

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.

APEC SEMINAR ON TBT AGREEMENT

The Office of Standards Services (OSS), participated in the Asia-Pacific Economic Cooperation (APEC) seminar on the implementation of the Uruguay Round Agreement on Technical Barriers to Trade (TBT), held May 14-15, 1996, in Manila, the Philippines. An office representative spoke on the role and obligations of inquiry points, which are required under the agreement and which are responsible for responding to inquiries concerning standards, technical regulations, and conformity assessment procedures. The representative established the U.S. inquiry point at NIST in 1980 and supervises OSS' National Center for Standards and Certification Information (NCSCI). NCSCI also operates the inquiry point for the North America Free Trade Agreement and for the ISONET information network operated by the International Organization for Standardization.

The seminar was held under the auspices of the APEC Committee on Trade and Investment and hosted by the Office of the U.S. Trade Representative. Its purpose was to inform representatives from APEC countries of the TBT Agreement provisions and to describe national implementation experiences. The APEC countries are Australia, Brunei Darussalam, Canada, Chile, People's Republic of China, Hong Kong, Indonesia, Japan, Republic of Korea, Malaysia, Mexico, New Zealand, Papua New Guinea, the Republic of the Philippines, Singapore, Chinese Taipei, Thailand, and the United States.

NIST is active in the APEC Sub-Committee on Standards and Conformance, a part of the Committee on Trade and Investment.

NIST CONDUCTS TRAINING ON PRICE VERIFICATION PROCEDURE

An Instructor Training School on the National Conference on Weights and Measures' (NCWM) "Examination Procedure for Price Verification" was conducted by NIST May 6-8, 1996, in Gaithersburg, MD. The Examination Procedure, which was adopted by the NCWM membership in July 1995, provides a uniform process for regulatory officials and retail store managers to follow to verify that prices charged consumers at store checkout counters are the same as the advertised prices. The procedure was developed in cooperation with industry in response to public concerns about price accuracy in retail stores, particularly those that use electronic scanning equipment.

Attending the class were 10 weights and measures officials from jurisdictions across the country who, in exchange for the training, had agreed to train others in how to use the procedure, starting with officials in their own offices. Also attending were observers from major retail stores and the National Retail Federation. Guest speakers included a representative of the Pennsylvania Food Marketing Association and an official from the Federal Trade Commission. In addition, the retail store representatives in attendance made presentations on the pricing practices of their companies. Field training was conducted at three Gaithersburg, MD stores.

ENERGY-RELATED INVENTIONS PROGRAM RECOMMENDATIONS

During the month of April, the NIST Office of Technology Innovation recommended two innovative technologies for commercialization to its Department of Energy partner under the Energy-Related Inventions Program.

- Water Saving Device for Toilets: Smart Flapper "the Smart Flapper is a water-saving device for installation on existing household toilets.
- Electric Utility Energy Storage Device—a design of a modular flow-through zinc/bromine battery that allows load-leveling by electric utility companies.

NIST ROLE ENSURES AGREEMENT BETWEEN U.S., IEC STANDARDS FOR MEASUREMENT OF ELECTRIC AND MAGNETIC FIELDS IN SUPPORT OF LOW-FREQUENCY BIOEFFECTS RESEARCH

A NIST scientist is serving as the Convenor of Working Group 11 (WG11) of International Electrotechnical Commission Technical Committee 85. Under his leadership, WG11 recently completed preparation of a working-group draft standard, "Low Frequency Magnetic and Electric Fields with Particular Regard to Human Exposure-Instrumentation Requirements and Guidance for Measurement Procedures." Working in collaboration with other participants in WG11, the NIST scientist prepared six drafts of the document which includes descriptions of instrumentation for characterizing quasi-static magnetic and electric fields (15 Hz to 10 kHz), terminology, requisite instrument specifications and calibration methods, examples of measurement protocols, and a comprehensive listing of sources of measurement uncertainty.

A representative of U.S. interests needed to be active in the committee developing the international standard in order to avoid technical conflicts between IEC and U.S. standards. Such conflicts would pose problems for several reasons. First, the United States is under some obligation as an IEC member to adopt the recommendations of IEC standards. Second, and more significant, U.S. companies desiring to sell in European markets could face a barrier, because IEC standards are automatically balloted by the European Committee for Electrotechnical Standardization (CENELEC) to become mandatory for the European Community, if approved.

Preparation of the IEC measurement standard was prompted by the January 1995 publication of CENELEC Prestandard, ENV 50166-1, "Human exposure to electromagnetic fields, Low-frequency (0 Hz to 10 kHz)." The European prestandard sets restrictions on human exposure to magnetic and electric fields in the specified frequency range and is intended for "provisional application" for 3 years. Within 1 year, discussions will begin to consider converting the prestandard into a European standard. The metrology standard prepared by WG11 complements the exposure document without endorsing the appropriateness of the recommendations of the latter document. Preparation of the final WG11 document was completed in about 1 year and was expedited through the use of an existing Institute of Electrical and Electronics Engineers (IEEE) standard during preparation of the first draft. Drafts of this standard, "Recommended Practice for Instrumentation: Specifications for Magnetic Flux Density and Electric Field Strength Meters—10 Hz to 3 kHz," had

been prepared earlier by the scientist in collaboration with other members of the AC Fields Working Group in the IEEE Power Engineering Society.

