasadena, California

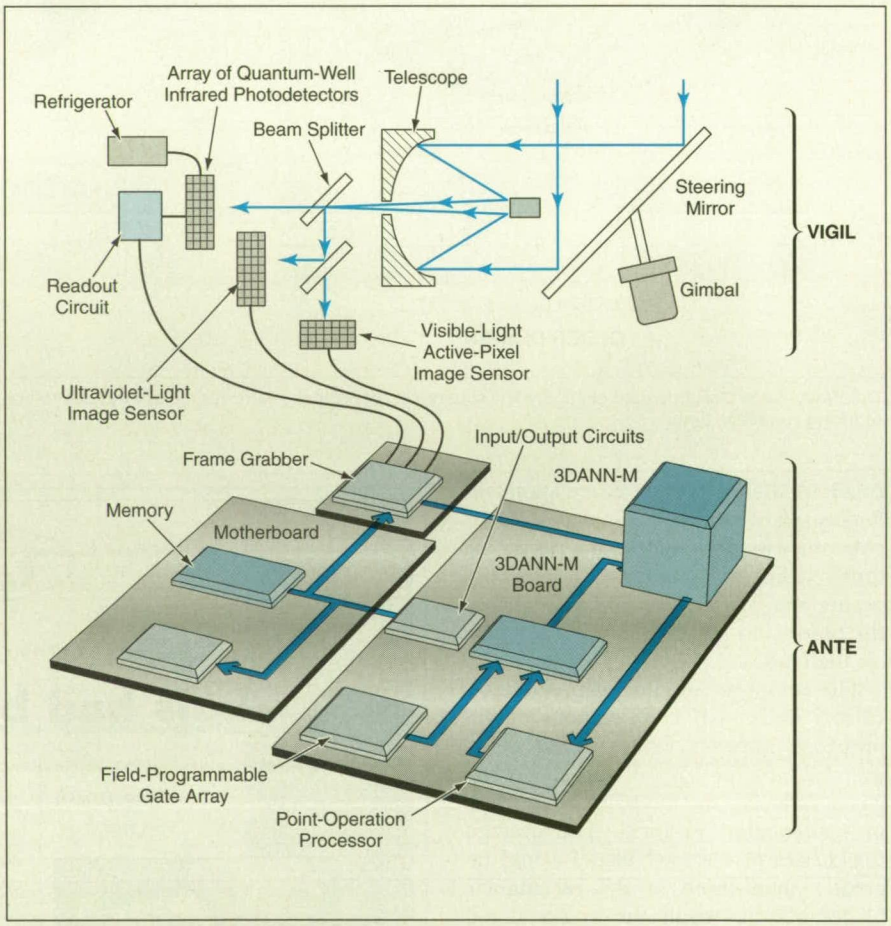
The Viewing Imager/Gimballed Instrumentation Laboratory and Analog Neural Three-Dimensional Processing Experiment (VIGILANTE) is a "smart" optoelectronic sensor system that features ultrafast processing of image information for recognition and tracking of targets. VIGILANTE serves as a test bed for generic automatic-target-recognition (ATR) applications, with emphasis on demonstrating ATR capabilities for military defense against cruise missiles. Other applications for sensor systems derived from VIGILANTE could include medical imaging and machine vision for industrial robots and robotic vehicles.

VIGILANTE comprises two main subsystems (see figure). The VIGIL subsystem is an airborne telescope used to acquire image data for target-recognition experiments and to test novel passive and active focal-plane image sensors. The telescope will ultimately include a 15-cm Cassegrain unit, a gimballed mirror, and optical and electronic channels for multiband (infrared, visible, and ultraviolet) image sensors.

The ANTE subsystem is a prototype image-processing/target-recognition analog/digital computer system. The core computing engine in this system is a three-dimensional artificial neural network (3DANN) of a type described in "Neural-Network Modules for High-Speed Image Processing" (NPO-19881), *NASA Tech Briefs*, Vol. 21, No. 10 (October 1997), page 26. A 3DANN is a low-power-consumption digital/analog integrated-circuit module, about the size of a sugar cube, that can process data at a rate as high as 10^{12} operations per second. The integrated-circuit stack of a previous 3DANN was mated to an array of infrared sensors. The 3DANN in ANTE is a modified version of the previous 3DANN, denoted "3DANN-M." The modifications enable VIGILANTE to accept data from an image sensor of arbitrary size and format. More importantly, the 3DANN-M can be used to perform general convolution operations on image kernels as large as 64 × 64 pixels.

VIGILANTE is designed to make the most of whatever imagery is presented, whether that imagery be monochromatic, multispectral, still, or moving. For this purpose, the VIGILANTE processing architecture is modeled after the image-processing architecture of the human eye and brain. The VIGILANTE image-recognition process is divided into four stages: collection of images from sensors, generation of synthetic images that augment raw images with additional information, fusion of all images, and semantic interpretation of fused images. The use of synthetic images is consistent with the hypothesis that the brain uses synthetic imagery to analyze scenes by comparing corresponding pixels among images of various types. This hypothesis is equivalent to a "rich pixel" concept, according to which the brain becomes a data-fusion machine at the pixel level, before it analyzes the entire scene in a semantic way.

By breaking complex image-recognition tasks into a series of regular operations, the VIGILANTE processing architecture maps image-recognition functions to a relatively small set of special-purpose electronic processing units that can implement a variety of algorithms. In particular, the special-purpose processing unit for generation of synthetic images (by such processes as spatial filtering, detection of motion, and identification of corresponding pixels in related images) is the 3DANN-M convolution device. Pixel-level fusion can be formed on such parallel-processing devices as single-instruction/multiple-data (SIMD) arrays. Relative to other functions, semantic analysis seldom presents a significant computational bottleneck and can ordinarily be performed by general-purpose computing hardware.



The **VIGILANTE System** comprises the VIGIL and ANTE subsystems. VIGIL includes an integrated optical system wherein incoming light is split by wavelength and directed to image sensors in three wavelength bands. ANTE contains a 3DANN, a point-operation processor, and ancillary circuits, all acting together to perform ATR functions in real time.

This work was done by Suraphol Udomkesmalee, Curtis Padgett, Wai-Chi Fang, and Steven Suddarth of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Systems category. NPO-20357*

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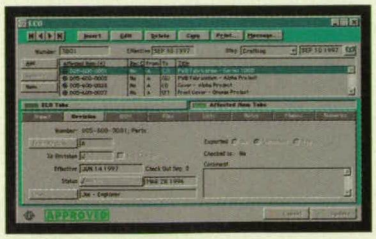


ConsenSys Software Corp., San Jose, CA, has introduced ConsenSys MedDev™ **medical design and document control software**. The program provides an automated, on-line design control solution that can replace paper-based systems to help medical device manufacturers streamline the regulatory approval process, as well as international regulatory compliance.

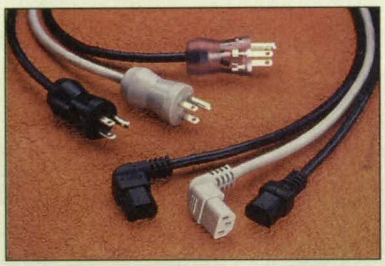
The system is built around ConsenSys 5.3 rapid PDM software, which is integrated with the MedDev protocol. A medical device database template has a user interface designed specifically for the medical device industry. MedDev tracks document relationships to provide traceability from requirements through design input, to design output, including device and production specs. It allows design reviewers to be automatically notified, record their comments, and enter electronic signatures. The online design review meets FDA guidelines.

For More Information Circle No. 745

The DV-Med™ line of disc-based **recorder/players** from Panasonic Medical & Industrial Video, Secaucus, NJ, offers medical professionals a range of recording and playback capabilities designed for memory-intensive applications. The units are engineered for systems compatibility with the medical industry's Digital Imaging and Communications in Medicine standard.

The Model LQ-D5500 is a 12" digital disc recorder/player that features up to 41 minutes of digital full-motion video, or up to 74,773 high-quality still images. The LQ-D100 is a 5.25" digital disc recorder/player designed for first-generation still image acquisition from a variety of medical imaging devices, such as ultrasound, x-ray, CT, and MRI.

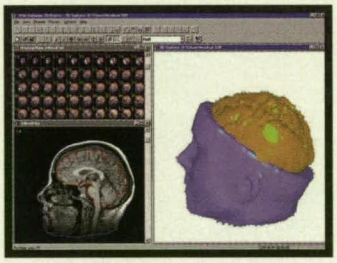
For More Information Circle No. 738



Panel Components Corp., Oskaloosa, IA, offers 36 standard configurations of North American molded hospital-grade **power cords and cordsets** that utilize the NEMA 5-15 plug with a choice of five different molded IEC 320 angle connectors. The cordsets are available in 18/3 and 16/3 SJT and SJTO (oil-resistant) cordage. The connectors and cordsets are available in black and gray; molded plugs are configured in black, gray, or clear.

The cords and cordsets are UL-listed and rated at 10-13 amps, depending on wire size, with service at 125 VAC. Interpower™ cords and cordsets are designed for use in hospital and medical settings for applications in physical therapy equipment, lab instruments, and other devices that are not directly patient-connected.

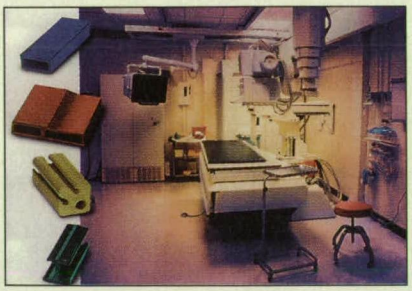
For More Information Circle No. 739



Able Software, Lexington, MA, has released 3D-Doctor **visualization software** for 3D image rendering, volume visualization, and image processing and analysis for magnetic resonance imaging (MRI), computed tomography (CT), microscopy, and ultrasonic testing applications. Object boundaries are extracted using fully automatic or interactive 3D image segmentation, and are used directly for 3D surface and volume rendering. A 3D rendering is constructed from 2D image slices in a few seconds.

Surface data can be exported as a raster image or vector file (DXF), with triangular faces for 3D modeling and other applications. Image measurements — including length, area, surface area, volume, image profile, and histogram — are obtained by drawing with the mouse. Image fusion allows users to see certain image features which may otherwise be invisible if not combined with images acquired by other means.

For More Information Circle No. 737



Composite structural shapes from Polygon, Walkerton, IN, can be used to replace metals in hospital, surgical suite, and examination rooms. The shapes are lightweight, non-conductive, and corrosion-resistant. The composites resist mold and mildew and are bio-compatible, making them easy to clean in medical applications such as framing for lamp stands, lighting fixtures, and hospital beds; stiffening boards; IV stands; and examination position devices.

The composites utilize fiberglass and carbon fiber, as well as DuPont Kevlar and E- and S-fiberglass fibers. Additives can be incorporated into the resin matrix to make the material static-dissipative, conductive, or flame-retardant. The shapes are suited for x-ray apparatus, and can be used for MRI suites, since they are non-magnetic.

For More Information Circle No. 741

Value+ Foams from Avery Dennison Specialty Tape Division, Painesville, OH, are **medical foam tapes** that feature a metallocene polyethylene foam facestock, non-sensitizing medical-grade adhesive system, and a release liner for moisture-stable processability and easy removal.

The single-coated foams are available in thicknesses of 1/32", 1/16", and 1/8" with varying coat weight of medical-grade adhesive systems. The non-irritating, pressure-sensitive adhesive makes the foam tapes suitable for both short- and long-term wear.

For More Information Circle No. 743

100-kHz Portable Data Logging & Control

The new LogBook/300™ data acquisition system from IOtech provides high speed, low cost, and ease-of-use — *without requiring a PC at your test site.*

The intelligent LogBook/300 executes your data acquisition applications and saves acquired data using low-cost PC-Card memory. And since you don't need a PC at the test site, you save cost, space, and avoid the threat of damage or theft to your PC.

For <$3,500, the LogBook/300 ***includes:***

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- AC or DC powerable
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LogView™ software is also included, providing a simple, yet powerful method to graphically set-up your application using your lab PC. No programming skills or expensive extra software is ever required!

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CIRCLE 401

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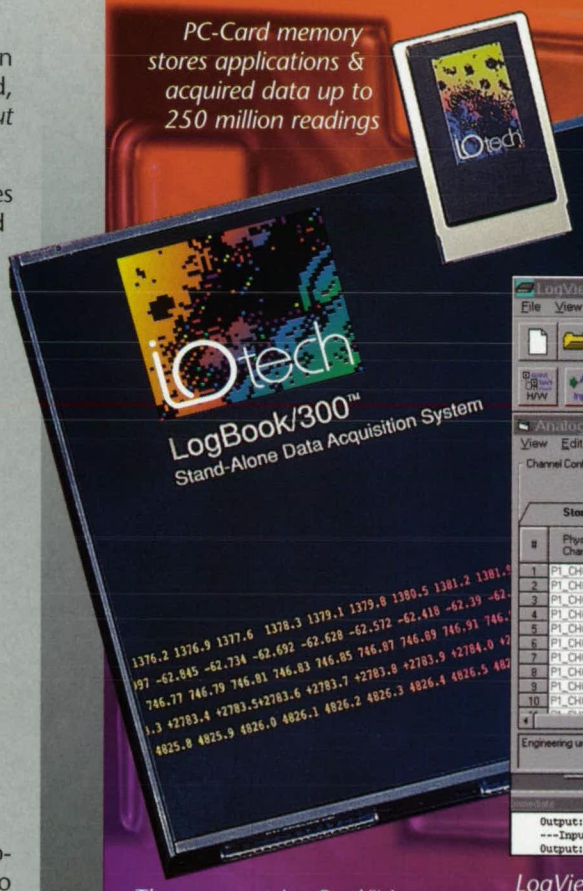

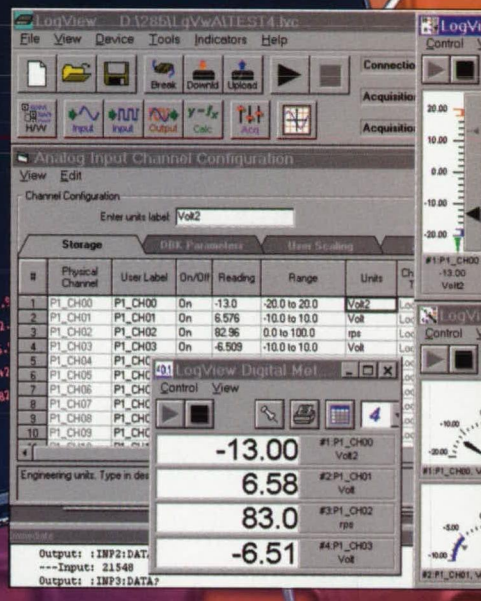

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CIRCLE 402

Portable Data Recorder

The ChartScan/1400™ paperless recorder from IOtech offers the familiar feel of a strip-chart recorder with the advanced features and ease-of-use of a PC-based data acquisition system. The recorder includes ChartView™ *Out-of-the-Box*™ software, which smoothly scrolls data over uniform grids that capture the look of chart paper. Expandable up to 128 isolated channels, the recorder offers a choice of four input connectors by way of plug-in scanning modules. Features include scan rates up to 147 channels/s, digital alarms, and more. Whether connected to a PC or used as a stand-alone instrument, ChartScan is an ideal solution for temperature and voltage data-logging applications. From $2690.

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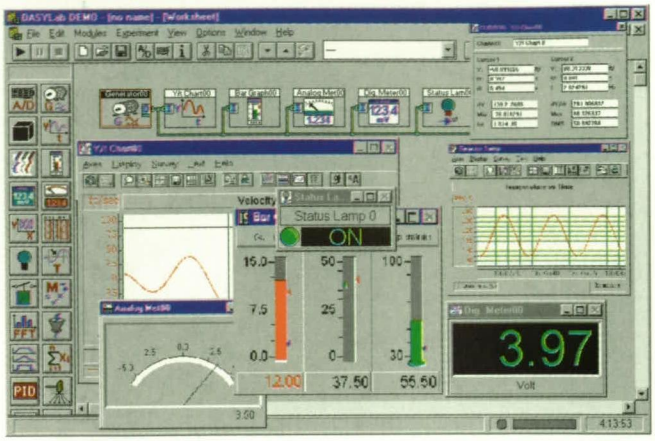
CIRCLE 403

Data Acquisition Software



DASYLab™ from IOtech is a Windows-based data acquisition application that provides effortless setup, acquisition, analysis, graphics, and control. DASYLab's no-programming, *connect-the-icons* environment eliminates the need for extensive training and programming time, providing flexible solutions in minutes, *not weeks*. Unlike other software that locks users into one brand of hardware, DASYLab supports data acquisition systems from a variety of suppliers, including IOtech's parallel-port, PC-Card, plug-in, and USB-based Daq products. DASYLab also supports IOtech's signal conditioning options for thermocouples, strain gages, accelerometers, and many other measurements. From $495.

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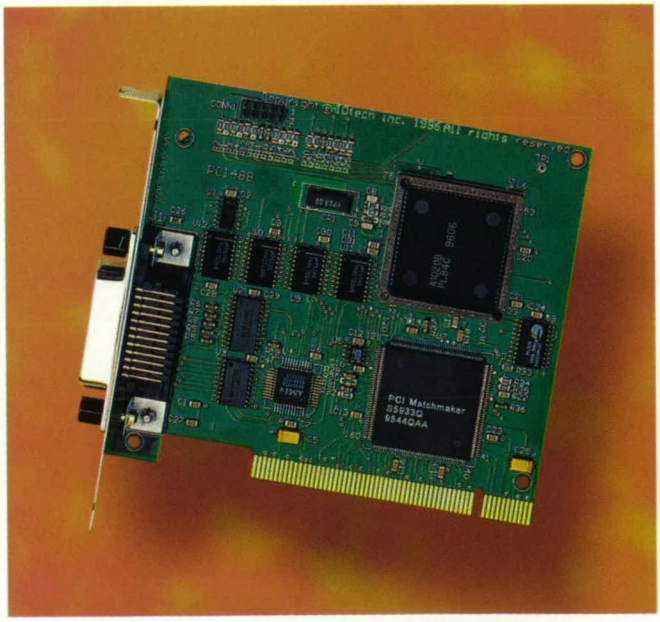
CIRCLE 404

PCI/IEEE 488 Interface



The Personal488/PCI™ interface from IOtech converts your PCI-bus PC into a high-performance IEEE 488.2-compliant controller capable of 1 Mbyte/s data transfer. In addition, it provides plug-and-play installation convenience and 8 digital I/O lines. Software support includes Windows® 95 and Windows™ NT drivers for most programming languages, including Visual Basic®, C™, C++, Delphi, and LabVIEW®. IOtech's Personal488™ family also includes IEEE 488.2 interfaces for ISA and PC-Card buses. $495.

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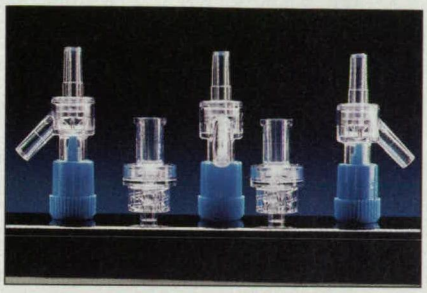
CIRCLE 405

Optical Gaging Products, Rochester, NY, has introduced the SmartScope Zip **video measuring system** for dimensional measurement of biomedical precision components. The non-contact coordinate measuring system is a benchtop unit that features precision zoom optics, multiple illuminators, and high-resolution video camera. Also included are a heavy-duty cast base, center-driven Y axis, and digital signal processing technology.

The Zip 200 model features measurement travel of 8 x 6 x 6"; the Zip 250 is increased to 12 x 6 x 6". An auto-calibrating zoom lens provides a range of programmable magnification. Self-optimizing field of view image processing measures both strong and weak edges. A high-speed autofocus function offers Z-axis measuring.

For More Information Circle No. 742



Bayer Corporation's Polymers Division, Pittsburgh, PA, offers **medical polymers**, including thermoplastic and polyurethane resins, and a lipid-resistant polycarbonate called Makrolon® DP1-1805. The polycarbonate bonds with PVC tubing and helps to alleviate cracking in high-stress applications where there is contact with intravenous fluid products, especially lipid emulsions.

The medical-grade polycarbonate can be used for luers, tubing connectors, Y-site medication ports, stopcocks, and other applications. It is available in selected tints and colors, and meets biocompatibility requirements of FDA-modified ISO 10993, Part I. It also withstands sterilization by radiation, ethylene oxide, and steam autoclaving.

For More Information Circle No. 746

Vesta, Franklin, WI, offers **medical silicone components and assemblies** for medical devices. The silicones used comply with FDA Biocompatibility Guidelines for medical products, and are compatible with human tissue and body fluids. They offer heat stability and can be used for medical implants.

The silicones are odorless, tasteless, and do not support bacteria growth. They are unaffected in shape, clarity, strength, or flexibility under repeated sterilization. The company also offers evaluation of physical specifications of a component, and recommendation of the ideal silicone compound and process parameters.

For More Information Circle No. 740

Custom and standard **precision balls** for medical components and equipment are available from Thomson Industries, Port Washington, NY. The precision balls are used in applications ranging from blood analysis to patient monitoring equipment. They meet ISO standards, and are manufactured in an ISO-9002 plant.

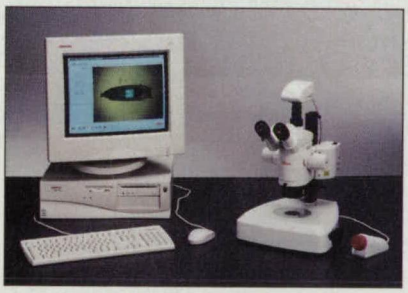
The balls feature sphericity within 3 millionths of an inch, and are available in a choice of 27 materials, including Type 316L surgical stainless steel, 52100 chrome steel, stainless steel, Monel, K-Monel, bronze, brass, non-ferrous, and ceramic. The balls meet or exceed standards of the American Bearing Manufacturers Association.

For More Information Circle No. 747

Servomex, Norwood, MA, offers the Pm1111E **paramagnetic oxygen transducer** for medical applications including anesthesia workstations and respiratory gas monitors. The transducer features accuracy of ±1,000 ppm O_2, response of 200 msec, low power consumption, and is manufactured to ISO-9001 constraints.

The transducer also meets requirements of manufacturers of cardio/pulmonary diagnostic, nutritional assessment, and metabolic analysis equipment. The units are shock- and vibration-resistant.

For More Information Circle No. 748



Leica Microsystems, Deerfield, IL, has introduced the DC 100 **digital imaging system** for medical applications. The optical components and software were designed for microscopy, and enable digitized images to be created, manipulated, and stored, whether the microscopic technique involves incident, transmitted, or fluorescence illumination. When combined with a microscope or stereomicroscope, the system is compatible with PC, TWAIN driver, and Leica QWin image analysis software.

Image information is digitized directly on the CCD sensor and displayed in real time on the monitor. The system features a 1/2" CCD sensor and reaches a resolution of 455K quadratic pixels. Image exposure can be manually or automatically controlled, depending on illumination quality.

For More Information Circle No. 744

Self-Checking Circuitry for Detecting Single-Event Latchups

A voting scheme would reveal anomalies in complex circuits with wide dynamic ranges.

NASA's Jet Propulsion Laboratory, Pasadena, California

High-performance electronic circuits would incorporate self-checking features for detection of radiation-induced single-event latchups (SELs), according to a proposal. The basic SEL-detection scheme calls for redundant circuitry and a current-voting scheme similar to voting schemes that have been used to reveal malfunctions in other redundant systems. The redundancy and voting scheme could also be combined with other fault-tolerance features [e.g., for detection of single-event upsets (SEUs)].

As in some older schemes for detecting SEL and other anomalies, the proposed current-voting scheme would involve detection of operating current outside the normal range for a circuit to be protected. However, unlike in some older methods for detecting SEL, no attempt would be made to establish precise limits of normal operating current — limits that could be difficult if not impossible to establish for a complex circuit that normally operates over a wide dynamic range of current and/or is subject to radiation or to variations in temperature. Instead, one would build a duplicate of the circuit to be protected and would operate both circuits concurrently under the same nominal conditions, using comparator circuitry to detect differences between the currents drawn by the two circuits (see left side of figure). Each of the duplicate circuits would serve as a high-fidelity model of "normal" behavior for the other. "Normal" behavior would be defined ratiometrically; that is, in terms of a range, α, of allowable fractional difference between the currents (or corresponding voltages) in the two duplicate circuits. Any excursion from the allowable range would be detected by the comparator circuitry, which would respond by triggering an alarm, shutdown, reset, or other appropriate corrective signal.

The current-voting scheme could be implemented, for example, by the current-comparison and threshold-logic circuitry shown on the right side of the figure. Potentials V_1 and V_2 are voltages representative of the currents flowing from a power supply (at potential V_{CC}) to each of two duplicate circuits. The values of R_1 and R_2 would be chosen so that $R_1/(R_1+R_2) = \alpha$. Thus, the left voltage divider (R_1,R_2) would provide comparison voltages V_1 and $V_1(1-\alpha)$, while the right voltage divider (R_1,R_2) would provide comparison voltages V_2 and $V_2(1-\alpha)$. Then the output of the upper comparator would go high if V_2 were less than $V_1(1-\alpha)$, whereas the output of the lower comparator would go high if V_1 were less than $V_2(1-\alpha)$. It is noted that in this scheme, it would not matter which voltage (V_1 or V_2) was the "normal" voltage; instead, if either voltage deviated from the other by a fraction $>\alpha$, the behavior would be deemed to be abnormal, causing the circuit to generate an "out-of-bounds" signal.

This work was done by Douglas W. Caldwell of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free online at www.nasatech.com*** *under the Electronic Components and Circuits category.*

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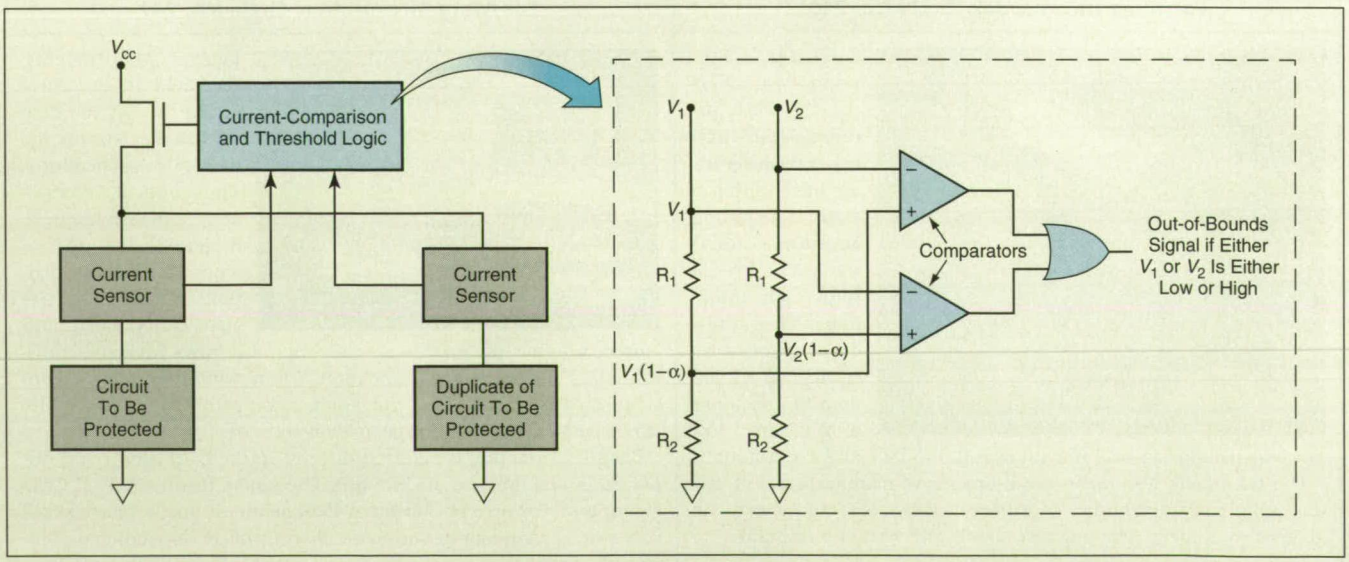

A **Duplicate of the Circuit To Be Protected** would be operated concurrently, under the same conditions. The currents drawn by the protected circuit and its duplicate would be indicated by V_1 and V_2. If either of V_1 or V_2 differed from the other by a fraction greater than $R_1/(R_1+R_2) = \alpha$, then the circuit would generate an "out-of-bounds" signal.

