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News Briefs

General Developments

Inquiries about News Briefs, where no contact person is identified, should be referred to the Managing Editor, Journal of Research, National Institute of Standards and Technology, Building 416, Room 119, Gaithersburg, MD 20899-0001; telephone: 301/975-3572.

"ELECTRONIC EYE" IMPROVES ACCURACY IN LIGHTING

A new device developed at NIST is giving the lighting industry its most accurate measure of brightness ever. This "electronic eye" is twice as accurate as the lighting standard it replaces, explains a NIST physicist. NIST scientists are using the electronic eye to maintain the candela, the international base unit for measuring light. The electronic eye—a photometer with a green filter (to measure brightness), a silicon photodiode (to direct current flow as determined by illumination) and an electronic circuit for signal processing—has an aperture that works much the same way as the human iris. This new candela standard will help the lighting industry meet new light bulb labeling requirements for brightness, energy efficiency, and color rendering. It also will help ensure proper illumination for vehicle control displays. With the electronic eye, NIST has shifted from a light source to a light detector as a primary standard. Although manufacturers can still purchase standard bulbs from NIST, they now can send their own detectors to NIST for on-site calibration. For more information on calibrations, contact the NIST Radiometric Physics Division, A221 Physics Building, Gaithersburg, MD 20899-0001, (301) 975-3216.

NAVY REVIEW POINTS WAY TO IMPROVED CMM PRACTICES

Coordinate measuring machines are state-of-the-art inspection tools for measuring the three-dimensional geometries of manufactured parts and assemblies of parts. A NIST survey of how CMMs are used in U.S. Navy manufacturing facilities identifies 11 high-priority issues that are key to improving CMM applications and quality assurance practices in the production of high-precision parts for weapons systems. The review of 22 Navy in-house and contractor-run production facilities found a significant portion of CMMs to be underutilized or used improperly—a problem also reported in studies of other industries. An estimated 20 000 machines are found in factories and laboratories worldwide. Areas warranting the Navy's attention include: integration of CMM inspection into design and manufacturing; calibrations and interim tests of CMM performance; effects of temperature, humidity and other environmental influences on CMM measurements; measurement methods for assuring the dimensional accuracy of large parts and assemblies; increased measurement throughput and flexibility; and improved understanding of measurement uncertainty and error budgets. The review by NIST researchers was commissioned by the Navy's Manufacturing Technology Program. Single copies of U.S. Navy Coordinate Measuring Machines: A Study of Needs (NISTIR 5379) are available from David Stieren, B113 Metrology Building, NIST, Gaithersburg, MD 20899-0001; (301) 975-3197; fax: (301) 869-0822, e-mail: dstieren@enh.nist.gov (via Internet).

STANDARD TO FOCUS ON TURNING CENTER PERFORMANCE

For prospective buyers of turning centers, determining how one machine tool stacks up against another can be as futile as comparing apples and oranges. That's because there are no agreed-upon methods for comparing the performance—especially the accuracy and repeatability—of different turning centers or, for that matter, periodically assessing the capabilities of machines already on the

shop floor. A solution is in the offing. In an effort partially supported by NIST, a committee of the American Society of Mechanical Engineers (ASME) has turned its attention to developing performance evaluation standards for turning centers. The emerging standard will build on a set of prescribed procedures for testing machining-center performance developed by the same committee and issued as an ASME standard in 1993. That standard, adopted by a growing number of machine tool users, incorporates many practical tests developed or validated at NIST. NIST researchers are now working with industrial collaborators to modify existing testing methods and devices or develop new ones tailored specifically to turning centers. For more information, contact Denver Lovett (who chairs the ASME Technical Committee on Machining and Turning Centers), Room 142 Shops Building, NIST, Gaithersburg, MD 20899-0001, (301) 975-3503, e-mail: lov@micf.nist.gov (via Internet).

ACCREDITATION FOR CALIBRATION LABS ANNOUNCED

The National Voluntary Laboratory Accreditation Program at NIST now will accept applications from calibration labs seeking accreditation to perform calibration services based on compatibility with international standards. The program will help manufacturers, exporters, testing labs and others to gain acceptance of U.S. calibration and test results between countries to avoid barriers to trade. NVLAP programs are operated in conformance with ISO/IEC Guide 58: 1993—Calibration and Testing Laboratory Accreditation System-General Requirements for Operation and Recognition. Accreditation is available to commercial labs; manufacturer's in-house labs; university labs; and federal, state and local government facilities. Foreign-based labs also may be accredited if they meet the same requirements as domestic labs and pay any additional fees required for travel expenses. To obtain an application package or for further information, contact James L. Cigler, program manager, NVLAP, A162 TRF Building, NIST, Gaithersburg, MD 20899-0001, (301) 975-4016, fax: (301) 926-2884.

1994 NVLAP PROGRAM DIRECTORY AVAILABLE

Manufacturers and governments are requiring laboratory accreditation as a key element in the acceptance of products in domestic and international markets. Recent revisions to procedures for the National Voluntary Laboratory Accreditation Program, administered by NIST, have made them fully compatible with the international standards (ISO/IEC Guides 58 and 25) used by other accreditation systems. The National Voluntary Laboratory Accreditation Program 1994 Directory (NIST Special Publication 810) lists more than 700 domestic and foreign laboratories that are accredited by NVLAP as of January 1994. The labs are listed alphabetically, by field of testing and by state. For a copy of SP 810 (1994 edition), send a self-addressed mailing label to: NVLAP, A162 TRF Building, NIST, Gaithersburg, MD 20899, (301) 975-4016, fax: (301) 926-2884.

EXAMINERS NEEDED FOR 1995 BALDRIGE AWARD

NIST is seeking applicants to serve on the 1995 board of examiners for the Malcolm Baldrige National Quality Award. Applicants for the board must be experts in quality management and capable of evaluating large and small manufacturing and service businesses. In addition, quality experts from the health care and education communities are needed to participate in a pilot program. NIST currently is working to adapt the Baldrige criteria and award program for these communities. Those selected for the board must take part in a three-day preparation course based on the award criteria and examination process. In addition, examiners are expected to spend 10 days or more reviewing applications, preparing feedback reports to applicants and, in some cases, participating in site visits. The Board of Examiners currently has 260 quality experts. Applications to serve on the 1995 board will be available in September from the Malcolm Baldrige National Quality Award Office, A537 Administration Building, NIST, Gaithersburg, MD 20899-0001, (301) 975-2036, fax: (301) 948-3716, e-mail: oqp@micf.nist.gov (via Internet). Examiner applications are due Nov. 1, 1994.

ATP PROJECT DEVELOPS WORLD'S BRIGHTEST GREEN LED

A private company, working with the Department of Physics at North Carolina State University (NCSU), has announced the development of a new, extremely bright, LED (light-emitting diode) with peak wavelengths in the pure green region of the spectrum. In work supported by the NIST Advanced Technology Program, the private company

combined its technology for producing high-quality crystals of pure zinc-selenide with novel fabrication techniques developed at NCSU to build LEDs that are estimated to be more than 50 times brighter than commercial green LEDs. Moreover, the company's LED, which is brightest around 510 nm, is significantly more "green" than existing commercial diodes (at about 555 nm), which have a pronounced yellowish cast. The ATP project is aimed at developing improved technologies for producing blue and green light microsources—among the hardest colors to achieve, but important for building full-color displays and in optical data systems. Researchers at the private company and NCSU now are attacking the problem of device degradation. With useful lifetimes of several hundred to 1000 h, the current LEDs are significant improvements on the state of the art but still degrade too quickly for commercial use. The company also hopes to modify the technology to produce true green/blue laser diodes.

WANT TO TRAP CESIUM ATOMS? USE MICROWAVES

Physicists at the National Institute of Standards and Technology and Harvard University have demonstrated for the first time that a cloud of atoms can be held at a temperature near absolute zero with microwaves. This experiment, reported in the May 16, 1994 Physical Review Letters, brings scientists one step closer to observing an exotic phase transition known as Bose-Einstein (or just Bose) condensation. Bose condensation is related to other macroscopic quantum phenomena such as superfluidity and superconductivity. In theory, certain atoms will condense into an unusual gas as the temperature approaches absolute zero. In such an ideal Bose condensed gas, a large number of atoms would have essentially no velocity. The microwave trap holds a small cloud of cesium atoms at a few microkelvins above absolute zero (-273 °C). In the experiments at NIST, scientists first used intersecting laser beams to slow and cool the cesium atoms in a vacuum chamber. Then the lasers were shut off, and microwave radiation plus a magnetic field held the atoms in place. Trapping atoms with microwaves offers physicists an edge in their quest to observe Bose condensation. The newly demonstrated trap has the advantage that unlike previous traps, it can, in principle, hold atoms in their lowest energy spin-state. This would increase the stability of the gas, making Bose condensation easier to obtain. As a next step, the researchers plan to test the microwave trap on hydrogen atoms at Harvard.