MBE METROLOGY CHAMBER ESTABLISHED IN RESPONSE TO INDUSTRY NEEDS

NIST has put into operation a reaction chamber dedicated to the validation of characterization tools for structures grown by molecular-beam epitaxy (MBE). This development responds to intense industry interest in being able to evaluate new characterization methods and to compare the results of differing methods. The principal instrument to be mounted in the growth and analysis chamber is a NIST-developed x-ray detector, which has a heated window that allows the measurement, during growth, of x-ray fluorescence signals that are produced by electrons from a special vertically mounted gun port. Successful operation of the system has been verified by measuring the gallium and arsenic x-ray L lines from a GaAs target mounted in the chamber. The goal is to provide evaluated metrology that will enable industry to control in real time the composition of films growing in an MBE system with much lower uncertainties than is possible today. For example, enhanced control of composition, and thus lattice constant, is critical to the realization of next-generation optoelectronic devices.

ROUND ROBIN CONFIRMS ACCURACY OF NIST-DEVELOPED JOSEPHSON VOLTAGE STANDARDS

During 1995 the National Conference of Standards Laboratories (NCSL) sponsored a round robin in which a set of four Zener reference voltage standards was shipped among 11 different national, military, and commercial U.S. standards laboratories to compare the accuracy of their Josephson voltage standards. All data were collected and analyzed by an independent coordinator. The just-released results, entitled the "1995 NCSL 10 V Josephson Array Interlaboratory Comparison," show that all participants are in agreement within the uncertainty of the traveling transfer standards, or about $\pm 0.05 \mu\text{V/V}$. NIST laboratories in Boulder, CO and Gaithersburg, MD were participants.

The basic design of these Josephson array voltage standards and the software that runs them were developed at NIST, and the systems were set up with on-site assistance from NIST personnel. Nine of the Josephson array chips were made at NIST; the other two are commercial versions of the NIST design.

The excellent agreement among all 11 standards laboratories can be attributed directly to a 10 year NIST

program to make the intrinsic accuracy of Josephson voltage standards widely available to the U.S. standards community. This high level of accuracy is helping U.S. industry advance the state of the art in digital voltmeters and voltage reference standards. On-going NIST research is focused on making Josephson standards that are smaller, less expensive, easier to use, and fast enough to be useful for detailed measurements of digital-to-analog and analog-to-digital converters, and the synthesis of ac waveforms.

NIST-INDUSTRY CONSORTIUM FORMED TO PROVIDE U.S. SEMICONDUCTOR INDUSTRY WITH NEEDED OVERLAY MEASUREMENT CAPABILITY

Four semiconductor equipment companies and SEMATECH, a consortium of integrated circuit manufacturers, have joined forces with NIST to develop instrumentation essential to support semiconductor manufacturers' efforts to pattern higher device densities into future generations of microelectronic chips. The new Scanning Capacitance and Electromagnetic Sensor Consortium participants plan to research new techniques of metrology for the parameter interlevel overlay in successive semiconductor chip layers. To meet identified goals in the Semiconductor Industry Association National Technology Roadmap for Semiconductors, successful feature overlay metrology will require an uncertainty below 5 nm. Consortium members will implement and evaluate two new overlay metrology approaches featuring scanning capacitance and electromagnetic sensors. Enhancements in semiconductor wafer metrology will help maintain the United States' leading position in producing overlay-metrology tools.

NIST PUBLISHES NEW EDITION OF DIRECTORY OF LAW ENFORCEMENT ASSOCIATIONS

The Office of Law Enforcement Standards, as part of its responsibilities under the National Institute of Justice Law Enforcement and Corrections Standards and Testing Program, has published the 1996 edition of NIST Special Publication 480-20, Directory of Law Enforcement and Criminal Justice Associations and Research Centers.

The directory provides the law-enforcement community with a listing of national, nonprofit professional and volunteer social-action associations and research centers active in the fields of law enforcement, corrections, courts, forensic science, and criminal justice. It also

contains references to international and foreign organizations that meet one or more of the following criteria: have a large number of American members; have a U.S. chapter; are judged to be of national interest. The directory describes the purposes and activities of each organization, its affiliations, and its publications and also presents mailing addresses, telephone numbers, names of officers, year of founding, membership information, and staff size.

SMALL BUSINESS PUTS STEP IN PRODUCTION

A small second-tier parts supplier to a major automobile manufacturer, already has STEP in production internally. STEP or Standard for the Exchange of Product model data (officially ISO 10303, published in December 1994) is being used to improve the sharing and reuse of product design data among supply chain partners. The parts supplier is also a participant in the AutoSTEP Supply Chain pilot sponsored by the Automotive Industry Action Group. The first real-time, round trip exchange of STEP data successfully took place in May on parts of realistic complexity. The most complex part (containing over 7 000 faces) did fail but the problems were isolated to a bad computer-aided design (CAD) model—not an issue with the STEP standard. This experience identified the need for design practices for the use of solid models by small manufacturers. Improvements are scheduled for this CAD model, and another exchange trial will be performed.

