

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 820, Room 126, Gaithersburg, MD 20899-0001; telephone: 301/975-3572.

GUM ADOPTED AS AN AMERICAN NATIONAL STANDARD

The ISO (International Organization for Standardization) Guide to the Expression of Uncertainty in Measurement, commonly called the GUM, has been adopted officially by ANSI (American National Standards Institute) as an American National Standard. This adoption was the culmination of an effort begun over 2 years ago by writing group Z540-2 of the NCSL (National Conference of Standards Laboratories) Accredited Standards Committee on General Requirements for Calibration Laboratories and Measuring and Test Equipment, or Z540. The official designation of the new standard is ANSI/NCSL Z540-2-1997, and its full title is American National Standard for Expressing Uncertainty—U.S. Guide to the Expression of Uncertainty in Measurement.

The standard complements ANSI/NCSL Z540-1-1994, American National Standard for Calibration—Calibration Laboratories and Measuring and Test Equipment—General Requirements, which is the U.S. version of ISO Guide 25. Two NIST scientists contributed significantly to the work of the Z540 Writing Group that steered the GUM through the rather intricate ANSI standards-writing process. The Writing Group was chaired by a representative from private industry and consisted of a number of other representatives from industry.

The ISO GUM was first published by ISO in 1993 (corrected and reprinted, 1995) in the name of the seven international organizations that participated in its development: BIPM (Bureau International des Poids et

Mesures), IEC (International Electrotechnical Commission), IFCC (International Federation of Clinical Chemistry), ISO, IUPAC and IUPAP (International Union of Pure and Applied Chemistry and International Union of Pure and Applied Physics), and OIML (International Organization of Legal Metrology). The GUM has been adopted worldwide by national metrology institutes, regional metrology organizations, laboratory accreditation services, and industrial organizations. It is the basis for the NIST policy on expressing measurement uncertainty and NIST Technical Note 1297 entitled Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results. NCSL, which has broad representation from U.S. industry, adopted the basic principles of the GUM and TN 1297 in 1994 in its Recommended Practice R-12, Determining and Reporting Measurement Uncertainties.

As a consequence of the adoption of the GUM as an ANSI standard and the resulting availability of the GUM at a readily affordable price through the NCSL, it is expected that the method of expressing measurement uncertainty advocated by the GUM and NIST TN 1297 will find ever increasing acceptance and use, which has in fact been quite phenomenal. It exceeds by far the initial expectations of the ISO Working Group involved in the preparation of the GUM.

IEEE STANDARD DEFINITIONS FOR TIME AND FREQUENCY

NIST staff in Boulder, CO have played a key role in the revision of IEEE Standard 1139-1988, Standard Definitions of Physical Quantities for Fundamental Frequency and Time Metrology—Random Instabilities. The IEEE standards committee was led by a NIST scientist and included representatives from NIST, private companies, other Government agencies, and BIPM. This revision incorporates recent NIST work on improving the confidence interval for measurements that are a substantial portion of the data length and on quantifying the confidence intervals for fully overlapped measurements.

IEEE Standard 1139-1997 provides the basis for specifications and acceptance testing for clocks, oscillators, and a range of other equipment used in timing applications and low-phase-noise systems such as are encountered in telecommunications, navigation, and high-performance radar systems.

SMART TRANSDUCER INTERFACE FOR SENSORS AND ACTUATORS STANDARD APPROVED

The sensor and actuator business including MEMS is a multibillion dollar enterprise in the United States. The world sensor market is expected to grow to \$13 billion by the year 2000. With the emergence of the smart sensor, digital communication, and networking technology, sensor companies are gradually applying these technologies into their devices. Along the way, sensor producers are striving for a common communication interface for the devices. This standardized interface not only will solve the device compatibility problem but also will minimize the risk of technology investment and provide the opportunity for achieving “plug and play” interoperability between sensors and networks.

A NIST scientist has led his group working on the common interface effort. He has conducted collaborative development projects and performed demonstrations on the implementation of the smart transducer interface technology at more than six sensor conferences and exhibitions with industry partners. Under his chairmanship, members of IEEE TC-9 Committee have developed IEEE 1451.2, Standard for a Smart Transducer Interface for Sensors and Actuators—Transducer to Microprocessor Communication Protocols and Transducer Electronic Data Sheet (TEDS) Formats, which was recently approved by IEEE.

As a result of the collaborative effort, several companies now are producing or developing 1451.2-compatible products.

A private company is planning to develop a series of Ethernet network products that will communicate with 1451.2-compatible devices.

Another company has developed smart transducer interface module (STIM) prototypes based on 1451.2.

A sensor manufacturer, has developed prototype STIM to be integrated into its sensors and actuators.

A large sensor and network user has indicated it will adopt the 1451.2 standard interface for its flight test instrumentation system.

A large connector and sensor provider is cooperating with another company to develop prototype “STIM in a Connector.”

Sensors and actuators are used in a wide range of applications such as industrial automation, process

control, machinery monitoring and control, and patient monitoring in hospital settings. The standard provides a common interface between smart devices and field networks to ease the connectivity of transducers to control networks, instrumentation, data acquisition systems, and computers. It will provide smart device engineers with a common set of interface criteria they can use to design their products. This is expected to speed up the smart sensor product development cycle.

UNIVERSITY OF MARYLAND ENVIRONMENTAL DESIGN TEAM COLLABORATION

NIST helped the University of Maryland Environmental Design Team (UMEDT) win two first-place awards at the 7th Annual Environmental Design Competition as part of the 1997 Waste-Management Education and Research Consortium in Las Cruces, NM. Five University of Maryland (UM) students, a UM Professor, and a NIST scientist worked on a tank waste retrieval concept called the Non-Destructive Retrieval Arm and Deployment System (NORADS).

NORADS is a cable-driven unfolding manipulator concept that deploys tank waste characterization equipment and retrieval tools in waste storage tanks. The team built a 1 m static model of the NORADS arm and RoboCrane—with a moving platform—to demonstrate the system capabilities during the competition/exposition. Awards included engraved crystal plaques (being displayed at the University of Maryland), \$4000 for first place in the competition, and \$500 for Outstanding Technical Merit. The NORADS report written by the team includes: process selection and description; construction details of the prototypes; prototype and process testing; economic assessment and business plan; and legal, health, and regulatory considerations for the proposed system. This thorough package of information and the prototypes built provided UM and NIST with an understanding of the total problem and a first place award.

EXTENSIONS EXPAND CAPABILITY OF S-CHECK

S-Check augmentations now allow users to acquire the tool with either syntax-checking of C code or with a capacity to handle multilanguages without syntax-checking (variant S-Check ML). R&D Magazine selected S-Check(r), an advanced software performance improvement tool developed by NIST, as a R&D 100 Award Winner for 1997. The tool is available at <http://cmr.ncsl.nist.gov/scheck/scheck.html>.

S-Check is especially suited for improving code running on parallel systems, where component interactions are common but difficult to evaluate with conventional profiler tools. Displayed in color graphical formats, results from S-Check provide programmers with quantitative predictions on the effect of code improvements in their programs without actually requiring the changes to be made, saving a lot of time. With the added extensions, the tool is stable and mature for extended marketing to a wide variety of users.

NEW NIST TOOL WILL HELP INDUSTRY MEASURE EFFECTIVENESS OF SOFTWARE

A new web-based tool, The Effective Manager (EFFTool), will aid the information technology (IT) industry to collect fault and failure data during software development and maintenance and to manage those projects through the analysis of the data. The release of the tool was announced at a ribbon-cutting ceremony in November 1997. NIST developed the tool to encourage the IT industry to provide NIST with such data so that NIST may generate public profiles from a generic set of the data from across many application domains and projects. The profiles are expected to provide industry with the capability to measure the effectiveness of software development methods and tools.

NEW SYSTEM FOR POLARIZATION-DEPENDENT LOSS MEASUREMENTS DEVELOPED

NIST recently has developed an automated, high-resolution, polarization-dependent loss and gain measurement system to aid in the study of a variety of measurement methods upon which commercial instruments are based. Optical components often have different transmission coefficients for different polarizations of light. In advanced optical communication systems and optical fiber sensor arrays—systems that contain many components and in which the polarization may vary with time—this polarization-dependent loss (PDL) can lead to unexpected and unacceptable signal degradation. There are now several commercial instruments that measure PDL; some report resolutions as low as 0.001 dB (0.001 dB corresponds to a transmittance change of 0.023 %), but there is currently no independent method of determining the uncertainty of the measurements they provide. The new system is a fixed-polarization-states measurement system in which four well-defined polarization states are generated; the PDL of a component can be derived from its transmittance of these states. Voltage-controlled, liquid-crystal, variable

retarders are used to switch polarization states rapidly, avoiding drift, and permitting the use of synchronous detection to monitor the transmittance as the polarization is switched.

To determine the uncertainty of measurements provided by the new system, a NIST scientist compared measurements with theoretical predictions of the PDL of well-defined components and with measurements obtained with a commercial instrument based on an all-polarization-states method (a system that scans continuously through all possible polarization states). Using a rotatable glass cube to produce a variety of PDL values, he obtained a resolution of better than 0.001 dB and agreement with theoretically calculated values to within 2 %. Good agreement with the lower resolution commercial measurement system also was obtained. Using an angled optical fiber connector, agreement with the commercial instrument was within 0.003 dB, with the uncertainty apparently dominated by PDL in other fiber connectors in the system. These ongoing studies suggest that the new system may be capable of measurements of PDL with an expanded uncertainty of ± 0.002 dB, provided fiber connectors are not used. Fiber connectors appear to increase the uncertainty by approximately 0.004 dB. This work may lead to the development of a Standard Reference Material for PDL.

FIRST AC-DC TRANSFERS ACHIEVED AT CRYOGENIC TEMPERATURES

To investigate the feasibility of making ac-dc difference calibration-level measurements at cryogenic temperatures, a team of NIST researchers has developed a prototype superconducting temperature sensor and successfully demonstrated the operation of a thermal converter employing this sensor. Two NIST scientists successfully carried out preliminary ac-dc difference measurements made at close to liquid helium temperatures using the transition-edge sensor developed and fabricated by three other NIST scientists, demonstrating the feasibility of using these devices for both ac voltage and current measurements.

AC voltage is measured most accurately in terms of a known dc voltage by an ac-to-dc transfer process using thermal transfer standards with known ac-dc difference. The present U.S. national primary standards of ac-dc difference are a set of multijunction thermal converters (MJTCs) of various design and manufacture, which have been used for both voltage and current measurements for several decades. Although these standards have ac-dc difference of less than about 5×10^{-7} over a narrow frequency range, modern instrumentation is beginning to challenge the accuracy of these converters as primary standards. With the advent of thin-film multijunction

thermal converters (FMJTCs), having performance rivaling that of traditional wire MJTCs, a new generation of primary standards for ac-dc difference is required. Significant sources of error that limit the ultimate accuracy of thermal converters used for making precision ac-dc transfer measurements arise from Thomson and Peltier effects in the heater and lead structures of these devices. One way to minimize these errors is to work at cryogenic temperatures, where these errors become negligible.

In the experiment, the sensor chip was mounted together with a prototype converter on a temperature-controlled platform in a dewar. The cryogenic sensor depends upon the change in resistance of a niobium-titanium meander line fabricated on a silicon chip. The sensor is first cooled to its critical temperature (the point where the material becomes superconducting) of about 9 K. It then senses the difference in the heat generated by ac and dc signals conducted through an adjacent phosphor-bronze heater. Since the transition region of the sensor is only a few millikelvin wide, any change in the heating of the sensor will produce a significant change in the resistance of the sensor. By using a feedback heater on the same chip as the sensor, and monitoring the feedback voltage required to bring the sensor resistance back to its initial value, changes in the heating effect of the signal can be detected, and an ac-dc difference measurement is made.