UNITED STATES HARMONIZES STANDARDS WITH UKRAINE

To enhance trade between the United States and Ukraine, NIST and the State Committee of Ukraine for Standardization, Metrology, and Certification (known as DERJSTANDART) have signed a memorandum of understanding on scientific and technical cooperation to remove nontariff trade barriers between the two countries. The MOU was completed on May 28, 1994, at the first informal meeting of the U.S./Ukraine Standards Working Group in Kiev. It recognizes the growing importance of the harmonization of standards and conformity assessment measures to improve international trade. For information, contact the Office of Standards Services, A603 Administration Building, NIST, Gaithersburg, MD 20899-0001, (301) 975-4000, fax: (301) 963-2871.

NETWORK FOR NEW YORK MANUFACTURERS EXPANDED

U.S. Commerce Secretary Ronald H. Brown announced a cooperative agreement with the state of New York on June 17, 1994, that officially launched the New York Manufacturing Extension Partnership. Headquartered at the Rensselaer Technology Park in Troy, NY, the New York MEP is the result of four recent awards from the Technology Reinvestment Project (TRP), the federal government's program to provide funds for dual-use (military and civilian) technology development, deployment and utilization. The TRP awards to New York State were used to expand the extension services provided by the former Northeast Manufacturing Technology Center, one of seven original MTCs established by NIST. Specifically, the expansion includes the operation of four regional New York MEP centers in New York City, Fishkill, Endicott and Amherst. The New York MEP, operated by the New York State Science and Technology Foundation, is affiliated with NIST's Manufacturing Extension Partnership. It is one of 28 extension programs funded through the TRP, bringing the current number of centers in the national MEP to 35. For more information on the New York MEP, contact Jeanne Selmer, New York

MEP, 385 Jordan Rd., Troy, NY 12180-8347, (518) 283-1010, e-mail: jeanne_selmer@mailgate.nemtc.itn.org (via Internet).

PAPER DETAILS CALIBRATION SYSTEM FOR POWER METERS

Using tunable laser diodes, NIST has developed a new method to calibrate optical power meters, the most common type of test equipment used in the optical fiber industry. This system is in addition to the existing one which NIST has used for years to calibrate optical power meters at fixed wavelengths using both collimated beam and fiber/connector configurations. To minimize measurement errors associated with the source wavelength and detector spectral responsitivity, NIST has installed tunable laser sources in the measurement system. With this system, optical power meters can be calibrated both at a particular source wavelength or over the range of wavelengths of the tunable laser diode. For a paper explaining the new system in detail, contact Sarabeth Moynihan, Div. 104, NIST, Boulder, CO 80303-3328, (303) 497-7765, e-mail: moynihan@bldrdoc.gov (via Internet).

NIST REPORTS ON METRIC, THE FEDS AND INDUSTRY

Most U.S. firms that do business abroad are predominantly metric because of global sourcing of parts, service, components, and production. A new report from NIST, A Metric for Success (NISTIR 5425), states, "The metric system cannot be avoided in international trade and commerce. It will be interesting to see how long the United States can hold out against the worldwide use of the International System of Units (known as SI), the modern metric system. What is even more curious is why would the world's leading industrial nation want to resist using a world standard?" The report discusses the worldwide metric momentum, inefficiencies and benefits, and emphasizes that "metric equals standardization." Also discussed is the role of the Commerce Department and NIST in the national transition to the metric system. A chronology of metric in U.S. history is included for reference. Copies of NISTIR 5425 are available from the Metric Program, A146 TRF Building, NIST, Gaithersburg, MD 20899-0001, (301) 975-3690, fax: (301) 948-1416.

ADVANCES IN FIBER OPTIC SENSORS FEATURED IN PAPER

Fiber optic sensors often have been used for measuring magnetic fields and electric current. These polarimetric sensors incorporate the Faraday effect whereby the plane of polarization of a light beam is rotated by a magnetic field. A recent paper highlights NIST research on the use of diamagnetic glasses and iron garnets as sensor materials. One part describes how the Faraday effect in glass (silica) can be used to make inexpensive current sensors from optical fiber. The sensor is formed by looping a single-mode optical fiber around a conductor. Current sensors using this fiber are approaching commercial availability for use in the electric power industry. The paper also describes NIST research using iron garnets, a class of ferromagnetic materials, for high-sensitivity magnetic field and electric current sensors. NIST has developed two current sensors employing iron garnets, and it expects additional materials research will result in iron garnet compositions specifically tailored for magneto-optic sensing applications. For a copy of technical paper 29-94, contact Sarabeth Moynihan, Div. 104, NIST, Boulder, CO 80303-3328, (303) 497-7765, e-mail: moynihan@bldrdoc.gov (via Internet).

BALDRIGE AWARD PROGRAM TRAINS PILOT HEALTHCARE AND EDUCATION EVALUATORS

The Malcolm Baldrige National Quality Award Program has just completed the training of its initial 44 pilot evaluators for education and healthcare. These pilot evaluators were trained using case study material developed for the 1994 Baldrige Award Board of Examiners and using case item material developed specifically for healthcare and educational institutions. Pilot evaluators will use the lessons they learned during training to assess healthcare and educational institution case studies. These case studies, together with evaluation notes and a sample feedback report (such as a Baldrige applicant would receive) will be made available to the public in the fall of 1994. It is hoped that the case study material will both educate healthcare and education institutions on use of the Baldrige Criteria in quality management assessment of their institutions, and also provide a learning opportunity by disseminating some current leading practices through the content of the case studies.

In 1995, full-scale pilot efforts are planned in healthcare and education. Organizations will be invited to submit applications; the applications will receive full review, with feedback to the applicants on their strengths and areas for improvement. Since this will be a learning activity for both the Baldrige Program and applicant organizations, no awards will be presented in the 1995 cycle. Subsequent to the pilot effort, a decision will be made on next steps for implementation of new award categories in healthcare and education.

NVLAP PROCEDURES

The Federal Register, Vol. 59, No. 84 of Tuesday, May 3, 1994, announced the final rule making changes to regulations pertaining to the operation of the National Voluntary Laboratory Accreditation Program (NVLAP). The NVLAP procedures are redesignated as Part 285 of Title 15 of the Code of Federal Regulations.

These procedures have been expanded to include accreditation of calibration laboratories; updated to achieve compatibility with conformance assurance and assessment concepts; modified to ensure consistency with relevant International Organization for Standardization documents; and revised to facilitate and promote acceptance of calibration and test results between countries to avoid barriers to trade.

The revised procedures will foster cooperation among laboratories and with other bodies, and establish the basis for bilateral and multilateral agreements.

NEW DIGITAL BRIDGE TO PROVIDE NIST CUSTOMERS IMPROVED IMPEDANCE SERVICES

NIST scientists have designed, developed, and fabricated a digital impedance bridge that will permit NIST to offer improved impedance services in response to customers' needs when it is put on line later this year. Commercial impedance bridges are used to make critical, practical measurements of component parameters; electronic circuits providing advanced performance, together with reduced size of components, make these measurements more difficult and more critical. Standards that will be calibrated by the new digital impedance bridge will in turn be used to calibrate commercial bridges and their ancillary equipment. Until the new bridge is in service, NIST is forced to rely on a venerable Maxwell-Wien bridge as the basis for its low-frequency impedance services. The new bridge measures two- or three-terminal impedances with precisions of 200 to 2000×10^{-6} depending on the measurement frequency in the range 20 kHz to 100 kHz, the magnitude of the impedance, and the nature of the transfer standard. The automated character of the bridge makes it highly flexible, and many more data points can be taken than were practical before.

The result is that customers will be able to get a comprehensive analysis of the performance of the transfer standards they submit, including information on drift and on frequency dependence. Other advantages of the digital bridge are that it offers more flexible scaling through its sampling system and it can be calibrated with "unlike" standards, i.e., calibration of a capacitive transfer standard at a given frequency does not require use of a standard capacitor but could use a standard resistor at that frequency. NIST scientists also have developed a special probe intended for calibrating inductors. The probe consists of a number of programmable ac resistors, each of which can be switch-selected so as to be within a few centimeters of the terminals of a standard inductor to minimize the effect of parasitic impedances. The inductor is compared to the appropriate probe resistor by equalizing the currents through both, using the bridge and its control software. The voltage across the inductor and the probe resistor is then digitized and the data are processed using a four-parameter sine fit to determine the phase and amplitude of each signal.

NIST HELPS MANUFACTURER INVESTIGATE TACKY SPOTS FOUND ON PARKING AREAS OF HARD DISKS

In a recent collaboration with a major U.S. manufacturer of computer disk drives, a NIST scientist applied a method known as lateral force microscopy to help the company investigate the presence of micrometer-sized sticky or tacky features on the surface of a hard disk. The possibility of these features occurring on any part of the surface of a disk where the read/write heads can be positioned interferes with the design goal of reducing head flying height, an essential requirement as the areal bit storage density increases in advanced magnetic media. Flying heights already are well below 100 nm. The features are micrometers in extent and 20 nm to 30 nm high, comparable to the

disk peak surface roughness of about 20 nm and therefore difficult to image by such common methods as optical or electron-beam microscopy. To the naked eye, the features appear as a dull ring coinciding with the area where the heads are parked.