HIGH-SPEED MILLING

The development of reliable high-speed spindles and motion control systems has led to an increase in industrial use of high-speed milling. One of the primary applications of this new technology is the manufacture of thin-walled aluminum components for aircraft. A NIST researcher, in cooperation with a researcher at the University of Maryland, is studying the complicated dynamic tool-workpiece interactions in high-speed milling. Time series, power spectra, autocorrelations, auto-bispectra and phase portraits data obtained in experiments conducted at NIST indicate that stiffness nonlinearities due to intermittent cut have a pronounced effect on the dynamics of the workpiece. Delay space reconstructions and point-wise dimension calculations indicate that the associated motions are characterized by a fractal geometry. The autobispectra indicate quadratic phase coupling at the spectral peaks associated with the cutter frequency. A phenomenological model with impact nonlinearities was developed to explain the

experimental results. The predicted results agree qualitatively with the experimental observations. The model predictions indicate that chaotic motions are possible over a large range of parameter values.

NEW TECHNOLOGY FOR PREPARATIVE DNA SEPARATIONS

Bioseparation researchers at NIST have developed a new method for the preparative separation of DNA. An electric field is applied to a chromatography column (a process termed electrochromatography) and very selective separations are achieved by varying the electric field strength, buffer flow rate, and the column packing material. DNA is captured and concentrated on the column using relatively low fields (1 V/cm to 5 V/cm). Since retention of DNA on the column is determined by its size, DNA fragments of varying sizes can be fractionated by varying the field strength and buffer flow rate. It is also possible to separate DNA molecules with different physical forms. Circular, supercoiled DNA can be separated from relaxed, circular DNA and linear DNA by changing the electric field strength. This new DNA separation technology appears ready for scale-up to preparative uses and for miniaturization to small-scale applications. Two patent applications have been filed by NIST scientists. One covers an improved electrochromatography device; the other is for the new process for concentrating and size-fractionating nucleic acids and viruses in porous media invented. At least one private-sector firm has expressed interest in commercializing the technology.

NIST-EPRI ULTRASONIC TECHNOLOGY ASSESSMENT PROGRAM FOR FLOW MEASUREMENT

NIST recently convened a one-day workshop with the Electric Power Research Institute (EPRI) to develop an Ultrasonic Technology Assessment Program aimed at improving liquid flow measurements in electric power generating plants and in other similar industrial environments. The 28 attendees represented stakeholders throughout the ultrasonic flow meter market: meter manufacturers, utility industry personnel (power plant operators and researchers involved in developing and testing advanced instrumentation and control systems), representatives from several U.S. Navy groups, and flow metrologists from national standards laboratories in Mexico and Japan.

During the workshop, NIST metrologists described the three phases of a program to test travel-time ultrasonic flow meters. The first phase will establish reference performance by testing meters in ideal installation

conditions where long straight lengths of constant diameter pipe precede the flow meter. These design conditions seldom exist where meters are installed in practice—especially in power plants. Therefore, phases two and three of the NIST program will assess non-ideal installation conditions on meter performance by testing meters downstream from typical pipe elements such as a single 90 degree elbow and a concentric reducer, respectively. This experimental program will be complemented with computational fluid dynamics modeling of the response of the flow meters in both ideal and non-ideal geometries. Workshop attendees suggested refinements to the program so that results will be more useful in practical situations. The combined experimental and modeling effort is expected to produce measurements and recommended practices for improved accuracy in the use of ultrasonic flow meters.

PRECISION Na LIFETIME MEASUREMENT

Atomic lifetimes are used as benchmarks for comparison of atomic structure theory and experiments. A long-standing discrepancy, of approximately five times the experimental uncertainty, for the light alkali sodium has finally been resolved with a new and unconventional measurement technique. Precision atomic data are often used as input in calculating the properties of molecular systems but it is not often that molecules are used to determine atomic properties to high precision. A team of experimental and theoretical scientists from NIST, however, have determined the sodium (^3P) atomic state lifetime to unprecedented accuracy by examining the spectroscopy of an unusual electronic state of the molecular sodium dimer. An excited diatomic molecule may be considered simply as a bound state of a ground level and an excited atom, so it is not surprising that the atomic properties are reflected in the optical spectrum of the molecule. Precision photoassociation spectroscopy (the binding of cold free atoms into excited molecular states) of a “purely long range” state of molecular sodium combined with an accurate theoretical treatment of the spectra led to a determination of the lifetime to 0.1 %, half the previously claimed uncertainty. The new value is in agreement with the most advanced theoretical predictions.

ATOMS FORM FINELY SPACED STRUCTURES IN OPTICAL STANDING WAVE

In an ongoing program to use light to control atomic deposition, researchers at NIST have discovered a novel phenomenon. While exposing a beam of chromium atoms to optical fields created using a special laser configuration, they found that chromium atoms were

deposited on a surface in a periodic array, as expected, but the periodicity was a factor of four smaller than expected. An atomic force microscope is used to observe the pattern created by passing atoms through two counter-propagating traveling waves with orthogonal linear polarizations. This light field focuses atoms to create an array of lines with a spacing of 53.2 nm, which is one-eighth of the fundamental wavelength of the light used.

Experimental and theoretical results now show that this high-frequency component of the spatial frequency is a result of the focusing in the optical potentials of the multilevel chromium atoms as influenced by Raman coherences.

The research demonstrates a uniquely high-resolution technique for measuring the spatial distribution of atoms and also represents a step toward creating more complex patterns by exploiting the vector nature of the electromagnetic field. A new level of understanding is provided for manipulating atoms with light, which might lead to eventual applications such as fabrication of nanostructured materials or devices for microelectronics or micromagnetics.