NIST REPORT RELEASED ON POSSIBLE SUBSTITUTES FOR GLOBAL WARMING GAS

NIST researchers have thoroughly analyzed available physical and chemical data for a wide range of gases to determine the potential for each as replacement for sulfur hexafluoride (SF₆) and to determine the data needs to be met before a gas could be pronounced a suitable replacement. A report of this work has now been released, NIST Technical Note 1425, Gases for Electrical Insulation and Arc Interruption: Possible Present and Future Alternatives to Pure SF₆. Sulfur hexafluoride is a man-made gas that became commercially available in 1947. It exhibits many properties that make it suitable for use as a high-voltage insulator or arc interrupter in equipment used in the transmission and distribution of electric power. In fact, 80 % of all SF₆ produced in the world is used for electric power applications. Technological advances over the last 20 years have made SF₆ the preferred dielectric gas in circuit breakers, gas-insulated transformers, gas-insulated transmission lines, and gas-insulated substations. As a result of this increased usage, the concentration of SF₆ in the environment is increasing by approximately 8.7 percent per year. This trend is

disturbing, since SF₆ has been shown to have the highest global-warming potential of all commonly used industrial gases, although the SF₆-contribution to global warming currently is estimated to be only 0.01 % to 0.07 %. The high potential for affecting the atmospheric results from the large cross section of the gas for infrared absorption and extremely long atmospheric lifetime of nearly 2000 years.

The report concluded that sufficient data were available to show that a mixture of SF₆ and nitrogen could be used in most applications, thus reducing the amount of SF₆ being used by the electric power industry. Other promising gases were high pressure nitrogen for insulation and mixtures of SF₆ and helium for interruption. As part of the research for the report, meetings were held between the NIST researchers and experts from around the world from electrical equipment manufacturers, electric utilities, and gas companies to document the practical barriers to using dielectric gases other than SF₆. The most prominent barriers appear to be the required recertification of equipment designed for use with pure SF₆ and potential recycling issues for gas mixtures. However, it seems clear that the use of gases other than SF₆ in equipment designed specifically for alternative gases is technically feasible.

FIRST VUV DOPPLER-FREE TWO-PHOTON MEASUREMENT IN He

Researchers at NIST have extended two-photon Doppler-free spectroscopy to the vacuum ultraviolet (VUV) spectral region to measure the He 1 ¹S→2 ¹S transition at 120 nm to an unprecedented accuracy of 1 part in 10⁸. This measurement determines the He ground state energy, which provides an ideal testing ground for precision quantum electrodynamics (QED) calculations of the Lamb shift in two-electron, three-body systems. In addition, the demonstration of Doppler-free two-photon spectroscopy in the VUV will permit significant improvements in high-resolution VUV spectroscopy.

The measurement technique uses short-pulse (a few nanoseconds) lasers, and precision-pulsed laser metrology requires detailed understanding of resulting small frequency chirps. NIST researchers collaborated with a researcher at the University of Connecticut to measure these rapid frequency excursions and model the effects on the measured He transition frequency. The new high-accuracy He transition frequency determines the ground state Lamb shift with a relative uncertainty of about 10⁻³, a factor of 10 smaller than the uncertainty of the best QED calculations.

With the VUV two-photon Doppler-free technique demonstrated, the experiment will be continued by the

University of Connecticut researcher. Researchers expect that straightforward metrology improvements will decrease the uncertainty by an order of magnitude.

MERCURY-ION MICROWAVE FREQUENCY STANDARD DEMONSTRATED

Using laser-cooled $^{199}\text{Hg}^+$ ions, NIST scientists recently demonstrated operation of a microwave frequency standard. The scientists locked a microwave source to the ground state ion hyperfine transition at 40.5 GHz. In this work, seven ions contained in a cryogenic linear ion trap with a Ramsey free-precession time of 100 s were used to achieve a fractional frequency stability of $3 \times 10^{-13, -1/2}$ and a reproducibility (uncertainty) of 3×10^{-15} . This rivals the performance of the best existing primary frequency standards. Using more trapped ions (up to about 100 ions appears feasible) is expected to further improve performance.

Trapped and cooled ions are useful for frequency standards for several reasons. The ions can be held in a well-controlled environment, significantly reducing systematic effects such as Stark, Zeeman, and Doppler shifts. Also, the same ions can be observed repeatedly and for very long times, so that narrow transitions can be observed with extremely high resolution.

Since fractional frequency stability improves with increasing frequency, it is estimated that substantially higher performance can be achieved using an optical, electric-quadrupole transition at 282 nm in the same ion. Experiments on the optical frequency standard, using methods similar to those described above, have been initiated.

IMPROVEMENTS IN NIST-7

In an effort to upgrade NIST-7 (the nation's primary frequency standard) and to add confidence to the evaluation of its systematic frequency shifts, NIST scientists have joined with the Communications Research Laboratory (CRL) of Japan to build a copy of NIST-7 for CRL. This project is fully funded by CRL but involves staff of both NIST and CRL. Once completed, the standard will remain in Boulder for comparison with NIST-7 for more than 6 months.

Aside from providing NIST with the opportunity to compare two like standards, assuring that the same results can be replicated, this project affords the opportunity to improve a number of the clock subsystems. For example, the pump laser system has been redesigned completely to be simpler and more robust, and optical fiber now is used to transmit laser beams to the state-preparation and state-detection regions of the standard. Also, the software for all control systems, including the

digital servosystem, has been completely rewritten using object-oriented-programming methods. As these subsystems are developed for the new standard, they are replicated and incorporated in NIST-7. Many of the improvements developed in this project also are being adapted for the new cesium-fountain standard.

A MULTICHANNEL GPS RECEIVER FOR COMMON-VIEW TIME TRANSFER

A NIST scientist has developed a multichannel, common-view receiver based on a commercial GPS (Global Positioning System) "engine." The system runs under the control of a simple personal computer with a commercial internal board used as a time-interval counter. One objective of this project is to replace the original (1985) NBS common-view receivers still used by a number of laboratories, since these are becoming increasingly difficult to maintain. A second objective is to move to multichannel technology and a higher level of automation for data handling. The increased volume of comparison data provided by the multichannel technology should somewhat improve the precision of comparisons, and the improved automation will facilitate handling of the larger volume of data. Since common-view time transfer continues to be the de facto standard for international time coordination and atomic-clock performance continues to improve, it is important to push the performance of this time-comparison method. In preliminary tests, two receivers in the same location have been referenced to the same clock. In this arrangement, the common-view differences provide a very good measure of the receiver performance. The resulting variance of 2.5 ns for these differences is indeed somewhat better than that observed with single-channel receivers.

PM NOISE IN PHASE DETECTORS

Two NIST scientists, in collaboration with a scientist from the Centro Nacional de Metrologia in Mexico, have measured the phase modulation (PM) noise floor of a number of phase detectors for both homodyne (same-frequency) and heterodyne (different-frequency) detection. These measurements then guided them in development of a model for noise in commonly used phase detectors.

In the homodyne case, they found that the baseband noise added to the noise floor. They demonstrated that for most mixers the low frequency portion of the noise was 3 dB to 6 dB lower in the heterodyne than in the homodyne configuration. Their results should have impact on the design of nearly all low-phase-noise equipment used in applications such as frequency

synthesis, telecommunications and radar. Since low-noise, high-frequency homodyne detectors are more expensive than heterodyne detectors operating at the same frequency, the circuit designer can reduce cost and maximize performance by using heterodyne techniques as much as possible within higher frequency parts of a circuit.

A MICROWAVE OPTOELECTRONIC OSCILLATOR

NIST scientists have demonstrated low-noise oscillation at 1 GHz and 8 GHz in a new class of optoelectronic oscillator (OEO). While these oscillators are still in an early phase of development, their performance is already superior to that of all conventional, competing technologies. Furthermore, these can be scaled to operate at still higher frequency, and their noise performance should improve with continuing development. OEOs have potential application wherever high-performance microwave oscillators are used including frequency synthesizers, atomic frequency standards, and radars.

The optoelectronic oscillator is made up of about 1 km of optical fiber on a spool, a diode laser that launches a modulated signal into the fiber, and a photo-detector that receives the signal. The received signal is amplified, filtered, and sent back to modulate the diode laser thus providing gain and closing the loop. A key element of the design is the filter that suppresses all but the desired mode in the fiber. For the 8 GHz oscillator, 90 kHz separates the modes, and a filter in the optical path reduces the nearest side modes to 50 dB below the carrier.

SCANNING ELECTRON MICROSCOPE TELEPRESENCE WEB SITE INITIATED

A NIST scientist, in collaboration with researchers within and outside of NIST, has established a prototype scanning electron microscope (SEM) telepresence web site at squint.cme.nist.gov.

The site has a prototype web page with a real-time image from the SEM and the NIST/NAMT (National Advanced Manufacturing Testbed) digital notebook. The site already has proven valuable in some collaborative work between NIST and a private company in California. For this experiment, samples from the private company were viewed in the NIST instrument, and a researcher at the private company viewed the images via the Internet on-line and commented on the suitability of the fields being observed. Suitable images for subsequent use then were captured in California of the on-line image. Other refinements to the project are being implemented, including remote instrument access.

DEVELOPMENT OF A METHOD FOR THE EVALUATION OF FIRE-RESISTANT OIL SPILL CONTAINMENT BOOM

Intentional burning is emerging as one of the accepted methods of mitigating oil spills at sea, particularly in remote areas. Intentional burning requires that a portion of the oil spill be corralled in a fire-resistant oil spill containment boom to control the burn. Presently there is no standard method for evaluating the performance of fire-resistant oil spill containment booms when subjected to both fire and waves. Under sponsorship of the U.S. Coast Guard and the Minerals Management Service of the U.S. Department of Interior, researchers at NIST have designed a wave tank capable of evaluating a 15 m section of boom by subjecting it to a 5 m diameter fire with 0.3 m high waves. The unique wave tank was constructed at the U.S. Coast Guard Fire and Safety Test Detachment in Alabama. A draft test protocol developed by NIST, based on guidelines from the ASTM committee responsible for oil spills, was evaluated using five typical fire-resistant oil spill containment booms selected by the sponsors. The evaluation of the protocol was a success; however, a few areas in need of refinement were identified. Although pass-fail criteria have not been finalized, the fire-resistant boom manufacturers were able to gain insight into the performance of their products under realistic conditions. The results of the evaluation will be presented to the ASTM committee responsible for oil spills.

ASTM ADOPTS IMPACT-ECHO STANDARD

ASTM Committee C9 on Concrete and Aggregates has adopted the first standard test method in the world on the use of the impact-echo method for measuring the thickness of concrete pavements, walls, slabs, and other slab-like structures. The standard is an outgrowth of pioneering research performed at NIST in the mid 1980s and further refinement in the 1990s at Cornell University. The impact-echo method uses impact-generated stress waves to detect the presence of internal defects (cracks, voids) in concrete, or it can be used to measure the thickness of a defect-free member. The method is being heralded by practitioners as one of the most significant developments in the last 15 years in the area of nondestructive testing of concrete.

TRIBOLOGY SOFTWARE AND DATABASES AVAILABLE

Through the Standard Reference Data Program, NIST is making available software developed under efforts to produce a computerized tribology information system (ACTIS) free to the public. This software consists of the following modules:

NIST TRIBO-Materials Database—numeric database of tribological properties of all classes of materials; NIST TRIBO-Ceramic Database—numeric database of tribological properties of ceramics; Lubricants Database—database of properties of lubricants; Lubricant Advisor—expert system for lubrication problems; Gear Performance—calculations on gear design; Ball Bearing Performance—calculations on ball bearing design; Roller Bearing Performance—calculations on roller bearing design; and CAM Interface—interface to all modules.

To obtain a copy of the software, please contact Joan Sauerwein at ext. 2208, fax: (301) 926 0416, or joan.sauerwein@nist.gov.

ENERGY-RELATED INVENTIONS PROGRAM RECOMMENDATIONS

In October 1997, NIST recommended three innovative technologies to the Department of Energy for government support under the Energy-Related Inventions Program:

A Pilot Plant Processor for the Production of Silicon Sheet—a process and apparatus for growing sheets of semiconductor material. It focuses on producing low-cost, high-quality, single-crystal silicon sheet directly from bulk molten polycrystalline material.