The scientist's work shows that morphology and friction can be correlated using lateral force microscopy to identify sources of increased friction. The lateral force microscope is a derivative of the atomic force microscope, which can achieve atomic resolution. In the atomic force microscope, a small cantilever having an integral tip is scanned over the surface of a specimen, and deflections up and down are plotted to provide a topographic map. Servoing arrangements maintain the force between tip and specimen surface nearly constant. In lateral force microscopy, the tip is scanned over the specimen perpendicular to the long axis of the cantilever. When a variation of friction between the tip and specimen surface is encountered, the cantilever twists slightly. It is this twisting that is plotted as a function of tip position. Collaboration is continuing with the disk drive manufacturer regarding the source and chemical composition of the sticky features.

OPERATION OF SNS JUNCTION FOR VOLTAGE STANDARD DEMONSTRATED AT 38 K

NIST scientists recently carried out an experiment that serves as a proof-of-principle demonstration for the operation of superconductor-normal-superconductor junctions for voltage standards at elevated temperatures, near 40 K. This temperature can be reached with closed-cycle refrigeration systems and does not require liquid helium as a cryogen. Although potentially offering uncertainties of parts in 10^{10}, Josephson-Junction voltage array standards have found limited acceptance in industry even where their capabilities would be advantageous because they require liquid helium for cooling to near 4 K. As an original inventor and developer of the array standards, NIST is investigating approaches that would increase their utility.

As part of this work, the division team fabricated a single yttrium/barium/copper oxide step-edge junction with a gold barrier and illuminated it with 62 GHz electromagnetic radiation. When they measured the current-voltage characteristic, they found the amplitude of the first quantized voltage step to be 1 mA at 38 K, a value large enough to show that the junction could operate at elevated temperatures without being limited by thermal noise. The results of this experiment were not consistent with predictions of the commonly used resistively shunted junction model, and a NIST scientist formulated a new long-junction model that provided a better understanding of the results. The theoretical understanding coupled with the empirical results offer optimism that the proposed rapidly programmable array can be implemented. The next experiment will be to demonstrate operation of a junction over a ground plane; following that, methods for reliably fabricating literally tens of thousands of nearly uniform junctions will need to be developed (not necessarily at NIST) to result in a practical device. The work is described in a submission to Applied Physics Letters.

CRADA ESTABLISHED WITH PRIVATE COMPANY TO EVALUATE NEW CALIBRATION TECHNIQUE AND THERMAL TRANSFER INSTRUMENT

NIST scientists are working with a private company to evaluate the high-voltage (100 V to 1000 V) performance of a new automated thermal transfer instrument, Model TRS-104, and to verify the innovative step-up techniques recommended by the manufacturer for characterization at those voltages. A cooperative research and development agreement (CRADA) has been established for these purposes.

The project will involve the exchange of well-characterized thermal converters to be used by the private company to study the performance of the new instrument and the impact of the new step-up technique. Although the philosophy underlying the step-up technique is well established, the company's staff believes that its new method will permit customers to minimize the number of calibration points required to calibrate the instrument. The CRADA will enable the company to determine if such an approach is feasible. In the course of this project, NIST staff will re-examine the techniques used to calibrate NIST working standards used for ac-dc difference measurements at high voltages; reassess the performance of the NIST high-voltage range resistors; and perform extended measurements on the company instruments. This effort is expected to yield improvements in NIST services as well as a means of verification for the new instrumentation.

This is the fourth CRADA undertaken by NIST in the past 5 years to evaluate the performance of state-of-the-art instrumentation in this critical measurement area. Such agreements familiarize NIST staff with the characteristics of instruments and standards soon to be on the market and help industry market superior products.

NII CHALLENGES ADDRESSED IN WORKSHOP

NIST recently co-sponsored a Workshop on Advanced Digital Video in the National Information Infrastructure (NII). The wide range of applications that are proposed for NII—including marketing, manufacturing, medicine, education, and entertainment—impose varying and complex demands on the NII, including capabilities and flexibilities that are not available in existing computer or television systems, and are exciting intense interest in how the NII develops. In response, the organizers of the workshop provided a forum for defining a vision of the role of digital video within the NII, identifying the architectural, scaling, and performance issues in realizing this vision, and recommending the research, experiments, and steps to be taken to resolve these issues. Experts in information services, broadcasting, computing, consumer electronics, and government policy broke up into groups to focus on architectural considerations, modular decomposition, interoperability, display performance, image capture and display requirements, and digital delivery service.

A full report of the workshop is being prepared for publication. A feature of the workshop was a demonstration of the proponent high-definition television systems that were incorporated into the Grand Alliance proposal to the Federal Communications Commission for adoption as a broadcast standard in the United States.

PROJECT FOR IMPROVING PISTON TURNING MACHINES COMPLETED WITH SUCCESS

A collaborative project to improve piston turning machines for the automotive industry has been conducted for the past 13 months at NIST with industrial participants from automobile manufacturers, a machine tool builder, and the National Center for Manufacturing Sciences. NIST researchers characterized one of the new-generation piston turning machines loaned from the machine builder, modeled its thermal behavior, and generated software to predict the behavior during the actual cutting operation.

At the end of the development phase, NIST researchers carried out several days of testing on the shop floor, cutting aluminum piston billets over 6 h periods. In an attempt to simulate actual production conditions, certain environmental conditions were varied and production stoppages corresponding to plant coffee breaks and lunch hours were incorporated into test periods. Results showed up to five times improvement in the accuracies of the billets machined with NIST thermal compensation technology as compared with those machined without it.

NEW, POWERFUL THEORY FOR ELECTRON-IMPACT IONIZATION CROSS SECTIONS

In collaboration with the University of Nebraska-Lincoln, a NIST scientist has developed a new, powerful theory that predicts electron-impact ionization cross sections, needed for modeling and understanding the interaction of electron beams with gases, liquids, and solids. This new theory is expected to provide sorely needed ionization cross sections for applications in plasma processing, radiation damage monitoring, fusion device design, and in basic atomic and molecular physics.

The theory, using readily available atomic and molecular data, produces cross sections that agree with known experimental results within 5% to 10% from threshold to several keV in incident energy. The theory has been verified successfully for light atoms, ions, neon, and hydrogen and water molecules. The theory is being applied to angular distributions of ejected electrons and proton-impact ionization cross sections. Preliminary results on angular distributions are very promising too. When utmost accuracy is not required, ionization cross sections based on a simpler version of this new theory can be calculated using a PC program such as LOTUS-123.

LABORATORY SPECTRA OF A STRATOSPHERIC CHLORINE RESERVOIR MOLECULE OBTAINED

The chlorine nitrate ($ClONO_2$) molecule serves an important role in the stratospheric chlorine cycle. It is formed in darkness by the reaction of chlorine

monoxide with nitrogen dioxide, and the chlorine removed by this reaction is thus prevented from reaction with the stratospheric ozone. During daylight hours, however, it is photolyzed back to its original components. It is sometimes referred to as a chlorine reservoir. The concentration of stratospheric chlorine nitrate is monitored using infrared spectrometers usually carried on balloon or aircraft flights.

Previous laboratory studies of chlorine nitrate were unable to resolve the rotational fine structure of the infrared bands, which is obscured by several very low frequency vibrational states. In order to model the temperature dependence (and, therefore, shape) of the observed stratospheric chlorine nitrate infrared bands, it is necessary to know the energy levels and transition probabilities of each band used for concentration monitoring.

In collaboration with a private company, NIST scientists have obtained completely resolved spectra of $ClNO_3$ using a newly constructed pulsed nozzle molecular beam apparatus coupled with a diode laser spectrometer. The resulting cooling obtained as the molecular beam passes into a vacuum greatly simplifies the spectrum by removing the lines originating in vibrational states. The $ClNO_3$ band centered at 1292.5 cm^{-1}, one of the IR bands used for remote sensing, has been completely resolved at a beam temperature of 25 K and with spectral resolution of 0.001 cm^{-1} or better. With this molecular information, models are being developed to predict the spectrum of this band at stratospheric temperatures in order to improve the monitoring accuracy.

NIST COMMISSIONS MEDICAL AND INDUSTRIAL RADIATION FACILITY

NIST has installed an electron accelerator as the heart of a new user facility for the medical and industrial radiation communities. The Medical & Industrial Radiation Facility (MIRF) is based on an rf-powered, traveling-wave electron linac (linear accelerator) donated by the Radiation Therapy Center of Yale University-New Haven Hospital. The accelerator provides electron energies from 7 MeV to 32 MeV at an average beam current of up to 0.1 mA.

Medical linacs are used for treating 500 000 cancer patients annually in 1300 treatment facilities in the United States. The medical dosimetry applications of the MIRF relate to development and testing of instruments and dosimetry systems for use in the clinical facilities. The MIRF also offers unique opportunities for industrial research and a number of companies and consortia have expressed interest. Other accelerator applications currently under investigation include electron-beam treatment of waste water (University of Maryland), curing of polymer composites (Oak Ridge National Laboratory), radiation effects on electronics (University of Maryland), and use of the accelerator for production of channeling radiation and coherent bremsstrahlung (Catholic University and George Washington University).