NIST DEVELOPS A NEW BROADBAND POLARIZER

High-quality polarizers are being developed at NIST as part of a large effort to develop spectral polarimetry in the ultraviolet, visible, and infrared spectral range. One of the primary goals is characterization of optical materials. A linear polarizer has been designed and constructed by researchers at NIST for use in a broad spectrum from the visible to the IR regions. The polarizer is constructed with four germanium plates arranged in a chevron geometry. Input radiation is incident near Brewster's angle for the first plate such that the reflected beam is preferentially *s*-wave polarized. The reflected beam passes to the successive plates always intersecting near Brewster's angle. The *s*-wave polarization state is preferentially reflected at each first surface so the overall polarization at the output of the device is almost completely *s*-wave polarized. Negligible beam deviation has been demonstrated. Construction of alternative geometries involving fewer plates, characterization of spatial uniformity, and extension of its use farther into the infrared are being explored.

Measurements of polarized light have potential in imaging systems for contrast enhancement, edge definition, and object discrimination. Possible applications of polarization enhancements for viewing are edge definition in infrared emissions and glare reduction in illuminated images. A broad spectral range of polarization

components are needed for imaging. The development of this broadband polarizer and its subsequent characterizations will provide the basis needed for determining materials and components used in imaging systems.

INTRINSICALLY ABSOLUTE RADIOMETRY USING CORRELATED PHOTONS

NIST is investigating the application of correlated photon techniques to radiometric problems. The latest development uses correlated photons to make intrinsically absolute measurements of radiance. This technique is the first and only method that measures radiance directly; all previous methods indirectly deduce radiance from measurements of aperture area, geometry, and radiant power. This method has the additional unique characteristic that measurements of infrared radiance can be made using visible detectors.

The technique uses optical parametric down-conversion to produce correlated pairs of photons. In this process, a nonlinear medium causes photons from a pump beam to, in effect, spontaneously decay into pairs of photons. The decay is under the constraint of energy conservation, with momentum conservation determining the output angles of the two photons. By adding a second input to the down-conversion process, this decay process can be stimulated. To achieve this, the second input must spectrally and spatially overlap one of a pair of down-converted photons. Since the two "decay" photons are created at the same time, this second input stimulates not only the production of the overlapped beam, it also enhances the output of the correlated beam (which is at a different wavelength and emitted along another direction). Since the down-conversion process is nonresonant, it can be arranged to produce correlated photon pairs consisting of one visible and one infrared photon. Such a configuration allows infrared radiance to be measured using visible detectors.

This method has been used to measure the absolute radiance of a high-temperature discharge arc source. Absolute spectral radiance has been measured out to nearly 5 μm , using only visible detection. An initial accuracy check, comparing these measurements to those tied to conventional standards, has verified the results to about the 3% level. These measurements extend further into the infrared and are of higher accuracy than any previous demonstration of this method. In addition, these measurements have produced the highest thermally stimulated down-converted output ever observed. Long range plans include achieving higher accuracies, making these methods continuously tunable, and extending the spectral range further into the infrared.

NIST HOSTS MEETING OF THE IAEA PROGRAM ON QUALITY ASSURANCE IN RADIATION PROCESSING

The first meeting of the International Atomic Energy Agency (IAEA) Coordination Research Program on Characterization and Evaluation of High-Dose Dosimetry Techniques for Quality Assurance in Radiation Processing was hosted by NIST May 13-16, 1996. The IAEA works to improve the scientific and technical capabilities of developing countries in the safe and peaceful applications of nuclear energy. The meeting at NIST began the process of reviewing current research on dosimetry at the high dose levels of ionizing radiation used for radiation processing, with the aim to provide recommendations for improved measurement quality assurance and quality control in this important field. Radiation processing, in the form of gamma rays from cobalt-60 and electron beams from accelerators, is used in the United States and worldwide in a wide variety of applications, including the sterilization of medical products, the processing of polymeric products, the treatment of foodstuffs, the disinfection of waste, the purification of water, and the cleaning of flue gases. The meeting convened representatives from Canada, China, Denmark, France, Hungary, India, Japan, Poland, Thailand, the United States, and the IAEA. The meeting included a tour of the NIST dosimetry facilities. NIST is a world leader in the development of high-dose, passive dosimetry systems including radiochromic films, alanine/EPR media, and graphite calorimetry.

STATE-OF-THE-ART NEUTRON DIFFRACTION RESIDUAL STRESS INSTRUMENT

Neutron diffraction is the only inspection technique by which subsurface triaxial stress distributions can be determined nondestructively. It, thus, represents the only method to characterize certain stress fields and is the standard reference method against which alternative, portable techniques can be tested or calibrated.

Newly commissioned at the BT-8 beam port at the NIST research reactor is a state-of-the-art facility for texture, residual stress measurements, and single-crystal diffraction. A basic monochromator drum has been modified to safely allow take-off-angles up to 120° for high-resolution diffraction measurement of residual stresses. Unique primary and secondary beam-aperture systems are incorporated that allow a choice of potential sampling volumes from 5 mm × 5 mm × 5 mm down to 1 mm × 1 mm × 1 mm. Each system translates toward or away from the sample to facilitate the study of large material structures or components without requiring re-alignment of apertures or repositioning of samples. The sample table has 170 mm translation motion in the

x, *y*, and *z* directions and can accommodate samples with a mass of up to 50 kg. Among the other features are a new 1 mm resolution position-sensitive detector system and a four-crystal monochromator system with remote selectability. The new instrument—in addition to those features that facilitate sample handling, measurement continuity, and versatility—is about an order-of-magnitude faster in measurement time than the previously used BT-6 spectrometer—and equal or superior to other neutron instruments, worldwide, for precise stress measurements.