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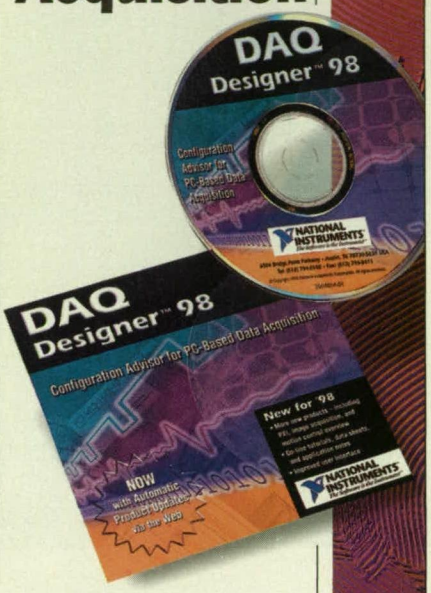

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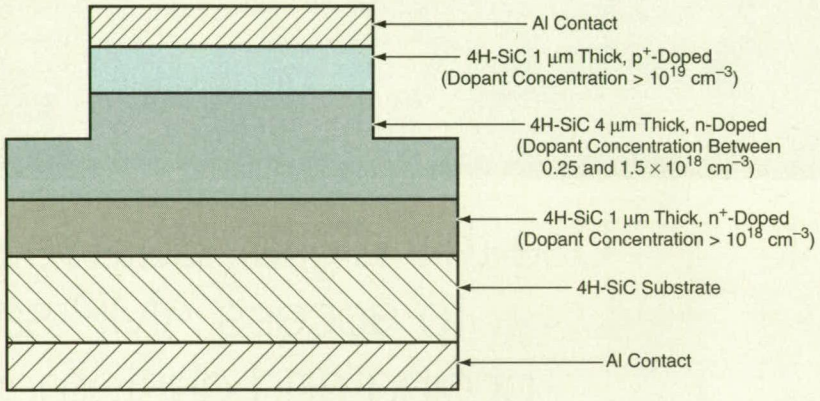
Stable Breakdown Obtained in Silicon Carbide Rectifiers

Damaging junction hot spots and current concentrations can be eliminated.

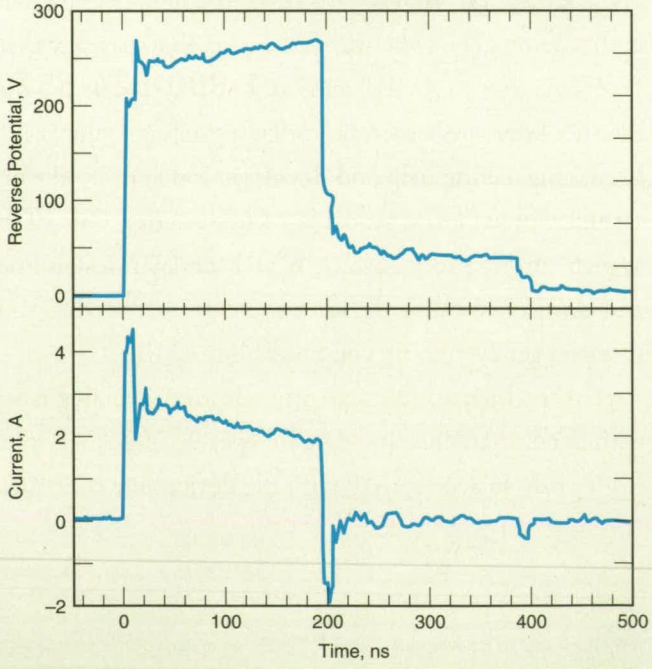
Lewis Research Center, Cleveland, Ohio

Experiments have revealed that stable breakdown-voltage characteristics can be achieved in silicon carbide rectifiers. Stable breakdown-voltage characteristics are essential to the ability to withstand overvoltage transients and are therefore necessary for reliability in high-power semiconductor switching and rectifying devices.

Silicon carbide semiconductor devices can function under high-temperature, high-power, and high-ionizing-radiation conditions beyond the endurance limits of silicon semiconductor devices. Consequently, SiC devices are undergoing development for eventual use in potential applications that include high-voltage switching in electric-power distribution and electric vehicles, increasingly powerful microwave electronic circuits for radar and cellular communications, and sensors and con-



CROSS SECTION OF DIODE



RESPONSE OF DIODE TO A REVERSE-BIAS OVERVOLTAGE PULSE

The **Voltage and Current Responses of the Diode** are consistent with a positive temperature coefficient of breakdown voltage. Ignoring the displacement-current spike at the leading edge of the current waveform, the peak breakdown current of about 2.5 A corresponds to a current density of about 5×10^4 A/cm^2.

Blood centrifuge covers were produced from RP 6453, chosen for its high heat deflection temperature, good impact resistance and flame retardance. Nearly 1,500 covers were molded in 12 months for installation on centrifuges shipped throughout the world.*

Leaf blower parts were shot from RP 6451, a high heat deflection, impact resistant material. The contract called for 30 parts to be molded for use in functionality tests, set up and testing of assembly-line fixtures, and marketing photography.

Forty 20-lb. automotive bumper fascias were cast from RP 6450, a dimensionally stable, impact-resistant polyurethane with properties similar to the RIM material being used for the end-parts. Prototypes were built for fit-and-function analysis and air-flow testing.

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trols for advanced, cleaner-burning, more-efficient engines. However, prior to the experiments reported here, SiC semiconductor devices had exhibited unstable breakdown-voltage characteristics and were therefore questionable for incorporation into high-power circuits.

In this context, a stable or unstable breakdown-voltage characteristic of a semiconductor rectifier is synonymous with a positive or negative value, respectively, of the temperature coefficient of breakdown voltage. Silicon power rectifiers in use today are highly reliable, partly because they have positive temperature coefficients of breakdown voltages.

During large overvoltage transients, a device can become momentarily reverse-biased at a potential greater than its reverse breakdown voltage. If the device has a negative temperature coefficient of breakdown voltage, then local junction heating from breakdown current causes the local breakdown voltage to decrease, thereby giving rise to a further local increase in breakdown current. The breakdown current becomes concentrated into one or more high-current-density filaments at junction hot spots, which leads to physical junction damage and device failure. If the device has a positive temperature coefficient of breakdown voltage, then local junction heating from breakdown current increases the local breakdown voltage, preventing local concentration of breakdown current; thus, breakdown current distributes nearly evenly across the entire area of the diode junction.

The experiments were performed to determine whether the unstable breakdown observed previously is a fundamental property of SiC or whether it arises because of impurities and crystalline imperfections that could be reduced by improvements in techniques for growing SiC crystals. For the experiments, SiC rectifier diodes were fabricated by use of the crystal-growth process described in "Chemical Vapor Deposition of Silicon Carbide With Controlled Doping" (LEW-15803), *NASA Tech Briefs*, Vol. 20, No. 12 (December 1996), page 80. The figure shows the diode structure and current and voltage waveforms recorded when one of these diodes was subjected to an overvoltage pulse with a duration of 200 ns. These waveforms show that as the device becomes heated by the breakdown current during the pulse interval, the voltage across the device increases, while the current through the device decreases; this behavior is consistent with a positive temperature coefficient of breakdown voltage and thus with a stable breakdown-voltage characteristic needed for reliability. The diode sustained repeated overvoltage pulses without measurable degradation of its junction.

This work was done by Philip G. Neudeck of **Lewis Research Center** *and Chris Fazi of U.S. Army Research Laboratory. For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Circuits category.*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Lewis Research Center, Commercial Technology Office, Attn: Tech Brief Patent Status, Mail Stop 7–3, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-16551.

TRL Fixture for Cryogenic Testing of Microwave Components

One can complete a test without interrupting a cryogenic and/or vacuum condition.

Lewis Research Center, Cleveland, Ohio

A single-block fixture enables the rapid and accurate electrical characterization of planar microwave electronic components, by use of the through-reflect-line (TRL) technique, in air or in a vacuum at any temperature from ambient down to cryogenic temperatures. Heretofore, the TRL technique has involved the use of a split-block fixture in a procedure that unavoidably and undesirably includes breaking vacuum and/or thermal cycling back to room temperature. The design of the present single-block fixture makes it possible to complete the testing of a microwave component without interrupting a vacuum and/or cryogenic condition.

A planar microwave device under test (DUT) is typically characterized by use of an automatic network analyzer (ANA). To be able to characterize the DUT as a discrete, isolated device, one must be able to compensate mathematically for the electromagnetic characteristics of the test fixture, coaxial-to-microstrip transitions, coaxial cables, and other components used to couple test signals between the ANA and the DUT. For this purpose, one must perform calibration measurements to characterize the ensemble of all components of the test system up to a set of reference planes where the DUT is to be installed in the test fixture.

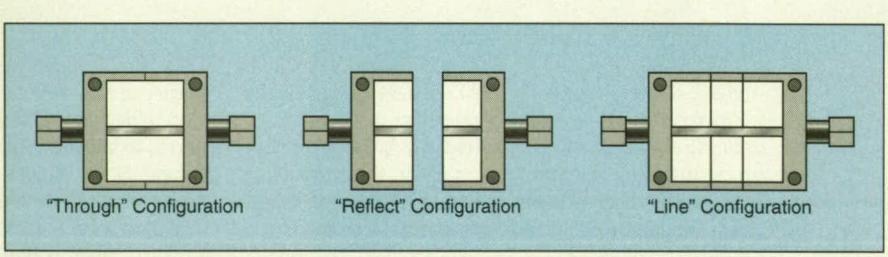
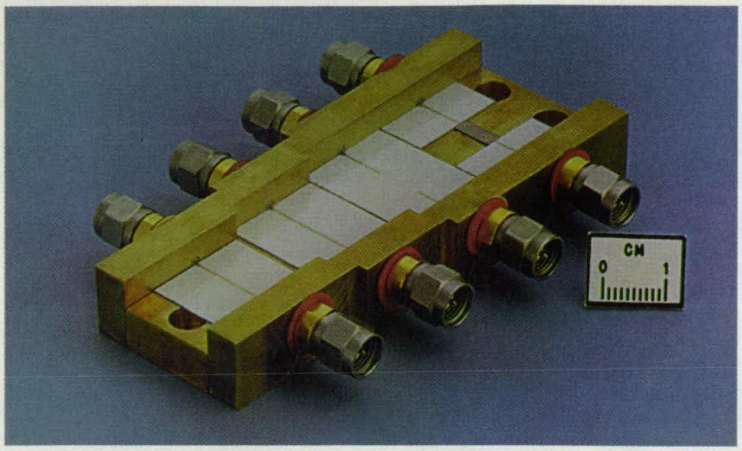


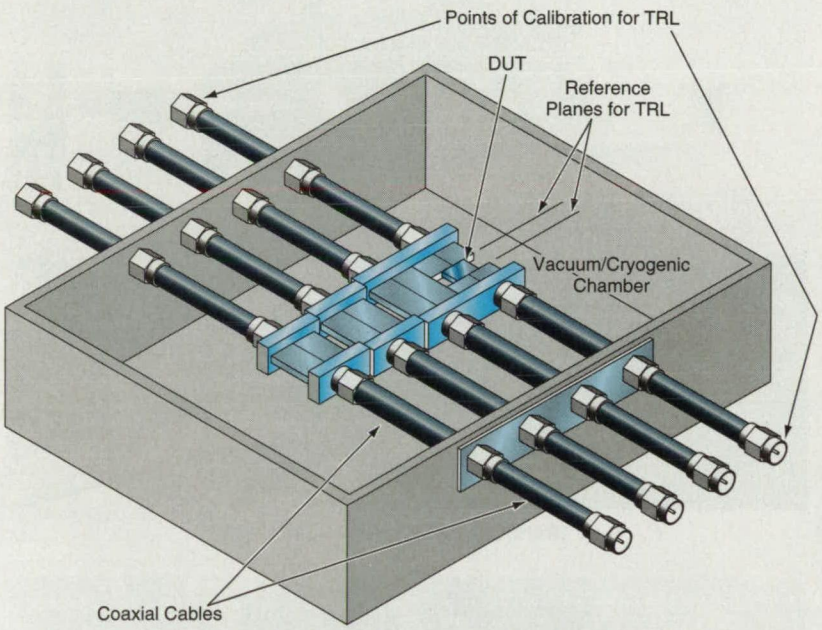
Figure 1. The **Predecessor to the Single-Block Fixture** is a split-block fixture that is used in three different configurations.

For calibration measurements, one inserts a calibration standard — a device with known electromagnetic characteristics — in place of the DUT. In the split-block version of the TRL technique, the split block is configured in three different ways to obtain different calibration standards (see Figure 1). The split-block version of the TRL technique works well at room temperature. However, this version is too cumbersome for vacuum and cryogenic testing, in that the block must be rewired and reconfigured between calibration steps. The rewiring and reconfiguration must be performed under ambient conditions and they take time, adding to the cost of testing. During the rewiring and reconfiguration time, ANA reference levels can drift, with consequent increases in measurement errors. In contrast, there is no need to reconfigure or rewire the present single-block fixture; therefore, calibration can be completed more easily and quickly at any temperature, and measurements can be more repeatable.

The single-block fixture (see Figure 2) holds the DUT plus through, reflect, and delay (line) calibration standards in their prescribed test setups and is placed in a vacuum/cryogenic chamber. The



PHOTOGRAPH OF FIXTURE



SIMPLIFIED VIEW OF FIXTURE IN TEST SETUP

Figure 2. The **Single-Block TRL Fixture** holds the DUT and the calibration standards in the vacuum/cryogenic chamber. Connections between and external ANA and one of the devices on the fixture are made through the appropriate input/output pair of coaxial cables.

fixture includes a 0.010-in. (254-μm)-thick alumina substrate with etched gold strips serving as transmission-line conductors. The input and output transmission lines are patterned for a characteristic impedance of 50 Ω.

Connections between external circuitry and these input/output lines are made via coaxial connectors and coaxial-to-microstrip transitions. Coaxial cables run from these connectors to points outside the vacuum/cryogenic chamber. There are no moving parts and there is no switching of electrical connections in the vacuum/cryogenic chamber. Instead, access to the DUT or to one of the calibration standards is gained by connecting, outside the vacuum/cryogenic chamber, to the appropriate coaxial cable.

This work was done by F. A. Miranda and B. T. Ebihara of **Lewis Research Center** *and A. S. Creason of Ohio Northern University, M. Mejia of University of Pennsylvania, and S. S. Toncich of Bird Electronics. For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Circuits category.*

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Laser Doppler Velocimeter System for Use on Gas Turbines

The LDV transceiver has been ruggedized to withstand engine vibrations and noise.

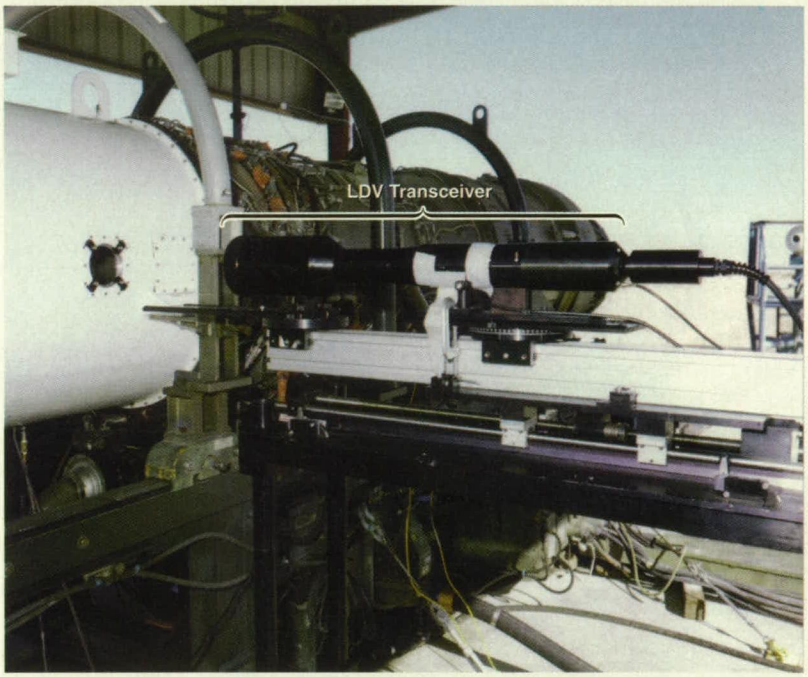
Dryden Flight Research Center, Edwards, California

A laser Doppler velocimeter (LDV) system has been developed for use on practical gas-turbine engines. The system has been used to measure inlet and exhaust velocities on an F-100 EMD engine from an F-15 airplane (see Figure 1). To perform this work successfully, it was necessary to develop several novel subsystems, including a rugged LDV transceiver, a high-performance frequency-domain signal processor, and equipment for adding seed particles to the inlet and exhaust flows. In addition, it was necessary to provide for remote control of the system from a blockhouse at a distance of 30 m from the engine.

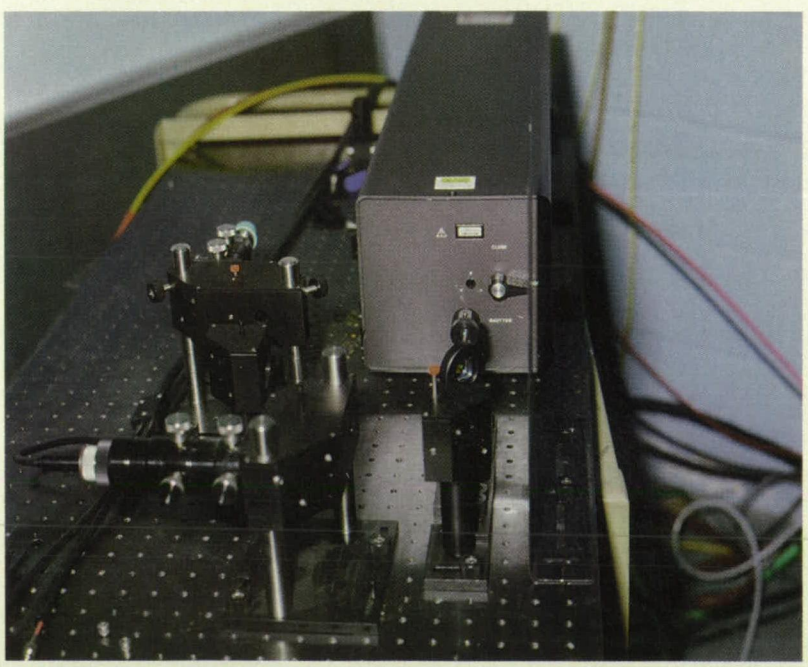
The LDV transceiver features a special ruggedized design: The main structural component of the transceiver was machined from a billet of aluminum, and all optics were hard-mounted on this component. This was necessary to enable the LDV transceiver to survive the intense vibrational and acoustical fields that surround a practical gas-turbine engine.

A 40-MHz Bragg cell provides frequency shifting for the LDV. The laser beam is generated by an argon-ion laser in the blockhouse and delivered to the LDV transceiver by a 30-m-long, single-mode, polarization-preserving optical fiber (see Figure 1). The intensity of the laser beam emerging from the end of the fiber-optic link in the LDV transceiver is monitored remotely; that is, from within the blockhouse. A second 30-m-long multimode optical fiber delivers the scattered light received from seed particles passing through the interferometric LDV probe volume to a photodetector in the blockhouse. This photodetector is a photomultiplier/preamplifier combination developed specially to perform at signal frequencies >120 MHz — well in excess of characteristic response frequencies of typical photodetectors in older LDV systems.

The frequency-domain signal processor, known as the Real-Time Signal Analyzer™ (RSA), was developed to provide an easy-to-operate, extremely

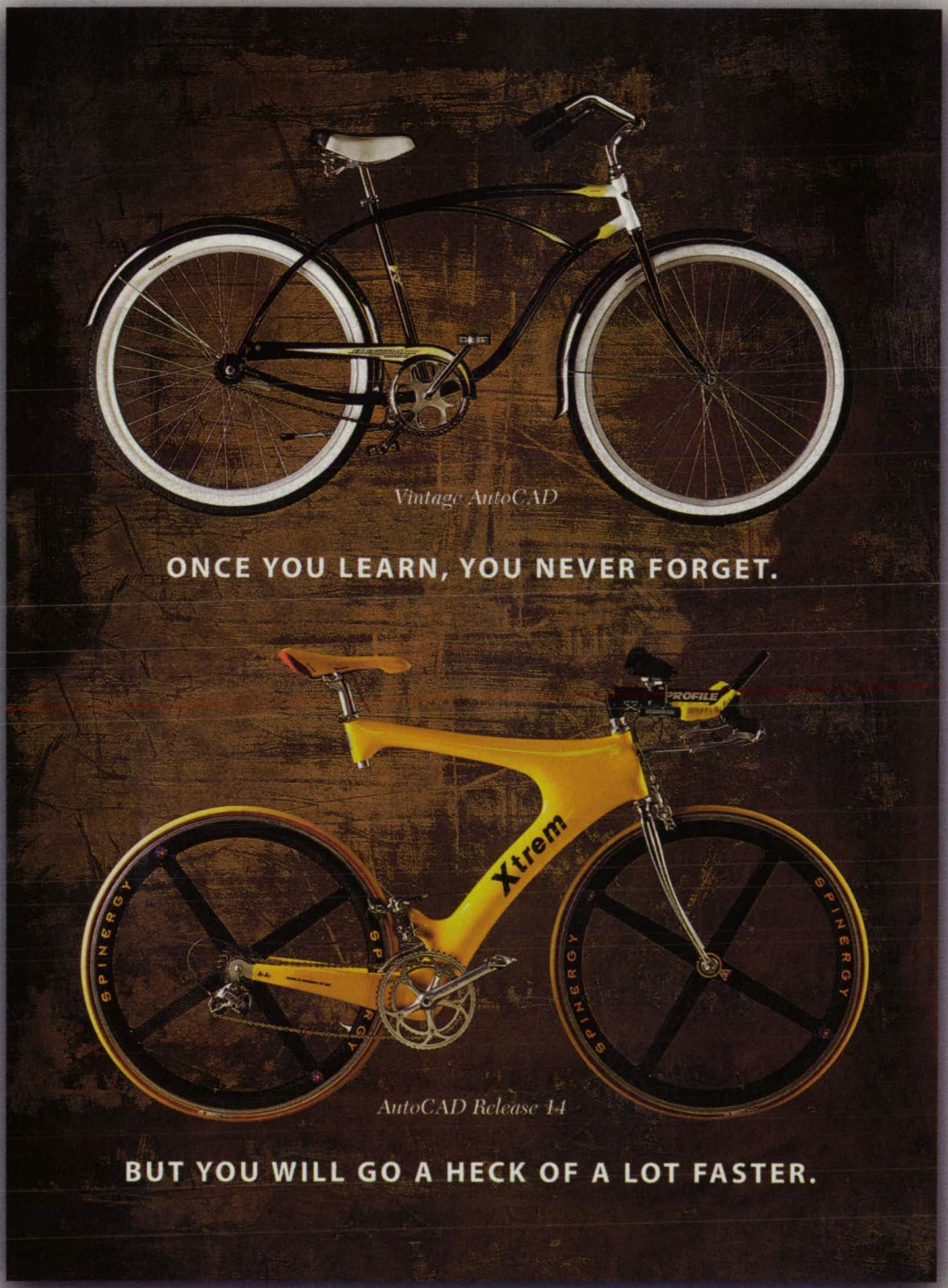


LDV TRANSCEIVER MOUNTED NEAR ENGINE



LASER AND ASSOCIATED OPTICS IN BLOCKHOUSE

Figure 1. The **LDV System** includes a rugged LDV transceiver mounted near the engine and connected via optical fibers to optical and electronic instrumentation in the blockhouse.



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capable processor of LDV signals. The RSA can perform up to 107 measurements per second on LDV signals and is thus capable of performing at rates well in excess of any expected data rates. Not only is the potentially noisy LDV signal measured in the frequency domain by use of discrete Fourier transforms, but the Doppler burst is also detected in the frequency domain, enabling operation at signal-to-noise ratios well below 0 dB. The output of the RSA is delivered to a laptop computer, where the results are displayed in real time and stored. All control over the RSA is exercised via this computer.

Two seeders were developed. One was an evaporation/condensation seeder that introduced a propylene glycol smoke, as a nonhazardous seeding material, into the inlet flow. This seeder was specially designed to minimize perturbation of the inlet flow and eliminate a possibility of introduction of foreign objects that could damage the engine. The other seeder — of the fluidized-bed type — introduced refractory seed particles into a moderate-pressure engine bypass airflow downstream of the engine to enable LDV measurement of the exhaust flow. Both seeders were required to provide copious amounts of seed to obtain adequate data rates at the high flow rates of a practical gas-turbine engine.

Figure 2 presents some results from a sample test run, showing inlet and exhaust axial speeds for a transient ramp from idle to full military power, then back to idle. The success in using this system to perform ground-based measurements raises the hope of accomplishing such measurements in flight on a practical aircraft in the future.

This work was done by Kimberly Ennix, Tim Conners, and Dean Webb of **Dryden Flight Research Center** *and Roger Rudoff, John Hanscom, Robert Shearrer, and William D. Bachalo of Aerometrics, Inc. For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Systems category.*

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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Sunnyvale, CA 94086

Refer to DRC-98-08, volume and number of this NASA Tech Briefs *issue, and the page number.*

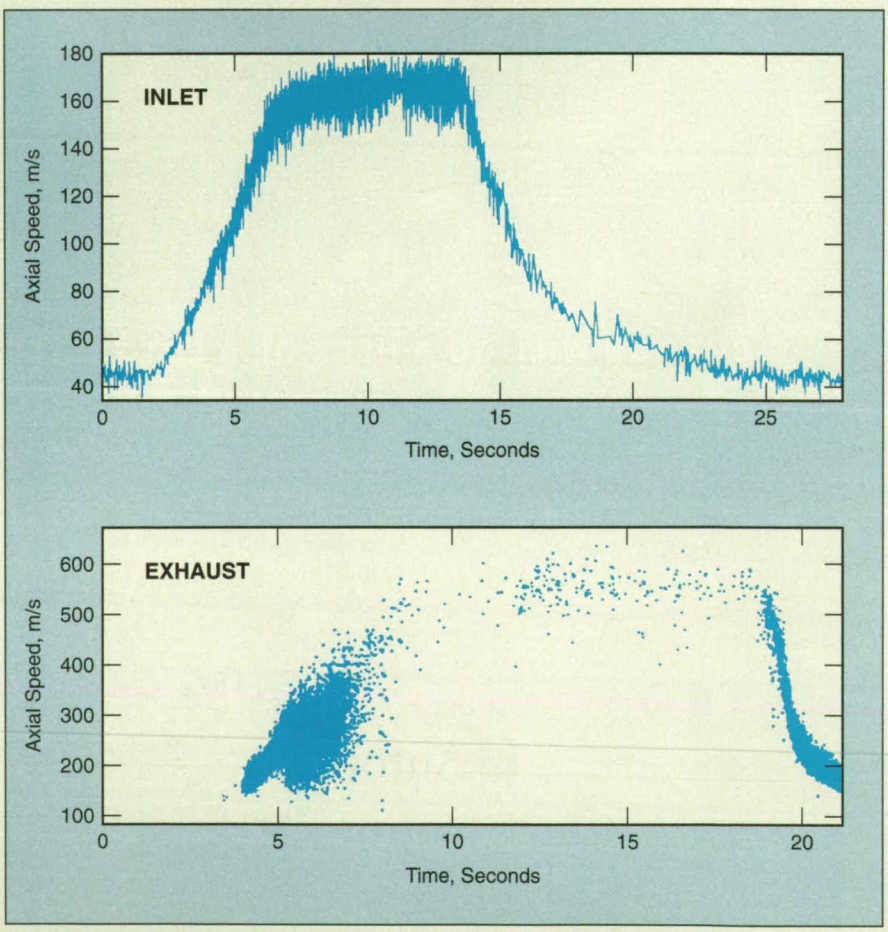

Figure 2. These **Plots Show Axial Speeds** in inlet and exhaust flows as measured by use of the LDV system during a transient from idle to full military power then back to idle.

Updated Program for Computing Stresses in Spur Gears

DANST-PC is version 3.01 of a computer program for analysis of the statics and dynamics of spur-gear systems. ["DANST" signifies "Dynamic Analysis of Spur Gear Transmissions." A previous version was described in "Computing Stresses in Spur Gears," *NASA Tech Briefs*, Vol. 19, No. 12 (December 1995), page 73.] The program can be used for parametric studies to predict the static transmission error, dynamic load, tooth-bending stress, and other properties of a pair of external spur gears as they are influenced by operating speed, torque, stiffness, damping, inertia, and tooth profile. DANST performs geometric modeling and dynamic analysis for low- or high-contact-ratio spur gears. It can simulate gear systems with contact ratios ranging from one to three.