Linear Corrugating—a process for manufacturing corrugated cardboard so that the corrugations will use less wood fiber while preserving the same crush strength. With the new process, corrugations in finished corrugated cardboard boxes will run up and down instead of across the box.

Linear Motor Refrigerator Compressor—is a small hermetic compressor driven by an integral linear electric motor initially intended as drop-in replacements for conventional compressor modules in residential refrigerators. The innovative feature is that the linear motor uses a radial magnetic field compared to an axial field in conventional linear motors.

STRUCTURE AND DYNAMICS OF METAL-HYDRIDE-BASED OPTICAL-SWITCHING MATERIALS

The interaction of hydrogen with the rare earth metals has been the subject of numerous investigations over the past 2 decades due to the unusual structures and properties observed in the α -phase solid solutions as well as the various ordered metallic and semiconducting hydride phases. This interest has intensified recently due to the discovery that these materials become optically transparent for H/metal stoichiometric ratios approaching three. This unusual property is currently be

ing adapted to the design of novel optical-switching devices. Various theories have been postulated for explaining these optical transitions, which remarkably occur for both hcp (e.g., YH_{3-x}) and fcc (e.g., LaH_{3-x}) materials. Nonetheless, the precise physics behind these transitions has yet to be satisfactorily resolved, with further progress awaiting more reliable experimental data concerning the rare-earth trihydride physical properties.

Scientists at NIST have been using neutron scattering methods extensively in conjunction with *ab initio* calculations to help provide a basis for understanding and tailoring the optical properties of these materials. Much progress has been made in characterizing the subtleties present in both the fcc and hcp trihydride structures and vibrational dynamics upon variation of the hydrogen-vacancy concentration and rare-earth metal. Moreover, the nature and mechanisms of hydrogen diffusive motions in the fcc trihydrides, which are a key to optical switching properties, have been firmly established. The interesting results to date have led to a number of invited lectures at international meetings concerned with these fascinating hydride materials. Further studies will focus on the differences in physical properties, if any, between rare earth trihydride polycrystalline bulk materials and thin-film samples being used in prototype applications.

THERMAL STABILITY OF SPIN VALVES

Magnetic multilayer “spin valve” materials exhibit a desirable combination of a large electrical resistance change and sensitivity to small applied fields that has made them attractive for development of magnetic field sensors, nonvolatile MRAM computer memory chips and especially for development of read heads for ultra-high density magnetic recording. Scientists at NIST are measuring the effectiveness of techniques to make these spin valves, which have layers only 2 nm or 3 nm thick, less susceptible to damage at elevated temperatures so that they can be incorporated into existing semiconductor fabrication techniques that involve annealing steps. A promising way to protect spin valves from the thermal degradation is to apply a surface coating as the top layer.

The researchers recently found that 5 nm thick protective coatings of Ta or Ta_xO_y allow the spin valve materials to survive half-hour anneals at temperatures up to 325 °C, which is sufficient for some widely used fabrication techniques. While thinner protective layers would be desirable because they shunt less current from the active magnetic layers, the measurements indicated that spin valves protected with thinner Au or Cu damaged after anneals at only 250 °C.

SIM PRESSURE WORKSHOP HELD

Scientists at NIST recently hosted an international workshop concerning absolute pressure measurements. The reliability of pressure measurements, along with other units of measure, is critical for international trade. The acceptability of products for performance and safety-related issues are based routinely on critical measurements, which are derived from industrial measurement standards. In particular, an increasing fraction of the maintenance of U.S. aircraft is done elsewhere in the Americas. The U.S. Federal Aviation Administration requires that altimeters and airspeed indicators on all commercial aircraft that fly in U.S. airspace be traceable to U.S. national pressure standards or an approved national standard. In many cases, in particular with European countries, the relationship between national pressure standards is well known because standards are compared routinely. This measurement infrastructure allows for mutual recognition of measurement capability, which is required for many regulatory and safety-related issues. This type of relationship, in most cases, has not existed with national standards laboratories within Central and South America.

To address this problem, NIST in conjunction with the Interamerican Metrology System (SIM) and the Organization of American States, has sponsored a number of workshops in different measurement areas. Attending the recent pressure workshop at NIST were participants from Brazil, Costa Rica, Jamaica, Mexico, and Peru (representing the five regions within SIM, SURAMET, CAMET, CARIMET, NORAMET and ANDIMET). The goal of the workshop was to familiarize the participants with a pressure transfer standard package, which will be used to conduct a comparison between laboratories in the Americas during the coming year. This transfer package, developed at NIST, covers a measurement range of 10 kPa to 1 MPa, which is critical to many industrial applications including avionics. In addition to acquiring experience with the transfer package, the workshop precipitated collaborations in pressure metrology between different laboratories, including NIST.

The workshop, and the subsequent comparison of pressure standards within the Americas is a necessary and crucial part of addressing technical trade issues within the Americas and lays the groundwork for establishing better trade relations.

**INTERNATIONAL CONFERENCE ON
SECONDARY ION MASS SPECTROMETRY
CO-ORGANIZED BY NIST**

The 11th International Conference on Secondary Ion Mass Spectrometry (SIMS XI) was held in Orlando, FL, September 1997. The conference was co-organized by

a NIST scientist in collaboration with a researcher from the Army Research Laboratories (ARL). This international conference was sponsored by the American Society for Mass Spectrometry and was held in conjunction with the 10th annual workshop on SIMS. The biennial SIMS conference series is the premier international forum covering all aspects of secondary ion mass spectrometry and is designed to serve as a "snapshot" of the current state of the art of the technique. Previous conferences have been held in the United States, Hungary, Japan, France, The Netherlands, and Germany.

Topics covered at SIMS XI included isotopic and geophysical analysis, biological and organic surface characterization, new developments in instrumentation, standards, surface and in-depth characterization of semiconductor materials, and fundamental measurements. A record number of more than 430 scientists from 27 countries attended SIMS XI, with more than 350 oral and poster technical presentations. The proceedings of the conference, which will contain more than 250 Papers, will be published in early 1998 by John Wiley and Sons as a 1200-page hardbound book entitled *Secondary Ion Mass Spectrometry: SIMS XI*.

**FIRST RESULTS OBTAINED ON
MULTIVARIATE ISOTOPIC FINGERPRINTING
OF INDUSTRIAL MATERIALS**

Scientists at NIST have demonstrated the complete discrimination of two sources of a single substance (monomer) used in chemical synthesis, and the correct quantitative apportionment of source components through dual isotopic characterization of the finished commercial product (high-tech copolymer). These first results were obtained from research performed under a cooperative research and development agreement, initiated in 1997. The objectives of this project are to use variations in natural levels of carbon isotopes (^{13}C , ^{14}C) to pinpoint sources of chemical feedstocks and to uniquely identify specific manufactured products. The distribution of carbon isotopes for the chemical species is measured, and in each case the location of the data in the two-dimensional ^{13}C - ^{14}C plane serves as a fingerprint for the source material. The dual isotopic signature is necessary for this project because the feedstocks or products to be distinguished are identical chemically.

To meet the research objectives, it is essential to perform the isotopic measurements at levels of uncertainty that are at the cutting edge of isotopic measurement science. NIST researchers anticipate that this new technology will have considerable technological and financial impact through its ability to prove authenticity among products that are identical in chemical composition but developed from different feedstock sources and/or manufacturing processes.

WORKSHOP SETS STAGE FOR OPTICAL FILTERS NIST TRACEABLE REFERENCE MATERIALS PROGRAM

Scientists at NIST hosted a recent Workshop on NIST Traceability in Chemical Spectrophotometry, attracting 32 participants from pharmaceutical and chemical companies, instrument and optical component manufacturers, government regulators, and NIST. The focus of the program was to establish a recognized traceability link to the NIST reference spectrophotometer through commercially produced reference materials for chemical spectro-photometry. The demand for such reference materials has been accelerated by the increase in both regulatory and voluntary quality control measures, exceeding NIST production capacity. A NIST Traceable Reference Material (NTRM) is a reference material produced and distributed by a commercial supplier that has a well-defined traceability linkage to existing NIST standards. The demand for Reference Materials traceable to NIST has begun to outpace NIST's ability to produce SRMs in many areas.

The NTRM concept was developed in 1992 to address this issue in general and implemented in the cylinder gas standards area due to the immediate need for a large number of gas standards of known pedigree for implementation of the "Emissions Trading" provision of the Clean Air Act of 1990. The Cylinder Gas NTRM program has been well accepted by all parties—the specialty gas industry, the regulatory community, and end-users of gas standards and has proven to be an excellent model for leveraging limited NIST resources for maximum impact.

The consensus of the workshop was that leveraging of the NIST measurement capability into the commercial sector was both feasible and desirable, as long as comparable quality and adequate traceability linkages and regulator agencies acceptance of NTRMs are assured. The attendees endorsed the concept of NTRMs for chemical spectrophotometry and agreed to participate in two additional meetings focused on developing protocols for implementing this new program.

QUANTUM FUNCTIONAL DEVICES WORKSHOP AT NIST

The Third International Workshop on Quantum Functional Devices was held at NIST in November 1997. The workshop was sponsored jointly by NIST and Japan's Ministry of International Trade and Industry. The workshop brought together researchers from the United States, Japan, other Asian nations, and Europe to discuss the physics, fabrication, characterization, and

applications of quantum functional devices (QFDs). QFDs are exceedingly small, ultrahigh-speed electronic devices based on the quantized behavior of single or small groups of electrons, such as electron tunneling, electron wave interference, and discrete energy levels. QFDs are being studied as successors to traditional semiconductor microelectronic devices. About half of the 150 participants and about two-thirds of the papers were from Japanese laboratories.

Invited papers presented included "Atomic-Scale Characterization of Magnetic Thin Film Structures"; "Metrological Applications of Single Electron Tunneling"; and "Integration of SPM Fabrication and Characterization Techniques for Nanoelectronics Device Processing." Workshop participants toured NIST laboratories that are developing measurement techniques and standards relevant to QFDs and nanotechnology.

NEWRAD 97 FOCUSES ON REMOTE SENSING

NIST radiometry research was represented heavily at the Sixth International Conference on Radiometry-New Developments and Applications in Optical Radiometry (NEWRAD 97) held in Tucson, AZ, in October 1997. The conference, one of the most important assemblies of the international radiometry community, was organized by the Optical Sciences Center of the University of Arizona. More than 100 participants attended from Europe, Asia, Australia, and the Americas, representing national measurement laboratories and industry. In addition to discussion of general advances in radiometric science, the conference focused on radiometric calibration and measurement for remote sensing applications, particularly observation of the Earth's surface, oceans, and atmosphere from space in the ultraviolet through infrared spectral range.

Approximately one-third of the more than 40 talks and one-third of the nearly 100 posters were presented by NIST researchers. Other national standards laboratories represented included NPL (United Kingdom), BIPM (France), PTB (Germany), NRC-Canada, and CSIRO (Australia). Major radiometry users such as NASA and ESA also participated. Papers and discussions on remote sensing described calibration of satellite radiometric instruments before launch, on-board calibration using astronomical targets and on-board instruments, and vicarious calibration using well-characterized large area ground-based targets.

The proceedings will be published in an upcoming special edition of the journal *Metrologia*. The next NEWRAD conference is planned for 1999 in Spain,

followed by NEWRAD 2001 to be held at NIST during the NIST Centennial Year.

INDUSTRY WORKSHOP ON RAPID PROTOTYPING

An industry workshop was held at NIST in October 1997, to address “Measurement and Standards Issues in Rapid Prototyping.” Approximately 40 participants attended from industry, government, and academia. The workshop was sponsored jointly by NIST, the Rapid Prototyping Association of the Society of Manufacturing Engineers, and the National Center for Manufacturing Sciences.