Ongoing and new programs that will benefit enormously from these improved capabilities include collaborations with other government agencies and private industry.

PATENT FOR A WELDING CONTROL SYSTEM IS GRANTED TO NIST RESEARCHERS

Three NIST researchers were granted Patent 5,514,851, “Prevention of Contact Tube Melting in Arc Welding.” The patent covers a system to sense and control the arc length in gas metal arc welding. The system goes beyond previous technology by combining a light intensity sensor (to measure the arc intensity) with a current sensor (to correct for changes in the arc diameter). Tests show that the system is able to control the arc length to within 1 mm, when the contact-tube-to-work distance changes by 10 mm.

This system will be added to the previously developed arc sensing and control systems that are being evaluated for industrial applications under Cooperative Research and Development Agreements with private industry.

CHEMICALLY ASSISTED DIAMOND MACHINING OF ADVANCED MATERIALS PROJECT ENTERS PLANT TRIAL STAGE

Researchers at NIST have been studying surface chemical effects in the machining of advanced materials. One phase of these technical activities has focused on the chemically assisted machining of silicon nitride. Researchers discovered that different chemical compounds used as coolants achieved significantly higher sustainable grinding rates using diamond tools than commercially available grinding fluids. Basic research on the tribochemistry led to the conclusion that the diamond grits on the grinding wheel are being protected by the chemicals.

Working with an industrial partner, the researchers are conducting a plant trial to test the effectiveness of the experimental fluid. The fluid is being tested in an automated industrial production grinder producing hundreds of cemented tungsten carbide tool inserts a

day. The experimental fluid has performed effectively on a continuous basis since March 1996. To date over 30 000 inserts have been successfully machined. Test results suggest that the experimental fluid is capable of continuously grinding over 500 inserts before diamond wheel dressing becomes necessary. This is in comparison to the current commercial coolant in which periodic dressing is performed after every 30 inserts. These results confirm NIST laboratory data and suggest significant economic savings for the new fluid in terms of reduced diamond wheel consumption and increased productivity from dressing cycle down time. A second plant test on diamond grinding of silicon nitride ceramics is being planned.

INDUSTRY WORKSHOP ADDRESSES ON-LINE COMPOSITE PROCESS MONITORING

The “On-line Composite Process Monitoring” workshop, organized by NIST, brought together 16 researchers from the automotive, aerospace, and electronics industries to discuss needs for on-line sensors in the manufacture of polymer composites. The participants concluded that monitoring and control of the following microstructural features were equally important in improving composite manufacture: (1) fiber architecture, (2) voids and porosity, (3) the cure state of the resin, and (4) the state of the fiber-matrix interface. In addition, there was a consensus that an effective sensor must be inexpensive, precise, and easy to insert into high-speed manufacturing processes.

To determine the types of sensor needed to improve polymer composite manufacture, the workshop discussion began by enumerating end-use properties that are desirable, yet difficult to control. Since end-use properties such as stiffness, strength, and durability cannot be measured during manufacturing, the participants identified microstructural properties critical to obtaining the desired end-use performance and yet measurable during processing. Appropriate sensors were identified by their ability to measure the microstructure, or processing variables that control the microstructure. Currently, no on-line sensor is available to measure voids or porosity of the matrix or measure the state of the fiber-matrix interface.

Additional discussions focused on the industrial environments that on-line sensors must tolerate and the influence of manufacturing speeds on the role of on-line sensors in composite manufacturing. The durability of sensors in production environments was deemed essential to the successful implementation of any sensor. Manufacturing speed was identified as a key variable in selection of suitable sensors for a manufacturing

process. The workshop results will be used to guide the on-line sensor development research at NIST and at other research laboratories.

FASTLite IN DEMAND

NIST introduced a new model for fire growth and smoke transport on CD ROM at the National Fire Protection Association (NFPA) meeting and received an overwhelming response. More than 750 CDs were distributed in the first 2 1/2 days of availability at the NFPA meeting. The FASTLite disk contains the latest fire model, together with video clips of full scale fires from NIST research and is designed to be used by a diverse audience, from fire fighters to architects. Also included are instructions on how to access even newer information available on the Home Page of NIST’s Building and Fire Research Laboratory.

MANAGEMENT GUIDANCE ON FINANCIAL SYSTEMS ISSUED

NIST Special Publication 500-233, A Manager’s Guide for Monitoring Data Integrity in Financial Systems, provides an expanded list of suggested functionality of automated monitoring tools in accounting systems, describes individual tools, and gives guidance on implementing and using those tools. Written with the assistance of a work group of financial and system experts, the guide enables managers to identify and justify software tools and techniques to include in new or existing financial systems.

WORKSHOP ON QUALITY AND UNCERTAINTY SETS TONE FOR MEASUREMENT QUALITY CONFERENCE

The annual American Society for Quality Control (ASQC) Measurement Quality Division Conference held in Rockville, MD in April 1996, began with a one-day workshop where concepts of quality, measurement assurance, and uncertainty analysis were interwoven with case studies from the NIST measurement laboratories. The workshop was given by NIST staff, whose topics included the following: the relationships among check standards, measurement quality in the laboratory, and uncertainty analyses, the NIST policy on expressing measurement uncertainty and the use of check standards and auxiliary experiments for estimating type A components of uncertainty; estimation of type B components of uncertainty and the procedure for combining type A and B uncertainties by propagation of error techniques; and the linear calibration problem. The

wrap-up session involved the audience in a demonstration of how statistical thinking, as a foundation for quality and improvement, can be applied to decision processes.