IMPROVED TIME SCALE RELIABILITY

NIST scientists have substantially enhanced the reliability of the NIST time scale through development of completely redundant clock measurement systems. Two identical measurement systems, controlled by independent PCs, observe the same physical clocks and both run independent copies of the AT1 time scale. Both drive independent microsteppers to provide redundant physical realizations of UTC (NIST) in real time. One system is used as the official output, but the other can be switched into service should there be any failure of the primary system. The dual systems also are being used to study the performance of the AT1 algorithm in general and especially its robustness in the presence of measurement noise.

This work provides the basis for operational changes in the division's long-range plan. First, these systems will facilitate replacing all of the large computers with arrays of relatively cheap PCs. In addition to reducing maintenance costs, such a network (combined with GPS receivers) could facilitate widespread sharing of data and network-based dissemination of UTC (NIST) at very high accuracy. The development of dual measurement systems also provides the basis for moving the time scale when building and remodeling begins on the site. The longer term objective is to separate (at geographically different locations on the site) two groups of clocks with their independent measurement systems. These two clock systems would be interconnected, but the physical separation would guard against time-scale disruption by a catastrophe such as a major fire.

MECHANISM OF MATERIAL REMOVAL IN MACHINING OF CERAMICS

Grinding with diamond wheels is the most prevalent method of machining of advanced ceramics. In this machining method, material is removed by the individual diamond particles producing a series of parallel grooves on the machined surface. Existing models are based on the assumption that material removal occurs by the formation and propagation of cracks below the surface of each groove. These models have been developed for amorphous materials and, therefore, are not suitable for polycrystalline ceramics.

Recent research results at NIST obtained as part of the Ceramic Machining Consortium have shown that material removal in polycrystalline ceramics, e.g., aluminum oxide, occurs by three processes: (1) microfracture and chipping within grains; (2) intergranular fracture and grain dislodgement; and (3) removal of large segments by formation and propagation of subsurface cracks. The influence of each process depends on the load applied to the diamond particle and the microstructure of the ceramic. The researchers have found that the present models describing the material removal process as propagation of subsurface cracks are adequate for machining of fine-grained ceramics under large loads, but, under normal grinding conditions, the other microfracture processes provide a more accurate description of the removal process. These results provide new insights into the basic mechanisms of material removal and the specific role of ceramic microstructure, as well as the design of ceramics with improved machinability, thereby reducing the cost of machining.

MOLECULAR DYNAMICS OF ALTERNATIVE REFRIGERANTS

The importance of the development of alternative refrigerants to CFCs (chlorofluorocarbons) is highlighted by the looming Jan. 1, 1996 ban on CFC productions. For compressors in home refrigerators and auto air-conditioning systems, the chosen replacement is the hydrofluorocarbon (HFC) 134a (F_3C-CFH_2). Although an enormous effort has been given to the development of the HFCs, there is still much to be learned of the properties, chemistry, and interactions of these molecules.

A recent collaborative research effort has been initiated between scientists at NIST, and a private company, to investigate by neutron-scattering techniques the bonding state and molecular dynamics of HFC 134a and its isomer HFC 134 (HF_2C-CF_2H), encaged in the cavities of zeolite molecular sieves. Several neutron-scattering techniques are being combined with complimentary methods, such as infrared, Raman, and NMR, to obtain a better understanding of the guest-host interactions, bonding geometry and reorientational dynamics of the adsorbed HFCs 134 and 134a. The insight gained from this collaborative research effort is directed toward the development of improved methods for the separation and storage of the moleeular isomers 134a and 134, both of which are formed during industrial production of 134a.

SECRETARY OF COMMERCE APPROVES DIGITAL SIGNATURE STANDARD AS FEDERAL INFORMATION PROCESSING STANDARD (FIPS)

The Federal Register of May 19 announced that the Secretary of Commerce has approved the Digital Signature Standard (DSS) as FIPS 186. To be effective in 6 months, the DSS provides the capability to generate digital signatures that cannot be forged. This capability is needed by federal government agencies to carry out their responsibilities for electronic exchanges and to improve government operations through the use of information technology.

NIST AND THE U.S. NUCLEAR REGULATORY AGENCY (NRC) COLLABORATE ON NUCLEAR SAFETY

NIST Special Publication 500-216, Proccedings of the Digital Systems Reliability and Nuclear Safety Workshop, presents the results of a workshop held September 13–14, 1993, in Rockville, MD. The NRC, in cooperation with NIST, conducted the workshop to provide a forum for the exchange of information among experts within the nuclear industry and experts from other industries, regulators, and academia. Topics covered a broad range of safety issues such as areas where current software engineering practices may be inadequate for safety-critical systems, methods for reducing risk in such systems, and research directions in the use of digital systems in nuclear power plants.

NEW PUBLICATION PRESENTS PROCEEDINGS OF TEXT RETRIEVAL CONFERENCE

NIST Special Publication 500-215, The Second Text REtrieval Conference (TREC-2), constitutes

the proceedings of this symposium held at NIST August 31–September 2, 1993. Co-sponsored by NIST and the Advanced Research Projects Agency, the conference was the second in an ongoing series of workshops to evaluate new technologies in text retrieval. The event was attended by 150 people involved in the 31 participating groups composed of industry, academia, and government researchers.

The goal of the conference was to bring together research groups to discuss their retrieval results using a large test collection. Attendees reported on a wide variety of retrieval techniques, including methods using automatic thesauri, sophisticated term weighting, natural language techniques, relevance feedback, and advanced pattern matching. As results had been analyzed with a common evaluation package, groups compared the effectiveness of different techniques and discussed how differences between the systems affected performance.

DISTRIBUTED SUPERCOMPUTING SOFTWARE SUBJECT OF NEW REPORT

NISTIR 5381, Distributed Supercomputing Software: Experiences with the Parallel Virtual Machine—PVM, focuses on defining the profile requirements culminating from NIST's assessment of the Parallel Virtual Machine (PVM). Developed by researchers at the Oak Ridge National Laboratory and Emory University, PVM is a distributed system consisting of a portable suite of software designed for use by parallel and supercomputing application engineers. NIST researchers are studying PVM to assist them in defining the system service requirements needed to support parallel programming and supercomputing activities in the general-purpose distributed setting.

FIRST CUSTOMER USES NEW CALIBRATION SERVICE

A step-gage calibration done for a private company inaugurated a pilot measurement program offered by NIST at the Y-12 facility at the Department of Energy Oak Ridge Centers for Manufacturing Technology. The calibration was performed on Y-12's M-60 large-volume, high-accuracy coordinate measuring machine. The new service leverages NIST's measurement expertise and Y-12's specialized equipment, enabling the two organizations to respond to a previously unmet measurement need voiced by automobile, aircraft and heavy-equipment manufacturers. Under the arrangement, NIST metrologists supervise calibrations of end standards and step gauges up to 1.35 m long, and issue a calibration report. Manufacturers use these standards to verify the accuracy of their own measurement machines. Previously, U.S. companies were forced to obtain such services from foreign measurement laboratories. In terms of accuracy, cost and turnaround time, the new domestic calibration service tops the performance of the best foreign supplier, which has been benchmarked by NIST. For more information, contact David Stieren, B113 Metrology Building, NIST, Gaithersburg, MD 20899-0001, (301) 975-3197, e-mail: dstieren@enh.nist.gov (via Internet).

NEW THERMOCOUPLE CAN "TAKE THE HEAT"

A NIST researcher has invented a class of materials for thin-film thermocouples that allows measurement of temperature changes up to 1200 °C in microsecond increments. Made with molybdenum silicide or titanium silicide, the NIST thermocouples can measure temperature changes in hostile environments such as inside diesel or jet engines. Widely used fine-wire thermocouples have much slower response rates (tenths of seconds). More advanced thin-film platinum/rhodium thermocouples have microsecond response rates but deteriorate at 700 °C to 900 °C. The patented NIST materials are made with a thin, outer layer of heat-resistant silicon dioxide that protects an electrically conducting molybdenum or titanium silicide layer and a pure silicon layer underneath. Temperature changes cause proportional changes in voltage in the silicide layer. For more information, contact Kenneth Kreider, A303 Physics Building, NIST, Gaithersburg, MD 20899-0001, (301) 975-2619, e-mail: kkreid@enh.nist.gov (via Internet).

MOTIONLESS REFRIGERATOR LIQUEFIES NATURAL GAS

A new cooperative research and development agreement between NIST and a private company aims to apply refrigeration technology developed by NIST and Los Alamos National Laboratory to the task of liquefying natural gas. NIST and LANL scientists invented the thermoacoustically driven orifice pulse tube refrigerator (or TADOPTR), which has no moving parts, contains tubes of helium gas and is capable of producing a temperature of 112 K. The helium gas is repeatedly compressed and expanded with sound waves rather than with a mechanical compressor as in most conventional cooling systems. The company has obtained the development license as well as the exclusive license to the patents through LANL.