The workshop was successful in identifying measurement issues and standards needs across the rapid prototyping industry. Participants developed specific recommendations to address these needs. As a result of the workshop, a white paper has been prepared and distributed. A need for comparisons of different rapid prototyping systems was expressed at the workshop—especially in terms of part accuracy, speed of operation, and overall cost. Also, there was considerable interest in reviewing and comparing the data formats used for rapid prototyping processes. The workshop participants are looking for continued input from users, suppliers, and researchers in the field of rapid prototyping. Follow on work from this workshop may include NIST taking an active role as participants in a standards committee.

WORLDWIDE ROUND ROBIN AIMS TO ESTABLISH A UNIFIED ROCKWELL HARDNESS SCALE

In 1995, NIST proposed a metrology approach to unify the international Rockwell C hardness scales. From 1995 to 1996, NIST conducted a round robin among five national laboratories and published the results in 1996 and 1997. Based on these results, a worldwide round robin was proposed by ISO TC164/SC3, and sponsored by the BCR (Community Bureau of Reference of EEC), with the aim of establishing a worldwide unified Rockwell hardness scale using geometrically calibrated standard Rockwell indenters. Twelve institutions from 11 countries, mostly national metrology laboratories, agreed to participate in this international round robin. This project will take about 2-1/2 years.

The first meeting was held in October 1997, in Madrid, Spain. Fourteen delegates from the United Kingdom, Germany, Italy, the United States, Denmark,

China, Brazil, Austria, Japan, and Spain, as well as the European Commission, attended the meeting. Two NIST researchers attended the meeting, one of whom introduced the NIST metrology capability for the precision geometric calibration of the standard indenters to ensure traceability and reproducibility for the worldwide common scale. Two Rockwell diamond indenters were brought to NIST and combined with the other NIST standard indenters. All of these indenters will be calibrated by NIST to select the “common indenters” to be used in the international round robin.

NIST COLLABORATES IN ATM NETWORK TESTS OF A PROTOTYPE VIDEO DIAL TONE SYSTEM

Video dial tone (VDT) systems promise to make a wide range of video services available in the home and workplace including, for example, video-on-demand, electronic marketplace access, Internet access, and multiplayer games. A prototype VDT system recently has been developed by a private company in collaboration with European partners, utilizing ATM (asynchronous transfer mode) technology. ATM is a cell-based routing and multiplexing technology designed to be a general-purpose, connection-oriented transfer mode for a wide range of telecommunication services. ATM routing is characterized by uniformly sized 53-byte packets and offers quality of service (QoS) guarantees not easily available from packet-switched systems.

NIST's high speed network technologies group collaborated with the private company in testing the prototype VDT system last summer. The tests specifically addressed the impact of ATM network QoS parameters on the performance of the VDT video-on-demand service. At the completion of laboratory testing, NIST arranged an interstate demonstration of the system, accessing a video server in New Jersey. The connection to New Jersey was actually made through three interconnected ATM networks: the NIST campus ATM network, the Washington metropolitan area ATM testbed (ATDNet), and the private company's ATM network. Test results clearly show that ATM QoS is a critical issue of common concern to the VDT system developer and the ATM network service provider and should be addressed by both in coordination. The test results will be released for use by VDT system developers to pursue robust and stable VDT system designs and by ATM network service providers to plan for VDT system QoS needs.

TREC WORKSHOP PROMOTES RESEARCH IN INFORMATION RETRIEVAL

In November 1997, NIST co-sponsored the sixth Text REtrieval Conference (TREC-6) with the Information Technology Office of the Defense Advanced Research Projects Agency as part of the TIPSTER Text Program. Started in 1992, the series promotes research in information retrieval by providing appropriate test collections, uniform scoring procedures, and a forum for organizations interested in comparing their results.

Fifty-one groups including representatives from 12 countries and 17 companies participated, making TREC-6 significantly larger than previous TREC conferences. Participants used the same test collection consisting of about 2 GB of text (over 1 million documents) and a given set of information needs. In addition, four new optional retrieval tasks were introduced in TREC-6: cross-language retrieval, where documents in one language were retrieved in response to questions in a different language; spoken-document retrieval, where segments of audio news broadcasts were retrieved in response to textual queries; the retrieval of 10 good documents for a question within a 5 minute deadline; and retrieval using a 20 GB (7.5 million documents) corpus.

Papers presented at the conference are available on the NIST TREC Web site at <http://trec.nist.gov>. Also available are the proceedings of TREC-5, which were published in November 1997 as NIST Special Publication 500-238.

NIST/BAM COLLABORATION ON REFERENCE COATINGS

NIST and the Surface Technology Division of the Federal Institute for Materials Research and Testing (BAM) in Berlin have just completed the first year of a 3-year collaboration in the development and characterization of standard reference coatings for optical, tribological, wear, and adhesion testing. In the first year, coatings of amorphous silica and silicon nitride were prepared in thicknesses of 0.1 μm and 1.0 μm on several glass substrates using chemical vapor deposition techniques. In addition, one silica/silicon nitride multi-layer of 1 μm total thickness was prepared. A BAM scientist spent 5 months at NIST studying mechanical properties (hardness and Young's modulus) of these films using nanoindentation techniques. In the remaining 2 years, a NIST scientist will visit BAM to further develop and characterize reference coating candidates. As a consequence of this interaction, reference coatings are being developed that can be used to calibrate a variety of test instruments, including

ellipsometers, depth profiling systems, instrumented micro- and nano-indenters, and wear and scratch testers.

POWER DOUBLING FOR WWVB COULD HELP KEEP YOU ON SCHEDULE

For everyone who made a New Year's resolution to be more on time for meetings and events in 1998, there's good news from NIST.

WWVB, the low-frequency standard time and frequency radio station operated by NIST has doubled its broadcasting power to 23 kW, increasing the range of the extremely accurate time signal that can be used to automatically set the correct time in clocks, watches, VCRs, cars, and electronic gear of all kinds.

Controlled by the NIST atomic clock in Boulder, CO, WWVB had previously operated at 10 kW for more than 3 decades. WWVB transmits its time signal on a frequency of 60 kHz from a site near Fort Collins, CO. It is not audible and requires special receivers to decode.

The power upgrade improves WWVB's signal strength over the entire continental United States. This permits the use of less expensive receivers and antennas. Even radio-controlled wristwatches can now maintain accurate time. And now, manufacturers of various appliances, instrumentation and electronic devices can consider installing miniature receiver-clocks in their products.

Over the next year, a second high-powered transmitter and antenna will be brought online to double WWVB's total power once again (to between 40 kW and 50 kW) and provide additional reliability. When both transmitters and antennas are in operation, they can operate at less than maximum rated power. This greatly extends their life and reduces the chances of outages due to equipment failure.

BALDRIGE GUIDE TO PERFORMANCE EXCELLENCE IS UPDATED FOR 1998

While it doesn't have a fancy cover, one of the nation's most popular business publications does have an endorsement that's hard to beat: "The Malcolm Baldrige National Quality Award, which highlights customer satisfaction, workforce empowerment and increased productivity, has come to symbolize America's commitment to excellence," says President Clinton.

By defining the key factors that comprise a world-class organization, *Malcolm Baldrige National Quality Award—Criteria for Performance Excellence*, has become accepted around the world as the business

standard for performance excellence. Thousands of companies assess their performance against the criteria, but even more benefit can be gained by applying for the award. All applicants receive a detailed report on their company's strengths and opportunities to improve.

For the 1998 update of the "Criteria for Performance Excellence," call (301) 975-2036, fax a request to (301) 948-3716, or send e-mail to nqp@nist.gov. Single copies are free. The criteria also can be downloaded from the National Quality Program website at <http://www.quality.nist.gov>.

NIST MODELS THERMODYNAMICS OF REPLACEMENT REFRIGERANTS

Blends of hydrofluorocarbon refrigerants are the leading candidates to replace hydrochlorofluorocarbon-22, which is being phased out because it contributes to the depletion of the ozone layer. The mixtures most likely to take over for HCFC-22 are composed of refrigerants R-32, R-125 and/or R-134a. Working with the International Energy Agency and scientists from Japan, Germany and the United States, researchers at NIST have evaluated five thermo-dynamic property models for these mixtures. Their objective is to provide users with the information that allows them to select the model best suited to their needs.

The researchers found that all of the models are capable of predicting mixture properties with relative uncertainties on the order of 0.2 % in density, 1 % in isochoric heat capacity, and 0.5 % in saturated pressures (with the exception that one model should be used with caution above 5 mPa).

For a copy of the report detailing this research, contact Sarabeth Harris, MC 104, NIST, Boulder, CO 80303-3328, (303) 497-3237, e-mail: sarabeth@boulder.nist.gov. Ask for paper no. 53-97.

EXPERTS REPORT ON SEARCH FOR 21st CENTURY REFRIGERANTS

As the twentieth century closes, two major environmental concerns—ozone depletion and global warming—are matters of international debate and controversy. Some experts worry that alternative refrigerants adopted as substitutes for ozone-depleting chlorofluorocarbons are themselves "greenhouse" gases and will contribute towards global warming. An October 1997 international conference, sponsored by NIST and the American Society of Heating, Refrigerating and Air-Conditioning Engineers, took a look at this issue. Approximately 200 participants from industry, government, and academia attending "Refrigerants for the 21st

Century" addressed the merits of different refrigerants and technologies. The proceedings from the conference are now available.

Several alternative refrigerants and options are examined by the 16 papers in the proceedings. Detailed in these papers are each refrigerant's ozone-depletion potential, direct global warming potential, system efficiency, safety (such as flammability and toxicity) and cost.

Conference chair, a NIST scientist, called the conference a "dialogue among professionals." He said, "The conference presented the options for the next century and determined that there is no perfect refrigerant. Trade-offs between different refrigerants and technologies are unavoidable."

Anyone interested in ordering a copy of the conference proceedings should contact ASHRAE by phone at (800) 5-ASHRAE (527-4723), by fax at (404) 321-5478 or by e-mail at orders@ashrae.org.

FIRST STEP TAKEN TOWARD MUTUAL RECOGNITION FOR U.S., PACIFIC NATIONS

A new cooperative effort by laboratory accreditation organizations in the United States and in five Asian Pacific nations has taken the first step toward saving American companies millions of dollars in reduced market entry costs for exports.

The effort, defined by a mutual recognition arrangement signed in Tokyo in November, may lead to a binding Mutual Recognition Agreement (known as an MRA) between the nations in which the laboratory accreditation organizations reside. Under the current arrangement, the organizations themselves recognize the technical equivalence of test reports and calibration certificates issued by any of their accredited laboratories. Mutual recognition significantly lowers costs for U.S. companies because products need only be tested once, in the United States, to meet standards set by other countries.

The organizations signing the arrangement are members of the Asia Pacific Laboratory Accreditation Cooperation from Australia, Hong Kong, New Zealand, Singapore, Chinese Taipei and the United States. All of signatory organizations reside in nations which are members of the Asia-Pacific Economic Cooperation.

The arrangement supports the World Trade Organization obligations of the United States and other members to simplify conformity assessment procedures, such as testing and accreditation, and to prevent them from becoming barriers to trade. It is hoped that other APEC accreditation bodies will qualify to sign the APLAC arrangement and a subsequent MRA in the near future.

THREE DOCUMENTS CHRONICLE NEARLY 30 YEARS OF RESEARCH

Persons interested in the electronics and electromagnetic research programs of the NIST Boulder, CO, laboratories will want copies of the three comprehensive listings of nearly three decades of the agency's papers in this discipline.

First, "A Bibliography of the NIST Electromagnetic Fields Division Publications" (NISTIR 5063), lists published research between January 1970 and July 1997. Subject areas discussed include antennas, dielectric measurements, electromagnetic interference, microwave metrology and near-field antenna measurements.

The second volume is "Metrology for Electromagnetic Technology: A Bibliography of NIST Publications" (NISTIR 5064). It lists the publications of the NIST Electromagnetic Technology Division from 1970 to 1997. Topics covered include cryoelectronic metrology, and superconductor and magnetic measurements.