DANST is based on a four-degree-of-freedom, lumped-mass model of a gear transmission. The model includes driving and driven gears, connecting shafts, motor, and load. The equations of motion were derived from basic gear geometry and elementary vibration principles. The dynamic solution is found by integrating the equations of motion. The user is provided with many options, including (1) materials, basic gear geometries, and operating conditions; (2) various combinations of tooth profiles (including standard forms of tip relief or user-digitized profile modifications); (3) static or dynamic analysis; and (4) various printed and plotted outputs.

DANST is written in FORTRAN 77 for i386 and above IBM-PC-compatible computers running the MS-DOS, Windows95, or Windows NT operating system. A math coprocessor and VGA display are required. The source code and executable code are provided. DANST-PC has been successfully implemented on an i486DX computer running Windows95. To recompile the source code, one needs the plotting software package PLOT88 from Plotworks Software. The standard distribution medium for DANST-PC is one 3.5-in. (8.89-cm), 1.44MB diskette in MS-DOS format. DANST-PC was released to COSMIC in 1997.

This program was written by Fred B. Oswald of **Lewis Research Center,** *Hsiang H. Lin of the University of Memphis, and Irebert R. Delgado of the U.S. Army. For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Mechanics category. LEW-16575*

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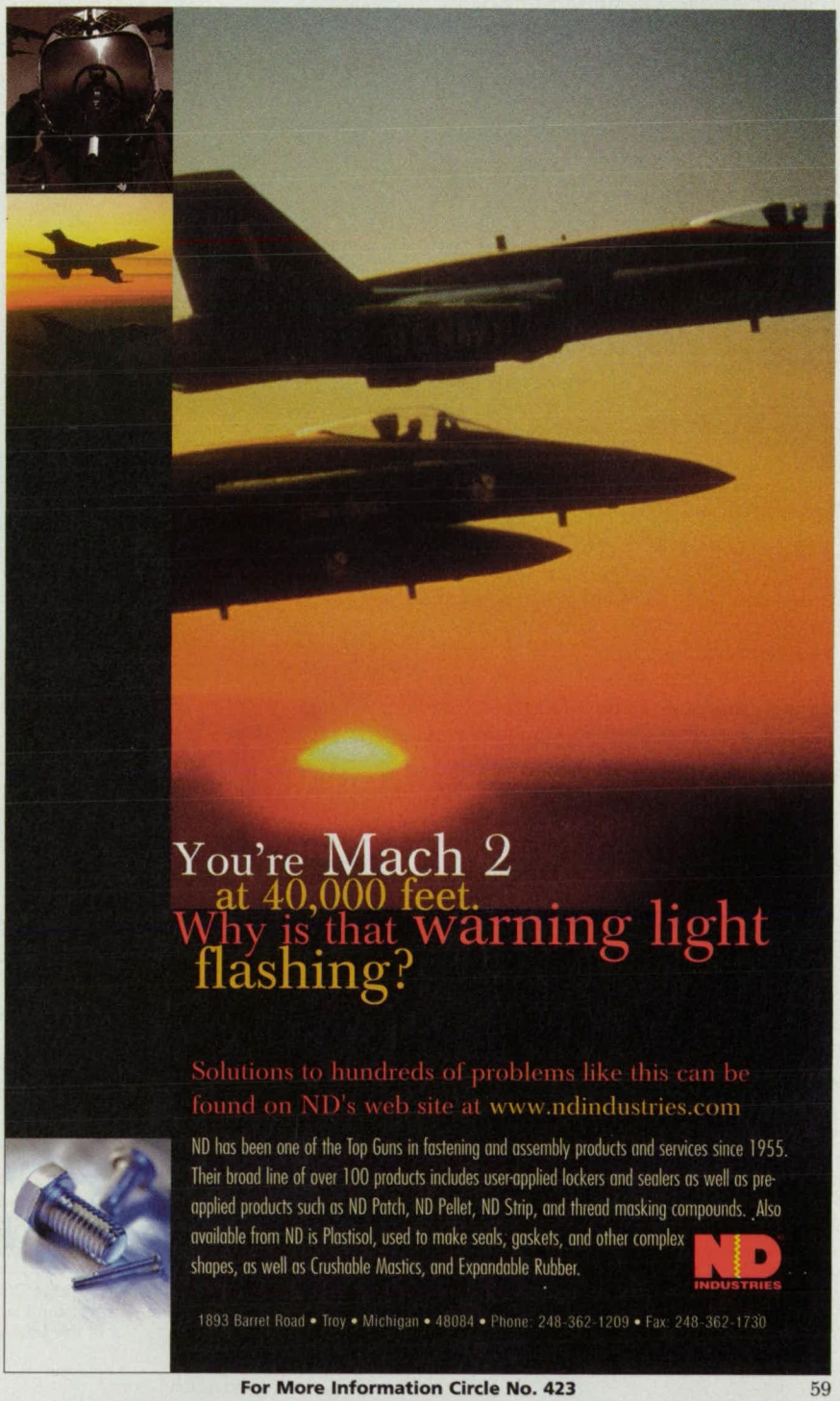

$LaNi_{5-x}Sn_x$ Electrodes for Ni/MH Electrochemical Cells

Capacities and cycle lives are increased.

NASA's Jet Propulsion Laboratory, Pasadena, California

Experiments have shown that improved hydride-forming negative electrodes for rechargeable nickel/metal hydride (Ni/MH) electrochemical cells can be made by substituting Sn for some of the Ni in $LaNi_5$. Since the year 1988, it has been known that partial substitution of Sn for some of the Ni in $LaNi_5$ slows the deterioration of reversible hydrogen-storage capacity and lowers the operating pressure for gas-phase cycling. However, prior to these experiments, the effects of the partial substitution on charge/discharge capacities on Ni/MH cells and on retention of their charge/discharge capacities during electrochemical reactions was not known.

Cyclic lifetime is an important issue in the technology of Ni/MH cells. Hydride-forming electrodes made of $LaNi_5$ undergo severe deterioration of charge/discharge capacities during charge/discharge cycling and thus have short cycle lives. It has been known since 1984 that the deterioration can be slowed by substituting small amounts of other elements for both La and Ni. Unfortunately, early attempts to prolong cycle lives in this way produced undesired side effects in the form of decreases in hydrogen-absorption capacities, slow kinetics, and prolongation of activation intervals (intervals of initial charge/discharge cycling needed to achieve full capacities).

The experiments showed that the electrochemical (charge/discharge) capacity of $LaNi_{5-x}Sn_x$ increases significantly with x up to about 0.25 (see Figure 1). The maximum discharge capacity observed in the experiments was slightly more than 300 mA·h/g — an impressive value for an alloy of this type and greater than the capacities (250 to 275 mA·h/g) of some of the misch-metal-based hydride-forming alloys that are being processed for electrodes in Japan and China. The substitution of Sn for some of the Ni results in low plateau pressures, with consequent low operating pressures and low self-discharge in alkaline rechargeable batteries.

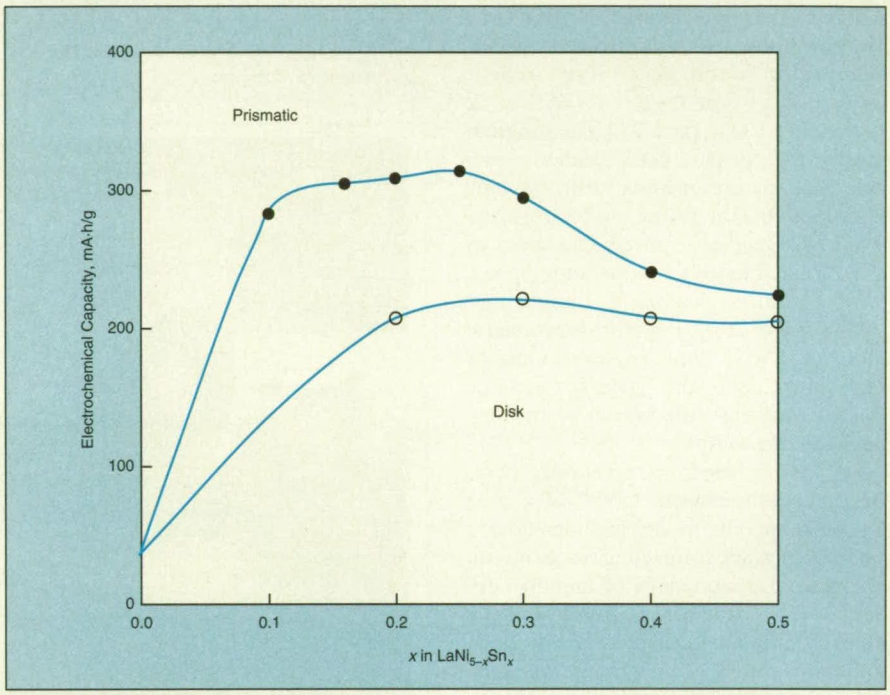

Figure 1. **Electrochemical Capacities** were measured on prismatic and disk specimens of $LaNi_{5-x}Sn_x$ with Sn concentrations ranging from 0 to 0.5.

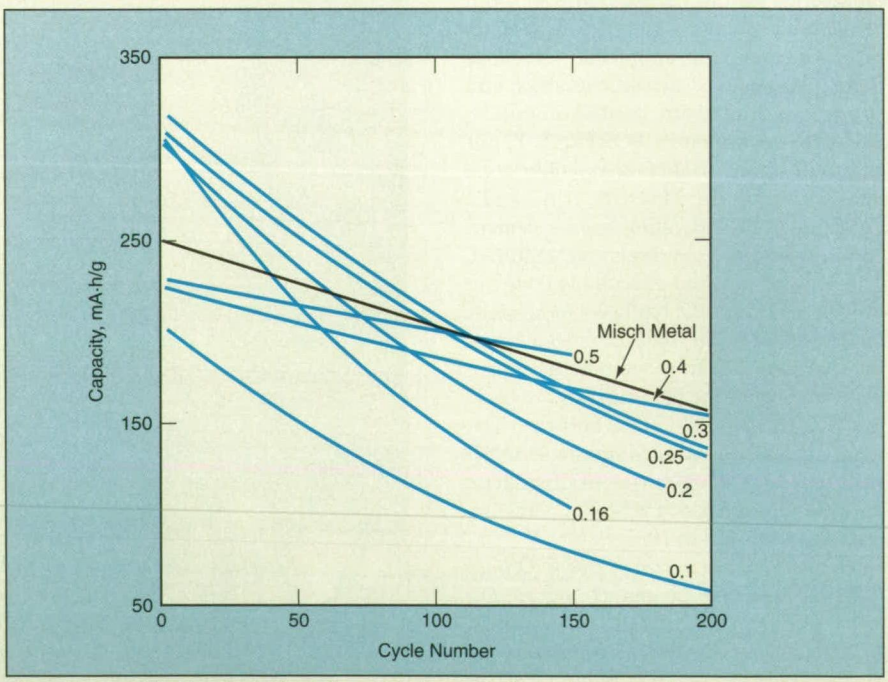

Figure 2. **Capacities Retained After Charge/Discharge Cycling** were measured on prismatic specimens of $LaNi_{5-x}Sn_x$, and on specimens of misch-metal-based hydride-forming alloys. The numbers alongside the curves denote the values of x in the $LaNi_{5-x}Sn_x$ alloys.

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The performances of $LaNi_{5-x}Sn_x$ alloys during charge/discharge cycling were evaluated in 250 mA·h, negative limited, prismatic laboratory cells (see Figure 2). The cells were designed in the MH-limited configuration to gain understanding of the life-limiting mechanisms of MH electrodes and to carry out a comparative evaluation of their cyclic lifetimes. Initial capacities were found to increase with x up to about 0.3 and then decrease with x beyond 0.3. After 100 full-capacity charge/discharge cycles, specimens with $x = 0.25$ and $x = 0.3$ exhibited capacities in excess of 200 mA·h/g — comparable to those of the best misch-metal-based alloys previously evaluated under identical conditions.

The capacities retained after 200 charge/discharge cycles were found to increase with x. Long activation intervals (30 charge/discharge cycles) were found to be necessary to achieve full capacities in the specimens with $x \geq 0.4$, but this is a relatively minor disadvantage in that after extensive charge/discharge cycling, these specimens emerged as the ones that retained the greatest capacities. These alloys with highest concentrations of Sn look promising for use at high temperatures, where the plateau pressures of other alloys are too high.

This work was done by Ratnakumar Bugga, Subbarao Surampudi, Brent Fultz, Charles K. Witham, Robert C. Bowman, Jr., and Adrian Hightower of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Materials category.*

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$LaNi_{5-x}Ge_x$ Electrodes for Ni/MH Electrochemical Cells

Equilibrium pressures are decreased while capacities and cycle lives are increased.

NASA's Jet Propulsion Laboratory, Pasadena, California

Experiments have shown that improved hydride-forming negative electrodes for rechargeable nickel/metal hydride (Ni/MH) electrochemical cells can be made by substituting Ge for some of the Ni in $LaNi_5$. A similar discovery regarding the substitution of Sn for some of the Ni was reported in the preceding article.

Hydride-forming electrodes made of $LaNi_5$ rapidly lose reversible hydrogen-storage capacities during charge/discharge cycling and thus have short cycle lives. It has been known for some years that the loss of reversible hydrogen-storage capacity can be slowed by substituting small amounts of other elements for both La and Ni. However,

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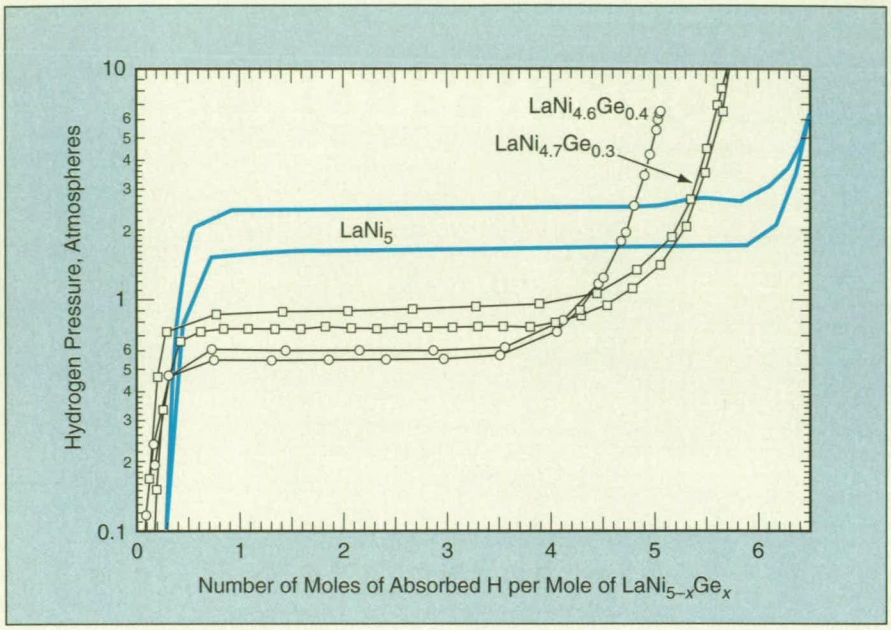

Figure 1. The **Equilibrium Plateau Pressure** for $LaNi_{5-x}Ge_x$ ($x > 0$) is less than 1 atmosphere — essential for preventing self-discharge in cells that must operate at atmospheric pressure.

early attempts to prolong cycle lives through substitutions of elements other than Sn or Ge resulted in undesired side effects in the form of large decreases in hydrogen-absorption capacities, prolongation of activation cycles (cycles of initial charge/discharge cycling needed to achieve full capacities), or slow kinetics.

Specimens of $LaNi_{5-x}Ge_x$ ($0.1 \leq x \leq 0.5$) for use in the experiments were made by induction melting in an argon atmosphere and annealed in vacuum at a temperature of 950 °C for 72 hours. In one of several experiments, gas-phase hydrogen-absorption capacities of specimens with $x = 0$, 0.3, and 0.4 were measured at a temperature of 23 °C. The data from these measurements (see Figure 1) show that the gas-phase hydrogen-absorption capacities of the Ge-substituted alloys are marginally lower (a small disadvantage) than those of the binary alloy $LaNi_5$. However, the data also show a significant advantage for Ge substitution in that the equilibrium plateau pressure of the Ge-substituted alloys is less than 1 atm (< 0.1 MPa) — less than half the equilibrium plateau pressure of $LaNi_5$.

In another experiment, electrochemical capacities of prismatic $LaNi_{4.6}Ge_{0.4}$ and $LaNi_{4.7}Ge_{0.3}$ electrodes were measured in charge/discharge cycles in a negative-limited glass cell with NiOOH counter electrodes and an Hg/HgO reference electrode. For comparison, some measurements were

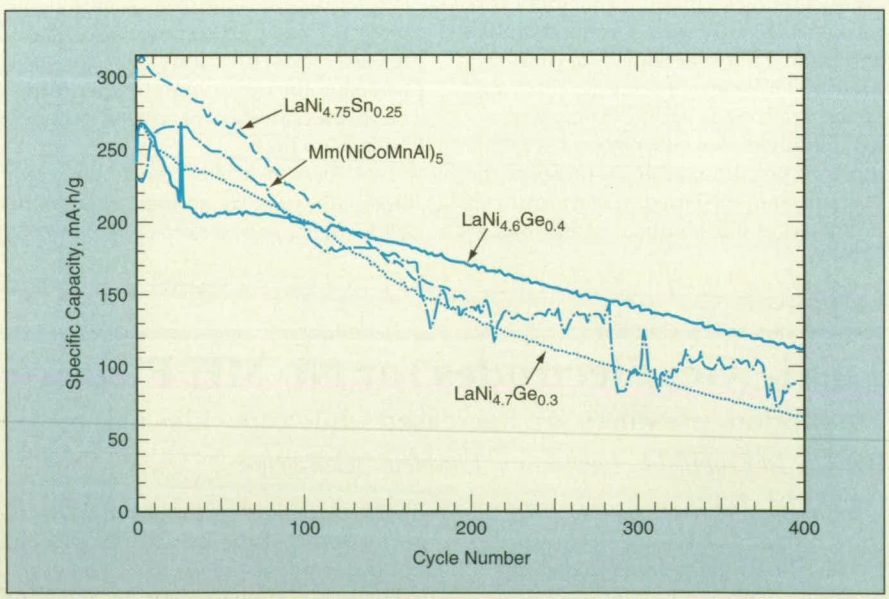

Figure 2. The **Specific Charge Capacity** retained after many charge/discharge cycles is greater for at least one of the Ge-substituted alloys than it is for the Sn-substituted alloy. The performance of a misch-metal-based alloy is also shown for comparison.

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performed on an Sn-substituted electrode with optimal composition of $LaNi_{4.75}Sn_{0.25}$, and on an electrode of composition $Mm(NiCoMnAl)_5$ (where "Mm" denotes misch metal). The data from this experiment (see Figure 2) show that all the alloys exhibit rapid loss of capacity during the first 10 to 20 cycles, but thereafter, the loss of capacity slows. The data also suggest that in the long term, the Ge-substituted alloys retain more capacity than does the optimal Sn-substituted alloy.

Another experiment focused on electrochemical kinetics for absorption and desorption of hydrogen. As quantified in terms of exchange-current densities, the kinetics of $LaNi_{4.6}Ge_{0.4}$ and $LaNi_{4.7}Ge_{0.3}$ were found to be improved over those of $LaNi_5$ — comparable to the kinetics of $LaNi_{4.8}Sn_{0.2}$.

In conclusion, the substitution of appropriate amounts of Ge for Ni in $LaNi_5$ results in alloys that are better suited for use in negative electrodes in rechargeable electrochemical cells. When developed further, these cells can be expected to exhibit high specific energy and power densities, low internal pressures and self discharge, and long cycle lives.

This work was done by Ratnakumar Bugga, Charles K. Witham, Brent T. Fultz, Subbarao Surampudi, Robert C. Bowman, and Adrian Hightower of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Materials category.*

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Improved Bond-Coat Layers for Thermal-Barrier Coatings

Compositions and processes are chosen to tailor microstructures and coefficients of thermal expansion.

Lewis Research Center, Cleveland, Ohio

Current production thermal-barrier coatings (TBCs) have been shown to be capable of reducing the average temperatures of metallic components by 50 to 80 °C and hot-spot temperature by up to 140 °C. This substantial temperature reduction has been used to extend the life of metallic components in aircraft turbines. However, for critical applications aimed at improving engine performance where significantly higher temperatures are involved, higher-durability TBCs are required. An improved bond coat incorporating metallic and cermet layers has been

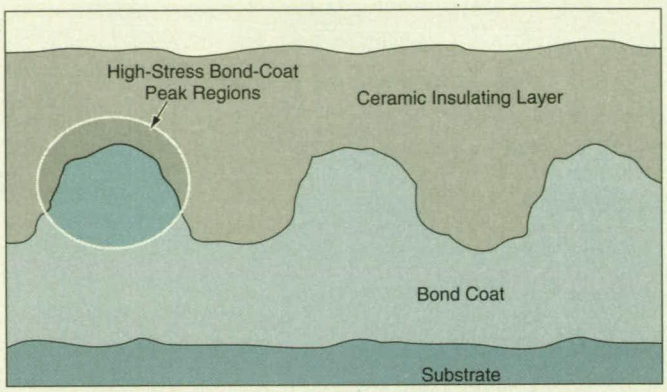

Figure 1. Schematic of a **Typical Two-Layer TBC** shows the area of high stress in the peak region.

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demonstrated to increase the thermal-fatigue life of a plasma-sprayed thermal-barrier coating (TBC) by a factor of two or more. These TBCs can be applied to components in gas turbines and in diesel engines.

A typical TBC comprises a single metallic bond-coat layer, 0.005 to 0.008 in. (about 0.13 to 0.020 mm) thick, coated with a single ceramic top-coat layer, 0.005 to 0.020 in. (about 0.13 to 0.50 mm) thick. The bond-coat layer is typically MCrAlX, where M signifies Ni, Co, or Fe and X signifies Y, Zr, Hf, Yb, or another reactive element. The ceramic top-coat layer is typically zirconia partially stabilized with 6 to 8 weight percent of yttria. The bond coat is typically processed by plasma spraying, while the top coat can be processed by either plasma spraying or electron-beam physical vapor deposition. For TBCs using a plasma-sprayed top coat, the bond coat is prepared with a rough surface to improve bonding.

In spite of the necessity of bond-coat roughness to enhance adhesion, the roughness also tends to intensify the stresses that occur at the interface between the ceramic and the bond coat. Recent work has shown that the high stresses are particularly significant in the vicinity of the peaks in the rough bond coat (see Figure 1). Detailed investigation has further shown that the stresses can be minimized by matching the thermal expansion of the peaks of the bond coat to the ceramic top coat.

Figure 2 illustrates a TBC design that addresses these problems through the use of a two- layer bond coat. The first layer of the bond coat is a typical MCrAlX, as described for a conventional TBC above. The second layer of the bond coat incorporates a fine dispersion of a particulate second phase in an MCrAlX matrix. The second phase is required to have a coefficient of thermal expansion as low as, or preferably lower than, the yttria stabilized zirconia ceramic layer, it must be stable up to the intended use temperature, chemically inert with respect to the MCrAlX matrix, and must be chemically compatible with the thermally grown alumina scale. Candidate second-phase materials include alumina, chromia, yttrium-aluminum garnet, nickel-aluminum spinel, yttria, mullite, and other oxides.

Since the goal is to achieve expansion matching of the second-layer peaks to the yttria stabilized zirconia, the particulate second phase must have dimensions less than that of the peaks, typically less than 5 μm, and must be well dispersed in the MCrAlX matrix. The volume fraction of the

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particulate must be high enough to achieve substantial matching of the peak expansion to that of the ceramic layer. For the case of alumina additions to MCrAlX, an alumina volume fraction of 0.71 is required to achieve a near-zero thermal expansion mismatch. In practice, the thermal expansion of the second layer must be balanced against the other requirements for the layer, such as ductility and oxidation resistance.

Coatings to date have been plasma sprayed using starting powders produced by mechanical alloying. The mechanical-alloying process that has been developed has produced plasma-spray starting powders with up to 20 volume percent of a fine dispersion of submicron alumina particles. The ceramic layer life was doubled for TBCs, using a bond coat of only 5 volume percent alumina additions. This technologically important, and repeatable, increase in life could be used to push the TBCs to higher operating temperatures.

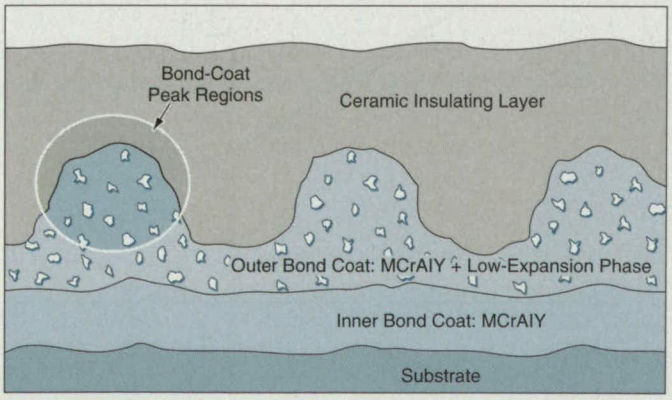

Figure 2. **Fine Particles** of a low-thermal-expansion phase are well dispersed in the matrix of the second bond-coat layer to reduce or eliminate the thermal expansion mismatch with the ceramic insulating layer.

Higher volume percentages of alumina, up to 20 volume percent, were expected to provide even longer lives due to better expansion matching with the ceramic. While some samples did exhibit longer lives, these compositions also exhibited widely varying oxidation responses. The net result of the erratic oxidation response was a reduction in the average life for these coatings. Alternative thermal-spray processes, such as high-velocity oxy-fuel spraying (HVOF), have proven to produce more homogeneous particle distributions and hold the promise of even higher gains in TBC life. The HVOF coatings are currently being tested.

This work was done by William J. Brindley and Robert A. Miller of **Lewis Research Center** *and Beverly J. M. Aikin of Case Western Reserve University. For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Materials category.*

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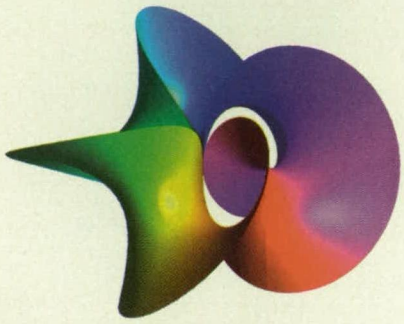

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Trading Risk Versus Cost of a Composite-Material Structure

Tradeoffs are performed by use of a probabilistic method.

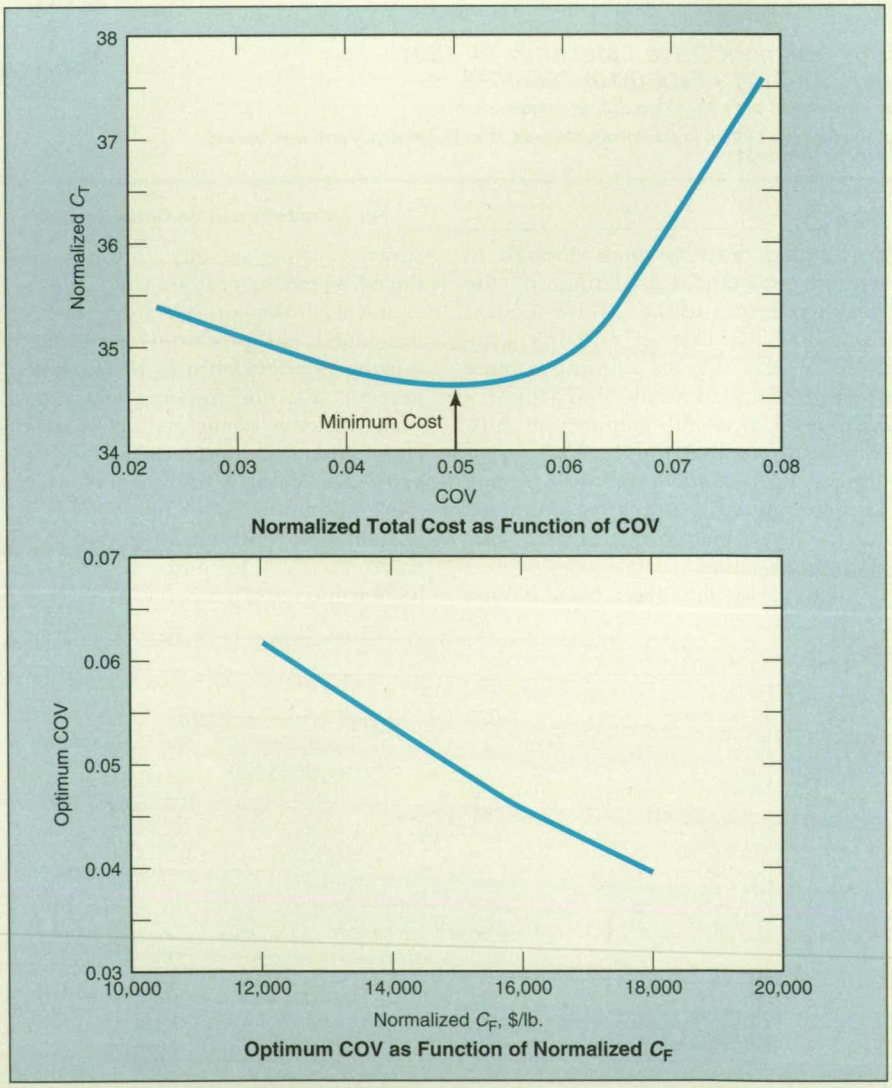
Lewis Research Center, Cleveland, Ohio

A probabilistic method has been developed for use in designing a composite-material structure to achieve a balance between maximum reliability and minimum cost. This method accounts for all naturally occurring uncertainties in properties of constituent materials, fabrication variables, geometry, and loading conditions. Heretofore, it has been common practice to use safety factors (also called "knockdown factors") to reduce design loads on composite structures in the face of uncertainties. Safety factors often dictate designs of structures substantially heavier than they would otherwise be, but provide no quantifiable measures of reliability. The present method involves a quantitative approach to reliability; the equations of the method are formulated to yield a design that is optimum in the sense that it minimizes a reliability-based cost.