The NIST and LANL scientists will assist the company in upscaling the TADOPTR into two versions that will be manufactured, tested and marketed by the company. The first will liquefy 1900 L of natural gas per day, while the second will increase that output to 38 000 L/d. The cost of TADOPTR liquefaction plants will be very economical, with liquefaction taking place on-site and eliminating transportation costs. This means TADOPTRs may help in areas removed from natural gas pipelines and in the production of natural gas to fuel the "clean-car" vehicles of the future. For more information, contact Ray Radebaugh at Div. 836.02, NIST, Boulder, CO 80303-3323, (303) 497-3710.

CONSORTIUM SEEKS MORE PREDICTABLE PAINTS

Private companies and the Federal Highway Administration have joined NIST in a cooperative research and development consortium to help get new, highly predictable paint products more quickly to market. Because of health and environmental concerns, the chemical makeup and manufacturing processes for making paints have changed tremendously over the past decade. Unlike older paints, new formulas do not have a well-established history of performance. Also, reliable methods of predicting performance have not kept pace with the changes. As a result, potential problems with painted products could cost manufacturers millions of dollars to repair. The consortium's goal is to find a better way to predict the service life of paint. It is expected to last 3 years. For further information contact Jonathan Martin, B348 Building Research Building, NIST, Gaithersburg, MD 20899-0001, (301) 975-6717.

NIST, CHILE TO COLLABORATE ON ANALYTICAL METHODS

Chilean and American scientists are collaborating to improve techniques for analyzing environmental samples and advanced materials. A new international agreement between NIST and Chile's Commission of Nuclear Energy will expand the analytical capabilities of both institutes. An early goal of the joint program is to develop and apply two neutron beam analytical methods. Scientists at NIST will help the Chileans develop instruments for neutron depth profiling and prompt gamma neutron activation analysis. These techniques offer advantages over other methods in that they do not destroy samples. Chilean scientists will provide NIST with advanced materials samples, such as lithium-based superconductors and ceramics, for analysis and comparison of results. Following the nuclear methods work, the collaboration could be extended to other analytical methods, such as electrochemistry and mass spectrometry.

VIRTUAL REALITY TESTBED UNDER WAY

Virtual reality allows a user to interact with a simulated environment as though it were real. Among its many applications is the ability to realistically practice jobs that are too dangerous, too expensive or impossible to carry out for real. Private companies are using virtual reality techniques to help factory workers fabricate complex wiring assemblies, to test visibility from construction equipment before it is built or to study improved methods of automobile assembly. To enhance the usability and further the development of virtual reality technology, NIST has established an Open Virtual Reality Testbed. The testbed, which includes prototype virtual reality systems, was set up to encourage the development of standard interfaces so that component virtual reality systems from different vendors are interoperable. A description and sample demonstration of testbed activities is available online through the World Wide Web at http://nemo.ncsl.nist.gov/-sressler/OVRThome.html. For more information, contact Sandy Ressler, B266 Technology Building, NIST, Gaithersburg, MD 20899-0001, (301) 975-3549, e-mail: sressler@oops.ncsl.nist.gov (via Internet).

"FARSIGHTED" DETECTOR SEES MORE INFRARED

Night vision goggles that detect infrared radiation are a common feature in spy thrillers. But seeing in the far infrared (longer wavelength infrared radiation) has proved more difficult. Now NIST researchers have developed a detector sensitive enough to do the job. The detector consists of an antenna and strip of superconducting material built into an integrated circuit. The circuit is cooled to 90 K, the material's superconducting transition temperature. Even tiny amounts of far infrared radiation collected by the antenna heat the superconductor near its transition point causing relatively large changes in electrical resistance. The device is twice as sensitive and responds 1000 times faster than other nitrogen-cooled thermal detectors. Arrays of the new detectors could be useful for atmospheric studies. For more information, contact Joseph Rice at B208 Physics Building, NIST, Gaithersburg, MD 20899-0001, (301) 975-2133.

JOINT OPTOELECTRONICS AGREEMENT NOW IN PLACE

The United States and Japan have agreed on the last critical step before realization of a joint program to further the design and development of the advanced computing technologies integrating optical and electronic components. The agreement was reached at a recent meeting between two Japanese organizations, the Ministry of International Trade and Industry and the Real World Computing Partnership, and five U.S. agencies. It establishes the process for funding a "broker" through which the Joint Optoelectronics Project will be carried out in the United States. The broker is a service that links designers of advanced computer systems dependent on optoelectronic devices and modules with suppliers of such components in research and development divisions of companies in both countries. Each country will have its own broker, but suppliers in both nations will be available to Japanese and American designers. According to the agreement, NIST will oversee the selection of the broker in the United States. The two brokers will cooperate to bring together designers of innovative, advanced computer systems and fabricators of optoelectronic components, allowing the designers to evaluate their ideas by manufacturing experimental prototypes.

SOFTWARE "BUILDS" PROCESS CONTROL SYSTEMS

New NIST-developed software shows promise as a tool for rapid prototyping of manufacturing control systems. Developed as part of a NIST-led consortium, the software was used successfully to design and operate the control system for a laboratory-scale process for making metal powders. The Expert Control System Shell, or ECSS, features a rule-based expert system to assist designers and a graphical user interface resembling a control panel. Designers can choose from among on-screen versions of push buttons, toggle switches, slide controls and other types of actuators. User-interface options for displaying process data include dials, charts and graphs. The control system can be operated manually or under the full or partial command of the expert system. If the designer chooses, the overall control system can be partitioned into a series of concurrently running modules that synchronize their activities by swapping electronic messages. Data also are logged for post-process analyses as well as for simulations of process changes. A NIST computer scientist who is the ECSS designer suggests that with further refinement and field testing, the software could be used to build control system architectures for other types of dynamic manufacturing processes as well as be adapted to other computer platforms. For more information on ECSS, contact Steve Osella at A127 Metrology Building, NIST, Gaithersburg, MD 20899-0001, (301) 975-4263, e-mail: osella@cme.nist.gov (via Internet).

DEMO PUTS INTEROPERABILITY TO THE TEST

A group of computer networking equipment makers have shown that the Integrated Services Digital Network could be used to link their products and provide communication between diverse applications. The multicompany hookup used the Point-to-Point Protocol running over an ISDN basic rate interface B-channel to demonstrate interoperable, local- and wide-area-network connectivity at a recent meeting of the North American ISDN Users' Forum, or NIUF, held at NIST. PPP is a set of protocols developed by the Internet Engineering Task Force that allows dissimilar LAN connection equipment to negotiate quickly which features and protocols will be supported by both ends of a network connection. As part of the demonstration, vendors and end users accessed Internet, read their electronic mail and sent files back home. Interoperability, a key component of the National Information Infrastructure, will enable rapid expansion of telecommuting, remote Internet access and connection with branch offices. Seven vendors from the United States, Canada and Europe participated in the demonstration. For technical information, contact Jeff Fritz of the NIUF's Enterprise Network Data Interconnectivity Family on (304) 293-2060 or jfritz@wvnvm.wvnet.edu (via Internet).

CRADA PARTNERS SEEK BETTER-BEHAVED VAV SYSTEMS

An air-delivery system known as variable air volume, or VAV, can save energy dollars by delivering just the right amount of air to areas of a building that need it. But outdated and complex control strategies for VAV systems are creating problems such as control instability, poor air quality, and inadequate humidity control and ventilation supply. Now, NIST and a private company are teaming under a cooperative research and development agreement to help improve the control and operation of VAV systems. Using a special NIST

laboratory that contains a VAV air-handling system, researchers from NIST and the company will evaluate currently used control methods, then develop and test alternative control techniques and strategies. Also, various methods for detecting and diagnosing faults on-line will be explored. The CRADA project is expected to end in April 1996. For more information, contact George Kelly, B114 Building Research Building, NIST, Gaithersburg, MD 20899-0001, (301) 975-5870, e-mail: gekelly@enh.nist.gov (via Internet), or John Seem, Johnson Controls Inc., 507 E. Michigan St., Milwaukee, Wis. 53201, (414) 274-4677.

LUNAR REFLECTOR WORKS THROUGH SILVER ANNIVERSARY

One of the space program's longest-running experiments—and one with a NIST connection—celebrated its 25th anniversary in July by continuing to return data. During their pioneering moon landing on July 20, 1969, the Apollo 11 astronauts set up a laser reflector to make precise measurements of the distance between the Earth and moon. The still-operational experimental station reflects a powerful laser pulse aimed at it from telescopes on Earth. By measuring how long the pulse takes to return to Earth (the round trip takes about 2.5 s), scientists have defined the Earth-moon distance to within 2.5 cm. The reflector was designed primarily by a NIST scientist at the Joint Institute for Laboratory Astrophysics, operated cooperatively by NIST and the University of Colorado. It consists of a briefcase-sized aluminum panel studded with 100 corner reflectors (the corners of precision-ground glass cubes that have been cut off at 45 degree angles), each about 3.8 cm across. When a ray of light enters the cut-off surface, it is internally reflected from the three sides of the corner, exits the cut-off surface parallel to its entry path and then returns to its source. The same principle is used in bicycle reflectors. The Apollo 14 and 15 missions delivered two other reflectors, including one with 300 cube corners. All three reflectors are targeted almost nightly by scientists at observatories in Texas and France.