The third publication is "A Bibliography of the NIST Optoelectronics Division" (NISTIR 5065). Subject areas covered include high speed measurements, laser radiometry, fiber optic measurements, integrated optic measurements, optical fiber sensors, fiber and discrete components, dielectric materials and devices, and semiconductor materials and devices.

Copies of all three bibliographies are available at no charge from Sarabeth Harris, MC104, NIST, Boulder, CO, 80303-3328, (303) 497-3237, e-mail sarabeth@boulder.nist.gov.

NIST HELPS NAVY SAVE MILLIONS OF DOLLARS

A NIST scientist at Boulder, CO, is co-recipient of the \$10 000 Best of Program Award for 1997 from the James F. Lincoln Arc Welding Foundation. The foundation was established in 1936 to recognize excellence in arc welded design and engineering. The NIST scientist and a researcher from the Naval Surface Warfare Center in Bethesda, MD, were cited for the welding procedure they developed to repair worn joints in a railroad-type track at NSWC's Model Towing Basin. Their repair cost only \$240 000, avoiding replacement of the one-mile-long track for a cost estimated between \$5 million and \$20 million.

The smooth, precision-made track is used to carry instrumented carriages weighing 57 tons, which measure the hydrodynamic characteristics of ship models. The track was first laid more than 50 years ago and expansion joints had begun to wear, causing unacceptable shock and vibration in the carriage.

The solution was to rebuild the rail to the original dimensions with weld metal of the same hardness. Because of the tremendous demand on the towing basin, they had to do the welding repair on weekends. They developed procedures for grinding and welding that permitted restoration of the original rail dimensions while matching the original surface hardness. As a result, vibration in the carriage was reduced by more than 75 %, eliminating the effects of the worn joints.

For more information on this procedure, contact Sarabeth Harris, MC 104, NIST, Boulder, CO 80303-3328, (303) 497-3237, sarabeth@boulder.nist.gov. Ask for paper no. 46-97.

NIST TESTS USED TO VALIDATE CRYPTOGRAPHIC PRODUCTS

Five new cryptographic modules recently were validated for conformance with Federal Information Processing Standard (FIPS) 140-1, Security Requirements for cryptographic modules. FIPS 140-1 specifies four separate levels of security provided by Cryptographic Modules, with each level providing increased security and assurance.

The cryptographic modules were validated under the Cryptographic Module Validation program, a joint effort between NIST and the Communications Security Establishment (CSE) of the Government of Canada. NIST and CSE serve as the validation authorities for the program. Currently, there are three National Voluntary Laboratory Accreditation Program (NVLAP) accredited laboratories that test cryptographic modules. These new validations increase the number of cryptographic products available for use in securing sensitive information.

For more information on FIPS 140-1, validated modules, and the accredited laboratories, visit the Web site at <http://csrc.nist.gov/cryptval>.

U.S. AIR FORCE REDUCES ENERGY CONSUMPTION USING NIST TECHNOLOGY

Two photovoltaic solar water heaters, using technology developed by NIST, have been installed on military housing units in Okinawa, Japan. The units completed initial tests and became fully operational on Jan. 1, 1998. The U.S. Air Force and NIST anticipate that the two-year-long test of the photovoltaic solar water heaters will reduce the water heating energy consumption within the two selected housing units by 75 % while providing experimental "on-the job" field data to NIST researchers seeking to improve computer simulation models used to predict system performance.

The two solar systems use photovoltaic cells to convert solar radiation into electrical energy. The NIST technology, patented in 1994, includes an array of photovoltaic modules, a water storage tank incorporating multiple electrical resistive elements and a microprocessor controller that selects the combination of elements that results in the maximum energy collection. The site in Okinawa was selected by the Air Force due to the high cost of electrical energy and favorable solar conditions. The annual operating cost of an electric water heater for a family of four in Okinawa is approximately \$1350 compared to \$450 in the United States.

NIST-PRIVATE SECTOR COLLABORATION ON POLYMER BLENDS UNDER PROCESSING CONDITIONS

NIST researchers working in collaboration with researchers from a major oil company, have determined that density is a key controlling parameter in the processing of polyolefin blends. This result is useful for industrial material design because the miscibility properties can be predicted from a set of pressure, volume, and temperature measurements.

The collaborative project was initiated to understand the behavior of polyolefin blends (e.g., polyethylene and polypropylene) under processing conditions. The driving force of this project is the commercialization of a new catalyst technology, which permits unprecedented control of the molecular structure of polyolefin materials. Customers will have a wide selection of materials, which can be blended together to tailor products with improved processing and final properties. The “salad in a bag” now available at supermarkets is an example of the use of this new technology to create materials with new properties—in this case, controlled gas permeability.

To fully exploit the capabilities of these new tailored materials, processors will need to understand what governs the miscibility of the polyolefin blends under processing conditions of high temperature, pressure, and shear. Previous work has focused on quiescent blends at atmospheric pressure.

A series of small-angle neutron scattering experiments has been carried out using both pressure and shear to examine how the interactions between different polyolefins are modified by the presence of these external fields. In the case of increasing shear, the phase diagram shifts to enhance miscibility, which accords with work on other systems. With increasing pressure the phase behavior is a function of density, at least for the most common class of blends, which becomes single phase upon increasing the temperature. The emergence

of density as the key controlling parameter for these blends was not predicted. Scientifically, these results yield new insights, which are being incorporated into theoretical models describing polyolefin blends.

NIST HELPS INDUSTRY ASSESS PERFORMANCE DEGRADATION OF NEW REFRIGERANTS

NIST scientists have used their latest computer simulation tools to document the degradation of air conditioning performance that would occur using new refrigerants with current equipment technology. This work was done under a cooperative research and development agreement with the Air Conditioning and Refrigeration Industry, the association of 170 companies representing more than 95 percent of all U.S. equipment manufacturing and sales.

NIST scientists used their air conditioning evaporator model, EVAP 5, and the latest refrigerant property routine from the NIST Standard Reference Data, REFPROP 5.0, to simulate the performance of typical evaporator coils using the current refrigerant, R-22, and the leading candidate for replacement, R-407C. The primary variables were the degree of maldistribution of air flow across the coils and the maldistribution of refrigerant flow within the tubes. The study found that cooling capacity of the coils could be degraded by as much as 40 % due to maldistribution of air flow and could occur equally badly for R-22 or R-407C, depending on the configuration chosen for the air flow pattern and the refrigerant circuitry within the coil. The study found no unique advantage or disadvantage to the use of the new refrigerant.

NEW ANSI STANDARD FOR ELECTRICAL PACKAGING DESIGNS

A new standard entitled “Initial Graphics Exchange Specification Layered Electrical Product (LEP) Application Protocol” recently completed the ANSI approval review period. The standard is intended to improve the fidelity of design data transfer of electrical packaging designs when they are exchanged between computer-aided design (CAD) systems, or from CAD to computer-aided manufacturing (CAM) systems using the Initial Graphics Exchange Specification (IGES) transfer format. Standards such as this will allow manufacturers and engineers to exchange accurate design information electronically, for example, via the Internet.

The new ANSI standard culminates earlier NIST work in a Navy ManTECH program on Hybrid Microcircuit Assembly CAD to CAM transfer. During

this phase of the standards development, a NIST scientist was principal modeler, leading a team of 11 industry experts. The final ManTECH report was published as NIST TN 1295. NIST then worked with the Electrical Applications Committee (EAC) of the voluntary IGES Standard Project, within U.S. Pro, to achieve consensus on the ManTECH work. The EAC recognized that the Hybrid Microcircuit specification also could benefit the exchange of printed wiring and custom integrated circuit packaging designs, and a process toward generalization of the specification was begun. The EAC version of the specification achieved consensus and IGES Project approval in June 1995. The NIST scientist served as interim chair of the EAC as well as editor for changes during the development, review, and balloting of the standard.

One of the newer research thrusts for NIST is in meeting the needs of the electronics industry in the area of improving automation through information infrastructures. The effort often involves working closely with standards organizations to achieve the information flow needed to support improved design-to-product cycle times. The EAC has been one of these standards organizations, involved in electrical packaging design data, including mixed technology product models. These models are usually multiple two-dimension fabrication layers, but some designs require full three-dimensional CAD representations. The EAC is confident that the objects in the new LEP standard not only will provide the means for achieving the desired design data fidelity but also will provide a means to migrate more easily to or integrate with other object-based transfer and data-sharing paradigms.

ENERGY-RELATED INVENTIONS PROGRAM MAKES RECOMMENDATIONS

In November 1997, the NIST Office of Technology Innovation found three innovative technologies worthy of government support under the Energy-Related Inventions Program. They were:

Method and Apparatus for Providing Shortest Elapsed Time Route Information to Users (Traffic Assist[®] Traveler Information System)—a patented process and apparatus, configured as a motorist subscription service to provide least-time routes (LTR) from origins to destinations specified by subscribers. The LTRs are calculated on a real-time basis from large numbers of inductive loop sensors placed by the California Department of Transportation in pavements of major municipal roadways.

Clean Production of Coke from Waste Carbonaceous Fines—a process for manufacturing metallurgical grade coke from the powdered coke and powdered coal

normally discarded in landfills. In the process, a precise amount of powdered coke is mixed with a precise amount of powdered coal, and then a proprietary binder is used to bind the coke and coal powder into briquettes or blocks.

Model-Based Neural System for Wireline Well Log and Core Analysis—the application of pattern recognition algorithms via computer software to guide the interpretation of well log data taken in boreholes drilled in the search for petroleum. The innovative feature is the application of neural net mathematics to the analysis of well log data.

NEW NMR DATA ON IRON SULFUR PROTEINS THAT PARTICIPATE IN OXYGENASE BIOCATALYSIS

The putidaredoxin-cytochrome P450cam oxygenase enzyme system has considerable potential for the industrial production of high-value chemicals in which hydroxyl groups are introduced into hydrocarbons in a regio- and stereo-specifically controlled manner. The rate-limiting step in the biocatalytic cycle is that of electron transfer between the putidaredoxin (Pdx) protein and the catalytic enzyme cytochrome P450cam. To date, only ¹H NMR spectroscopy has been successful in determining some of the structural features of putidaredoxin that control the rate of electron transfer. The existing NMR derived structure of Pdx may be uncertain within about 0.8 nm of the Fe₂S₂ cluster.

NIST scientists report new spectral data on the Fe₂S₂ cluster by using Pdx protein prepared in such a way that every nitrogen atom of the 106 amino acid residues is labeled with the ¹⁵N isotope. The ¹⁵N NMR line widths were found to be up to 100 times smaller than the line widths of protons near the paramagnetic cluster. New resonances were found that include a set of 16 paramagnetically broadened signals from ¹⁵N nuclei that are structurally close to the iron-sulfur cluster of the protein. Reduced distances between certain paramagnetically affected ¹⁵N nuclei and the center of the iron-sulfur cluster have been calculated from the ¹⁵N spin lattice relaxation times, based on the assumption of a dominant electron-nuclear dipole-dipole relaxation mechanism. These are the first structural results for this protein's redox centers, providing a basis for interpreting the mechanism and rate of electron transfer from the iron-sulfur cluster. The results are reported in the journal *Magnetic Resonance in Chemistry* (Vol. 35, pp. 743-751, 1997). New studies are under way using Pdx protein in which only six cysteine residues, including four in the iron sulfur cluster are isotopically labeled with ¹⁵N. These NMR spectra are expected to provide further details about structure around the redox center,

as well as introducing new structural data about the dynamical differences between the oxidized and reduced states of the protein.

IMPROVED INFRARED SPECTRAL RESPONSIVITY SCALE REALIZED

An improved spectral responsivity scale covering infrared (IR) wavelengths from 2 μm to 20 μm with typical relative uncertainty better than 0.25 % has been realized at NIST. The scale was realized with much greater sensitivity than previous scales in this spectral region by using a cryogenic bolometer developed at NIST. The scale will be disseminated through spectral responsivity calibrations of IR detectors using a new detector comparator facility, substantially extending the spectral range of low uncertainty calibrations offered by the division.