The derivation of the equations includes the definition of a probabilistic sensitivity that quantifies the change in reliability relative to a change in each random variable (design parameter). The probability of failure for a given performance is given by

$$P_f = \Phi(-\beta), \qquad (1)$$

where β is a reliability index and Φ is the cumulative distribution function of a normally distributed random variable. The probabilistic sensitivity factor for the ith random variable X_i is defined by



The **Normalized Total Reliability-Based Cost** (normalized C_T) in a test case was computed as a function of the COV for a normalized failure cost (normalized C_F) of $15,000/lb. The optimum value of the COV (the value for which the normalized C_T reached a minimum) was computed as a function of the normalized C_F.

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$$SF_i = \frac{\partial \beta}{\partial X_i} = \frac{u_i^*}{\beta} \qquad (2)$$

where u_i^* is the most probable failure point of a limit-state function in a unit normal probability space. The sensitivity of the reliability index to the mean m_i of the normally distributed random variable X_i with standard deviation σ_i is given by

$$\frac{\partial \beta}{\partial m_i} = -\frac{SF_i}{\sigma_i} \qquad (3)$$

Similarly, the sensitivity of the reliability parameter to the standard deviation is given by

$$\frac{\partial \beta}{\partial \sigma_i} = -\frac{SF_i u_i^*}{\sigma_i} = -\frac{\left(u_i^*\right)^2}{\beta \sigma_i} \qquad (4)$$

The reliability-based total cost function, C_T, is the criterion that enables one to achieve the balance between reliability and cost. This function is given by

$$C_T = C_I + P_f C_F, \qquad (5)$$

where C_I is the cost of manufacture and C_F is the cost incurred in event of failure of the structure. The cost of manufacture can be expressed as

$$C_I = \sum_{j=1}^{N} C_j\left(p_j\right) + C_o \qquad (6)$$

where p_j is a distribution parameter (which can be either m_j or σ_j), $C_j(p_j)$ is the manufacturing cost associated with the jth distribution parameter, and C_0 is a constant cost. The total cost can be minimized when

$$\frac{\partial C_T}{\partial p_j} = 0 \qquad (7)$$

for all j from 1 to N.

Then after substitution of terms from equations 1, 5, and 6 and use of the chain rule for derivatives, equation 7 becomes

$$\frac{\partial C_j\left(p_j\right)}{\partial p_j} + C_F \frac{\partial \Phi(-\beta)}{\partial \beta} \frac{\partial \beta}{\partial p_j} = 0 \qquad (8)$$

for all j from 1 to N.

For a normally distributed random variable, $\partial\beta/\partial p_j$ can be calculated by equations 3 and 4. Equation 8 represents a system of N nonlinear equations that, if solved, yield a design with an optimum tradeoff between reliability and cost.

This method can be considered a special case of method for comprehensive probabilistic assessment of composite structures. The comprehensive method is implemented in the Integrated Probabilistic Assessment of Composite Structures (IPACS) computer code. [The comprehensive method was described from a slightly different perspective, with emphasis on computation of structural responses and fatigue lives, in "Probabilistic Analysis of Composite-Material Structures" (LEW-16092), *NASA Tech Briefs*, Vol. 21, No. 2 (February 1997), page 58.]

The method was demonstrated in test case in which the objective was to minimize the reliability-based cost of a lower side panel of a composite (graphite-fiber/epoxy-matrix) fuselage structure, using, as a design parameter, the coefficient of variation (COV) of the modulus of longitudinal elasticity of the graphite fibers. For the case studied, the minimum normalized total cost for a normalized failure cost of \$15,000/lb (\$33,000/kg) was found to occur at COV = 0.05. The optimum COV as a function of the normalized failure cost was also computed (see figure).

This work was done by Christos C. Chamis of **Lewis Research Center** *and Michael C. Shiao and Surendra N. Singhal of NYMA, Inc. For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Materials category.*

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Trefoil Rotary Flexure

Tri-lobed inner support enables low rotational stiffness while providing rigidity for high radial and axial stiffnesses.

NASA's Jet Propulsion Laboratory, Pasadena, California

The figure illustrates a device that flexes to allow rotation about a single axis through a total range of ±12°. This device was designed to offer the following advantages over commercial flexural pivots:

- Greater ratios of radial to rotational and axial to rotational stiffness for a given load capability;
- Higher load capabilities for a given rotational stiffness;
- No shift in the center of rotation assuming flexures are uniform in thickness;
- Theoretical unlimited fatigue life at ±10° excursion;
- Monolithic construction for higher reliability and greater likelihood of attaining the theoretical fatigue life; and
- No global buckling modes.

The device is called a "trefoil rotary flexure" because its flexible members are three radial, equally spaced thin plates that extend from an outer cylinder to the inner tri-lobed support. The distance from the inner terminus of the flexures to the rotational axis is made as small as possible to minimize rotational stiffness. The three lobes of the inner support are joined at the rotation axis to provide an extremely rigid attachment for the flexure elements, allowing high radial and axial stiffnesses. The tri-lobed support rotates relative to the outer cylinder on the flexures to create the flexural pivot motion. The total rotational range of ±12° is defined by hard stops in the lobes and the outer cylinder.

The lobes, fins, and outer cylinder are integral parts of the monolithic device, which was fabricated by electrical-discharge machining of a solid metal rod. To reduce concentrations of stresses and thereby ensure long fatigue life, generous fillet radii were incorporated at the inner and outer ends of the fins.

This work was done by Robert J. Calvet of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Mechanics category.*

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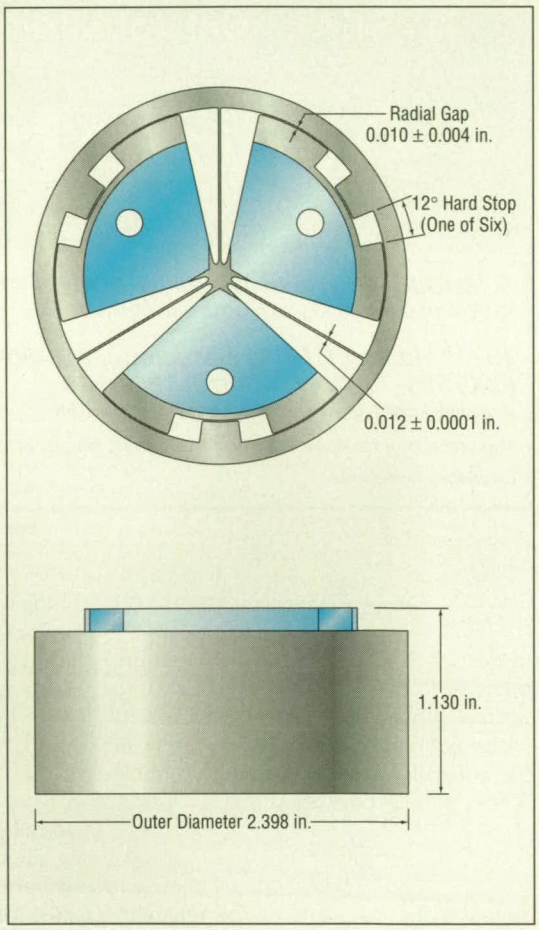

This **Trefoil Rotary Flexure** is a monolithic device, machined from a solid metal rod. It is designed for high radial and axial stiffness, low rotational stiffness, and long fatigue life.

Subliming Solid Microthrusters

Devices using solid propellants would eliminate waste and leakage common with gaseous propellants.

NASA's Jet Propulsion Laboratory, Pasadena, California

Devices are proposed that would sublime solid propellants to generate small thrusts for maneuvering spacecraft with masses of no more than 15 kg. With solids rather than gases in propellant tanks, there would be no leakage and thus no waste of limited quantities of propellants. There would also be none of the bulk, weight, and cost of plumbing like that needed for handling liquid or gaseous propellants if the propellant tank would be integrated with the subliming solid thruster.

The propellant in a subliming thruster would be contained in an aluminum tank (see Figure 1) with an outlet connected to the subliming solid

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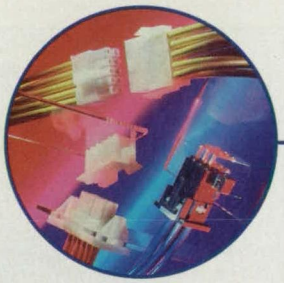

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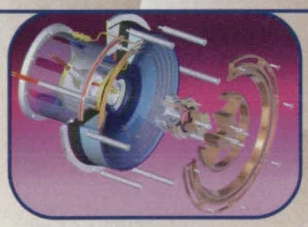

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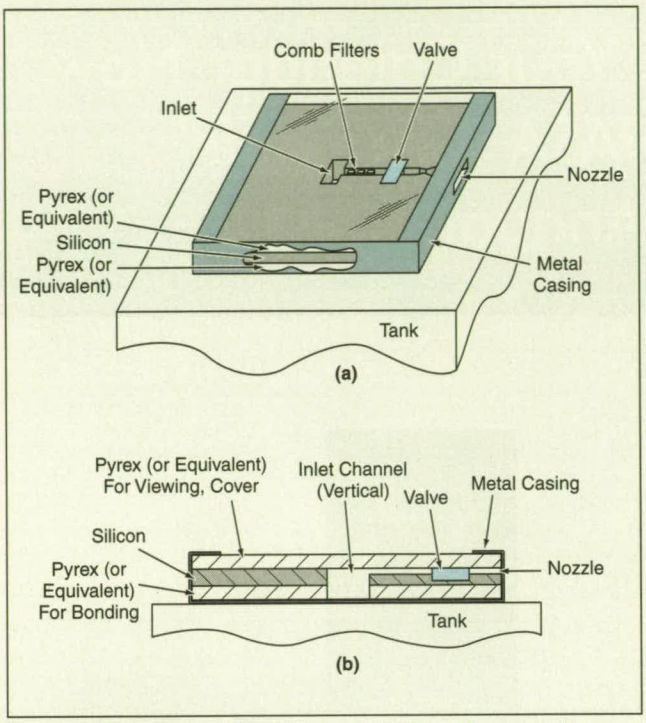

Figure 1. The **Concept of the Subliming Solid Microthruster** is illustrated in oblique view (a) and side view (b).

microthruster chip. This chip, micromachined from silicon, contains a nozzle and an integrated filter. Ultimately, a thruster valve will also be integrated into this chip. A wire electric heater could be wrapped around the tank, or else a film electric heater could be deposited on the tank. The propellant material (e.g., ammonium hydrosulfide) would be sublimed on command by activating the heater.

Opening a valve placed into a flow-path between the nozzle and tank (see Figure 2) will allow the vapor to flow to whichever nozzle faced in the direction opposite the required direction of thrust. The wall of the tank could be as thin as 0.020 in. (0.5 mm) because the vapor pressure that it would have to withstand would be very small; thus, the tank could be very light in weight.

This work was done by Juergen Mueller, Lilac Muller, and Thomas George of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Mechanics category. NPO-19926*

Figure 2. **Microthruster Model** shows the level of miniaturization that can replace bulkier units.

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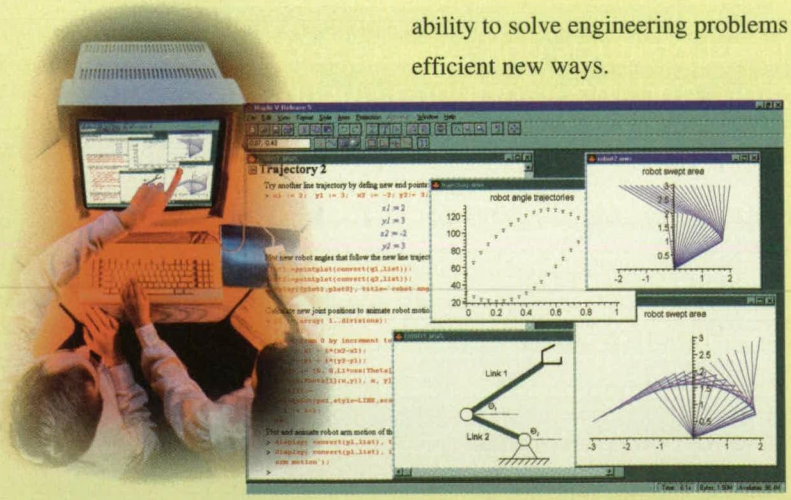

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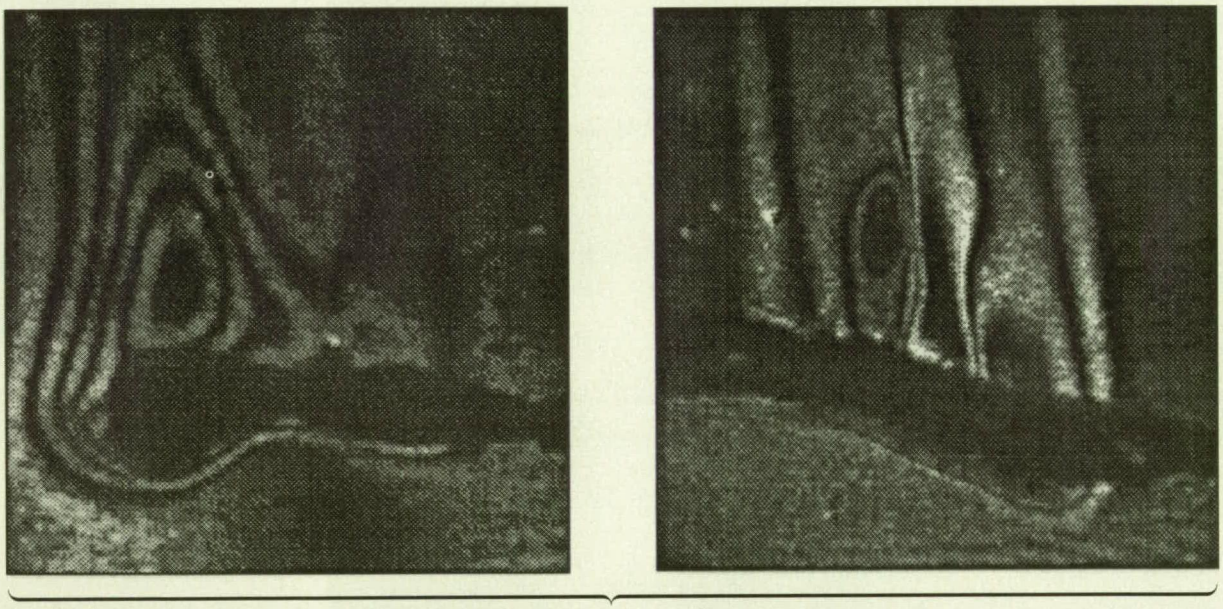
Doped ZnTe: a Developmental Photorefractive Material

This material can be used in optical processing of information at wavelengths from 0.6 to 1.3 μm.

Lewis Research Center, Cleveland, Ohio

Zinc telluride is a semiconductive material that has been found to become photorefractive when it is suitably doped with vanadium or with manganese and vanadium. The combination of photorefractivity and semiconductivity make this material attractive for use in a variety of applications, including optical power limiting (for shielding eyes or delicate sensors against intense illumination), holographic interferometry, providing reconfigurable optical interconnections for optical computing and optical communication, and correcting for optical distortions and combining laser powers via phase conjugation. In comparison with other important photorefractive materials based on III-V and II-VI binary compounds, ZnTe:V offers superior photorefractive performance at wavelengths from 0.6 to 1.3 μm.

Undoped or doped ZnTe can be grown by physical vapor transport in a



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Flame Horizontal, Drop of KCl Injected Into Flame

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closed ampoule. The source material lies at one end of the ampoule and is made to sublimate by heating that end to a suitable temperature. The resulting vapor is transported to the other, cooler end of the ampoule, where it condenses to form a boule of the material. Ideally, the boule thus formed should be a single crystal (as distinguished from a polycrystalline mass). For successful growth of a single crystal, it is necessary to adjust the thermal gradient and other conditions to make the rate of transport commensurate with the rate of integration of condensing molecules and atoms into the growing crystal.

In an effort to learn how to optimize conditions for single-crystal growth, the diffusive and convective effects of heat and mass transfer have been investigated both experimentally and theoretically. Topics addressed in these investigations have included effects of process parameters, effects of buoyancy-driven convection on transport properties, growth fluxes, and crystal-growth rates (deduced from growth fluxes, assuming fast kinetics at growth interfaces). The results of these investigations indicate that for a given gradient of temperature, the ratio between the partial pressures of Zn and Te at the source strongly affects the rate of transport. The rate of growth changes with both the temperature and the gradient of temperature between the source and the growing crystal.

Experiments have been performed to determine the optical absorption spectra, electrical resistivities, photorefractive properties, and microstructures of specimens of doped ZnTe. Among other things, it has been found that the yield of photorefractive crystals is very low when vanadium is the only dopant, but that one can increase the yield, the photorefractive gain, and the diffraction efficiency by doping with manganese in addition to vanadium.

An experiment was performed to investigate optical power limiting in ZnTe:V by the field-shielding effect, which is a nonlinear effect that occurs in the presence of an applied electric field and that results in partial darkening. For example, in one case, the transmission of a specimen at a wavelength of 0.83 μm was 20 percent at an incident radiant flux density of 6 mW/cm^2, but decreased to 1 percent when the flux density was increased to 1 W/cm^2.

Experiments were performed to investigate the utility of ZnTe:V:Mn for real-time resonant holographic interferometry. These experiments involved, variously, two- or four-wave mixing, using pulsed dye or continuous-wave He/Ne or diode lasers. Holographic image transfer and two-wavelength resonant holographic interferometry were demonstrated; in particular, a ZnTe:V:Mn crystal was used in a demonstration of resonant holographic interferometric spectroscopy, which is a technique for obtaining chemical-species-specific interferograms by recording two holograms simultaneously at two slightly different wavelengths near an absorption spectral peak of the species in question (see figure).

This work was done by Walter M.B. Duval of **Lewis Research Center**; *Sudhir B. Trivedi, G. V. Jagannathan, Xiaolu Wang, Jolanta I. Soos, and Robert D. Rosemeier of Brimrose Corp.; H. Zhou and Abdelfattah Zebib of Rutgers University; and W. H. Steier and Mehrdad Ziari of the University of Southern California. For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Machinery/Automation category.*

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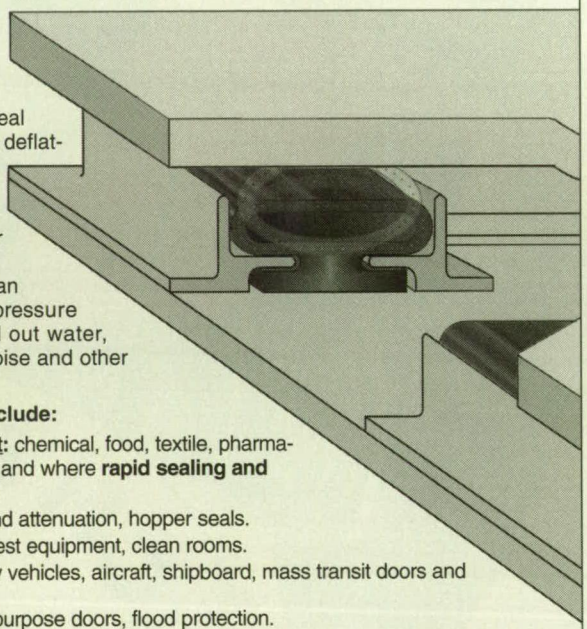

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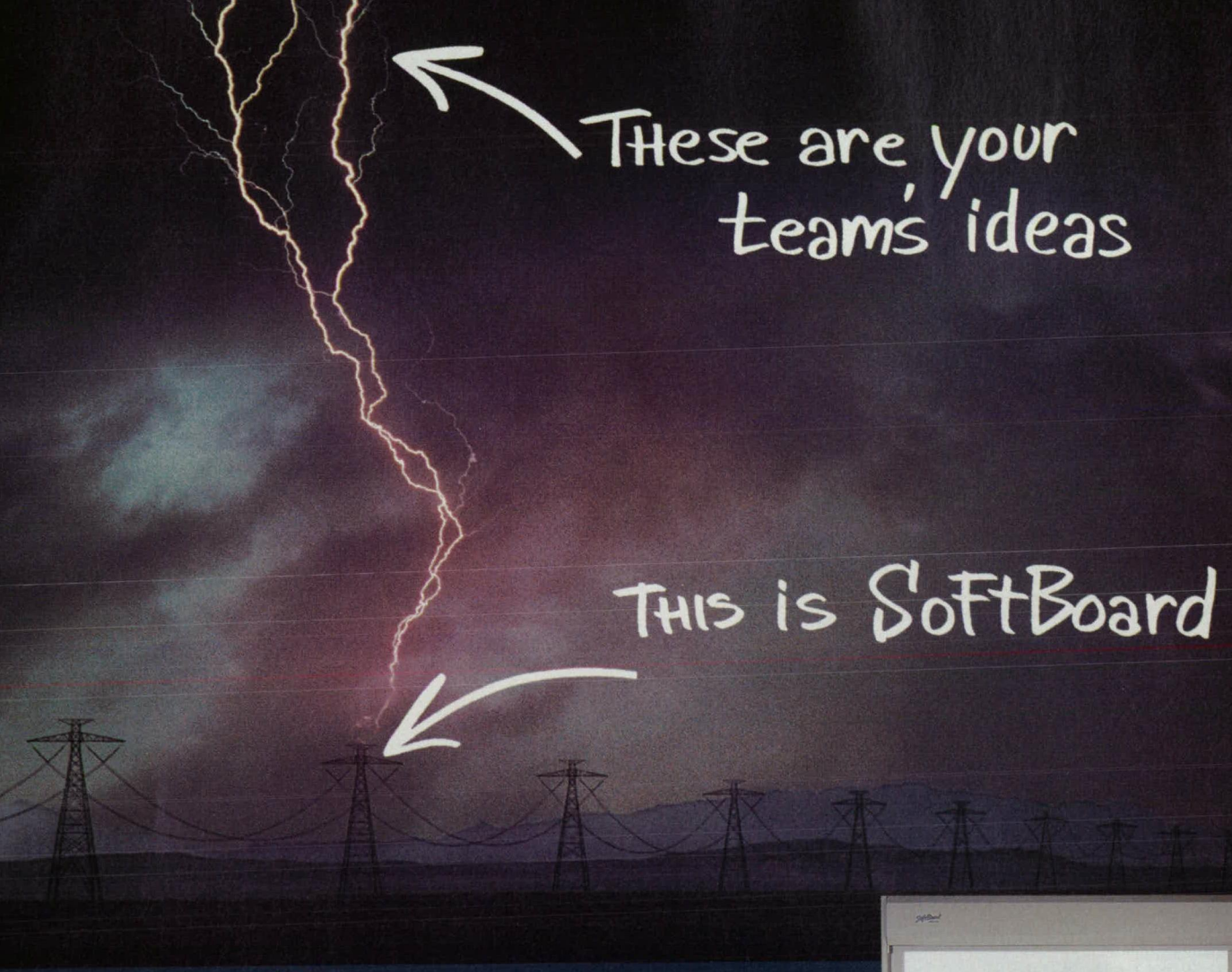

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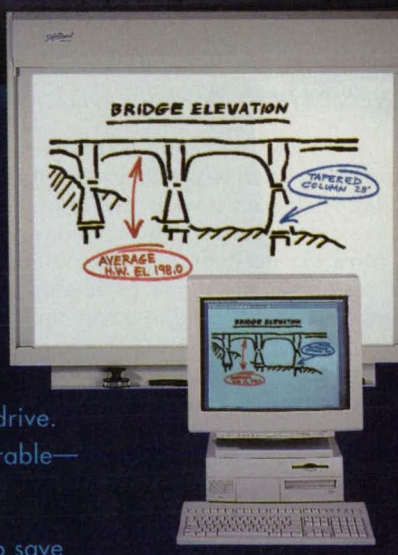

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Microlenses for Calibrating Phase Doppler Particle Analyzers

Microlens devices give repeatable results and are small, easy to use, and relatively inexpensive.

Lewis Research Center, Cleveland, Ohio

Simple optical devices called "scattering reticles" have been invented for calibrating Phase Doppler Particle Analyzers (PDPAs), which are optical instruments that analyze scattered light to determine the sizes and velocities of droplets. A scattering reticle comprises a polymeric plano-convex microlens, typically with a diameter of about 60 μm, on a glass substrate about 4 mm thick. In operation, a three-axis positioning stage is used to hold the substrate and move the microlens into the intersection of laser beams that defines the probe volume of a PDPA. The PDPA collects and analyzes the light scattered from the microlens.

Heretofore, PDPAs have been calibrated by use of droplet generators, which are difficult to use, are unreliable, and do not give repeatable results. Scattering reticles are easy to use, are small and inexpensive in comparison with droplet generators, and exhibit a high degree of repeatability.

To be useful for calibrating a PDPA, an optical device must scatter light in a manner similar to that of the droplets to be observed by the PDPA.

Ideally, the microlens on a scattering reticle should be hemispherical, but small deviations from hemisphericity are permissible.

Typically, a PDPA responds to light scattered by a microlens in the same way as to light scattered by droplets with a monodisperse size distribution. Scattering reticles with microlenses have been tested on two PDPAs, yielding results that were in agreement.

This work was done by Edward A. Hovenac of NYMA, Inc., and Steven James Bever of Wabash College for **Lewis Research Center.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Physical Sciences category.*

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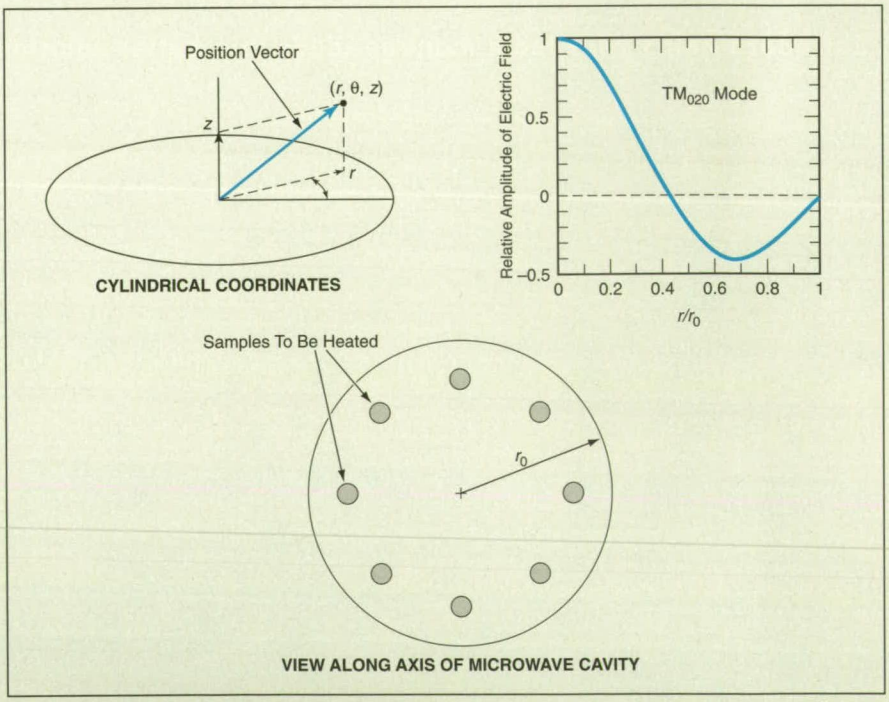
Microwave-Heating Technique for Batch Processing

Multiple samples are positioned to exploit symmetry in cavity modes.