NIST TO COOPERATE WITH ARGENTINA AND ECUADOR

In order to provide a mechanism for scientific and technical cooperation in chemistry, physics, and engineering measurement sciences, NIST recently signed a Memoranda of Understanding with the National Institute for Industrial Technology of the Secretary of Industries, Argentine Republic; the Secretariat of Science and Technology, Argentine Republic; and the Ecuadorian Institute of Standardization, Republic of Ecuador. These memoranda will provide a framework for the exchange of scientific and technical knowledge, services, and the augmentation of scientific and technical capabilities. The agreements will be effective immediately for a period of 5 years.

NIST DATA CLARIFIES MODEL FOR TIME-DEPENDENT DIELECTRIC BREAKDOWN

A NIST scientist has carried out work that appears to resolve the choice of competing models for predicting voltage breakdown in integrated circuits. For devices to be reliable, silicon dioxide insulator layers on integrated circuit chips must resist voltage breakdown through years of normal use, and device designers need to be able to estimate this performance. The reliability of oxide layers can be predicted by subjecting the devices to high-voltage stress at elevated temperatures and extrapolating device failure rates to voltages and temperatures at which the devices would normally be used. Calculations of expected device failure times from the time-dependent dielectric breakdown (TDDB) data depend on the model chosen for performing the extrapolation. Until recently, two models contended for calculating t_{50} from the TDDB data, where t_{50} is the time at which half of the devices would have failed. One model assumed that t_{50} was depended on reciprocal electric field; the other model assumed a linear dependence on electric field.

The scientist realized that if he could heat his specimen devices to temperatures higher than those normally used in this type of stress testing, he could reduce the electric field to values much nearer those actually encountered by devices in normal use. At the same time, by using lower fields, he could avoid failures from breakdown mechanisms that occur at high fields but that are not likely to apply in normal device operation. Accordingly, the NIST scientist used a specially designed wafer chuck to stress his specimens at temperatures as high as 698 K (425 °C). The resulting low-field data revealed a linear dependence of t_{50} on electric field. The field dependence of data taken at higher electric fields can not be clearly distinguished; either the linear or reciprocal field dependence can be used to describe the data. The scientist presented these results in a paper on TDDB at the recent International Reliability Physics Symposium.

UNCERTAINTIES IDENTIFIED FOR RADAR CROSS-SECTION MEASUREMENTS

In a study of major government facilities, NIST scientists have identified significant sources of measurement uncertainties encountered in both static and dynamic radar cross-section ranges. Radar cross section is a parameter that defines how easy it is to detect the presence of an object illuminated by a radar beam for a given orientation of the object with respect to the beam. Radar cross-section measurements are used to determine the stealthy performance of aircraft and missiles and other military vehicles; they are now becoming of interest for civilian applications, including air traffic control, highway traffic control, and shipping operations. The division team developed methods for estimating component uncertainties and for combining these into an overall uncertainty budget.

The goal was to provide a reasonable and uniform methodology for evaluating radar cross-section measurements that can be used for both indoor and outdoor test ranges to produce compatible estimates of uncertainty. A benefit of the process is that uncertainty estimation identifies sources of error on which attention needs to be concentrated to improve measurement quality. The team studied and compared alternative methods of estimating uncertainties. The overall uncertainty budget for a specific measurement was developed as a hierarchy of uncertainty budget tables, where the lower-level tables provide the details that are summarized in the upper-level tables. A spreadsheet computer program was developed to facilitate the construction of such a hierarchy of uncertainty tables. A thorough analysis of measurement uncertainty is a first step in the development and implementation of a program for certifying radar cross-section ranges. Additional details can be found in a report Proposed Uncertainty Analysis for RCS Measurements (NISTIR 5019).

METHOD FOR ASSESSING ACCURACY OF ON-WAFER MICROWAVE MEASUREMENTS BENEFITS INDUSTRY IN NIST VISITS

NIST researchers in collaboration with the NIST/Industrial MMIC Measurement Consortium, have developed a method for experimentally determining the accuracy of on-wafer measurements when performed using commercially available instrumentation in industrial environments. On-wafer measurements play a critical role in the design of monolithic microwave integrated circuits (MMICs). On-wafer measurements also have reduced test costs and thereby significantly reduced the total cost of MMICs making them cost effective in commercial applications such as personnel communications, wireless networks, and intelligent highway vehicles. Heretofore, the industry lacked adequate methods of evaluating the accuracy of on-wafer measurements.

Beginning in July 1993, NIST researchers began testing the verification method at industrial sites to determine its effectiveness in quantifying measurement errors. Over the following 9 months, they tested the method at several locations comparing actual measurement errors to bounds on those errors predicted by the NIST-developed verification method. The results showed that the technique effectively revealed errors in the industrial measurements. These errors were sometimes as large as 30%, large enough to frustrate the design process and lead to increased cost. The magnitudes of the errors were so large and the experiments so convincing that several participants have been prompted to adopt entirely new calibration procedures. The results of the verification method were also useful in diagnosing the causes of the calibration errors. This ability to pinpoint the source of calibration failure turned out to be an extremely important aid to engineers who otherwise would have had no guidance in how to correct such problems. The NIST team has begun to explore ways of establishing the method as an industry standard.

MONOLITHIC SINGLE-FREQUENCY SOLID-STATE WAVEGUIDE LASER DEMONSTRATED

Working in collaboration with a researcher at a University and with a CRADA partner, NIST scientists have demonstrated a monolithic single-frequency solid-state waveguide laser. This development will have important ramifications for metrology since the rare-earth doped glass waveguide laser is extremely stable with respect to thermally induced wavelength drift and optical feedback that plagues typical semiconductor lasers. Furthermore, the waveguide laser, because of its centimeter-scale size, is more thermally and more mechanically stable than a similarly doped optical fiber laser. These attributes show the potential for applications of the new device as both stable reference standards and stable sources.

The waveguide laser is forced to operate in a single longitudinal mode by virtue of a distributed-Bragg reflector grating that was photolithographically formed on the surface of the waveguide. The

laser was fabricated in a special neodymium-doped phosphate glass that was developed in collaboration with a private company. The device is distinctive since it demonstrates single-frequency laser action is possible in a range of approximately 20 nm around the fluorescence peak at 1052 nm. The waveguide geometry is compatible with optical fibers. This aspect of the device could be important since many new local-area network fiber optic communication systems are envisioned to operate in this wavelength band. Work is also under way to demonstrate similar results in erbium-doped glass operating around the traditional telecommunication wavelength of 1544 nm. Initial results indicate that it now should be possible to fabricate arrays of lasers that operate at identical or displaced wavelengths.

NIST SOFTWARE SIMPLIFYING RESISTIVITY DETERMINATION IN DEMAND

A NIST scientist has developed and published a collection of computer programs for calculating resistivity profiles of semiconductor wafers from measurements of their spreading resistance or four-probe resistance. There has been considerable interest in the NIST package, called RESPAC; several U.S. semiconductor companies have requested it. Resistivity is the most important property for specifying semiconductor material and for evaluating its suitability for use in integrated circuits, power devices, or other applications. The NIST scientist's set of 10 FORTRAN77 programs incorporate simplified routines for the necessary mathematical operations and are suitable for use on a personal computer or workstation. NIST SP 400-91, Semiconductor Measurement Technology: A Collection of Computer Programs for Two-Probe (Spreading) Resistance and Four-Probe Resistance, documents the software and supplies background material to enable the reader to use it in an optimal manner.

FIRST DIRECT MEASUREMENTS DEMONSTRATE LOW-NOISE PERFORMANCE POTENTIAL OF HIGH-TEMPERATURE JOSEPHSON JUNCTIONS

Two NIST scientists have made the first direct measurements of the microwave-frequency noise of Josephson junctions made from high-critical-temperature superconductor material. Using yttrium/barium/copper oxide step-edge junctions developed in previous work and an ultralow-noise 1 GHz measurement system, they have measured (for the lowest-noise device) a maximum available noise temperature of 32 K ± 2 K at a physical temperature of 4.3 K. The peak noise temperature is in good agreement with published simulations of the ideal resistively shunted junction model. The results imply that such junctions are capable of noise performance in millimeter-wave and terahertz detection and mixing applications that approach the fundamental quantum mechanical limits.