The cryogenic bolometer accurately measures input powers in the 10 μW to 20 pW range, much smaller than possible with the previous pyroelectric detectors used in this spectral range. The bolometer absolute spectral responsivity was calibrated at several wavelengths by intercomparison with the division's high accuracy cryogenic radiometer (HACR), the NIST primary standard for optical power measurements. The relative responsivity of the bolometer was independently determined over the 2 μm to 20 μm spectral range and tied to the HACR absolute scale at the intercomparison wavelengths. The bolometer responsivity is very flat over the entire spectral range.

STUDIES OF MICROMOTION IN RF TRAPS

Researchers at NIST recently developed a method to sense the "micromotion" of trapped ions in microwave clocks, better estimating uncertainties due to second-order Doppler shifts from ion motion. NIST researchers measured the micromotion ion velocity to an upper relative uncertainty limit of 2×10^{-17} for a $^{199}\text{Hg}^+$ microwave clock.

Doppler shifts in the absorbed and emitted microwave radiation due to motion of ions in a clock contribute to frequency uncertainties. Minimizing ion motion by laser cooling substantially reduces the time-dilation or second-order Doppler shift in frequency standards. However, part of the motion of trapped ions depends on the trapping fields and cannot be directly reduced by laser cooling. In the Paul-RF trap used in the $^{199}\text{Hg}^+$ microwave clock, the micromotion caused by the trapping fields is minimized by confining a string of ions along the axis of a linear-Paul trap as first demonstrated at NIST. But sensitive diagnostic techniques are needed to determine when this condition has been achieved.

The researchers used three non-coplanar laser beams to sense the ion micromotion velocity by examining first-order Doppler shifts in the induced fluorescence. This information controls the application of compensation potentials to the trap electrodes, tailoring the trapping field to minimize ion micromotion.

LOW NOISE REGENERATIVE FREQUENCY DIVIDERS

NIST scientists recently demonstrated exceptionally low noise regenerative frequency dividers operating at frequencies up to 40 GHz, believed to be the highest frequency direct electronic division ever achieved. Such high-performance dividers are critical for frequency standard realization, such as components in frequency synthesizers and for frequency synthesis chains linking the microwave and optical regions. The dividers also may be useful for high-data-rate telecommunications systems.

The dividers achieve good stability through use of a filter within the regenerative loop that rejects the image frequency. Their noise properties are insensitive to the loop phase, making them practical devices for application in the microwave region. The regenerative divider noise is so low that it would support synthesis with a fractional frequency stability of 10^{-18} for longer averaging time.

SIMPLIFIED OPTICAL-FREQUENCY TRIPLER

A simplified optical-frequency tripler has been demonstrated in a collaboration between NIST scientists and scientists at the University of Colorado, Rice University, and a private company. The tripler is based on a new non-linear optical crystal, periodically poled lithium niobate (PPLN), and the discovery of several special phase-matching conditions.

The collaboration researchers demonstrated a simultaneous phase matching of second-harmonic generation (SHG) and sum-frequency mixing of the SHG with the fundamental to produce the third harmonic. With only a single pass through a 2 cm long PPLN crystal, 195 μW of 3.56 μm radiation from a CO laser was frequency-tripled to 7.3 nW at 1.19 μm . Eleven other wavelengths between 1 μm and 4 μm meet the special phase-matching conditions for frequency tripling.

The new tripler should be particularly important for constructing certain stages of an optical-frequency-synthesis chain for coherently linking the cesium-atomic-clock frequency in the microwave region to the frequency of future optical clocks (such as Hg^+) in the visible. The collaborators also found 10 special phase

match points where second harmonic generation is cascaded twice to yield fourth-harmonic generation, which also may be useful for synthesis chains.

OPTICAL COHERENCES IN DENSE ATOMIC MEDIA

NIST scientists collaborated with scientists from Texas A&M University, the University of Munich, the Max-Planck Institute, and the Lebedev Institute to study optical-coherence effects in dense rubidium vapor. They discovered narrow resonances that result from interferences in stimulated Raman transitions in the vapor. The results of these studies were published recently in *Physical Review Letters*.

These effects drastically alter the observed lineshape, making it more difficult to find the true center of the atomic line. Such lineshape changes could limit high-accuracy measurements in certain types of optical detection in rubidium atomic clocks. However, because the coherence-induced interferences are spectrally sharp, they are potentially useful for higher resolution spectroscopy and possibly higher detection sensitivity for other applications.

GOLD MICROINDENTATION HARDNESS STANDARD

The development of an electroformed gold microindentation hardness standard has been the subject of a 2-year program at NIST. The standard will be used to verify the calibration of microhardness instruments when used for measurements of soft materials at low applied forces.

The request for this standard has come mainly from the electronics industry where gold is electrodeposited on silicon to effect wire bonding and on printed circuit board contacts. The general plating industry for precious metals also has requested a standard for process control of addition agents to gold electrolytes.

Project researchers have produced a 24 K gold, low load microhardness standard prototype by incorporating two technologies, electroforming and single-point diamond turning. Two critical issues were recognized and resolved. First, the hardness of the electroformed gold was found to vary with the thickness of the deposit, so a method was developed to generate a uniform deposit of 200 μm thickness. Second, conventional metallographic polishing of such a soft material results in the imbedding of grinding and polishing media into the surface, so single-point diamond turning was used to generate the required flat surface. Using these methods, prototype microhardness standards having the required hardness and surface finish characteristics have been produced.

This microindentation hardness standard is expected to fill a void in the low hardness, low load standards presently offered. Production and sales are expected within one year following fabrication scale-up.

MEASUREMENT CAPABILITIES EXTENDED AT THE NIST CENTER FOR NEUTRON RESEARCH (NCNR)

Scientists at the NCNR recently tested the world's first phase-space-transformation (PST) chopper for neutrons, a device which, in effect, focuses the energy distribution of a beam of neutrons towards a desired value. Experiments carried out at the NCNR's soon-to-be-commissioned high flux backscattering spectrometer (HFBS) have demonstrated that the PST device can increase the neutron flux incident on a sample under investigation by more than a factor of four. Although the idea behind the PST chopper was originally conceived in 1984, the NCNR chopper is the first realization of such a device and represents an extremely important advance in the field of neutron optics. This breakthrough, along with other special features of the HFBS, will open up important new applications of neutron spectroscopy. In particular, certain details of atomic and molecular motions, which are often a key to the understanding and exploitation of the properties of complex materials, will be examined for the first time.

The process of phase space transformation exploits the physics of Bragg diffraction from moving imperfect or "mosaic" crystals. The focusing occurs as a result of the preferential Doppler shifting of slower neutrons to faster speeds, and faster neutrons to slower speeds, all relative to a desired target speed. The NCNR PST chopper is composed of 180 carefully selected crystals of highly oriented pyrolytic graphite. These are precisely aligned and mounted inside cassettes affixed to the periphery of a 1 m diameter disk that rotates at 4700 revolutions per minute, or roughly 250 m/s.

The higher neutron flux afforded by the PST chopper will greatly extend the measurement capabilities of the ultrahigh resolution HFBS. This spectrometer, unique in the world, will be used to measure the dynamics of a wide variety of systems (ranging from buckyballs to catalysts to Portland cement) on a time scale previously almost inaccessible.

NIST'S LONGITUDINAL STUDY ON DNA SAMPLE

The results of NIST's long-term study on DNA stability were presented at the Second Joint Conference on DNA Databanks and Repositories and CODIS user's group meeting, Chicago, IL, in December 1997. The study

provides insight and directions for forensic laboratories that store bloodstains for DNA typing. Nearly every state in the United States now has laws governing the DNA typing of convicted offenders in the criminal justice system.

A NIST scientist presented results taken over the past three and one-half years. Bloodstains on especially prepared filter paper have been stored at ambient (laboratory room temperature), -20°C , -80°C , and liquid nitrogen vapor temperatures for 40 months. DNA from six bloodstains was quantified by identical methodology at time points: 0, 1, 2, 4, 8, 12, 24, and 39 months. At the same time, DNA aliquots were tested for their ability to be typed. The results of the experiments indicated a 40 % decrease in the DNA recovered from the stains stored at ambient temperature, as compared to the stains stored at the lower temperatures. The downward trend of the DNA recovered from the stains stored at ambient temperature was apparent from the 8-month storage time point and has continued on a downward trend from that time point.

Since the start of this DNA stability study, other matrices for the storage of bloodstains have been developed. New temperature studies are under way to study some of these matrices. These studies will have an impact on the nature of storage requirements for nearly 10 million samples that will be stored over the next 8 to 10 years.

A NEW LOOK AT NANOPARTICLE GROWTH

One of the major obstacles to the widespread use of nanoscale materials is the difficulty in producing fine particles with the desired chemical purity, phase, and morphology. These challenges are exacerbated greatly by the need to produce these materials in both large quantities and at a sufficiently low cost. The conventional wisdom is that a vapor phase growth process is the synthesis method of choice to satisfy these two requirements. However, vapor phase growth processes have the unfortunate and little understood propensity to form agglomerated particles rather than the spherical particles required for industrial use. Agglomeration will occur when the time between particle collisions is less than the sintering time.

While considerable attention has been paid to the development of phenomenological models for particle growth and agglomeration, little attention thus far has been directed at understanding the growth phenomena, especially at a fundamental molecular level. This situation has now been rectified to some extent as a result of molecular dynamics computations of nanoparticle growth that have been performed by researchers at NIST. These dynamical simulations have been con-

ducted for a broad range of temperatures and particle sizes. It has been shown that particle growth rates are extremely dependent on both size and temperature. Looking at the motion of the atoms during sintering reveals fundamental phenomena consistent with previously existing models. Thus, NIST's atomistic computations have been able to explain on a molecular level, for the first time, the previously mentioned phenomenological models. The validation of the functional form of the phenomenological models, as well as the ability to use these molecular level computations to obtain the input parameters necessary to implement these less fundamental models, has greatly increased their usefulness. The NIST researchers also are using these models to allow the first accurate descriptions of the sintering behavior of very small clusters (60 to 960 atoms). Future work is aimed at understanding the growth of metal and mixed metal oxides, which encompass the largest class of industrially relevant particulate chemistries.

NIST CONTRIBUTING TO IMPROVED WASTEWATER TREATMENT

In 1996 alone, over 32 billion gallons per day of sewage wastewater were discharged by 16000 treatment facilities in the United States. Before being released into the environment, wastewater must be disinfected to remove pathogens. This is most commonly done with chlorine because of its effectiveness and low cost. To reduce the toxic effects of "residual chlorine" that remains after disinfection, sulfite compounds are added to wastewater to reduce any chlorination byproducts. However, several studies have shown that such dechlorinated wastewater still provides some toxic stress to aquatic life.

In collaboration with the University of Maryland researchers at NIST have developed a new detection approach for the environmentally harmful organic chlorination products formed in sewage wastewater processing. Liquid chromatography (LC) was combined with a detection scheme based on post-column reaction of the N-chloramines followed by electrochemical detection. The method was used to evaluate the effectiveness and rate of commercial dechlorination processes used to remove the toxic N-chloramines. Although "inorganic" N-chloramines rapidly dechlorinate, the LC method revealed that peptide and protein-nitrogen in the sewage are dechlorinated slowly with half-lives of over 20 minutes. Currently, the team is working on two aspects of the problem: identifying the specific wastewater peptides involved and using a marine chemiluminescent bacterium as a probe to evaluate the contribution of specific peptides to aquatic toxicity. The results of these studies will allow sewage process engineers to modify and monitor wastewater

treatment processing to ensure that the harmful organic N-chloramines are dechlorinated fully before discharge of the wastewater.