NEW TECHNIQUE FOR PERFORMING STATIC ANALYSIS OF PROGRAMS DEVELOPED

NISTIR 5799, Application of the Pointer State Subgraph to Static Program Slicing, introduces a new method for conducting static analysis of programs that contain unconstrained pointers. Static analysis tools help programmers understand software that must be enhanced or debugged.

The new technique is based on the pointer state subgraph, a reduced control flow graph that takes advantage of the fact that in any program there exists a smaller program that computes only the values of pointer variables. The pointer state subgraph is useful in building static analysis tools. The report discusses the application of the pointer state subgraph to program slicing and reports experimental results that show reduced processing time and reduced data storage space.

NEW PUBLICATION DESCRIBES INTEROPERABILITY EXPERIMENTS WITH CORBA

NISTIR 5824, Interoperability Experiments with CORBA and Persistent Object Base Systems, describes the design and development of interoperability experiments using the Common Object Request Broker Architecture (CORBA) products. The experiments focus on using CORBA products with Persistent Object Base (POB) systems and investigating methodologies for integration of new or legacy distributed applications through the CORBA middleware infrastructure. The work is part of NIST's technical assistance to the Advanced Research Projects Agency (ARPA) in the evaluation of POB systems.

FIVE ADDITIONAL FEDERAL IMPLEMENTATION GUIDELINES FOR ELECTRONIC DATA INTERCHANGE ISSUED

NIST recently published five new guideline documents in NIST Special Publication Series 881 for Federal Electronic Data Interchange (EDI) Conventions. Dealing with the procurement and finance areas, the new NIST Special Publications 881-5 through 881-9 bring the total number of ICs issued to date to nine documents.

NIST was designated as the organization responsible for coordinating the development of Federal Implementation Conventions (ICs) for EDI. ICs are defined by functional-area experts who create and select options

from standard EDI Transaction Sets to yield the implementations to be used for practical Electronic Data Interchange. These ICs are made available to Federal agencies and industry by electronic and paper means.

NEW PUBLICATION DESCRIBES SOFTWARE VERIFICATION AND VALIDATION (V&V) IN THE HEALTH CARE ENVIRONMENT

NIST Special Publication 500-234, Reference Information for the Software Verification and Validation Process, explores the use of V&V as an aid in determining that software requirements are implemented correctly and completely and are traceable to system requirements. Like many other U.S. industries, the health care industry relies increasingly on computer systems to reduce administrative overhead, control escalating costs, and improve the accuracy of stored information. Using a structured approach to analyze and test software, V&V helps to ensure that those system functions controlled by software are secure, reliable, and maintainable.

SCHROEDINGER'S CAT IN AN ATOMIC CAGE

They say, "You can't be in two places at one time," but "they" may be wrong. Scientists at NIST have just disproved the adage by preparing a beryllium atom that is simultaneously located in two widely separated places. The scientists isolated a single beryllium ion (an atom with one of its two outer electrons stripped away) in an electromagnetic trap and cooled it nearly to absolute zero with precisely tuned laser beams. Next, additional laser pulses were delicately applied, producing tiny forces that gently shoved the ion's two "superposed" electron-spin states apart without collapsing them to a single entity. This bizarre state, of being in two well-separated places at once, can be visualized by imagining a large, shallow, round-bottomed bowl with a marble simultaneously at opposite sides of the bowl, rolling from side to side and through itself at the center. The experiment provides a glimpse of quantum superposition states at a scale never seen before. As detailed in the May 24 issue of *Science*, this experiment has connections to the works of Albert Einstein and Erwin Schrodinger, who described thought experiments in quantum mechanics which seemed to defy reality. Schrodinger, for example, considered the possibility that a cat could be made to be both dead and alive at the same time. "Schrodinger's cat" soon became a shorthand way to refer to a whole class of superposed states. Until now, however, no one has ever prepared a particle where the superposition was transformed into a physical separation on so large a scale under such controlled conditions.

DIRECTORY LISTS LABS MEETING INTERNATIONAL STANDARDS

To help improve U.S. trade, the National Voluntary Laboratory Accreditation Program at NIST is now fully compatible with the international standards for laboratory accreditation and quality system management used by other accreditation systems worldwide. The new NVLAP 1996 Directory (NIST Special Publication 810), lists approximately 700 domestic and foreign testing and calibration labs that are accredited by NVLAP to meet the requirements of international standards as of January 1996. The directory is an important guide for identifying providers of assured quality testing and calibration services. Accreditation of labs under international standards assures manufacturers, exporters and government agencies that their test reports and services will be accepted in the global marketplace. Labs are listed in alphabetical order, by field of accreditation, by state or country, and in numerical order by NVLAP Lab Code within listings of testing and calibration laboratories. For a copy of SP 810, send a self-addressed mailing label to: Laboratory Accreditation Program, Building 820, Room 282, NIST, Gaithersburg, MD 20899-0001, (301) 975-4016, fax: (301) 926-2884, e-mail: nvlap@enh.nist.gov.