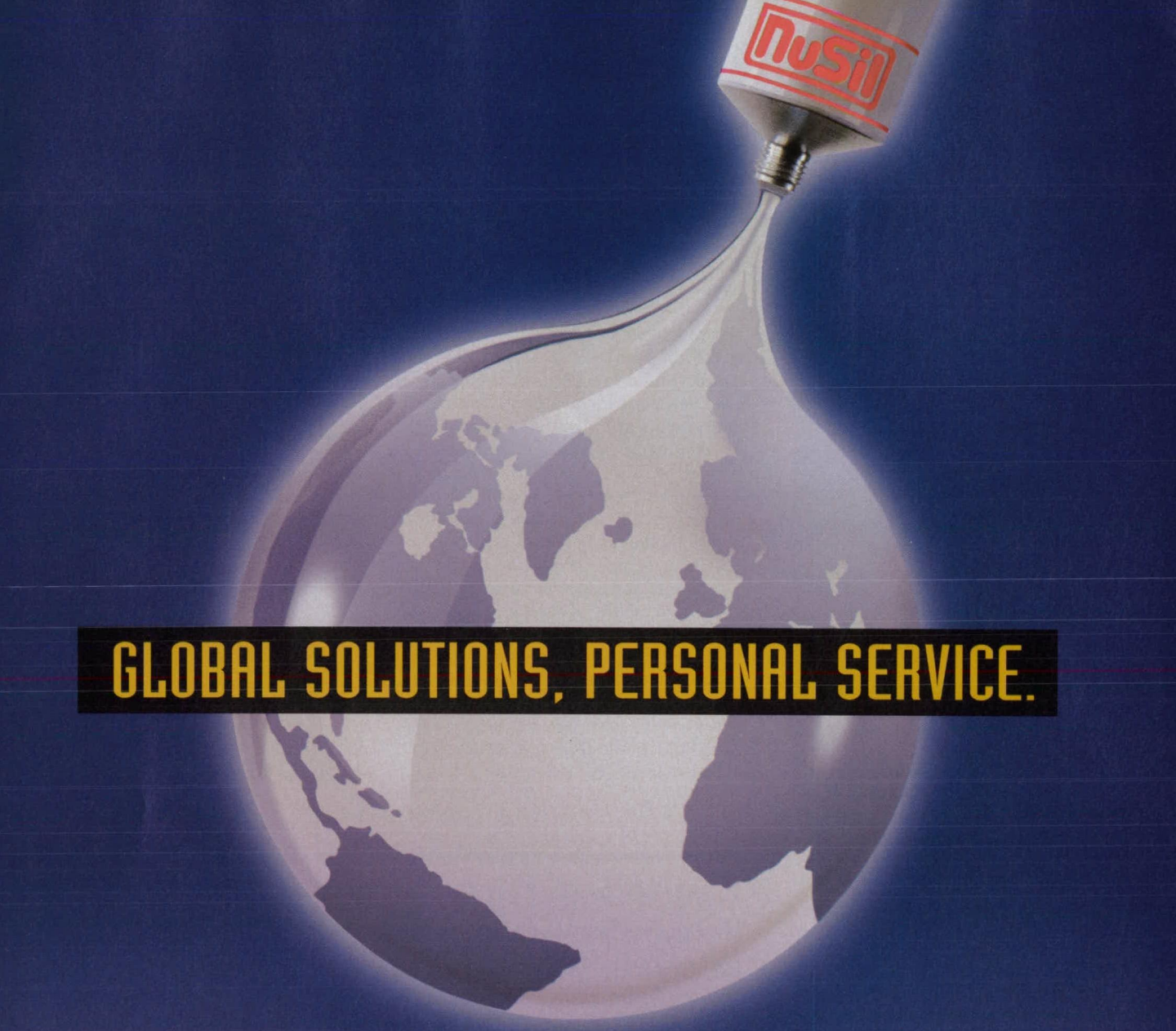
NASA's Jet Propulsion Laboratory, Pasadena, California

A microwave-heating technique provides for batch processing of multiple, identically sized and shaped samples of the same material. The technique involves (1) excitation of a symmetrical electromagnetic mode or modes in a symmetrical microwave cavity and (2) positioning the samples symmetrically in the cavity so that all samples are exposed to the same electromagnetic-field conditions and thus the same heating conditions. Typically, the electromagnetic mode(s) and the pattern for mounting the samples are chosen to maximize the heating effect and make it as nearly spatially uniform as possible.

For example, the figure illustrates an application of the technique to microwave heating of N (in this case, $N = 8$) rod samples in a circular cylindrical cavity of radius r_0. In this case, the microwave excitation is supplied in the TM_{020} mode, in which the electromagnetic field depends on radial position r but is independent of azimuthal angle θ and of axial position z. Then for iden-



The **Samples Are Positioned** at equal angular intervals at a radius chosen to minimize nonuniformity and maximize coupling to the electric or magnetic field in the TM_{020} mode. Other modes with exploitable symmetries could also be used.



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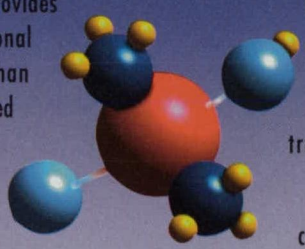

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tical treatment, the samples should be positioned in the cavity at the same radius at equal angular intervals $\Delta\theta = 2\pi/N$.

When the cavity is empty, the magnitude of the electric field attains maxima at $r = 0$ and at the cylindrical surface $r/r_0 \approx 0.6941$, while the magnitude of the magnetic field attains maxima at the cylindrical surfaces $r/r_0 \approx 0.3336$ and $r/r_0 \approx 0.9658$. To a first approximation, assuming that the samples perturb the electromagnetic field minimally, the samples should be positioned on one of these surfaces to maximize heating: If the samples are electrically resistive or nonconductive, then they should be positioned at $r/r_0 \approx 0.6941$ for maximum coupling to the electric field; if the samples are highly electrically conductive, then they should be positioned at $r/r_0 \approx 0.3336$ or $r/r_0 \approx 0.9658$ for maximum coupling to the magnetic field.

Of course, the samples can be expected to perturb the electromagnetic field, the degree of perturbation increasing with the size of the samples. In the absence of an exact theory for the effect of the samples on the electromagnetic field, it could be necessary to conduct experiments to determine the radial position for maximum and/or most nearly uniform heating.

The same principle can be applied to microwave heating of multiple spherical or disk-shaped samples. In this case, the samples should not only be mounted at the same radius and at equal angular intervals but should also be mounted at the axial-mid-length plane to minimize nonuniformity of heating by enforcing symmetry with respect to z.

This work was done by Martin Barmatz and Henry W. Jackson of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Physical Sciences category.*

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Refer to NPO-19771, volume and number of this NASA Tech Briefs *issue, and the page number.*

Easy-to-Use High-Temperature Strain-Sensor Systems

Pd/Cr strain gauges are prestabilized and precalibrated under controlled conditions.

Lewis Research Center, Cleveland, Ohio

Easy-to-use high-temperature strain-sensor systems based on strain gauges made from Pd/Cr-alloy wires have been developed. These systems include strain-gauge units comprising Pd/Cr wires bonded to high-temperature metal-alloy shims by flame spraying of ceramic materials. Optionally, a strain-gauge unit can be supplied alone, but ordinarily, it is delivered as part of a system that also includes an integral, weldable-terminal high-temperature cable and a bridge-circuit-completion module at the cool end of the cable (see figure).

Strain gauges made from Pd/Cr-alloy wires, and techniques and materials used to fabricate them, have been described in a number of previous articles in *NASA Tech Briefs*. Pd/Cr-wire strain gauges can be used to measure static strains at temperatures up to 1,400 °F (760 °C). However, the successful use of these strain gauges entailed considerable difficulty prior to the development of the present systems. This is because in order to realize the full potential of Pd/Cr strain gauges, it is necessary to adhere strictly to installation, stabilization (heat treatment), and calibration procedures unlike those of conventional practice for lower-temperature strain gauges. The major advantage afforded by the development of present systems does not lie in any single fundamental physical concept, but, rather in the establishment of the practice of performing all critical steps in a controlled laboratory environment at the factory, before use in the field.

The prefabrication of strain-gauge units containing Pd/Cr wires bonded to shims overcomes the installation difficulty. The critical flame-spraying steps are performed under controlled factory conditions, rather than by the end user. Each unit includes a margin of shim material around its periphery; the margin can be used to attach the strain-gauge to a test structure (a structure on which

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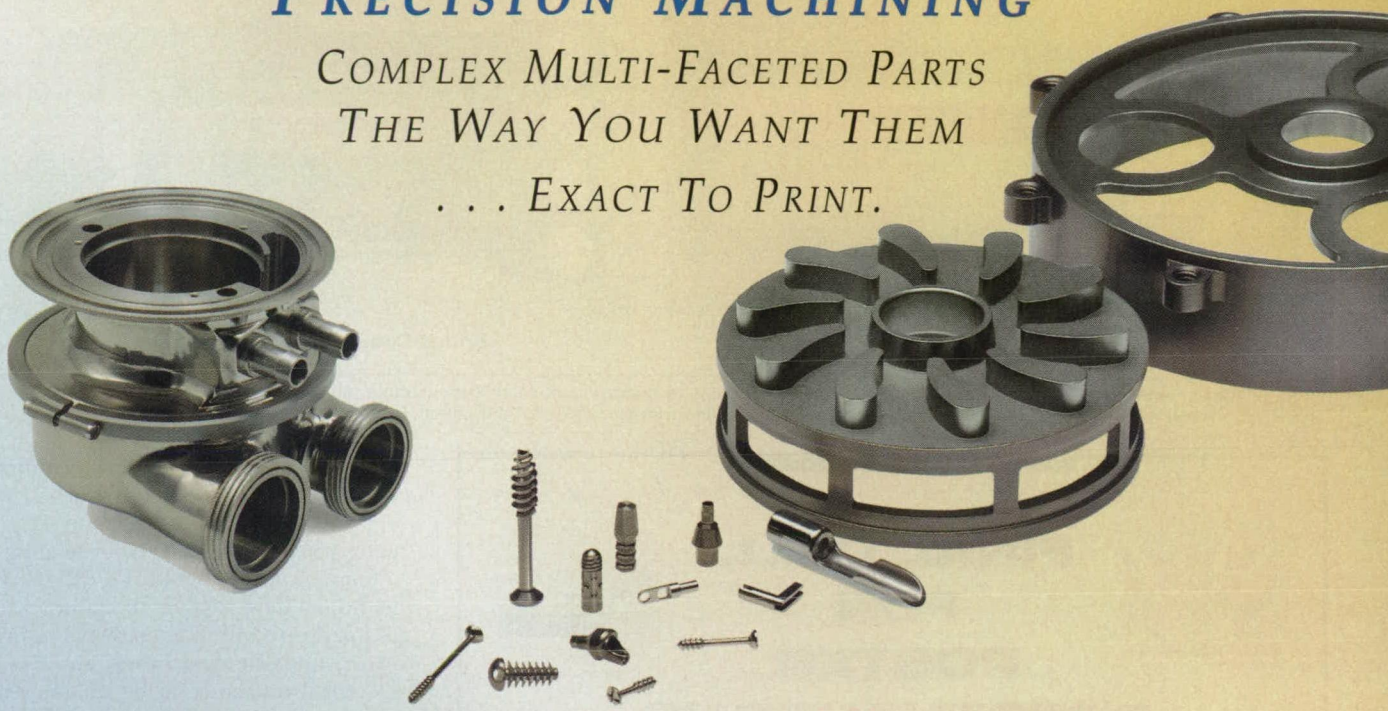

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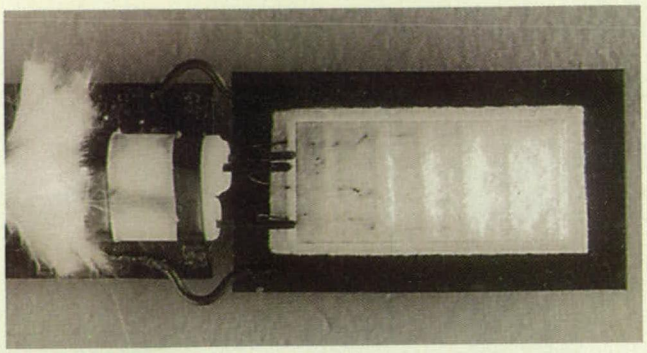
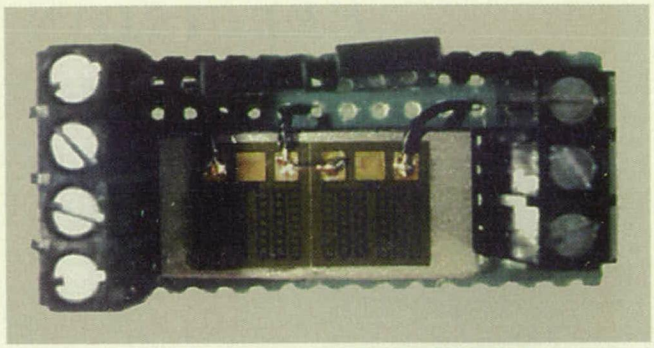


Weldable Strain-Gauge Unit With Terminal



Bridge-Circuit-Completion Module

A **Strain-Measurement System** comprises a strain-gauge unit, a cable, and bridge-circuit-completion module. All critical steps in fabrication, installation, stabilization, and calibration are performed under controlled conditions prior to delivery of the system.

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strain is to be measured) by ordinary spot-welding at the end-use site.

Prior to calibration, each strain-gauge unit is prestabilized by heating at a temperature of 1,440 °F (782 °C) for 50 hours. Care is taken to maintain this temperature within a narrow margin of error; underheating causes changes in electrical resistance to be smaller than expected, while even momentary overheating destroys a temperature-compensation feature. In other words, both underheating and overheating introduce calibration errors.

To prepare for calibration, a strain-gauge unit is tack-welded to a bar of the same material on which it is to be used to measure strain. Strain readings are taken at temperature intervals spanning the full test temperature range, using a calibrated ballast (bridge-completion) resistor inserted in the bridge-circuit-completion module. If necessary, the calibration procedure is repeated with different bridge-completion resistors until a satisfactory calibration curve is obtained.

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This work was done by J.F. Lei of **Lewis Research Center** *and S. P. Wnuk, Jr., and V. P. Wnuk of Hitec Products, Inc. For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Physical Sciences category.*

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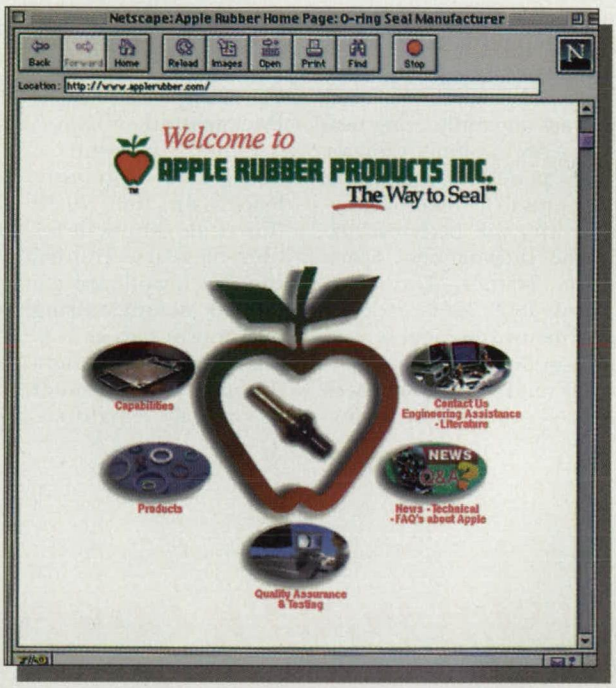

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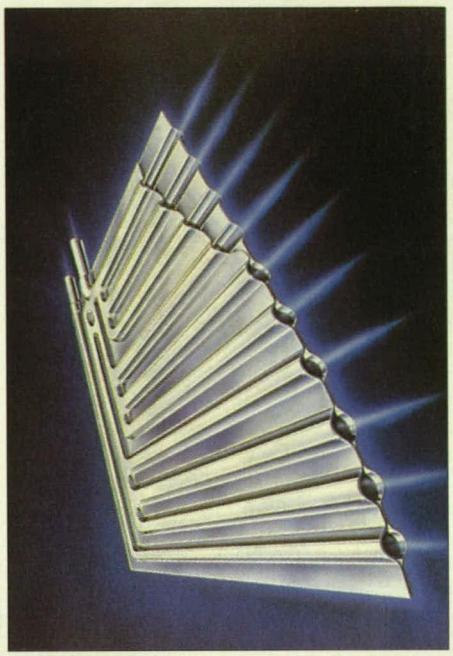

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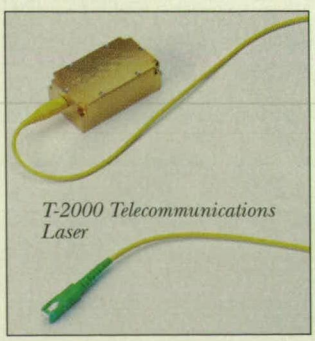

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Circle No. 772

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Coatings, locking and sealing products

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NYLOK® TRUE BLUE® self-locking nylon patches, strips and pellets

Coatings, Locking and Sealing Products

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Nylok has expanded into a multi-national organization with worldwide sales through a network of 20 licensees in Europe, Asia, South America, Australia, and Africa authorized to produce and market the Nylok self-locking process and its other products.

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Circle No. 771

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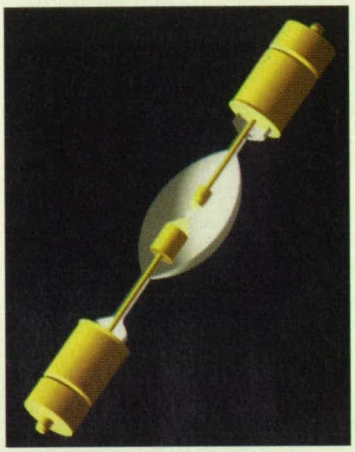

ASAP model of an H4 bulb.

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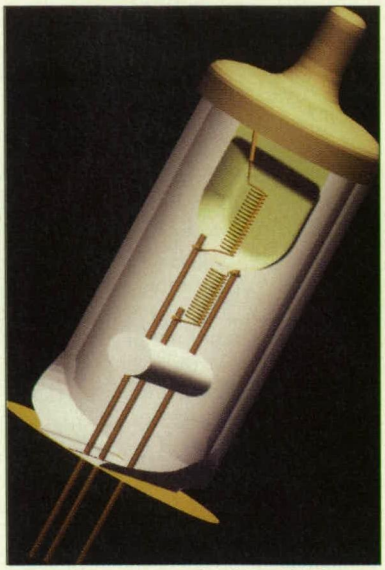

Arc source modeled in ASAP.

For more information, contact Breault Research Organization, 6400 E. Grant Road, Ste. 350, Tucson, AZ 85715; Tel: 800-882-5085; Fax: 520-721-9630; e-mail: info@breault.com; www.breault.com

Circle No. 776

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Astro-Med, Inc. is a leading supplier of specialty printer solutions to customers around the world. Astro-Med customers include leading aircraft manufacturers, automotive product manufacturers, telecommunications companies, electrical utilities, steel companies, and paper manufacturers.

Astro-Med specialty printers are total systems that display, monitor, analyze, and print data for aerospace, industrial, and medical applications. The machines, computer electronics, software, and consumables all are developed and manufactured by the company.

At NASA in Huntsville, AL, Astro-Med recorders are used to capture important telemetry data.

Examples of Astro-Med products include the MT95K2, which has become the world standard in chart recorders, especially in telemetry applications. Because of its power and versatility, the 32-channel K2 can perform a variety of tasks that previously required a battery of instruments. Other recorders from Astro-Med include the "Dash" line of portable units, which range from 2 to 30 channels. The recently introduced Dash 8u is an 8-channel recorder with universal inputs that features a 10.4-inch color LCD monitor, a 2-Gigabyte internal hard drive, and a 100-Megabyte removable Zip drive for data transfer and archiving.

Other Astro-Med products include portable paperless data acquisition systems. The AstroDAQ is a complete, ready-to-use system that can record up to 30 channels. The AstroDAQ 2 is a very compact and lightweight version, especially suitable for portable field applications.

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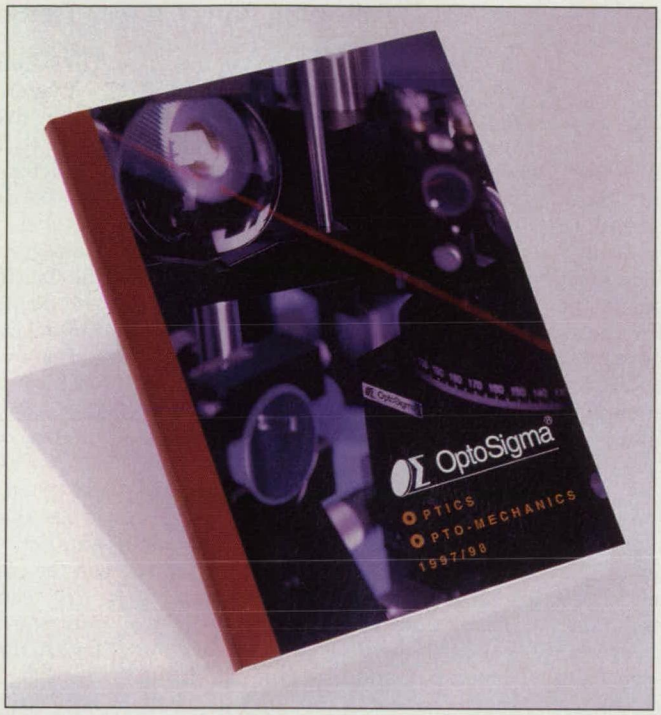

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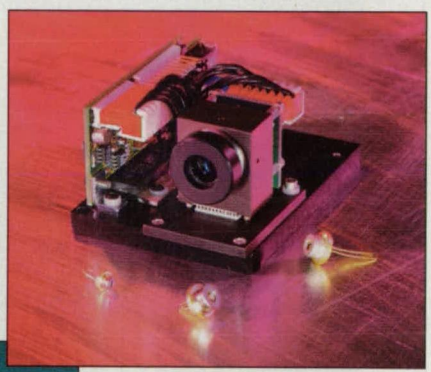

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Circle No. 780

ALGOR®

Scientists Use Finite Element Method in Developing New Cancer Detection Technique

By Dr. Jonathan Ophir, Professor of Radiology

A variety of techniques are used, including x-rays, ultrasound, biopsies and physical examinations, to detect tumors and determine which are malignant or benign. The most accepted and sensitive means for detecting breast lesions, for example, is with x-ray mammography. While this method is sensitive for detecting lesions, only about 20% of those identified by mammography are found to be cancers when biopsied.

Reducing the number of unnecessary biopsies is an important goal in breast cancer management. The average biopsy costs between $2,000 and $3,000 and causes considerable stress to patients. Given the cost and trauma associated with surgically sampling all cases where patients had mammographically detected lesions, there is a strong incentive to develop additional non-invasive methods to accurately determine if a lesion is benign or malignant.

Researchers are working on just such a technique that relies on ultrasound imaging. They call it elastography and it uses ultrasound to detect lesions and tumors and helps doctors determine whether they are malignant or benign. Elastography images the strains induced in the tissue as a result of a small external mechanical compression. To develop this imaging technique, researchers have employed a valuable modeling and analysis tool from the computer-aided engineering (CAE) field: the Finite Element Analysis (FEA) software of Pittsburgh-based Algor, Inc.

Tissues and Tumors

The elasticity of soft tissue depends to a large extent on its molecular building blocks (fat, collagen, etc.) and the microscopic and macroscopic structure of these blocks. In the normal breast, for example, glandular structures may be firmer than surrounding connective tissue, which in turn is firmer than subcutaneous fat. The standard medical practice of soft tissue palpation (examination by touch) to search for lumps is based on the qualitative assessment of tissue stiffness and the fact that certain pathologic conditions, such as malignant tumors, often manifest themselves as changes in the tissue's mechanical properties. But in many cases, despite stiffness differences, the small size of a pathological lesion and its location deep in the body, or both, prevent detection and evaluation by palpation or other techniques.

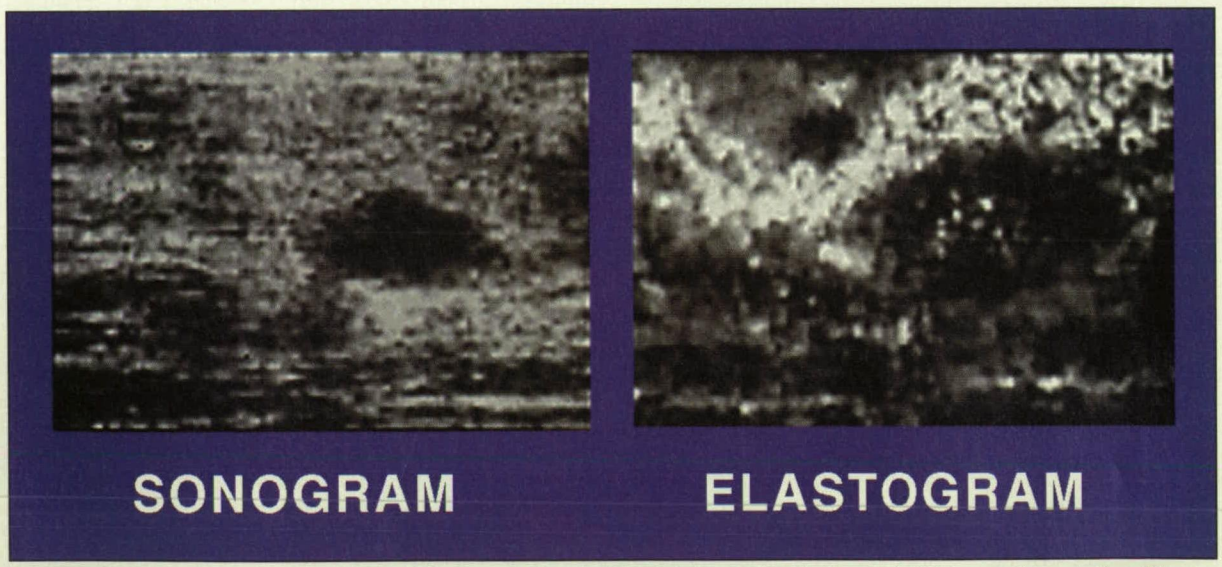
How Elastography Works

Tissues deform slightly when a small displacement is externally applied. Tissues that are more elastic deform more than tissues that are harder or less elastic. These internal deformations show up on elastograms, letting doctors assess the hardness or stiffness of tissues and decide whether or not there is a tumor in the imaged tissue. If a tumor's elastic properties are fairly uniform throughout, it tells doctors the tumor is benign. Cancerous tumors, on the other hand, grow in a very disorganized way. Therefore, malignant tumors have elastic properties that vary from one area to another, which should also show up on the elastogram.

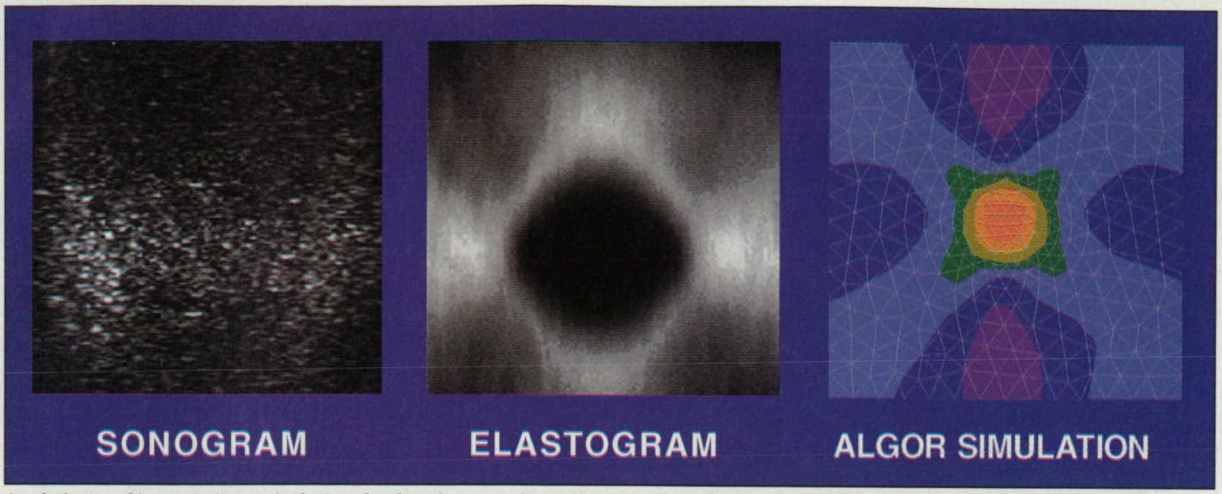
To create an elastogram, two ultrasound images of the same breast tissue are taken: one of the tissue in its normal, uncompressed state, and another when the tissue is slightly compressed. These images are compared point-by-point using signal processing algorithms to determine how the tissue elements moved when compressed, then converted into an image or elastogram.