FedCIRC PROVIDES ADVICE IN HANDLING COMPUTER SECURITY INCIDENTS

FedCIRC (Federal Computer Incident Response Capability) is developing a timely schedule of training courses to help users minimize the impact of incidents and to provide increased awareness of computer security threats and available tools to resolve incidents and problems. FedCIRC was established by NIST in the fall of 1996 to provide proactive and reactive computer security-related services, technical support, and cost-reimbursable technical assistance. To date, six organizations have subscribed to the service: the Department of Justice, the Department of State, the U.S. Customs Service, the Department of Agriculture National Finance Center, the General Services Administration Federal Supply Systems, and the Department of the Treasury Bureau of Alcohol, Tobacco, and Firearms.

The first FedCIRC Annual Workshop, held in November 1997, attracted 89 participants from industry and government. Topics included threat and intruder tools and techniques, legal issues, electronic crime, intrusion detection, secure communications, and how to establish an incident response capability. The annual workshop is one of many training programs FedCIRC offers to industry and government. The workshop in February 1998, at NIST, focused on establishing a computer security forensics program.

APLAC LABORATORY ACCREDITATION AGREEMENT

The National Voluntary Laboratory Accreditation Program (NVLAP), became one of the first accrediting bodies to be included in the signing of a Mutual Recognition Arrangement among the bodies of six countries within the Asia Pacific Laboratory Accreditation Cooperation (APLAC) at a ceremony held in Tokyo, Japan, in November 1997. This culminated activities that began in 1995 involving reciprocal assessments of NVLAP and the other accreditation bodies to assess compliance with ISO/IEC Guide 58, Calibration and Testing Laboratory Accreditation Systems-General Requirements for Operation and Recognition. The accreditation bodies included in the arrangement are NVLAP and A2LA of the United States, NATA of Australia, IANZ of New Zealand, HOKLAS of Hong Kong, CNLA of Chinese Taipei, and SINGLAS of Singapore. Accreditation bodies in 12

more Asia Pacific countries are members of APLAC and may join the arrangement when successfully assessed to the ISO Guide 58 requirements.

Under the arrangement, signatories recognize the technical equivalence of test reports and calibration certificates issued by laboratories accredited by any of the other signatories. The arrangement supports the World Trade Organization and the Asia-Pacific Economic Cooperation obligations of the United States and other members to simplify conformity assessment procedures, such as the accreditation of testing and calibration laboratories, and to prevent them from becoming barriers to trade.

NIST HELPS TO DETERMINE RESEARCH NEEDS FOR ARSON INVESTIGATION

NIST in partnership with the Bureau of Alcohol, Tobacco and Firearms (ATF), University of Maryland's Department of Fire Protection Engineering, and a private company co-hosted the International Conference on Fire Research for Fire Investigation. The conference was attended by 76 fire investigation experts and fire researchers from the public and the private sector. International expertise came from Canada, Great Britain, Italy, Scotland, and Sweden.

The focus of the meeting was to examine and document the research needs of arson investigators and develop the list of technical requirements for addressing the research needs. The technical requirements relating to facilities and personnel will be considered in the design and construction of ATF's Fire Investigation Research and Education Center (FIRE Center). The center will be constructed in the Washington Metropolitan Area and will be part of a \$62 million ATF research and investigation laboratory. Plans call for the center to be operational by 2001.

SYMPOSIUM HELD ON FRACTURE MECHANICS IN ELECTRONIC PACKAGING

A NIST scientist and a researcher at the Institute for Materials Research and Engineering in Singapore, organized and chaired a symposium entitled "Application of Fracture Mechanics in Electronic Packaging" at the 1997 ASME Mechanical Engineering Congress and Exposition in Dallas, TX, in November 1997. The organizers edited the proceedings volume, which was distributed at the symposium. The symposium consisted of 23 papers, nearly half of which were from industry or were produced by industry-university teams. By comparison with a similar event 2 years ago, this year's symposium had several papers on underfill

and adhesion and only a few on solder, whereas 2 years ago, most of the papers were on solder. The papers made it very clear that fracture mechanics has become the preferred method for quantitative evaluation of inter-facial adhesion. The proceedings are available from ASME as combined volume AMD-222, EEP-20.

OIML MEETING HELD IN BRAZIL

The 32nd meeting of the International Committee of Legal Metrology (CIML) took place in Rio de Janeiro, Brazil, in October 1997. The meeting was hosted by the National Institute for Metrology, Normalization, and Industrial Quality (INMETRO). Representatives of 45 of the 56 member nations participated in the meeting, along with several of the 44 corresponding member nations. Two NIST scientists participated on behalf of the United States.

Highlights of the meeting included the approval of five OIML Recommendations, namely, Instruments for Measuring the Mass of Liquids in Tanks; Automatic Liquid Level Gauges for Fixed Storage Tanks (revision of OIML R85); Evidential Breath Analyzers; Instruments for Measuring Vehicle Exhaust Emissions (revision of OIML R99); and Measuring Systems for Cryogenic Liquids (revision of OIML R81). The United States was responsible for the revision of OIML R81 and provided significant input for the development/revision of the other approved recommendations. NIST reported on the status of technical work and will lead a task group to review the status of specific projects within technical committees and recommend priorities for work. The International Bureau of Legal Metrology (BIML) reported on the status of the OIML Certificate System: more than 300 certificates have been issued since the system was established in 1993. Twenty-four recommendations are a part of the Certificate System; however, most certificates have been issued for nonautomatic weighing instruments and load cells. Reports were presented on liaison with other international organizations, namely ISO and IEC, and on the efforts of the Development Council to assist developing countries. An international seminar on “the role of metrology in economic and social development” will take place in June 1998 at the Physikalisch-Technische Bundesanstalt (PTB) in Germany, co-sponsored by OIML, BIPM (International Bureau of Weights and Measures), and IMEKO (the International Metrology Confederation), and PTB. A memorandum of cooperation was signed between the Interamerican System of Metrology and OIML. A NIST representative and the current president of SIM from Mexico participated in the signing

ceremony, together with representatives of OIML. Prior to the CIML meeting, INMETRO sponsored a tour of their laboratories and a Workshop on “Metrology of the World” in which papers on metrology activities in Europe, Asia, the Americas, and OIML were presented. A NIST paper on “accreditation as applied to legal metrology activities” was presented at the workshop and also at the CIML meeting.

The next CIML meeting is scheduled for Seoul, Republic of Korea, in October 1998.

MEMORANDUM OF UNDERSTANDING WITH ICC

NIST has executed a Memorandum of Understanding (MOU) with the International Code Council (ICC) to mutually support the development and maintenance of appropriate building and construction codes that promote health, safety, and welfare; reduce human and economic losses resulting from hazards; and avoid creation of technical barriers to trade. Under this MOU, NIST will assist ICC in its code development and maintenance processes by providing measurement methods, test data, and expert opinions. For its part, the ICC is committed to advancing the development of a set of performance-based codes, an important objective consistent with NIST’s mission. NIST and ICC’s efforts are expected to further establish the United States as a leader in the development of international codes and standards. The ICC (<http://www.intlcode.org/>) is an umbrella organization, founded in 1994, by the Building Officials and Code Administrators International, the International Conference of Building Officials, and the Southern Building Code Congress International as a nonprofit organization to develop a single set of comprehensive and coordinated national codes for building construction.

VIETNAMESE DELEGATION VISITS NIST

Twenty-one officials of Vietnamese companies attended a seminar on U.S. standards and conformity assessment in November 1997. Hosted by NIST, the seminar was part of an ongoing effort to introduce foreign officials to U.S. technology and principles regarding metrology, standards development, and conformity assessment. This activity promotes the exchange of information and helps to eliminate technical barriers to trade in the global marketplace. The delegation was led by the director of Planning and Cooperation, Department for Standards and Quality at the Vietnamese Ministry of Science and Technology, STAMEQ.

The program included presentations by various NIST staff on the role of the U.S. Government in standards and conformity assessment; the role of the private-sector; U.S. and foreign laboratory accreditation programs; the services of the NIST National Center for Standards and Certification Information; construction and building standards; the role of the NIST Office of Weights and Measures in maintaining uniformity in the U.S. marketplace; and ISO 14000 environmental standards and ISO 9000 quality standards. The group also visited a certified ISO 9000 company in Gaithersburg, MD.

INDUSTRY WELL REPRESENTED AT NAMT WORKSHOP

NIST held its third National Advanced Manufacturing Testbed (NAMT) workshop in November 1997 in Pleasanton, CA, to review the progress to date on the development of machine tool performance models and data repository, and to plan future activities. To facilitate industrial participation in the project, NIST established a consortium last summer. Members of the consortium include NIST, and three private companies. Several other potential industrial partners are finalizing their membership.

The first day was devoted to presentations by NIST staff including talks on a visualization model of machine performance, progress at NIST on coordinate measuring machines measurement uncertainty modeling and prediction, machine tool classification data modeling, the Data Dictionary, and the data repository, which included its capabilities for remote uploading and analysis. The final day was devoted to the development of detailed plans for future efforts, including use of the repository. It is anticipated that a follow up workshop will be held at NIST in the summer of 1998.

1997 WORKSHOP ON KNOWLEDGE-BASED SYSTEMS SPONSORED

NIST sponsored the 1997 Workshop on Knowledge-Based Systems (KBS) Interoperability in November 1997. Held in response to the growing need for integrating knowledge in distributed computing systems, the workshop attracted about 25 participants, representing views from KBS developers, vendors and researchers, and engineers who use knowledge-based (KB) and CAx systems in their design and manufacturing activities.

Two main themes emerged: (1) interoperability among KB systems and CAx systems is difficult to achieve, and (2) current standards do not address many of the interoperability issues associated with KB systems. Details of this workshop can be found at <http://www.mel.nist.gov/msidevent/workshop/kbi97/>.

NIST WORKSHOP ON STATISTICAL DESIGN OF EXPERIMENTS BENEFITS INDUSTRY ENGINEERS

Forty engineers from key U.S. industries learned the latest statistical experiment design and analysis techniques for improving product and process quality at a recent NIST workshop. Engineers from the computer, electronic, chemical, biomedical, automotive, materials, and polymer industries attended the five-day workshop on "Improving Product and Process Design Using Experiment Design" at NIST in December 1997.

The workshop covered statistical designs that have proven best for three important problems: ferreting out the most important parameters from a large number of potential parameters; converging to an optimal operating condition starting from a "best guess"; and identifying settings of controllable parameters that reduce process variation. As part of a team, students ran a series of hands-on experiments to reinforce the underlying design concepts. Each student also designed an experiment for a project under way in their laboratory and consulted with an instructor to discuss their work. Details of the next workshop, scheduled for the fall of 1998, will be announced at <http://www.itl.nist.gov/div898/>.

NEW OPTICAL PROPERTIES CONSORTIUM LOOKING FOR MEMBERS

NIST is inviting companies to join a new consortium on optical properties of materials. The consortium, being organized in response to requests from industry, NASA, and the Department of Defense, will address critical needs for high-accuracy optical measurements, new standards development and evaluation, and dissemination of optical properties of materials data.

Optical properties of materials, such as ultraviolet to infrared transmittance, reflectance, absorptance, light scattering, and refractive index, are critical to producing and characterizing devices and materials. A wide range of industries, including pharmaceuticals, communications, semiconductor production, and optical components manufacturing, could benefit from improved measurement accuracy, new standards and calibrations for optical properties of advanced materials currently under development.

The diverse industrial sectors interested in optical properties previously had no single source at NIST for assistance, explains the consortium leader at NIST. The consortium's goal is to provide information that will help reduce manufacturing cost and improve product quality for both military and civilian markets.

For more information, contact Raju Datla, B208 Physics Building, NIST, Gaithersburg, MD 20899-0001, (301) 975-2131, raju.datla@nist.gov.

**CLAY COMPLEXES AVOID AGGREGATION,
PREVENT AGGRAVATION**

The potential of using clay as the filler in certain composite materials is well understood and appreciated. But clay is most effective when it is fully dispersed into its constituents—negatively charged platelets about 1 nm thick and 20 nm to 200 nm in diameter—and bonded into a matrix using an appropriate cationic organic intermediary.