NIST SEMICONDUCTOR METROLOGY EFFORTS LISTED

A bibliography listing more than 500 recent NIST semiconductor-related metrology studies, research reports, published papers and software programs is available upon request. The bibliography covers the full range of NIST expertise in semiconductor metrology in the areas of electronics and electrical engineering, manufacturing engineering, chemical science and technology, materials science and engineering, and fundamental physical sciences relevant to the metrology needs of semiconductor materials, equipment, instrument and device manufacturers. Listed computer programs related to semi-conductor materials properties and devices cover areas such as thermal analysis, two- and four-probe resistance calculations, linewidth metrology, ellipsometric measurements, design, modeling and process evaluation, circuit simulation, and electronic properties. Requests for NIST List of Publications LP 103: Publications for the Years 1990-1995 should be directed to Jane Walters, B344 Technology Building, NIST, Gaithersburg, MD 20899-0001, (301) 975-2050, fax: (301) 948-4081, e-mail: walters@eel.nist.gov.

RUSSIA, NIS STANDARDS EXECUTIVES HOSTED BY NIST

NIST recently hosted a delegation of standards leaders from Russia and three members of the New Independent States: Belarus, Kazakstan and Ukraine. The sessions covered the structure and operation of the U.S. standards system, the role of conformity assessment, and the relationship between government and the private sector. The delegates received briefings from regulatory agencies and visited key private-sector standards developers and certifiers across the United States. The aim was to reinforce the delegates' understanding of standards and conformity assessment activities that are under discussion or negotiation within the U.S./Russia Business Development Committee's Standards Working Group and the U.S./Ukraine Joint Commission on Trade and Investment's Standards Working Group. The meeting at NIST also provided the officials with the same information gained by their subordinates who have participated in the Special American Business Internship Program/NIST Standards Training. Russian and Ukraine officials believe the knowledge acquired during their visit will aid their currently in-progress accession to the World Trade Organization.

FUTURE WTO MEMBERS LEARN TO PROVIDE DATA

In an effort to help prospective members prepare for entry into the World Trade Organization, the NIST Office of Standards Services and the Department of Commerce's Commercial Law Development Program recently co-sponsored a seminar on standards information for representatives from Lithuania, Romania, Russia and Ukraine. The seminar instructed these countries on how to develop an information infrastructure as required by the WTO. The WTO Agreement on Technical Barriers to Trade (TBT Agreement) requires member countries to maintain national inquiry points for information on standards, technical regulations and conformity assessment procedures that might affect trade between nations. Seminar topics included setting up a national standards information center, sources of information, computerized databases and indexing tools. The NIST National Center for Standards and Certification Information is the U.S. standards inquiry point, as well as the U.S. standards information source under the North American Free Trade Agreement.

FIRST VIEW OF MOLECULAR ASSEMBLY CAPTURED

In recent years, scientists have been interested in using neat, uniform rows of molecules packed on metal surfaces to develop very fast and highly specific sensors, but until now no one understood how the molecules formed these rows. A NIST chemist and a visiting University of Texas graduate student have observed for the first time the formation of these densely packed rows known as self-assembled monolayers, or SAMs. Reporting in the May 24, 1996 issue of *Science*, the NIST chemist and visiting student describe how alkanethiol molecules assemble on a single-crystal gold surface. The NIST team captured molecular-resolved images of growing SAM layers with a scanning tunneling microscope (STM). They found that the molecules first form a two-dimensional lattice gas, then transition into low-density island clusters, and finally undergo a surface phase transition involving reorientation of the alkyl chains to form a dense monomolecular film.

REPORT ON ISO ENVIRONMENTAL STANDARDS PUBLISHED

The International Organization for Standardization is currently developing a family of “environmental management” standards that address management of systems and the environmental aspects of products in the areas of life cycle assessment and labeling. NIST is participating in the international effort through the American Society for Testing and Materials, which serves as the U.S. Technical Advisory Group administrator for three technical subcommittees: environmental performance evaluation, life cycle assessment, and terms and definitions. The NIST report, *ISO Environmental Management Standardization Efforts* (NISTIR 5638-1), summarizes the work of ISO Technical Committee 207 on Environmental Management Standardization that was formed in June 1993. Individual standards approved by TC 207 and adopted by ISO as international standards will be designated as part of the ISO 14000 series. The other subcommittees are environmental management systems, auditing and environmental labeling standards. European interests are requesting that TC 207 develop environmental management and auditing standards quickly to support new EU legislation that went into effect in April 1995. Copies of NISTIR 5638-1 are available from Mary Saunders, Office of Standards Services, Building 820, Room 287, NIST, Gaithersburg, MD 20899-0001, (301) 975-2396, fax: (301) 963-2871, e-mail: mary.saunders@nist.gov.

ARC-LIGHT SENSING MAKES SENSE FOR WELDING

As automation becomes more prevalent in gas-metal-arc welding, the demands for productivity, quality and reliance on statistical process control also become greater. One of the major obstacles to automation is the difficulty in developing techniques for measuring process parameters in real time. In a recent publication, researchers at NIST discuss the measurement in real time of arc length and droplet-transfer frequency through the use of arc-light sensing. A measure of arc-light intensity was obtained by using a photodiode and treating the arc as an optically thin, volume source. Arc length was estimated from the detector-output voltage and arc current. Furthermore, the arc-light-detector output varied with droplet detachment; thus, it was used to detect droplet detachment. Control of Gas-Metal-Arc Welding Using Arc-Light Sensing (NISTIR 5037) is available for \$27 prepaid from the National Technical Information Service, Springfield, VA 22161, (703) 487-4650. Order by PB 96-131461.