Using FEA to Develop Elastography

To make sure the technique works on different types of tumors



The sonogram and the corresponding elastogram of a breast were taken simultaneously from the identical anatomical site on a volunteer patient. The sonogram shows the presence of a solitary hypoechoic (dark) lesion. The elastogram shows the same lesion as being hard and larger, most likely due to desmoplasia that causes hardening only around cancerous lesions. It also shows a soft core, suggestive of a necrotic center. Additionally, a second small (~6mm) lesion is detected on the elastogram at 10 o'clock relative to the main lesion. This anatomical structure is not visible on the sonogram. The elastogram's ability to display the smaller lesion demonstrates its capability of detecting tumors in the earlier stages of development.



A gelatin test object contains an inclusion that has the same ultrasonic properties as the surrounding medium, but is three times harder. The sonogram (left) does not detect the presence of the inclusion, while the elastogram (center) demonstrates it well. The bright region centered on the inclusion in the elastogram is a stress-concentration artifact predicted from the Algor software simulation of the sample at a 45 degree angle (right). (Test object courtesy of Dr. T. Hall from the University of Kansas Medical Center.)

in various locations, researchers created and imaged simulated tumors with varying conditions: from a malignant tumor near the chest cavity to a cyst near glandular tissue. These models are processed to create a simulated elastogram, letting doctors determine whether they could use the new method to detect tumors in those situations. While it might be more accurate to use human subjects rather than computer models, it would be nearly impossible to find people with all the necessary combinations of tumors and body locations for testing.

For each hypothetical placement of tissue the researchers wish to study, Algor's Superdraw is used to create a 2-D computer model of the tissue in its normal state. Building and analyzing three-dimensional models for this application does not offer significant advantages because elastograms are two-dimensional. Automatic meshing quickly prepared the models for analysis. Since elastograms render all areas of a sample with the same resolution, there's no need to refine meshes even in areas of interest.

With a standard mechanical hydraulic-testing apparatus, researchers determined the material properties of real breast tissue including muscle, fat, glandular tissues and various types of lesions. Data from real-life tests of breast tissues are made available to the FEA's linear stress processor.

Typically, tissue models are compressed about one percent. This is done by applying fixed boundary conditions and boundary elements to simulate pressure. Algorís linear stress analysis software then determines stresses, deflections and strains.

While most design engineers are interested in stress values from the analysis, those developing elastography look at displacements and strains in a model to predict what an elastrogram of that tumor/location combination will look like.

From the analysis, researchers determine if it will be difficult for doctors to detect a tumor in a particular tissue arrangement using elastography. If so, they perform real-life testing on gelatin models constructed to imitate the hard-to-image lesions and breast tissues. Comparing results of the finite element analyses on models with elastograms of gelatin test objects lets researchers optimize the procedure and develop new software algorithms that better display strain.

Although still in an early stage, the initial results of this clinical work are promising. Researchers have identified several possible indicators for distinguishing between benign and cancerous lesions. In the future, the researchers will try using elastography to detect and evaluate other kinds of cancer, particularly prostate cancer. Currently, two diagnostic methods are used to detect prostate cancer: digital rectal examination and traditional sonography. Even with these two detection options, however, a large number of prostate cancer cases go unrecognized. Successful cancer treatment will still depend on early detection and evaluation.

Additional contributors:
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Dr. Thomas Krouskop, Baylor College of Medicine in Houston
Dr. Michael Insana, Professor of Radiology, University of Kansas Medical Center

Algor produces premium mechanical engineering tools for Virtual Prototyping based on the finite element method. Scientists have used Algor to research the biomechanics of conditions, such as scoliosis, and develop medical devices such as biopsy needles and dental implants. Engineers in the aerospace, automotive, medical and consumer products industries use Algor to develop designs in less time at lower costs. More than 16,000 scientists and engineers located in over 60 countries use Algor's finite element analysis, Mechanical Event Simulation for Virtual Prototyping, CAD interfacing and piping analysis software. In addition, the Algor Publishing Division offers books, videos and multimedia products which help engineers do better design, simulation and analysis with virtually any engineering software.

For more information, contact Algor, Inc., 150 Beta Drive, Pittsburgh, PA 15238-2932; Tel: 412-967-2700; Fax: 412-967-2781; e-mail: info@algor.com; www.algor.com

Circle No. 785

AMP®

World Leader in Interconnection

As the world's leading manufacturer of electrical, electronic, and fibre-optic connectors and interconnection systems, AMP supplies products and services to manufacturers, subcontractors, governments, and network installation organizations around the world. AMP produces the largest selection of interconnection products of any company in the industry.

Leadership in Connector Technology

Leadership in the connector businesses addresses markets that are expected to grow at 6% to 8% each year for the rest of the century. AMP enjoys a 17% market share, and maintains leadership by issuing a steady stream of new products and application tooling, and through continuous improvement in quality and service. AMP invests 10-11% annually on product and process innovation. To focus the investments on customer needs, AMP created a global technology office in 1997 and appointed a new Chief Technology Officer. This office unifies the company's technology resources — including more than 6,000 engineers, scientists, technologists, and support people — and is enhancing the company's world-class science and engineering processes for more efficiency.

By increasing manufacturing capacity and capability, and expanding into new and developing geographic regions, the AMP network of manufacturing facilities and sales offices now spans 53 countries, including 32 in the Europe, Middle East, and Africa region.

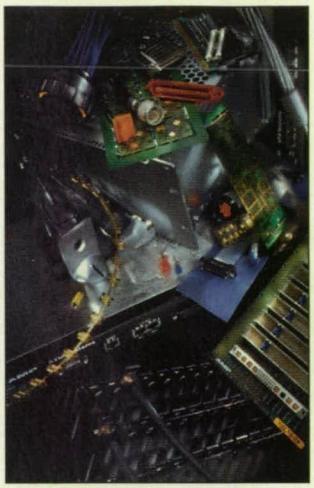
Products and Markets

Major AMP markets include: automotive; household appliances; computers; industrial machinery; networking and premises wiring; consumer and home electronics; telecommunications; and aerospace.

Key products are: terminals; connectors; splices; switches; opto-electronic products; fibre management hardware; passive fibre-optic products; sensors; micro-electronic packaging devices; application tooling; cable and cable assemblies; printed circuit boards; backplane assemblies; networking/premises systems and services; wireless devices; and building products (electrical).

Customer Service

AMP history is marked by innovation in customer service, and in recent years, the company has pioneered a number of industry firsts. For example, AMP offers automated fax service, providing fast information around the clock. The electronic catalogue, available in eight languages, provides on-line product information via the Internet. 3D CAD models are available on CD-ROM and on the Internet for design engineers to use. A unique consulting service provides computer simulation and optimization of proposed interconnection systems.



For more information, contact AMP Incorporated; Tel: 1-800-522-6752; Fax: 717-986-7575; www.amp.com

Circle No. 773

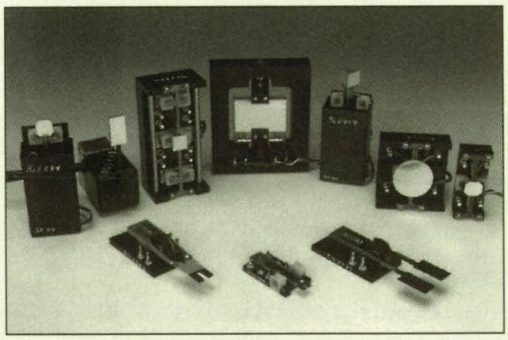
ELECTRO-OPTICAL PRODUCTS CORP.

Optical (Laser/Ion Beam) Modulation & Optical Scanning Components & Systems

Electro-Optical Products Corp. (EOPC) designs, manufactures, and supplies a comprehensive line of small size, low cost, long life, stock and custom components and (sub)systems with associated electronics for optical (laser/ion beam/x-ray) modulation and scanning systems. Our products are rugged, reliable, and compact size. They have virtually unlimited life and will never need manual adjustment or field service. The uses of EOPC's technology are practically limitless. The products are used in industrial, scientific, medical, aerospace, and military applications worldwide.

EOPC is a leader in the development and manufacturing of fixed frequency resonant optical scanners and choppers, which are especially suitable for dedicated applications, portable instruments, high volume OEM, and custom-system integration. Systems locked to an external clock, locked in a master/slave mode, and X, Y raster scan systems are available.

The fixed frequency tuning fork choppers (from a frequency range of 5 Hz to 6 KHz) with an aperture of up to 10 mm, can be constructed of low outgassing materials for ultra-high vacuum. They are cryogenic and high temperature capable, which makes them excellent candidates for use in harsh industrial environments, as well as in deep space environmental research. They are optimized to have very high frequency stability and high amplitude stability. The variable low frequency modulators are ideal for large beam chopping or for simultaneous chopping of multiple beams. If the metal vane is replaced with a mirror, they are used as beam deflectors. The high-reliability, low-cost, long-life laser beam safety (interlock) shutters have an integrated return spring and will return to the "off" position with a power failure. A simple drive circuit will provide TTL input commands.



EOPC offers a large selection of fixed frequency resonant optical scanners (from the range of 5 Hz to 20 KHz) with a maximum scan angle of 70°P-P optical. The scanners provide high reliability and high frequency stability, an excellent scan-to-scan repeatability, and very low wobble (<1 arc/sec). The 16 KHz and 8 KHz scanners are most suitable to meet the line scan high-resolution requirements for TV/HDTV. Also available from EOPC: modulators (DC to 1000 MHz), rotating choppers, high-speed fiber-optic O/E converters, universal radiometers and fiber-optic multiplexers for spectrometer users.

For more information, contact Electro-Optical Products Corp., P.O. Box 650441, Fresh Meadows, NY 11365; Tel: 718-776-4960; Fax: 718-776-4978; e-mail: techelp@EOPC.com; www.EOPC.com

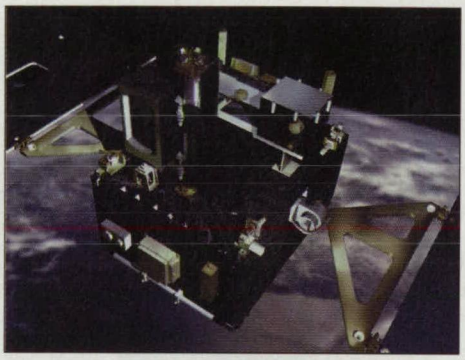
Circle No. 792

SPECTRUM ASTRO, INC.

Founded in 1988 for the pursuit of a new generation of low-cost, high-performance spacecraft, Spectrum Astro today is a fast-growing, full-service aerospace company for the research, development, design, manufacture, launch support, and on-orbit operations of advanced technology satellites.

The streamlined design and efficient performance of Spectrum's first satellite series, the Miniature Sensor Technology Integration (MSTI) Program for the Ballistic Missile Defense Organization, laid the foundation for the company's expanding role in high-profile defense and space exploration missions. Current space system programs performed by Spectrum Astro include: NASA's New Millennium Deep Space 1; the AFRL's MightySat Phase II spacecraft; and NASA's High Energy Solar Spectroscopic Imager (HESSI) spacecraft.

Meeting customer demand for lightweight space-system electronics, Spectrum has developed a growing line of compact, reliable subsystems for a wide variety of space programs, including Mars '98, Mars '01, Lunar Prospector, Gravity Probe B, and Space Station Furnace. The company's flight proven expertise includes all elements of space electronics systems, design, analysis, and manufacturing for telemetry, power, attitude control, and command and data handling.



Spectrum also designs and implements highly effective ground support systems in conjunction with its space systems. The company's electrical ground support hardware features user-friendly, point-and-click software interfaces for the support of integration and test, while Spectrum's platform-independent ground systems software package, AstroRT, provides real-time command, control, and data acquisition capabilities.

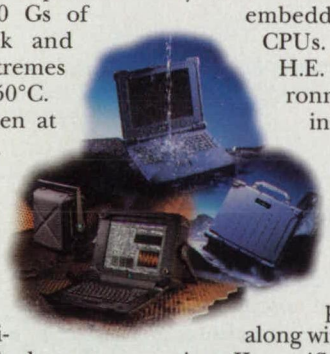
Spectrum's approach to bringing low-cost, innovative solutions to the evolving needs of the space industry has valuable applications in the commercial market. Current commercial projects include the Aster Satellite System, a high data rate, high capacity broadband communications service to operate in the newly opening V-band, and AstroNav, the next generation of spaceborne Global Positioning System (GPS) receivers.

For more information, contact Spectrum Astro, Inc., 1440 N. Fiesta Blvd., Gilbert, AZ 85233; Tel: 602-892-8200; Fax: 602-892-2949; e-mail: programdevelopment@specastro.com; www.specastro.com

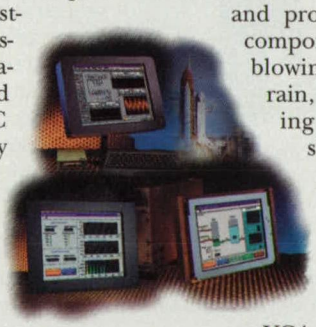
Circle No. 783

DOLCH COMPUTER SYSTEMS, INC.

With a founding engineering background in 1987 rooted in test, measurement, and data acquisition, Dolch Computer Systems, Inc. is today the leading supplier of rugged portable add-on computers and industrial flat-panel display systems. Dolch offers rugged and environmentally protected portable computer platforms with add-in expansion from one to ten slots in six different package styles. Primary applications include data acquisition, network testing, image processing, communications testing, and industrial PLC programming. Key components of Dolch's designs are the protection of the systems' core elements and the add-in boards from extremes of shock, vibration, temperature, and humidity. Attention to detail in design yields capabilities to withstand 30 Gs of transport shock and temperature extremes from -20°C to +50°C.



Dolch has been at the forefront in bringing flat-panel information display technology to the industrial environment. All metal engineered caseworks house and protect sensitive components against blowing dust and rain, while isolating them from shock and vibration. Screen sizes from 10.4" to 16.1" with resolutions from VGA to SXGA all offer sunlight-readable 800 nit options along with a range of touchscreens. All systems are available with embedded Pentium CPUs. Dolch's new H.E. (Harsh Environment) series of industrial monitors and operator interfaces offer NEMA4/4X levels of environmental protection along with Class 1 Division II certification. These systems operate from -40°C to +50°C.



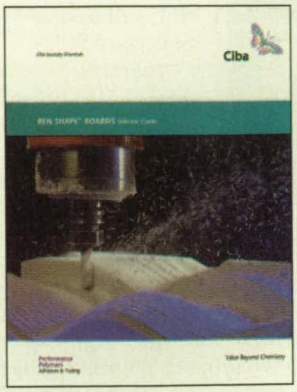
To support its development of sophisticated compute and display systems, Dolch has commissioned an internal environmental testing lab. This lab is equipped with an electrodynamic shaker system and a temperature/humidity chamber, both linked to a multi-channel data acquisition system. The lab is augmented with a high-sensitivity sound pressure measurement system and a power analyzer, and is directed by a full-time environmental engineer.

Dolch gained ISO 9001 certification through the Lloyds Registry in 1997 and maintains a continual process of employee training and quality improvement. All Dolch systems are designed and certified to meet FCC, UL, CUL, CSA, and CE, and are available throughout the world. Dolch products are sold and serviced from direct offices in the US, Germany, and the United Kingdom, along with a network of certified and authorized distributors in Europe, the Middle East, Africa, and the Far East.

For more information, contact Dolch Computer Systems, Inc., 3178 Laurelview Court, Fremont, CA 94538; Tel: 510-661-2220; Fax: 510-490-2360; e-mail: sales@dolch.com; www.dolch.com

Circle No. 781

CIBA SPECIALTY CHEMICALS CORP.



Ren Shape™ Work Boards

Ciba's line of Ren Shape™ board materials is designed to meet the diverse tooling, modeling, prototyping, and fabricating requirements across a broad range of industries. The board materials are used for building styling models, master models and prototypes, fixturing and duplicating aids, foundry patterns, metalforming dies, nickel electroplating mandrels, composite lay-up tools, and many other uses.

Ciba Specialty Chemicals Corporation, Performance Polymers, 4917 Dawn Ave., E. Lansing, MI 48823; Tel: 800-955-5509; Fax: 517-351-6255.

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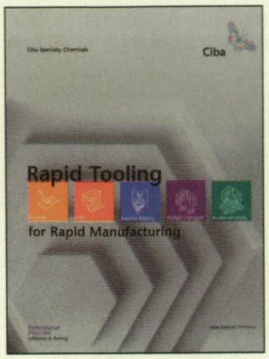

Rapid Tooling for Rapid Manufacturing

Advanced rapid manufacturing methods that reduce product-to-market lead times are described in a new eight-page brochure. The literature discusses products used for master model production via SLA or CNC-machining, casting of multiple prototypes in silicone rubber molds (focusing on Parts In Minutes™ Polyurethanes), and polyurethanes and epoxy tooling systems for initial and short-run part production.

Ciba Specialty Chemicals Corporation, Performance Polymers, 4917 Dawn Ave., E. Lansing, MI 48823; Tel: 800-955-5509; Fax: 517-351-6255.

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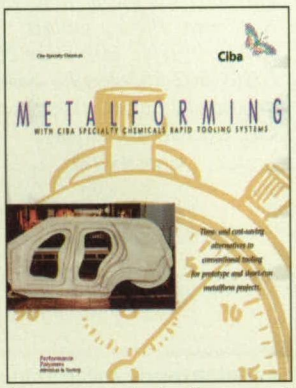

Metalforming Tooling Systems

Described in a 12-page brochure are our polyurethane board and casting systems that can reduce lead times and costs for metalform tooling. Ren Shape™ 5166 machinable polyurethane board and RP 6479-A/B casting polyurethane exhibit the impact strength, wear resistance, and compressive strength needed for forming draw dies, stretch forms, and hydroform tooling used in short-run or prototype metalforming projects.

Ciba Specialty Chemicals Corporation, Performance Polymers, 4917 Dawn Ave., E. Lansing, MI 48823; Tel: 800-955-5509; Fax: 517-351-6255.

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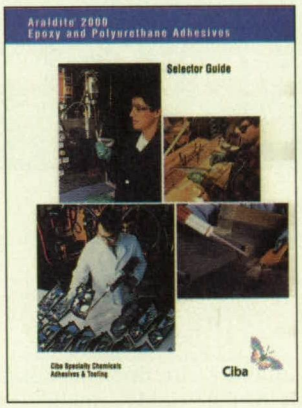

High-Performance Adhesives

Ciba Specialty Chemicals' Araldite® 2000 adhesives for repair, maintenance, and assembly are featured in a new brochure. The epoxies and polyurethanes offer properties such as fast setting, heat/chemical resistance, strength, and flexibility. Araldite® adhesives bond metals, plastics, ceramics, and rubber, as well as other materials. They are available in 50 or 200 ml cartridges and quart cans.

Ciba Specialty Chemicals Corporation, Performance Polymers, 4917 Dawn Ave., E. Lansing, MI 48823; Tel: 800-955-5509; Fax: 517-351-6255.

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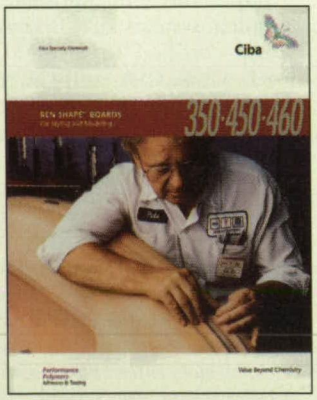

Styling and Modeling Boards

Ren Shape™ 350, 450, and 460 boards are described in this four-page brochure. These products are used by designers that require grain-free styling and modeling materials that produce high quality, dimensionally accurate models and patterns, either by hand carving or CNC milling.

Ciba Specialty Chemicals Corporation, Performance Polymers, 4917 Dawn Ave., E. Lansing, MI 48823; Tel: 800-955-5509; Fax: 517-351-6255.

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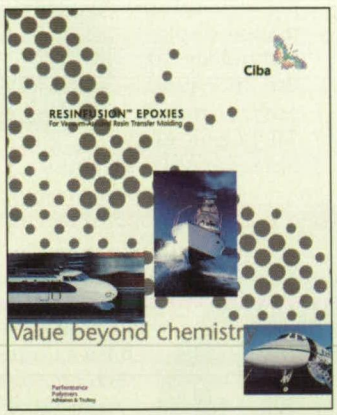


Resinfusion™ Epoxies

Our new Resinfusion™ epoxies used by composite manufacturers in the VARTM (Vacuum Assisted Resin Transfer Molding) process is explained in the literature package. The material offers good dimensional stability and excellent cured properties to support the production of high-quality composite parts and tooling. The VARTM process is also described.

Ciba Specialty Chemicals Corporation, Performance Polymers, 4917 Dawn Ave., E. Lansing, MI 48823; Tel: 800-955-5509; Fax: 517-351-6255.

Circle No. 791

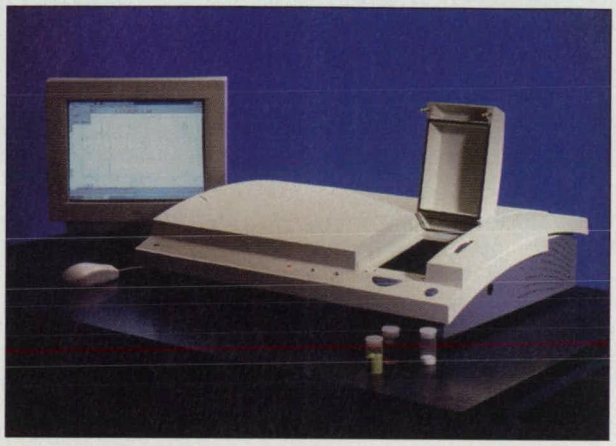
ANDOR TECHNOLOGY

Andor Technology specializes in the design and manufacture of instruments for spectroscopy and scientific imaging. Using the latest RISC processors and VLSI components, the company's product line features compact, high-performance CCD and intensified CCD (ICCD) cameras, as well as a new, easy-to-use Raman spectrophotometer — RAMANSPEC.

Andor's CCDs are ideal for low-light spectroscopy. Exposure times of several hours are possible thanks to hard vacuum seals and software-controlled thermoelectric cooling down to -90°C. At such low temperatures, "dark signal" (a phenomenon inherent in silicon-based CCDs) is greatly reduced. Moreover, software control allows the user to set and maintain an operating temperature that optimizes the CCDs quantum efficiency for a particular wavelength. Until recently, comparable — but rather less accurate — cooling performance was possible only by using liquid nitrogen.

Andor's ICCDs are the choice for transient spectroscopy, in areas such as plasma dynamics and laser ablation diagnostics. The ICCD's intensifier can be rapidly gated on and off to serve as an ultra-fast shutter operating on nanosecond timescales: gate widths of 5 ns are standard, and gate widths below 2 ns can be achieved with specially selected intensifiers. For very low light measurements (e.g. fluorescence lifetimes) the gain on the intensifier can be increased to achieve photon counting performance.

RAMANSPEC is Andor's latest instrument. When an intense beam of light scatters from a material, some of the light is shifted to new wavelengths according to the vibrational energy levels in the material. This "Raman-scattered" light serves as a "fingerprint" of the compounds in the material. Andor's RAMANSPEC combines into one neat, benchtop package the laser source, optics, and detector needed to produce high-quality Raman data. Requiring minimal sample preparation, RAMANSPEC can analyze solids, liquids, or powders, in a standard cuvette, or even in glass bottles or evidence bags — of particular advantage in the forensics lab. Combining high sensitivity with push-button operation, RAMANSPEC is suited to both routine analysis and leading-edge research.



RAMANSPEC

For more information, contact Andor Technology; www.andor-tech.com

Circle No. 784

CIBA SPECIALTY CHEMICALS CORPORATION

Injection molds machined in hours from Cibatool-Express™ moldmaking system successfully ran 250 polycarbonate production-quality bracket caps for automotive visor prototypes.

A pioneer in polyurethanes for prototyping, Ciba Specialty Chemicals, Performance Polymers, East Lansing, MI, today markets a full line of rapid manufacturing materials specially designed to help bring new products to market faster than ever before.

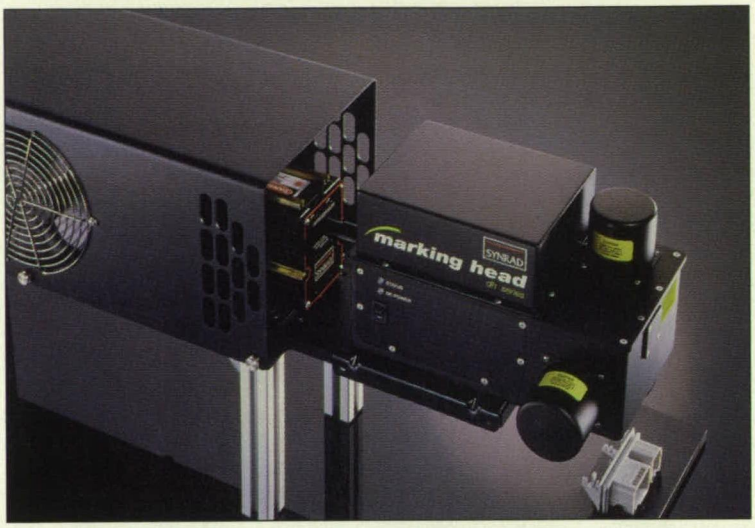
Most recently, Ciba, and its research partner, Johnson Controls' Prince subsidiary, Holland, MI, introduced a composite board for rapid machining of thermoplastic injection molds ... in 15 to 20% of the time needed to generate aluminum tooling. Known as Cibatool-Express™ moldmaking system, the new product produces mold surfaces that require little, if any, benching before being installed in a support structure and mounted in the press. Composite insert molds machined from the Cibatool-Express™ moldmaking system are durable enough to withstand temperatures and pressures required to run hundreds of dimensionally accurate (to ±0.005 inches) parts with high-quality surface finishes from production plastics including ABS, glass-filled polypropylene and polycarbonate.

In addition to the Cibatool-Express™ moldmaking system, Ciba supplies: Cibatool® photopolymers and Ren Shape® machinable boards for modelmaking; Ren® silicones and polyurethanes for prototype tooling; fast-setting Parts-In-Minutes® polyurethanes for prototypes and initial parts; and Ren Shape® machinable boards and Ren® casting epoxies for short-run tooling.

For more information, contact Ciba Specialty Chemicals Corporation, Performance Polymers, 4917 Dawn Avenue, East Lansing, MI 48823-5691; Tel: 800-955-5509.

Circle No. 782

SYNRAD



Headquartered just north of Seattle in Mukilteo, WA, Synrad was founded in 1984 by Peter Laakmann, a pioneer of the RF-excited CO2 laser. Synrad quickly attained a reputation as a design leader in the development and manufacture of innovative electro-optics technologies. With over 15,000 lasers delivered worldwide, it remains the recognized world leader in RF-excited CO2 lasers.

Available in power ranges from 10W to 600W, Synrad lasers are ideal in applications involving cutting, marking, and drilling on steel, plastic, wood, paper, and fabrics, as well as many other organic materials. The durable, compact lasers easily integrate into gantry systems, XY tables, and robotic arms. Since they're sealed, there are no consumables required — the lasers operate maintenance-free for up to four continuous years. Synrad's patented "all-metal" technology allows for mass production, enabling the company to offer superior-quality sealed CO2 lasers at very affordable prices.

Synrad also is a major supplier of laser marking systems. The rugged and compact DH Series Marking Head contains the latest fiber-optic and digital technology, which delivers high resolution and accuracy in tough manufacturing environments. Compatible with Synrad's 10 to 125W lasers, the DMH delivers crisp and permanent marks. Synrad has recently introduced WinMark Pro, the first Windows-based laser marking software. The ease of use and flexibility of this software make it ideal for marking alphanumerics, bar codes, and logos. WinMark Pro is ActiveX-compliant, allowing the user to create high-performance stand-alone laser marking applications using the most powerful and up-to-date programs such as Microsoft Access 95, Office for Windows 95, Visual Basic, and others.