WORKSHOP ON TESTING STRATEGIES TRANSFERS NIST METHODOLOGY TO INDUSTRY FOR ANALOG AND MIXED-SIGNAL PRODUCTS

NIST scientists hosted and presented the third workshop on Testing Strategies for Analog and Mixed-Signal Products at NIST in June to transfer NIST-developed methodology to industry. Efficient testing is an essential ingredient for competitive manufacturing of electronic products. In some cases, the testing cost can approach and even exceed the original manufacturing cost. For the past several years, NIST has conducted a program to develop widely applicable analytical tools that can lead to reduction in the number of test-point measurements and at the same time an improved prediction of the performance of the item under test. Participants were introduced to these tools and a comprehensive framework for developing and implementing efficient tests for analog and mixed-signal devices and instruments. For many of these products it is not physically or economically feasible to perform exhaustive testing. Therefore, test engineers must formulate abbreviated strategies that are economical to execute but still yield accurate measures of overall performance.

The attendees represented diverse application interests, ranging from down-hole instrumentation (such as used in oil exploration) to the testing of pacemakers, to the testing of two-dimensional, charge-coupled device arrays. The agenda consisted of tutorial material on matrix algebra, lectures on the theory of a mathematical procedure known as QR factorization and test point selection, and the development of accurate device error models using physical, a priori, and empirical approaches. Participants were given hands-on training in the use of a commercial software product to implement the matrix operations needed to develop a given testing strategy. Specific examples were presented on how to apply the NIST-developed methods to the problem of opti-

mizing the testing of data converters (analog-to-digital and digital-to-analog) and other mixed-signal devices, as well as the testing of instruments such as multirange ac-dc transfer standards.

ATP AND PED SPONSORS WORKSHOP ON ELECTRON BEAM MODELING

Accurate electron beam modeling is primary to the development of standards for both microanalysis and linewidth metrology. A NIST workshop on "Electron Beam Interaction Modeling for Metrology and Microanalysis in the Scanning Electron Microscope," the first of its kind, was held during the SCANNING 94/SouthEast Electron Microscopy Society (SEEMS) 94 Meeting May 17–20 in Charleston, SC. The NIST workshop was truly international with attendees coming from Japan, Europe, and Russia.

The workshop included four segments: modeling and its relationship to microanalysis, theoretical aspects of electron beam interaction modeling, modeling and its relationship to metrology, and a discussion and functional workshop session. During that session, a modeling round robin was agreed upon based on two defined standard structures, one for microanalysis and the other for dimensional metrology. During both afternoon laboratory sessions, participants demonstrated their own modeling programs. The output from this recent workshop will be archived in a special issue of SCANNING to be published in late 1994 or 1995. It is planned that the results of the round robin and any further work will be reported at a similar workshop in 1995.

NIST HOSTS WORKSHOP ON ADVANCED MACHINE TOOL STRUCTURES RESEARCH

NIST held a Workshop on Advanced Machine Tool Structures Research on April 29, 1994 to discuss issues related to the development of a new class of machine tools with parallel kinematics. Machine tools in which actuators work in parallel to produce tool or part motions—similar to the operation of Stewart platform flight simulators—promise many advantages over conventional machine tools. These include an expected order-of-magnitude increase in stiffness and accuracy, large acceleration capability, lower part production cost, and a full six axes of motion. An Advanced Machine Tool Structures Testbed (AMTST) is currently being established at NIST to identify and extend the limits of capability of these new machines. A primary objective of the workshop was to explore possibilities for using this testbed for joint research projects with industry. Approximately 40 attendees from industry, government, and academia participated in the workshop.

A NIST scientist presented the research activities planned for the NIST AMTST. The primary research objectives are to:

- adapt current performance evaluation procedures to this new class of machine tools;
- investigate high-accuracy metrology systems for parallel machine tools;
- examine the use of microactuation to enable extremely precise motions; and
- advance the state of the art in open architecture machine tool controllers as applied to parallel machines.

The characteristics of two experimental prototype parallel machines currently being developed by private industry were presented. The precision machining of titanium jet engine rotors as an application that could benefit from the stiffness and multiaxis machining capability of a parallel machine was discussed. Five additional speakers described research work and programs related to parallel machines.

A great deal of interest was expressed by the workshop attendees in participating in the research to be carried out in the AMTST. In the afternoon, there was discussion of the possible modes of interaction and participation. These ranged from supplying example test parts to be machined to more formal arrangements such as sending guest researchers and setting up cooperative research and development agreements. Attendees were encouraged to submit ideas and proposals for cooperative research in the AMTST to NIST.

BODY DIMENSIONS FOR APPAREL

Anthropometric data and apparel sizing is an important component of apparel quality. Apparel can not be top quality unless it fits consumers satisfactorily. In the United States, current sizing standards rely on body-measurement data that were gathered by the U.S. Department of Agriculture during the late 1930s. Changes are needed to accurately represent today's U.S. population. A NIST scientist has published a report entitled "Body Dimensions for Apparel." The report represents a preliminary set of body dimensions that are necessary in the manufacturing and fitting of apparel. It is the result of a comparison of five

body-measurement reports, including documents on national and international apparel sizing standards. The author expects that the information in the report will contribute to future body-measurement surveys as well as the development of new or improved sizing standards. In addition, access to anthropometric databases is expected to be an integral component of emerging technology for apparel design engineering.

In recent years, NIST has been developing the apparel product data exchange standard (APDES). The Defense Logistics Agency (DLA) is sponsoring the APDES project to extend the emerging international Standards for the Exchange of Product Model Data (STEP) to include apparel product data. This work is part of a larger DLA program to improve apparel manufacturing technology. These extensions will lay the groundwork for computer integration of the apparel product life cycle, and it will enable clothing manufacturers to reap the benefits of standardized product data representation. The report of body dimensions will serve as input for developing APDES.

HIGH-FIDELITY SENSOR

In past years, NIST has developed a high-fidelity sensor to measure dynamic material displacement in solids. Theoretical modeling work has provided a firm foundation for the interpretation of the sensor output from various excitation sources on plate structures. The sensor includes a conical-shaped piezoelectric ceramic for point pick-up of a surface displacement and is known as the "NBS conical transducer." The ceramic provides an effective coupling to metals, which possess a comparable acoustic impedance equal to the product of material density and sound speed. A calibration facility for acoustic emission (AE) technology in the kilohertz to megahertz frequency range has been implemented based on this research. Industry's application of this technology includes the monitoring of pressure vessel and aircraft structures for incipient material failure.

Recently, a parallel effort has shown promise for the development of a high-fidelity AE sensor that is applicable to polymeric materials, which have an acoustic impedance very different from that for metals. This particular sensor is designed with a polyvinyl diflouride piezoelectric film, attached to a plastic cone tip, to provide the displacement-voltage transduction. A potential application is for the general assessment of composite material quality and specifically for the bond integrity in multilayered structures.

COLLABORATION WITH HUNGARY'S NATIONAL OFFICE OF MEASURES

Scientists from Hungary's National Office of Measures (OMH) visited NIST recently to continue their collaborative research in pH and electrolytic conductivity under the auspices of the U.S./Hungary Science and Technology Program.

NIST and Hungary scientists conducted intercomparisons of the pH buffer standards that serve as the respective national standards for this important and ubiquitous analytical measurement. Under particular evaluation during this visit was sodium borate or borax, which is the buffer material for pH measurements around pH 9. These pH 9 measurements are important for the treatment of industrial boiler water. This material exhibits some unexplained liquid junction potential effects that may be related to impurities in the material.

Additional studies were initiated on standards for low-level electrolytic conductivity measurements critical to power plants, the pharmaceutical industry, and other users of high-purity water. Two different approaches have been adopted by NIST and OMH; NIST choosing potassium chloride or benzoic acid in an alcohol-water mixture, and OMH choosing dilute solutions of boric acid. These studies involved the comparison of data for the accuracy, reliability, stability, and compatibility of the two approaches. The goals of this program are international comparability and global harmonization of the standards for the measurements of pH and conductivity.

NEUTRON INTERFEROMETRY FACILITY OPERATIONAL

One of the results from modern quantum physics is that the elementary constituents of matter behave not only as particles but also as waves. This wave-particle duality means that elementary particles can exhibit interference effects analogous to those observed with light. Interference with light has been understood for centuries and is now widely used as a technological tool. Interference with "matter waves" is an emerging tool with great promise in both fundamental and applied science.

Its development and application is the thrust of the NIST Neutron Interferometry Facility, which recently became operational at the NIST Cold Neutron Research Facility. In this neutron interferometer, a beam of low-energy neutrons is coherently split and recombined by near-perfect crystals of silicon, just as a light beam can be split and recombined by partially reflecting mirrors. The interferometry facility employs a number of novel techniques to obtain the high degree of noise reduction (acoustic, vibrational, and thermal) required for these sensitive measurements. Particularly noteworthy is a stabilization system that maintains the position of a 41 metric ton, vibrationally isolated mass within ± 1 μm and ± 1 s of arc for operating periods of weeks to months. Interferograms taken at the new facility show phase contrast of up to 70% and phase stability of better than one degree per day. These characteristics, which represent considerable improvements on previous installations, will allow a variety of new investigations to be pursued.