This configuration maximizes the surface contact between the clay and the polymer, minimizes the amount of clay mineral needed to affect material properties, and ensures that the material is homogeneous at length scales only slightly larger than a clay platelet. The resulting material is a nanocomposite. Unfortunately, clay platelets tend to form large aggregates in the presence of organics and thus do not disperse homogeneously.

Scientists at NIST have prepared micelle-like clay/surfactant complexes that are stable and that resist platelet aggregation. These complexes have been polymerized to form nanocomposites. The scientists verified the homogeneous nanoscale dispersion of platelets using dynamic light scattering.

For two papers (listed together as no. 50-97) describing this research, contact Sarabeth Harris, MC 104, NIST, Boulder, CO 80303-3328, (303) 497-3237, sarabeth@boulder.nist.gov.

**PROJECT SUMMARIES OFFER GLIMPSE OF
TOMORROW'S BETTER HOMES**

Just about anyone who lives or works in a building (and that's just about everyone) has a stake in the projects described in NIST Building and Fire Research Laboratory Project Summaries 1997. The recently released annual report describes research in three fields: high-performance construction materials, automation techniques to speed construction, and systems to reduce fire and wind-related damage to dwellings. It also lists NIST life-cycle cost analysis programs.

Among the 165 listed projects: computer information systems concerning new high-performance concrete; guidelines for the repair or rehabilitation of earthquake-damaged welded steel frames; standards for air quality of residential ventilation systems; methods to test aircraft interior materials for fire safety; computer simula-

tions to predict building fire hazards; "environmentally friendly" alternative refrigerants for heat pumps; and economic analysis methods, data and software for energy and water conservation projects. Each of the research summaries includes a project description, recent results, the name of a NIST contact person, and where appropriate, the names of outside government or industry sponsors.

For a copy of NIST Building and Fire Research Laboratory Project Summaries 1997 (NIST SP 838-13), contact Noel Raufaste, B250 Building Research Building, NIST, Gaithersburg, MD 20899-0001, (301) 975-5905, noel.raufaste@nist.gov.

**NIST TO EVALUATE EVALUATORS OF
WATER QUALITY TESTING**

NIST recently announced draft guidelines to accredit commercial vendors to evaluate drinking and wastewater analysis laboratories. Rather than continuing to monitor the proficiency of water testing laboratories itself, as it has done for many years, the Environmental Protection Agency is allowing commercial and state laboratories to conduct proficiency testing with oversight from NIST and the EPA.

NIST is providing draft guidelines, Chemical Calibration: Providers of Proficiency Testing, to commercial vendors and interested states that wish to provide proficiency testing for laboratories testing drinking water and wastewater. The draft handbook covers the technical requirements of this program.

NIST will accept public comments on the draft until April 30, 1998. The handbook outlines how commercial and state laboratories can demonstrate their capabilities and technical competence to perform proficiency testing studies that meet state and EPA requirements. It is expected that prospective proficiency testing study providers will be able to apply for accreditation from NIST's National Voluntary Laboratory Accreditation Program beginning in June 1998.

Questions concerning the NIST role in this overall effort should be sent to Reenie Parris, B158 Chemistry Building, NIST, Gaithersburg, MD 20899-0001, (301) 975-3103. The draft guidelines are available on the World Wide Web at <http://www.cstl.nist.gov/-nist839>. Draft copies also can be requested by sending a fax to (301) 926-8671.

Standard Reference Materials

HETEROGENEOUS RADIONUCLIDES CERTIFIED IN OCEAN SEDIMENT (SRM 4357)

Most SRM users believe that Standard Reference Materials (SRMs) must be homogeneous. While great pains are taken to homogenize many SRM materials, environmental or natural-matrix materials are inherently heterogeneous to some degree, and heterogeneous SRMs are required for some applications. NIST recently certified the heterogeneous anthropogenic concentrations of ^{90}Sr , ^{137}Cs , ^{238}Pu , and $^{239}\text{Pu}+^{240}\text{Pu}$ in Ocean Sediment (SRM 4357, Irish Sea Sediment diluted 1:200 with Chesapeake Bay Sediment). By contrast, the heterogeneity of primordial radionuclides and their progeny concentrations were not detected.

The heterogeneity of the anthropogenic radionuclides were first evaluated with probability plot correlation coefficients (ppcc) for numerous families of distributions. Remarkably, the best ppcc shape and scaling factors for all certified anthropogenic radionuclides were for Weibull distributions. The data then were transformed and characterized for means, and 95 % tolerance limits with 95 % coverage. The uncertainty of the means and the tolerance limits then were determined by the bootstrap technique. The radionuclides were characterized for both mean and the tolerance limits for different potential applications: (a) for $n > 5$ laboratory measurements, the mean value should be evaluated against the certified mean value; and (b) for $n < 5$ laboratory measurements, such as for “blind” quality assurance testing programs, the tolerance limit would be the appropriate certified value for comparison.

This is the first known application of the combined use of the ppcc and bootstrap techniques to carefully certify heterogeneous radionuclide concentrations in natural-matrix radionuclide SRMs. The new ocean sediment will provide the ocean studies community with a much-needed SRM for methods validation and a common basis for comparison of international measurements around ocean-based nuclear waste dump sites.

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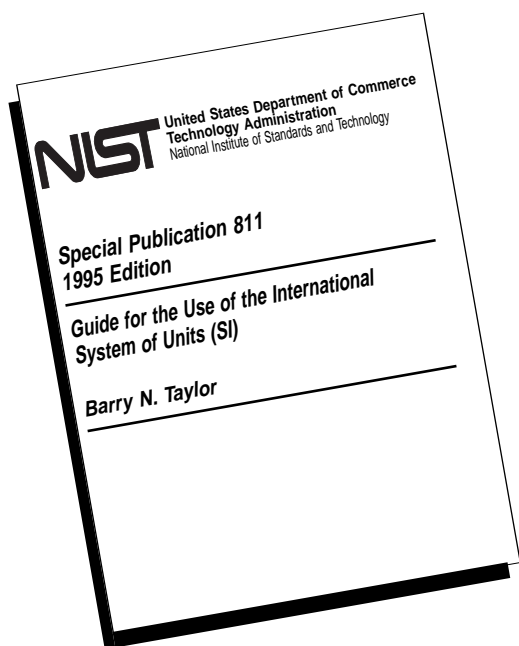
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The International System of Units (SI)

The Modern Metric System



Uncertain about the International System of Units (universally abbreviated SI), the modern metric system used throughout the world? Do you need to know the proper way to express the results of measurements and the values of quantities in units of the SI? Do you need to know the NIST policy on the use of the SI? Then you need the 1995 edition of the National Institute of Standards and Technology Special Publication 811, *Guide for the Use of the International System of Units (SI)*.

The 1995 edition of the National Institute of Standards and Technology Special Publication 811, *Guide for the Use of the International System of Units (SI)*, by Barry N. Taylor, is now available.

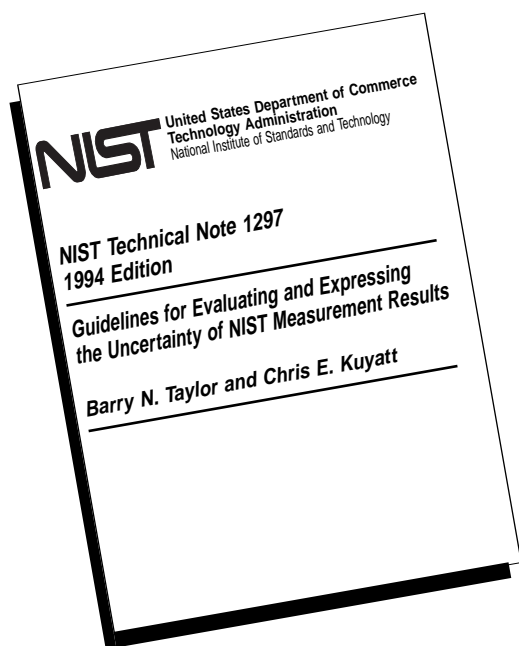
The 1995 edition of SP 811 corrects a number of misprints in the 1991 edition, incorporates a significant amount of additional material intended to answer frequently asked questions concerning the SI and SI usage, and updates the bibliography. The added material includes a check list for reviewing the consistency of written documents with the SI. Some changes in format have also been made in an attempt to improve the ease of use of SP 811.

The topics covered by SP 811 include:

- NIST policy on the use of the SI in NIST publications.
- Classes of SI units, those SI derived units that have special names and symbols, and the SI prefixes that are used to form decimal multiples and submultiples of SI units.
- Those units outside the SI that may be used with the SI and those that may not.
- Rules and style conventions for printing and using quantity symbols, unit symbols, and prefix symbols, and for spelling unit names.
- Rules and style conventions for expressing the results of measurements and the values of quantities.
- Definitions of the SI base units.
- Conversion factors for converting values of quantities expressed in units that are mainly unacceptable for use with the SI to values expressed mainly in units of the SI.
- Rounding numbers and rounding converted numerical values of quantities.

Single copies of the 84-page SP 811 may be obtained from the NIST Calibration Program, Building 820, Room 232, Gaithersburg, MD 20899-0001, telephone: 301-975-2002, fax: 301-948-3825.

Evaluating and Expressing the Uncertainty of Measurement Results



Uncertain about expressing measurement uncertainty? Do you need to know how NIST states the uncertainty of its measurement results and how you can implement their internationally accepted method in your own laboratory? Then you need the newly available 1994 edition of the National Institute of Standards and Technology Technical Note 1297, *Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results*.

The 1994 edition of the National Institute of Standards and Technology Technical Note 1297, *Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results*, by Barry N. Taylor and Chris E. Kuyatt is now available.

The 1994 edition of TN 1297 includes a new appendix—Appendix D—which clarifies and gives additional guidance on a number of topics related to measurement uncertainty, including the use of certain terms such as accuracy and precision. Very minor word changes have also been made in a few portions of the text of the 1993 edition in order to recognize the official publication in October 1993 by the International Organization for Standardization (ISO) of the *Guide to the Expression of Uncertainty in Measurement* on which TN 1297 is based. However, the NIST policy on measurement uncertainty, Statements of Uncertainty Associated with Measurement Results, which is reproduced as Appendix C of TN 1297, is unchanged.

It is expected that the 1994 edition of TN 1297 will be even more useful than its immediate predecessor, the 1993 edition, of which 10 000 copies were distributed worldwide.

Those United States readers who wish to delve into the subject of measurement uncertainty in greater depth may purchase a copy of the 100-page ISO *Guide* from the Sales Department of the American National Standards Institute (ANSI), 105-111 South State Street, Hackensack, NJ 07601. Copies may also be purchased from the ISO Central Secretariat, 1 rue de Varembé, Case postale 56, CH-1211 Genève 20, Switzerland.

Single copies of the 20-page TN 1297 may be obtained from the NIST Calibration Program, Building 820, Room 232, Gaithersburg, MD 20899-0001, telephone: 301-975-2002, fax: 301-948-3825.

NIST Technical Publications

Periodical

Journal of Research of the National Institute of Standards and Technology—Reports NIST research and development in those disciplines of the physical and engineering sciences in which the Institute is active. These include physics, chemistry, engineering, mathematics, and computer sciences. Papers cover a broad range of subjects, with major emphasis on measurement methodology and the basic technology underlying standardization. Also included from time to time are survey articles on topics closely related to the Institute's technical and scientific programs. Issued six times a year.

Nonperiodicals

Monographs—Major contributions to the technical literature on various subjects related to the Institute's scientific and technical activities.

Handbooks—Recommended codes of engineering and industrial practice (including safety codes) developed in cooperation with interested industries, professional organizations, and regulatory bodies.

Special Publications—Include proceedings of conferences sponsored by NIST, NIST annual reports, and other special publications appropriate to this grouping such as wall charts, pocket cards, and bibliographies.

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