For more information, contact Synrad, 6500 Harbour Heights Parkway, Mukilteo, WA 98275; Tel: 425-349-3500; Fax: 425-485-4882.

Circle No. 777

DIGI-KEY CORPORATION

From its beginnings in 1972, Digi-Key has earned a reputation of leadership in the electronics distribution industry resulting from a unified commitment to product availability, service, and performance. Digi-Key bridges the gap between suppliers and customers, delivering product and information with efficiency and reliability.

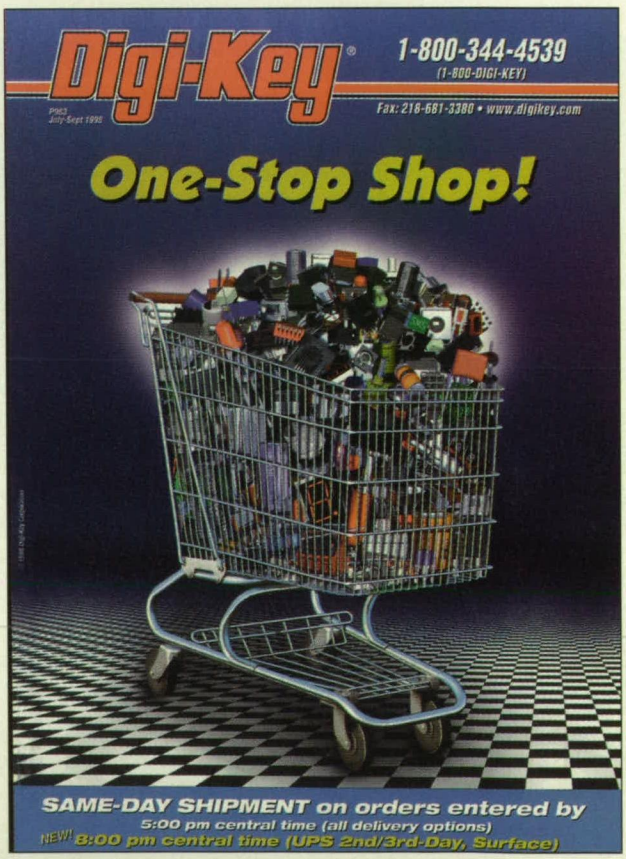
At the cornerstone of their marketing program is a 550-plus-page full-line catalog containing over 80,000 products from 195-plus vendors. Approximately 4.5 million customers and subscribers receive this catalog yearly with updates made every 90 days to accommodate constant product-line expansion and accurate pricing information.

Digi-Key also offers a comprehensive electronic media presence on the World Wide Web. Recognized as one of the industry's best sites, the link is open 24 hours a day, seven days a week (www.digikey.com). Beyond the obvious convenience, you will notice great content, access speed, ease of navigation, online parts search capabilities, online ordering, and communication options. In-depth information can be accessed through many industry links or an exact electronic copy of the latest catalog.

Find out for yourself why Digi-Key is the source for design engineers, managers, and purchasers. ISO 9002-certified, committed to product availability, a 90-plus-% fill rate, on-time delivery — from prototype to production — quality products, superior service, and performance.

For more information, contact Digi-Key Corporation; Tel: 1-800-344-4539; Fax: 218-681-3380; e-mail: sales@digikey.com; www.digikey.com; or contact the Volume Business Division; Tel: 1-800-3VOLUME (386-5863); Fax: 218-681-0215; e-mail: volume@digikey.com

Circle No. 768



STAHL SPECIALTY COMPANY

Stahl Specialty Company is a leader in the aluminum foundry industry and has been making castings from the tilt-pour permanent mold process since 1946. Applications such as automotive, agricultural, heavy truck, marine, and food service are some of the many markets served in which a casting design can prove to be more viable than other manufacturing processes. Stahl has been making parts for the automotive industry since 1978. One area of application for automobiles that Stahl has expertise in is suspension parts such as control arms. Stahl has supplied control arms to the automobile industry since 1993 and currently has applications on Cadillac, Pontiac, and Oldsmobile cars.

Weight Savings Plus Other Benefits

The main reason for converting suspension parts to aluminum from other materials such as iron castings and steel stampings is weight savings. This translates into lower vehicle weight and better fuel economy. One important side benefit discovered after the implementation of aluminum control arms was an improvement in unsprung weight of each wheel. Unsprung weight refers to the amount of mass of each wheel that is available to be "thrown around" as the vehicle encounters road imperfections such as bumps and potholes. When the wheel of a car with lightweight aluminum control arms passes over an abnormal road surface, the impact is less violent and yields a smoother ride. Additionally, aluminum control arms dampen the impact of bumps and potholes better than steel stamped control arms, resulting in less vibration transmitted through the car.

Important Features of Aluminum Control Arms

Aluminum control arms are fairly new to the automotive industry, but they are becoming more widespread each model year as the confidence level increases in their ability to perform in many different vehicle applications. Superior mechanical properties and casting soundness are a must for the aluminum control arm to be successful. Castings with high ultimate tensile strength are required, but ductility of the casting is a prime consideration. Aluminum control arms must show signs of deformation before failure, which places a premium on the elongation percentage of the casting. To achieve the elevated mechanical properties required for control arm applications, the castings must also have minimal internal anomalies such as porosity and oxides. A sound casting, combined with a custom tailored heat treat, will yield a casting with exceptional mechanical properties and durability.

For more information, contact Stahl Specialty Company, 111 East Pacific, PO Box 6, Kingsville, MO 64061-0006; Tel: 800-821-7852; Fax 816-597-3485; www.stahlspecialty.com

Circle No. 779

BUSAK+SHAMBAN

Providing the Industry With Seals for Extreme Conditions

The drive to improve the performance of fluid-power systems is causing design engineers to search for better seal alternatives. During the last few years, increasingly difficult operating conditions have forced engineers to look beyond traditional seal designs. The alternatives they seek are the spring-energized Turcon® Variseal™ and metal Wills Rings® C. These seals are manufactured and supported by the American Variseal Corporation, a division of Busak+Shamban.

The Turcon® Variseal™ combines the advantages of Turcon® — a blend of chemically inert PTFE resins and various fillers — with the resilience of spring energizers, making them ideal for both static and dynamic applications. The Turcon® Variseal™ line of seals are chemically inert, have extremely low friction, excellent wear resistance, and zero stick-slip. These seals utilize three spring designs to meet any force or torque requirement.

The Helical spring provides the highest unit load and is generally reserved for static applications. The V-spring loads near the edge of the lip, providing excellent wiping action for reciprocating applications. The Slantcoil® spring offers the greatest amount of friction control and maintains a nearly constant load over the life of the seal.

The Wills Rings® C has an innovative C-shaped profile with springback ability up to three times greater than conventional metallic O-rings, which compensates for hardware changes due to extreme pressure and temperature variations. The low seating load of the Wills Rings® C also results in a size and weight reduction of the mating hardware.

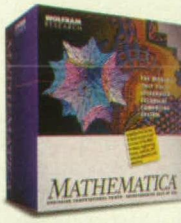
For more information, contact Pat Haggerty at 1-800-466-1727 or visit www.variseal.com

Circle No. 795

The spring-energized Turcon® Variseal™ and silver-coated metal Wills Rings® C.

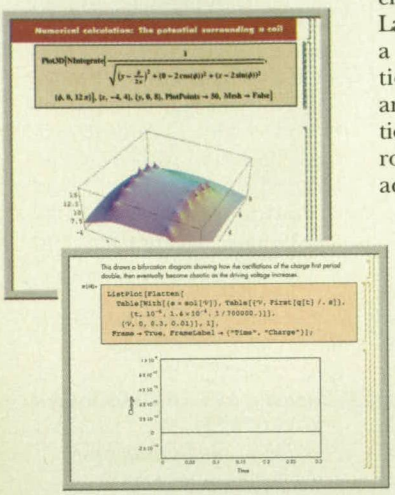
WOLFRAM RESEARCH, INC.

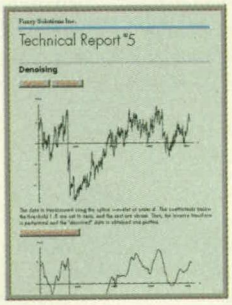
Mathematica®: Ten Years as the Leading Technical Computing System



Mathematica is the world's only fully integrated technical computing system, combining high-powered interactive calculation (both numeric and symbolic), visualization tools, and a complete programming environment.

Mathematica contains the world's largest collection of special functions, which can be used both symbolically and numerically. Its unique automatic arbitrary-precision control tracks numerical uncertainty within calculations and adjusts numeric precision as needed. Standard abilities include Fourier and Laplace transforms, a powerful collection of matrix and tensor operations, optimiztion, root finding, and advanced curve fitting. Symbolic algebra capabilities allow you to perform integration, differentiation, and power series expansion, polynomial factorization and manipulation, equation solving, and closed-form solution of ODEs and many PDEs.





Mathematica's power to integrate both symbolically and numerically is simply unbeatable. Mathematica takes calculations that previously were prohibitively difficult, and makes them not only feasible, but easy. DSolve and NDSolve can quickly solve a huge variety of differential equations, either symbolically or numerically to arbitrary precision.

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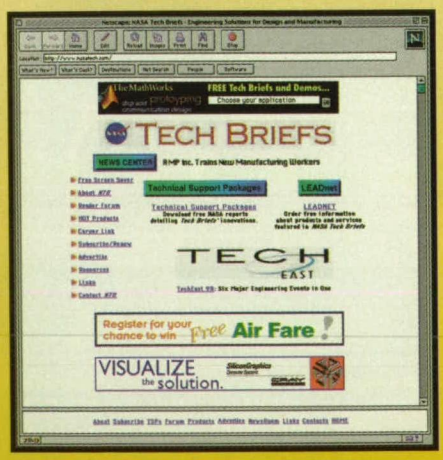

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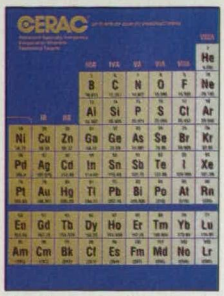

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Advanced Pressure Products

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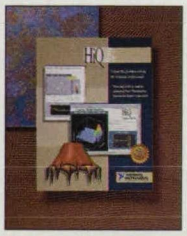

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Danfoss Electronic Drives

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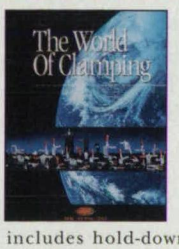

WORLD OF CLAMPING

The World of Clamping catalog covers DE-STA-CO's line of approximately 500 toggle clamps, and features expanded dimensional and application information. DE-STA-CO's toggle clamp line includes hold-down, latch, straight-line, and squeeze-action clamps. The catalog also contains DE-STA-CO's pneumatic and hydraulic clamping systems, and line of spacing products. (Catalog 197 REV 1). DE-STA-CO Industries, 2121 Cole St., Birmingham, MI 48009; Tel: 248-594-5600; e-mail: cust.serv@destaco.com; http://www.destaco.com

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Oregon Micro Systems Inc.

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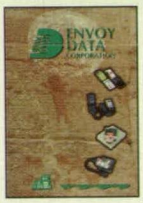

1998 PCMCIA PRODUCTS CATALOG

The new PCMCIA-PC CARD standard has been incorporated into applications such as datalogging, agriculture, digital film, and wireless communications. Envoy Data has just released its new catalog for these new applications, plus many other products like: memory; I/O (serial, parallel, SCSI, A/D) cards; PC card drives for ISA, IDE, SCSI; and industrial cards and drives, multimedia, industrial, and engineering tools for PCMCIA applications. Envoy Data Corporation, 6 E. Palo Verde, #3, Gilbert, AZ 85296; Tel: 602-892-0954; Fax: 602-892-0029; e-mail: info@envoydata.com; www.envoydata.com

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1998 MOTION CONTROL CATALOG

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Galil Motion Control

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OMEGA Engineering

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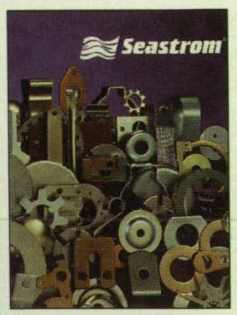

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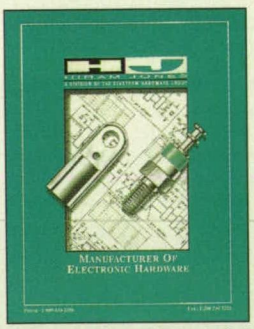

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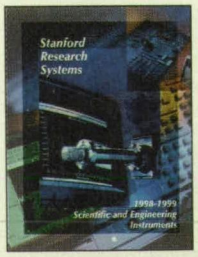

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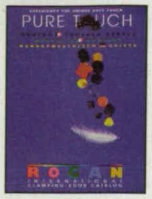

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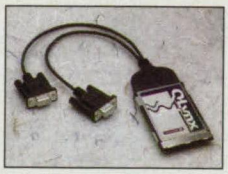

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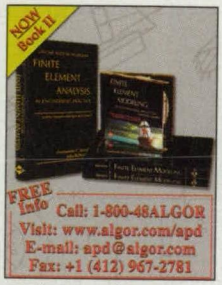

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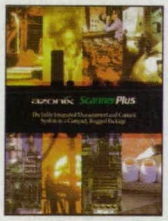

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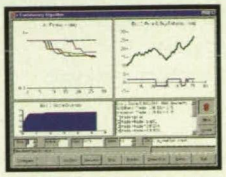
EXAIR Corporation

For More Information Circle No. 636



FREE EVOLUTIONARY ALGORITHM DEMO

e is an advanced software tool that solves problems through evolutionary processes. Given a training data set containing example inputs and outputs, e involves computer programs that model the data and can be applied to new cases. Applications include classification, modeling, prediction, data mining, financial analysis, control, and many others. For a free demo call 800-792-9258 or visit our Web site at www.sdi-inc.com.

System Dynamics International

For More Information Circle No. 637

MECHANICAL EVENT SIMULATION (MES) SOFTWARE

Algor's Accupak/VE MES software replicates real-world behavior of a mechanical design having motion and impact. Accupak/VE gives stresses over time using known physical data, not assumed forces. Engineers can view events as they unfold. To see a replay of this car suspension analysis and other analysis replays, visit Algor's home page or order your FREE CD-ROM. Tel: 412-967-2700; Fax: 412-967-2781; e-mail: info@algor.com; www.algor.com

Algor, Inc.

For More Information Circle No. 638

PORTABLE ROCKWELL TESTER

The new direct readout EquoStat tester has been developed for testing small or thin parts in the thickness range of .08" to 1.0". The hardness value HRZ can be converted to other hardness values (HV; HRC; HB; HR15N,) by pressing a key. West-Met Instruments, Inc., P.O. Box 1145, 936 Maple Street, Edmonds, WA 98020. Tel: 425-771-1292, 800-446-5670; Fax: 425-771-1722.

West-Met Instruments, Inc.

For More Information Circle No. 639

BALINIT® C TUNGSTEN CARBIDE/CARBON

Balzers Tool Coating offers new literature on Balinit® C Tungsten Carbide/Carbon (WC/C) composite coating. It provides comprehensive information on Balzers' WC/C coating, which is ideal for use in applications such as diesel fuel components, textile machinery drives, machine tools, aircraft gears, racing engines, and planetary drives in construction machinery and commercial vehicles. WC/C also is beneficial in dry machining and plastic molding operations. For more information on Balinit® C Tungsten Carbide/Carbon, contact Balzers Tool Coating Inc. at 661 Erie Ave., North Tonawanda, NY 14120. Tel: 716-693-8557; Fax: 716-695-1995

Balzers Tool Coating Inc.

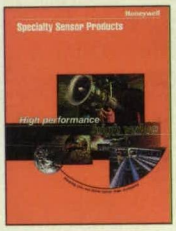
For More Information Circle No. 640

PRESSURE TRANSDUCER SELECTION GUIDE

This brochure provides specifications on the complete family of stainless-steel pressure transducers from Data Instruments. The transducers are fully calibrated and temperature compensated to assure long-term reliability and performance. DI offers pressure ranges from 0-5 to 0-20,000 psi. They are available in gauge, absolute, sealed, vacuum, and differential models, with voltage, current, or frequency outputs. Tel: 800-333-DATA (3282); www.datainstruments.com

Data Instruments

For More Information Circle No. 641

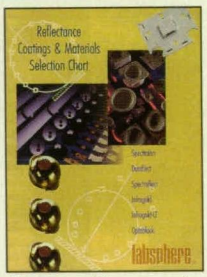


HONEYWELL SPECIALTY SENSORS

Honeywell offers precision silicon pressure transducers and magnetic sensors for commercial, industrial, avionics, and other applications. The pressure transducers are smart and networkable with analog and digital outputs. The magnetic sensors, used in high-sensitivity and low magnetic-field sensing applications - such as measuring the Earth's field - are available as component or networkable magnetometers. For Honeywell Solid State Electronics Center information: Tel: 800-323-8295; Fax: 612-954-2764; www.ssec.honeywell.com

Honeywell

For More Information Circle No. 642

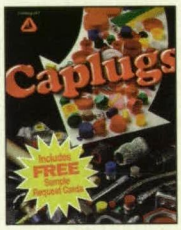


REFLECTANCE COATINGS & MATERIALS

Labsphere's four-page selection guide gives specifications and applications information for an extensive line of UV-VIS, NIR-MIR, and IR reflectance coatings and materials. An easy-to-read format guides users in selecting the most suitable material to use for a variety of reflectance applications. Labsphere, Inc., P.O. Box 70, Shaker St., North Sutton, NH, 03260; Tel: 603-927-4266; Fax: 603-927-4694; e-mail: labsphere@labsphere.com

Labsphere Inc.

For More Information Circle No. 643



NEW CAPLUGS CATALOG OFFERS FREE SAMPLES

The 74-page Caplugs catalog provides specifications on America's largest selection of protective closures, available in plastic, metal, paper, silicone, rubber, and vinyl. It includes handy postcards to order free samples from more than 1,200 stock caps, plugs, high-temperature masking parts, edge-liners, grommets, finishing parts, nettings, load-bearing furniture glides, and ESD protectors. Caplugs Division, Protective Closures Co., Division of Mark IV Industries, 2150 Elmwood Ave., Buffalo, NY 14207. Tel: (toll-free) 888-CAPLUGS; Fax: 716-874-1680; e-mail: sales@caplugs.com; www.caplugs.com

Caplugs

For More Information Circle No. 644

WORKBENCHES & SYSTEMS CD-ROM CATALOG

This interactive multimedia presentation covers Teclab's complete line of workbenches and laboratory systems furniture. Designed for Windows™, the CD-ROM presentation features hundreds of benches, including complete product specifications. Meeting the Challenge, Teclab's introductory video presentation, highlights unique features and benefits of a Teclab bench. You select what you want to see by simply clicking on the icons that interest you. Teclab, 6450 Valley Industrial Drive, Kalamazoo, MI 49009; Tel: 800-832-5227; Fax: 616-372-6116; http://www.teclab-bench.com

Teclab

For More Information Circle No. 645

Love Controls 32A is the first dual-display 1/32 DIN control on the market. This full-featured control offers ease of use and performance previously only available in larger formats. Visit the Love Controls web site, which contains full information on their complete product line, including controls, sensors, power controls, transmitters, and much more. Check out www.love-controls.com today. Love Controls Division, Dwyer Instruments, Inc., PO Box 338, 102 Highway 212, Michigan City, IN 46360; Tel: 219-879-8000; Fax: 219-872-9057; www.love-controls.com

Love Controls Division, Dwyer Instruments, Inc.

For More Information Circle No. 646

MINIATURE COLOR CAMERA

Hitachi Denshi has released a brochure describing the new miniature color camera — the KP-D8. The ultra-compact, one-piece unit requires only 12 V power in order to put out NTSC, PAL, or Y/C color signals. This high-sensitivity, high-resolution camera measures only 22mm x 22mm x 86mm.

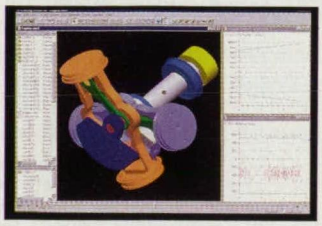
Hitachi Denshi America, Ltd.

For More Information Circle No. 647

New on DISK

Integrated Working Model 3D

Working Model 3D 3.0 functional simulation software from Knowledge Revolution, San Mateo, CA, has been integrated with Pro/ENGINEER mechanical-design software from Parametric Technology Corp. Working Model 3D for Pro/ENGINEER uses the Pro/ENGINEER solid-model geometry and assembly data as the basis for functioning parts, eliminating the need to recreate models for simulation, and allowing users to move from an assembly model to a functioning prototype. The software is available for Windows 95/NT. **Circle No. 711**

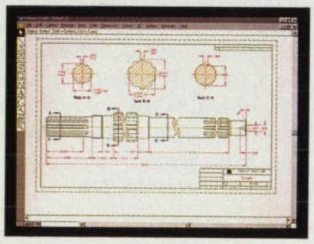


3D View and Markup Tool

3DReview 2.5 3D visualization and mark-up tool from Allegria Software, Laguna Hills, CA, is designed for 3D file format viewing, reviewing, and communicating. A native CAD format has been added to 3DReview, which can now view both SolidWorks97 PLUS and 98. This enables SolidWorks users to share designs with other departments, and requires no prior CAD experience. Cross-sections of a model can be defined and measured with simple points and clicks. 3DReview can be used to communicate via Internet and is available for Windows 95 and NT 4.0. **Circle No. 715**

Advanced 2D CAD

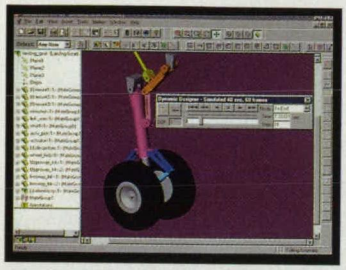
Ashlar, Santa Clara, CA, has introduced Vellum Draft 98 2D CAD software that features integrated parametrics and parametric symbols; ANSI, DIN, ISO, and JIS-compliant dimensioning; and Bill of Materials Management. The Drafting Assistant feature automatically identifies relationships such as endpoints, midpoints, center points, tangencies, and real and extended intersections. Constant feedback helps maintain alignments and ensure precise geometry. The software also allows operators to use the same drawing many times through integrated parametric modeling for two-way associativity. When the design is changed, the dimensions are updated, and vice-versa. **Circle No. 716**



Product Management Tools

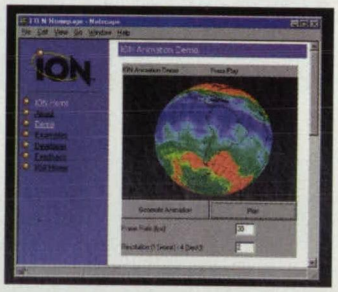
Windchill software tools from Parametric Technology Corp., Waltham, MA, are designed to unify information-management technology with a native Web architecture. The tool family includes Windchill Foundation, which addresses information-management problems within a single, consistent architecture; Windchill Document Manager, with vaulting, workflow, and life-cycle management capabilities; Windchill Configuration Manager, with applications addressing product structure, alternate views, and change management; and Windchill Information Modeler, an information-modeling and development environment. The Web/Intranet/Java application allows manufacturers to share information across a business unit without creating a common data model. **Circle No. 714**

Simulation Software for SolidWorks



Mechanical Dynamics, Ann Arbor, MI, has released Dynamic Designer/Motion for SolidWorks, a mechanical design tool built upon Mechanical Dynamics' ADAMS dynamic-solution engine. It is fully embedded within SolidWorks mechanical design automation software from SolidWorks Corp., enabling users to augment a SolidWorks assembly with joints, forces, cams, followers, and motion generators to produce a fully functioning computer model of the complete mechanical system. This model can then be run through realistic 3D dynamic-motion tests, with equations of motion automatically solved. A single menu selection lets the user post a simulation to an internal Web site. It can then be viewed from remote locations, using VRML 2.0. **Circle No. 718**

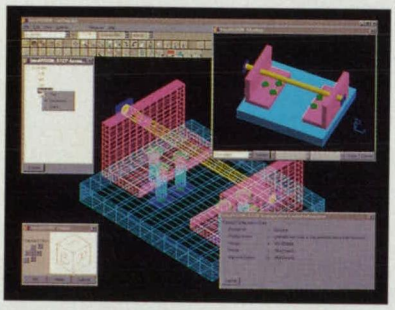
Web-Based Visualization

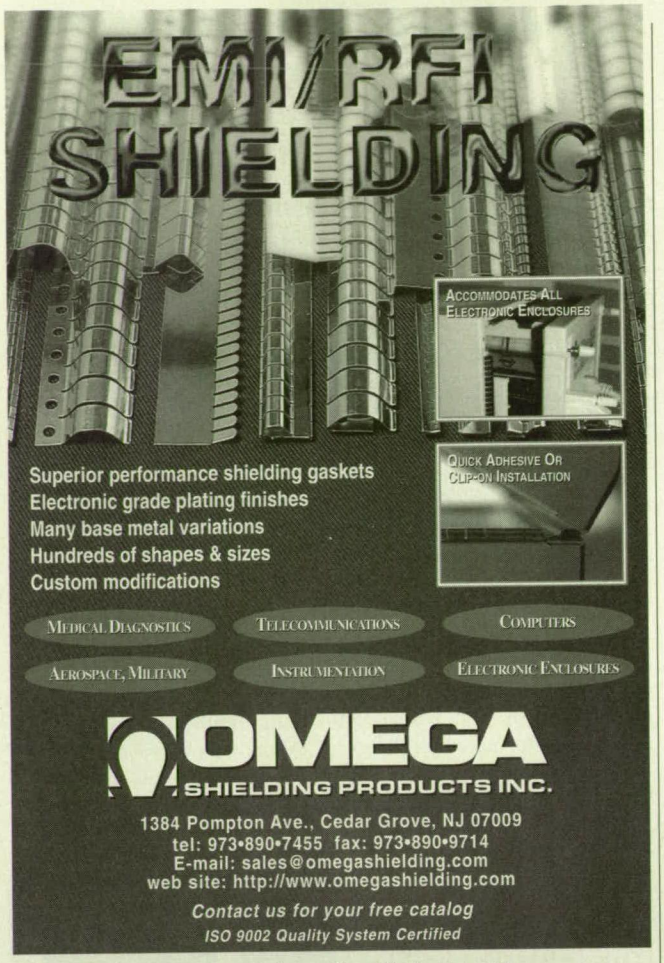


Research Systems, Boulder, CO, has released Version 1.1 of ION (IDL on the Net), an Internet extension to IDL (Interactive Data Language) 5.0 programming language for engineers, scientists, and software developers building data-analysis and data-visualization applications. ION is designed for organizations needing to access, visualize, and analyze shared data from remote locations. It resides on a public Web server, a proprietary intranet server, or both, and supports Internet servers running on Windows NT, all popular versions of UNIX, Linux, and Solaris X86. Applications already written in IDL can be converted for access over the Internet, and only basic knowledge of IDL and HTML are required. **Circle No. 719**

STEP Viewing Software

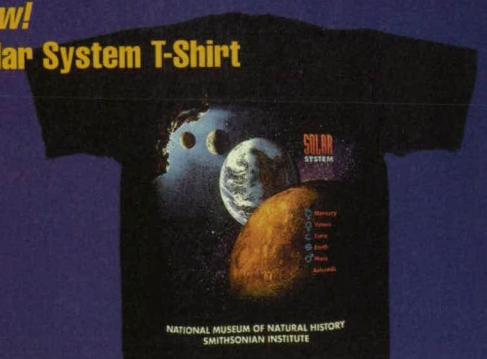
InterData Access, Westchester, IL, has released IntraVISION® software that allows users to access graphical and document information produced from a variety of different applications. The STEP viewing software allows users worldwide to share, communicate, and review all types of data, and provides standard access to geometry and product configuration data relating to parts and assemblies. It supports IGES, VDAFS, and DXF/DWG formats, and can be used in rapid prototyping with support of stereolithography. Features include access to electronically stored documents, engineering drawings, raster images, plot files, and 3D models and assemblies; real-time 3D rotation; and rendering and shading of 3D surface models. It is available for Windows and UNIX platforms. **Circle No. 713**





For More Information Circle No. 442

New!
Solar System T-Shirt



Dramatic full-color illustration on high-quality black cotton shirt. Available while supplies last in children's sizes 2-4, 6-8, 10-12, or 14-16; adult sizes M, L, XL, or XXL. $15.95 each.