The ionizing radiation research program at the NIST Neutron Interferometry Facility will include fundamental metrology studies and a variety of materials science studies. One very promising avenue of research is the application of neutron phase topography for the investigation of hydrogen and hydrogenous impurities in metals and other media. The NIST Neutron Interferometry Facility will be opened as a national user facility in 1995; proposals for time allocation are already being considered.

HIGH MAGNETIZATION ADVANCED MAGNETIC NANOCOMPOSITES

A cooperative research and development agreement (CRADA) between NIST and a private company has resulted in the improved engineering of magnetic nanocomposites comprised of a high concentration of 5 nm diameter γ-Fe_2O_3 clusters finely dispersed in a polymer resin. These materials, prepared by the ionic exchange of Fe ions with protons inside the polymer, can be designed to be superparamagnetic at room temperature and thereby possess a high magnetization without remanence. Since the CRADA was signed a year ago, this collaboration has enabled the private company to optimize the processing of these nanocomposites, resulting in an increase in the saturation magnetization of the ferrofluid version of the superparamagnetic material by a factor of 2. This ferrofluid version now possesses magnetization values approaching 17 $A \cdot m^2/kg$, i.e., 15% larger than that possessed by common magnetic fluids. These materials are particularly attractive as advanced toner materials, new generation magnetic refrigerants, high-density magnetic recording media, and high-sensitivity indicators in medical diagnostics.

DEVELOPMENT OF NEW STANDARDS FOR THE CONTINUOUS STEEL STRIP INDUSTRY

Electrogalvanized steel for automobile body panels has become one of the steel industry's major products. Because of this, a great deal of effort has been focused on improving the quality of the coated sheets and reducing manufacturing costs. One of the primary ways the industry can accomplish this is through on-line monitoring of processing and coating parameters. In response to steel industry requests, NIST is developing new zinc on steel Standard Reference Materials for calibrating on-line coating thickness gauges.

Because plating processes vary from line-to-line, the basic goal of this development effort is to provide industry with a uniform, well-characterized zinc coating as a baseline for their thickness measurements. NIST researchers have been working closely with coated strip steel, automotive, and instrumentation manu- facturers to ensure a standard that will meet their needs for assessing manufacturing as well as performance capability.

Other applications for the zinc-coating thickness standard are calibration of laboratory x-ray fluorescence instruments and acceptance testing by end users of the electrogalvanized product.

IMPROVED ACCURACY IN QUANTITATIVE PHASE ANALYSIS

The accurate measurement of phase abundance by powder diffraction methods is important to a broad range of technologies. It has particular application to analyzing the polymorphs of silicon nitride and zirconia, two ceramic materials being developed for structural applications in automotive and aircraft engines. The Rietveld method, wherein the entire diffraction pattern is used for a refinement of crystallographic, microstructural, and instrument parameters, provides the most accurate and precise method of obtaining results from powder diffraction data.

Therefore, the Rietveld analysis of x-ray and neutron powder diffraction is being investigated at NIST, in collaboration with the Los Alamos National Laboratory, for use in certification of Standard Reference Materials (SRMs) for quantitative analysis.

The accuracy of a quantitative analysis can be considered in terms of an ability to match a calculated result from properly characterized specimens. Rigorous evaluations of the models used in the Rietveld code were possible by working with well-characterized samples prepared from SRMs and SRM-candidate materials. Several improved models were incorporated in the Rietveld code, the most notable of which concerned the contribution of thermal diffuse scattering to the background. Using the Rietveld method, the researchers have verified that SRM 676, an alumina powder, is phase pure to within 0.2% with 95% confidence. They also have certified SRM 656, for analysis of two polymorphs of silicon nitride, not only with respect to the crystalline phase composition but also to the amorphous content.

NONDESTRUCTIVE EVALUATION OF NATURAL GAS PIPELINES USING GAS-COUPLED ULTRASONICS

Collaborating with Southwest Research Institute (SWRI), NIST researchers have shown that it is feasible to use gas as a couplant for ultrasonic inspection of natural gas pipelines. In the past, the use of gas couplants was restricted to the transmission and pitch-catch geometries. The NIST/SWRI work demonstrates that such restrictions can be overcome so that the same transducer can be used to send and receive the probing ultrasonic signals at MHz frequencies. In addition to static tests using a specially designed apparatus at NIST, measurements were carried out in a flowing gas in a pipeline test facility at SWRI. The experimental data indicate that it may be feasible to adapt the basic NIST/SWRI method for in-service inspection of natural-gas pipelines for thickness gaging and flaw detection.

ADDITION TO NIST PROFICIENCY SAMPLE FACILITY DEDICATED

An addition to the Proficiency Sample Facility of the NIST Construction Materials Reference Laboratories (CMRL) was dedicated on May 18, 1994. CMRL is jointly sponsored by NIST, the American Society for Testing and Materials, and the American Association of State Highway and Transportation Officials. The addition was constructed to keep up with growing demand for proficiency samples of construction materials such as concrete, cement, soil, and asphalt. The CMRL supplies over 8000 samples annually to construction materials testing laboratories to help evaluate testing equipment and procedures. Construction of this facility at NIST is an excellent example of cooperation between the federal and state governments and private industry in promoting the quality of construction.

NIST DEVELOPS LARGE BUILDING INPUT FILES FOR MULTIZONE INDOOR AIR QUALITY MODEL

NIST has developed input files for the multizone airflow and indoor air quality model CONTAM88. These input files describe four large buildings: a 12-story multifamily residential building, a five-story mechanically ventilated office building with an atrium, a seven-story mechanically ventilated office building with an underground parking garage, and a one-story school building. The physical characteristics of each building and its idealization as a multizone airflow system are described. These input files enable a user to employ CONTAM88 (and the most recent version of the program CONTAM93) to study airflow and contaminant dispersal in large buildings without developing building idealizations and inputting them into the program. Results of selected computer simulations are presented to demonstrate the effects of wind speed, indoor-outdoor temperature difference, and the percentage of outdoor air intake in the supply air on building air change rates and interzonal airflows in these four buildings. The report describing these input files (NISTIR 5440, CONTAM88, Building Input Files for Multi-Zone Air Flow and Contaminant Dispersal Modeling) also contains an appendix with a database of building component air leakage values.

NIST CO-SPONSORS WORKSIIOP ON STANDARDS DEVELOPMENT AND THE NATIONAL INFORMATION INFRASTRUCTURE (NII)

On June 15–16, 1994 NIST, the Science, Technology and Public Policy Program at Harvard University, and the Technology Policy Working Group of the Information Infrastructure Task Force co-sponsored an invitational workshop on standards development and the evolving NII. NIST Director Arati Prabhakar and Lewis M. Branscomb, director of the Science, Technology and Public Policy Center for Science and International Affairs at Harvard, opened the workshop discussions. Prabhakar said that the Information Infrastructure Task Force is working in partnership with the private sector to set public goals for the NII and that the issue of standards is pervasive to every application area. Branscomb focused on the importance of standards

as components of the government's technology policy and the need to define the roles of government, industry, and other groups in standards development.

Workshop presenters and panelists discussed new praetices and new institutions in standards development, conceptualizing the standards process, the evolution of standards institutions, the role of the government, requirements for interoperability, and the impaet of intellectual property rights on standards development. James Burrows, CSL director, participated in a panel on standards policy and the NII. Papers presented at the workshop and position papers eontributed will be published and will also be available in electronic form.

SPECIFICATIONS OF AN ELECTRONIC RESEARCH NOTEBOOK FOR THE NIST SCIENTIFIC STAFF ISSUED

NISTIR 5395, Preliminary Functional Specifications of a Prototype Eleetronic Researeh Notebook for NIST, presents a study on the feasibility of using eleetronie researeh notebooks (ERNs) at NIST. The study team interviewed the NIST technical and scientific staff to survey eurrent notekeeping practiees and identify speeifie needs for the ERN. A set of basie and enhanced ERN features resulted from the survey; eurrent teehnologies and products were then assessed to see how requirements eould be met. The publieation eoneludes with a proposed system eonfiguration where functional specifications for a basie ERN are defined.

Standard Reference Data

PROTEIN DATABASE NOW INCLUDES NASA EXPERIMENTS

A newly expanded database on crystal growth conditions of biological macromolecules is now available to help the pharmaceutical and food industries improve medicines, vaccines, food products and other industrial processes. The NIST/NASA/CARB Biological Macromolecule Crystallization Database has been expanded to include the NASA Protein Crystal Growth Archive and data from international microgravity experiments. The database was developed by a NIST research ehemist and associate director of the Center for Advanced Research in Biotechnology. Version 3.0 of the Biological Macromolecule Crystallization Database includes data on more than 2000 crystal structures of 1500 biologieal macromolecules. Users can seareh for data by 20 different parameters, sueh as macromolecule name, crystal density, crystallization method and year reported. The expanded database is available for $415. To order the NIST/NASA/CARB Biological Macromolecule Crystallization Database, contact the NIST Standard Reference Data Program, A323 Physics Building, Gaithersburg, MD 20899-0001, (301) 975-2208, fax: (301) 926-0416, e-mail: srdata@enh.nist.gov (via Internet).