Rush me ___ (number) Solar System T-Shirts in the following
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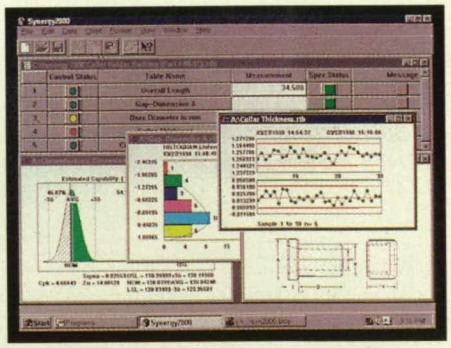
New on DISK

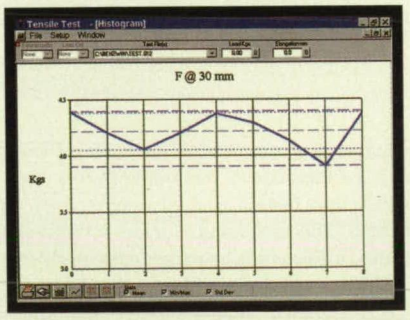
Updated Assembly Software

Boothroyd Dewhurst, Wakefield, RI, has released Design for Assembly (DFA) 8.2 and Design for Environment (DFE) 1.1 software that allow product engineers to compare design alternatives for manufacturability and profitability. Enhancements to DFA include a Product Quality Assessment feature that gauges the design quality of products, and the ability to import machining, injection molding, and sheet metalworking cost estimates. DFE 1.1 features an editable materials database, and a manufacturing-processes database that has been expanded to include information on metal casting, electrodischarge machining, and metal forming. **Circle No. 712**

Statistical Process Control



Synergy™ 2000 statistical process control (SPC) and enterprise-wide quality management software from Zontec, Cincinnati, OH, is a 32-bit application designed for mission-critical manufacturing networks that require the speed, stability, and multi-tasking capabilities of Windows 95/NT. The program delivers real-time SPC, including simultaneous data acquisition, charting, monitoring, analysis, reporting, and multi-plant communication from any network PC. Users can create an unlimited number of variable and attribute data tables with sample sizes up to 100. The software includes native database interfaces to Oracle®, Microsoft Access®, and SQL Server®, and accepts data from virtually any gauging resource. **Circle No. 720**



Data Analysis Software

Benzwin 2000 data acquisition and instrumentation control software from Benz Materials Testing Instruments, Providence, RI, acquires test data, presents it in real-time graphical format, and produces reports both graphically and in tables. Reports can include test parameters, operator-selected results, average standard deviation, coefficient of variation, and maximum and minimum test results. Graphic reports can be generated as histograms, which plot test results including deviation, memory variation of tolerance, and consistency. The software can acquire 5 to 100 test samples per second, and can adjust and run several tests simultaneously. It is available for Windows 95/NT. **Circle No. 717**

New on the MARKET

Professional Windows Workstations

Compaq Computer Corp., Houston, TX, has introduced two new professional workstations for Windows NT. The AP200 and AP400 are tested and certified with workstation applications. The AP200 is an entry-level workstation that can be configured as a minitower or desktop. Features include a single Pentium II slot 1 processor (350 MHz or 400 MHz/512k) and an AGP-based 2D/entry 3D open GL graphics controller. Standard memory is 64 MB or 128 MB, expandable to 384 MB in 3 DIMM slots. The AP400 desktop system supports up to two Pentium II slot 1 processors (350 MHz or 400 MHz/512k), offers high-performance graphics for 2D and 3D applications, and supports up to 1 GB of 100 MHz ECC SDRAM. It also supports multiple monitors with a single graphics controller. **Circle No. 735**

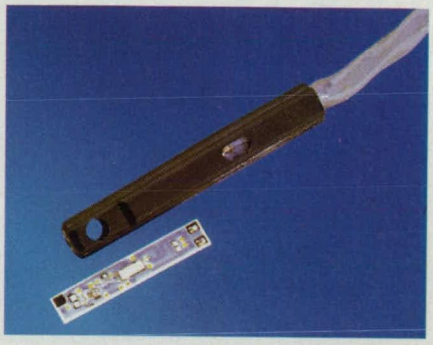
Hardened Bars & Tubes

A.M. Castle & Co., Castle Metals®, Franklin Park, IL, offers NitroSteel® bars and tubes that are hardened by the Nitrotec (Nitriding, Oxidizing, Protection) process. The products are corrosion- and wear-resistant, retain lubrication, and resist pitting and flaking. They are used in applications in agriculture, material handling, and industrial equipment such as hydraulic and pneumatic piston rods, hydraulic cylinders, and pivot pin stock. The process involves nitriding diffused into the steel, rather than being deposited on the steel — the iron nitride wear layer is part of the original steel's surface. The bars are now offered in new lengths of 12' and 24'. **Circle No. 736**

Terminal Eliminates Mouse, Keyboard

The ST3500 Serial Graphics Terminal from Deeco, a division of Lucas Varity, Hayward, CA, eliminates the need to use a keyboard or mouse to access or enter data, call up screens, or control the computer. Users interface directly via a finger or pointer. The terminal is designed for use under extreme operating conditions and is enclosed in a NEMA 4/12 (IP65) rated cast aluminum frame. Features include 16 levels of character zoom, text display on any 45° angle, normal and slanted fonts, and screen clipping and viewporting. Memory is upgradeable to 128K. The terminal can be mounted on swing arms, pedestals, walls, workbenches, or bolted to machinery. **Circle No. 732**

Sensors and Actuators

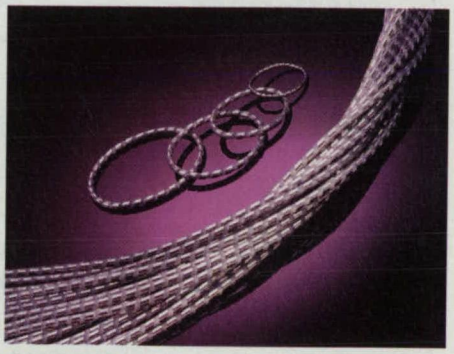


A line of speed/position, height adjustment, proximity, EGR throttle, and pedal position sensors is available from Wabash Technologies, Huntington, IN. The small, lightweight sensors utilize a range of technologies including thick-film potentiometric, variable reluctance, eddy current, Hall effect, giant magnetoresistive, reed switching, and traditional magnetics. The sensors are used in computers, information systems, instrumentation, industrial controls, test equipment, and automotive applications. **Circle No. 723**

Panel-Mount Terminal

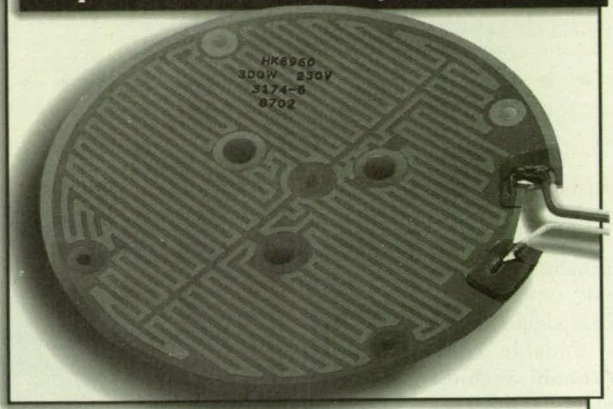
The QTERM-N15 Microterminal/Operator Interface from QSI Corp., Salt Lake City, UT, is a panel-mount operator-interface terminal for industrial applications. Features include a 20-character by 4-line supertwist display; lighted and vacuum fluorescent LCD displays are optional. Users can communicate via EIA-232 or optional EIA-422 and 5-volt buffered at up to 19,200 baud. The 12-key tactile keypad is available with a standard numeric legend or can be customized. The standard terminal operates on 28 mA from a 5 VDC supply, and can function from 7.5 to 24 VDC with an optional regulator. The front bezel and back panel are made of ABS plastic. **Circle No. 727**

Flexible EMI Gaskets



The Flexi-Shield EMI Gasket from Spira Manufacturing Corp., North Hollywood, CA, is made by wrapping a highly conductive spiral around a soft silicone tube or cord. The gasket is groove-mounted and flexes to fill uneven joint surfaces. It has no pieces to break off and short out equipment. Shielding quality is provided to 130 dB at 1 GHz. The conductive spiral is bonded to the inner tube or cord so the ends will not unwrap when cut. Materials are sold by the foot, cut to length, or made into o-rings. Standard materials are stainless steel and beryllium copper. **Circle No. 724**

Thermofoil™ Heaters
put the heat where you need it



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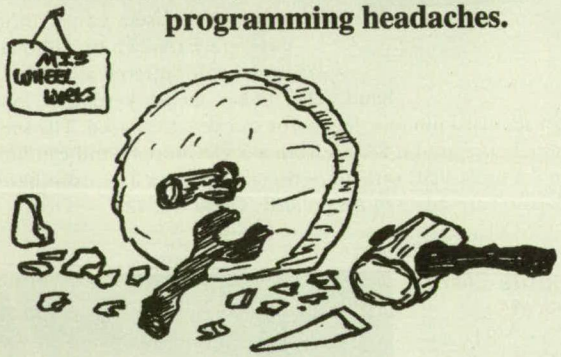
For More Information Circle No. 434

Why reinvent the wheel?

Save time, money & minimize your programming headaches.



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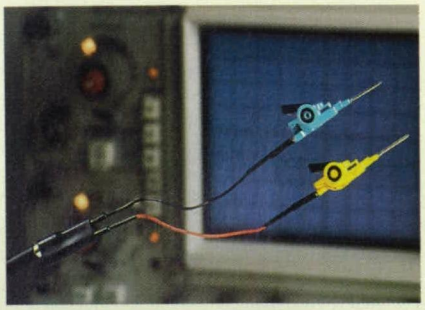
For More Information Circle No. 435

New on the MARKET

Transmitter Monitors Pressure

Patriot Sensors & Controls Corp., Simi Valley, CA, offers the KT Series pressure transmitter that integrates Silicon-on-Sapphire (SOS) sensing technology with a 4-20 mA output electronics package and a ruggedized, industrial housing. Two models are available: the KT425 provides 0.25% static accuracy, and the KT450 provides 0.50% static accuracy. Both models are offered in pressure ranges from 0-15 psi to 0-30,000 psi, and come with a variety of pressure fittings and electrical termination options. **Circle No. 722**

Oscilloscope Probe Kit



An oscilloscope probing kit from Emulation Technology, Santa Clara, CA, enables design and test engineers to perform fine-pitched probing from 0.8 mm to 0.3 mm with any standard oscilloscope. The probing adapter, with dual-lead adapter and ultra fine-pitched MicroGrippers™, can be used for probing fine-pitch surface-mount devices with standard oscilloscope probes. Three separate kits are available, each containing parts for use with two probes, including four MicroGrippers and two dual-lead adapters. **Circle No. 730**

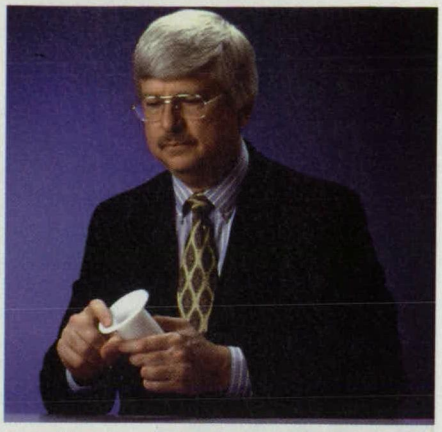
CCD Array Camera

Spectral Instruments, Tucson, AZ, has introduced the 600 Series CCD multiport digital camera designed for use with large-area scientific CCD arrays in low-light imaging applications. The system uses a 2,048 x 2,048 resolution CCD with a 2.6:1 reducing fiber optic for soft X-ray imaging. The camera features 16-bit digitization using an ultralinear converter at 20 to 200 kHz pixel rates. The system can be configured with one, two, or four analog processors/digitizers to accommodate CCDs with multiple output ports, or CCD mosaics. **Circle No. 725**

Mini Ultrasonic Sensors

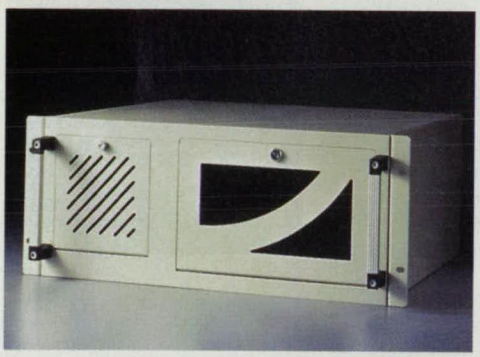
EDP, Livonia, MI, offers the SonaSwitch® miniature "smart" ultrasonic sensor available in two versions: Mini-S (two switched outputs) and Mini-A (analog output). The sensor has a 1.7-inch diameter, a depth of less than 1 inch, and weighs 0.6 ounce. All measurements are temperature compensated. Options include standard cold-rolled or stainless-steel transducers, and polymer coating for protection in harsh environments. The sensor includes an 8-bit microcontroller and all required circuitry to provide adjustable outputs over the entire operating range. **Circle No. 734**

New Fluoropolymer Resins



DuPont, Wilmington, DE, has introduced Teflon® NXT chemically modified fluoropolymer resins for applications requiring higher permeation resistance, lower creep, smoother surfaces, and better high-voltage dielectric properties. The resins provide chemical resistance, high and low temperature capabilities, anti-stick performance, and low friction. Parts made of the materials can be assembled by heat welding and shaped by thermoforming. They can be joined without adhesives using moderate pressure in an oven. They are available in grades tailored for processes used with conventional granular Teflon® PTFE, including compression, isostatic and automatic molding, and ram extrusion. **Circle No. 731**

Rack-Mount Chassis



MiTAC Industrial Corp., Fremont, CA, has announced the MCH-206 ruggedized industrial chassis with three 5.25" half-height and one 3.5" drive bays accessible from the front panel, plus one 3.5-inch internal drive bay. The chassis can be configured with a choice of passive backplanes and is available with a variety of CPUs up to Pentium II. The tower-, desktop-, or wall-mount chassis includes two 45 CFM cooling fans with dust filters, two power LED indicators, and one AT keyboard connector. It comes equipped with a flexible card clamp for add-on cards to protect against vibration. **Circle No. 728**

Bearings in Many Types, Sizes

Reid Tool Supply, Muskegon, MI, offers bearings available in various sizes (inch and metric) and load capacities. Types include single-row radial, double-row angular, linear (shafts and rails), mounted pillow blocks and flanges, thrust, roller-thrust, and spherical. Single-row radial ball bearings are available in plain, double-shielded, and double-sealed configurations. Double-row angular contact ball bearings are double sealed. Other options include press, bronze, and turntable bearings. **Circle No. 726**

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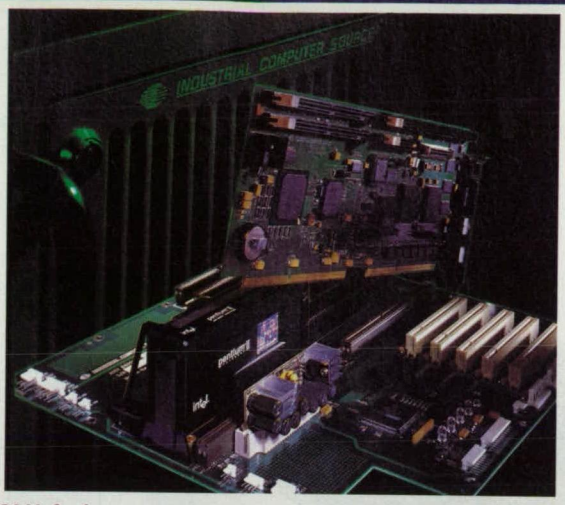

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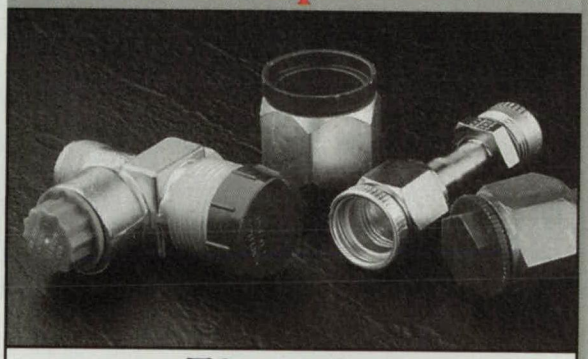

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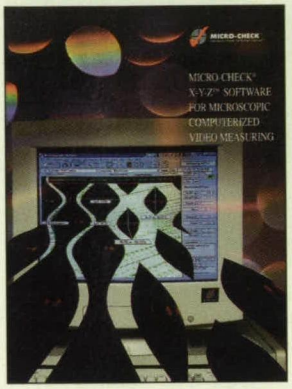
Industrial Identification

A general catalog of industrial identification and data collection products from Brady USA, Identification Solutions Div., Milwaukee, WI, is available on CD-ROM. Ten color-coded sections allow users to locate product categories, including thermal transfer, laser, high-resolution, and dot-matrix print technologies, along with wire marking and labeling, data collection, and software products. Included are several product-selection and ordering-information tools. **Circle No. 701**



Video Measuring System

Shima American Corp., Glendale Heights, IL, offers a six-page brochure and companion pricing guide for the Micro-Check® line of computer measurement systems, software, and instrumentation. The line includes color monitors, monochrome printers, and other measurement instrumentation devices such as video and digital micrometers, electronic thickness gauges, hardness testers, roughness testers, and a PC data logger. **Circle No. 703**

Servodrive Product Guide

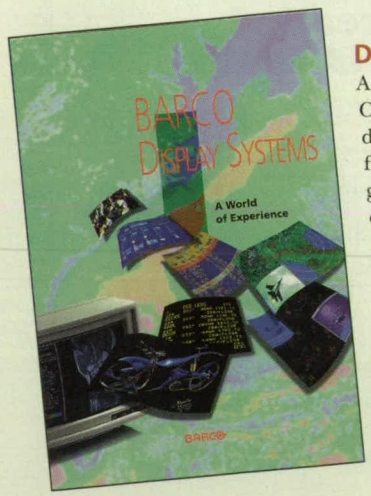
An 80-page catalog from Westamp, Chatsworth, CA, highlights the SP2k multi-axis integrated motion controller, servodrive, and machine I/O controller. Included are features, capabilities, connection schemes, performance-matched brushless servomotor data, and brushless servomotor connections for the company's products that can be used with the SP2k servodrive. **Circle No. 702**

Networking Products

The 136-page DataCom/Networking Cookbook Number 11 from Telebyte Technology, Greenlawn, NY, features fiber-optic networking products such as WDMs and T1/E1 modems. Industrial products include short-haul modems, interface converters, and fiber-optic devices suitable for DIN Rail mounting in a manufacturing environment. Also included are opto isolation and interface converter products. **Circle No. 704**

Oscilloscopes and Instruments

LeCroy Corp., Chestnut Ridge, NY, has released a 270-page catalog featuring the company's digital and analog oscilloscopes, test instruments, and accessories. Nearly 100 pages of application notes describe how oscilloscopes can be used to solve problems in circuits. Included are the LC584A series of DSOs, the Value Line of DSOs, and the DDA series of disk drive analyzers. The catalog is available on an interactive CD-ROM. **Circle No. 700**

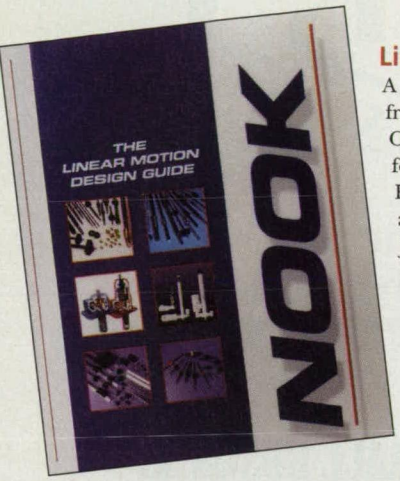


Display Subsystems

A brochure from Barco, Chromatics Div., Tucker, GA, describes display subsystems for applications in avionics, graphics and video, air-traffic control and air-defense, medical imaging, and industrial visualization. Products include Mil-tailored flat-panel displays, graphics controllers, LCD terminals, and high-resolution color displays. **Circle No. 709**

Lubricated Bearings

Garlock Bearings, a division of Coltec Industries, Thorofare, NJ, offers a 64-page catalog of DX prelubricated and DU self-lubricated bearings. The self-lubricated bearings are a steel-backed composite designed to operate at temperatures from -328° to 536° F. The DX prelubricated bearings, which incorporate a grease-retention system, are also steel-backed. Bearings are available in cylindrical, flange, or flat-strip form. **Circle No. 705**

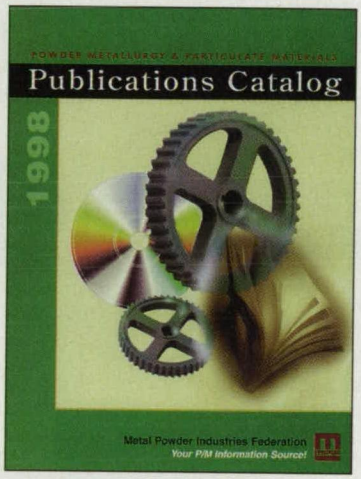


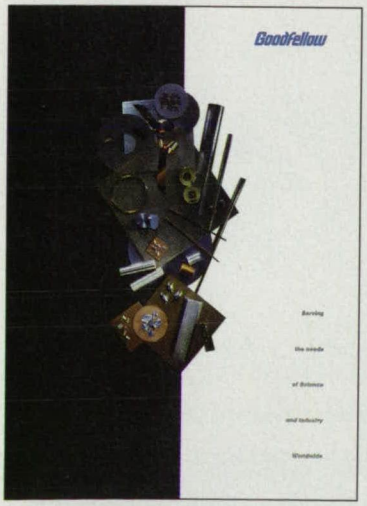
Linear Motion Products

A linear motion design guide from Nook Industries, Cleveland, OH, incorporates design guides for the ActionJac™, PowerAc™, PowerAc Plus™, PowerTrac™, and PowerTrax™ mechanical jacks, electric cylinders, acme and ball screw products, linear slide systems, and linear components. **Circle No. 706**

Powder Metallurgy

A 16-page catalog from the Metal Powder Industries Federation (MPIF), Princeton, NJ, lists print and electronic materials published or distributed by the MPIF. Included are proceedings of international conferences; textbooks and manuals; lectures; new standards; educational videos; and electronic products. Topics include particulate materials, cutting tools, tungsten and refractory metals, ferrous powder metallurgy, and cemented carbides. **Circle No. 707**





Metals and Materials

Goodfellow Corp., Berwyn, PA, offers a CD-ROM catalog accompanied by a 24-page product-selection and availability guide. Materials include a variety of metals and alloys, ceramics, polymers, compounds and intermetallics, and composites. Product description tables provide generic and brand names, forms in which materials are available, and sizes available. **Circle No. 708**

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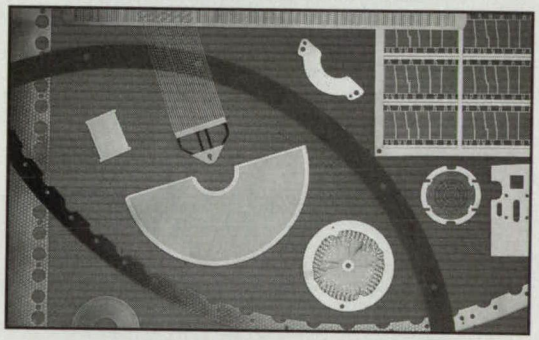

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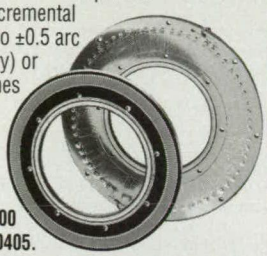

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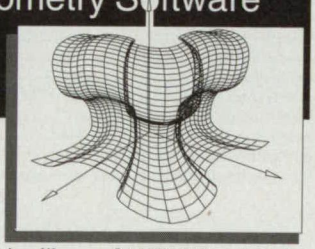

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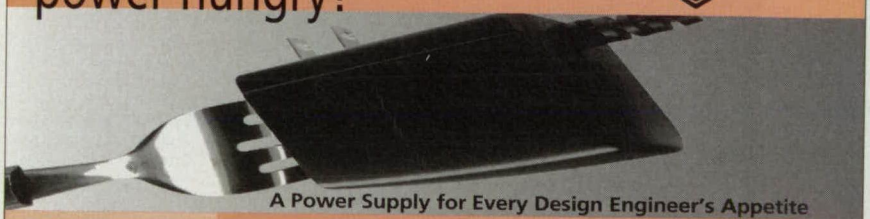

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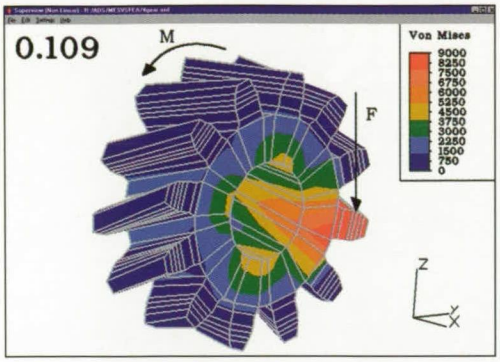
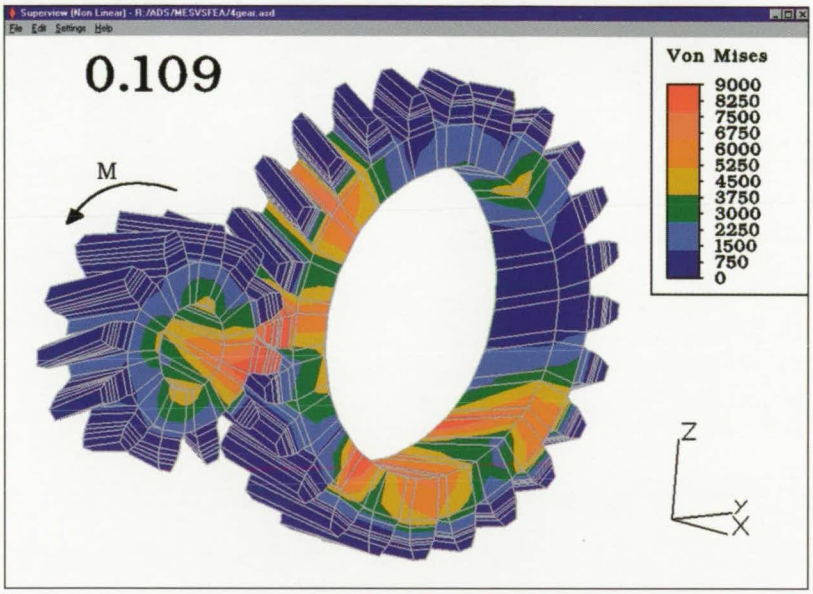
FEA: Old vs. New



In Linear Static Stress Analysis, the forces must sum to zero. The effect of the second gear is simulated by an assumed force or pressure at a single instant in time.



In Algor's Mechanical Event Simulation, the forces sum to Mass times Acceleration (F=MA). Impact forces are transmitted through actual contact between the teeth during gear acceleration.

Old:

In traditional linear static stress analysis, you begin by building an FEA model. Then you set up boundary conditions to anchor the model in three-dimensional space.

If the boundary conditions fail to stop the model from moving in all six primary directions (three degrees of freedom in translation and three in rotation), the static FEA process cannot work. After setting up the boundary conditions, you then apply the moment (M) or torque, which could be generated by an electric motor, and an assumed force (F) or pressure to simulate the reaction of the second gear. After analysis you will have a stress contour for one point in time.

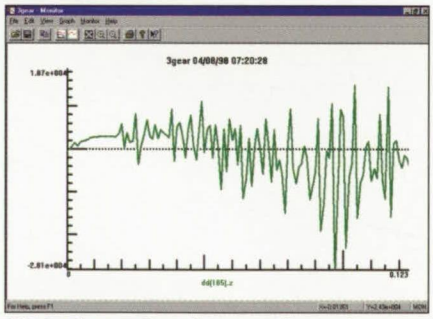
Because the gear teeth are constantly clashing in a random way, the impact forces cannot be known with any precision.

New:

In Algor's Mechanical Event Simulation, you begin the same way by building an FEA model. However, this time you include the second gear.

You place boundary conditions at the pivots. The big gear is free to rotate when forced by the driving gear. Inertia of the entire gear system resists the force of the motor.

When the analysis runs, you will know it's set up properly when you see the gears accelerating and stresses changing as you view the live on-screen "monitor program."



Plot of acceleration vs. time shows high-frequency impacts.

At the end, you see the stresses on all the gear teeth at every point in time.

And, you can make an analysis replay to see the results in real time or slow motion. In addition, you can run a Fast Fourier Transform on the displacement data to highlight any dangers from resonance.

See an analysis replay of this Mechanical Event Simulation at www.algor.com, or contact Algor, Inc. for the latest CD-ROM information/demo pack.

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