CIRMS PLANS FIFTH ANNUAL MEETING AT NIST

Measuring radiation more accurately will be the focus of the fifth annual meeting of the Council on Ionizing Radiation Measurements and Standards (CIRMS) to be held at NIST's Gaithersburg, MD, headquarters on Nov. 12-14, 1996. This year's theme is “University Contributions to Ionizing Radiation Measurements and Standards.” “The technical program will cover medical applications; public, occupational and environmental radiation protection; and radiation effects. CIRMS serves as a forum for discussing ionizing radiation measurements and standards issues, identifying new needs of the user communities, and disseminating information on standards. CIRMS brings together representatives from academic, industrial, and government agencies involved in nearly every aspect of ionizing radiation. For registration information, contact Lori Phillips by Aug. 30, at B116 Administration Building, NIST, Gaithersburg, MD 20899-0001, (301) 975-4513, fax: (301) 948-2067, e-mail: lori.phillips@nist.gov. For technical information, contact Bert Coursey, C229 Radiation Physics Building, NIST, Gaithersburg, MD 20899-0001, (301) 975-5584, fax: (301) 869-7682, e-mail: bert.coursey@nist.gov.

appliances, even wristwatches. Resetting clocks all over your house after power outages could become a thing of the past.” He feels receivers for such clocks could eventually be manufactured in quantity for less than \$10 each. The new transmitting equipment is already on site at the WWVB station, located a few miles north of Ft. Collins, CO.

NEW INTENSE SOURCE OF COOLED IONS DEVELOPED

A new technique with potential applications in the control and manipulation of chemical vapor deposition in semiconductor chip fabrication has been developed by NIST. Precise control over the deposition process is essential for maximizing efficiency and yield in the semiconductor industry. One problem is that the most desirable elements are often reactive molecules and ions present in very low concentrations. This makes them hard to isolate for detailed spectroscopic study. Furthermore, conventional electrical discharge techniques to prepare these species typically heat them up, which blurs and complicates their spectra. There have been many efforts to lower these temperatures by combining corona discharges with pinhole supersonic expansions, but the resulting densities drop off with the square of the distance from the nozzle. A NIST scientist recently developed a novel discharge source based on a pulsed slit supersonic expansion geometry, which yields high densities, low temperatures (20 K), sub-Doppler spectral linewidths, and 100 cm path lengths ideal for direct absorption spectroscopic applications. The method uses a pulsed negative voltage applied to the two insulated metal jaws that define the expansion slit. When synchronized with the gas, these pulses strike a smooth discharge with respect to the grounded valve body, causing electrons to flow upstream in the expansion. The net result is a discharge current wholly contained within the 300 μm by 4 cm region upstream of the slit which produces transient species cooled effectively to supersonic jet temperatures. This slit discharge device has proved to be a rich source of jet-cooled radicals and molecular ions.

ENERGY-RELATED INVENTIONS PROGRAM MAKES RECOMMENDATIONS

During the month of May, the NIST Office of Technology Innovation recommended three innovative technologies for commercialization to its Department of Energy partner under the Energy-Related Inventions Program.

- Automatic Gas Light—a patented control system for automatically turning off outdoor gas lights during the daylight hours.

- Nickel Based Superalloy with Improved Weldability and Oxidation Resistance—a new composition for superalloys with the essential feature being the addition of a large amount of palladium to nickel-based superalloys.
- High-R-Value, Environmentally Safe Rigid Foams Blown with Fluoroiodocarbons (FICs)—the use of a group of chemicals containing the elements fluorine, iodine, and carbon, known as fluoroiodocarbons, as blowing agents for the manufacture of such foam insulation materials as polyurethane, polyisocyanurate, and polystyrene.

INSTALLATION OF A HIGH-SPEED MACHINING TESTBED AT PRIVATE COMPANY PRODUCTION FACILITY COMPLETED

Two NIST researchers in conjunction with a private company’s personnel, completed the development and installation of a high-speed machining testbed at the company’s production facility in St. Louis, MO. The purpose of this project was to increase the shop productivity by achieving greater accuracy of machined parts. To accomplish the goal of the project, a new PC-based controller was developed and installed on an existing machining platform. The new hardware allows faster data throughput, thereby permitting faster cutting rates without sacrificing accuracy. Results of laser tests indicate that the positioning accuracy was improved from about 50 μm to better than 5 μm over 1.5 m travel range. Ball bar tests also were conducted through a range of slide travel speeds. The results indicate improvements in circularity and reduction in reversal spikes on the order of 20 μm , especially at travel speeds over 500 cm/min.

The new testbed allows the operator to run the machine and program parts in parallel, thereby decreasing machine downtime, and provide a central location for part program storage using a network.

SELF-LITHOGRAPHIC PROCESSING USED IN FABRICATING MULTICOMPONENT ARRAYS FOR GAS SENSING

NIST researchers have developed a new, efficient technique to produce planar arrays of miniaturized thin-film sensors for detecting gas concentrations in mixed atmospheres. Through the use of a newly designed and commissioned low-pressure metal organic chemical vapor deposition (MOCVD) system, NIST now has the capability to selectively deposit metal oxide thin films with differing compositions on the elements of microhotplate arrays that form the gas sensors.

NEW CONSORTIUM EYES INTEGRATED “TOOLKIT”

A new NIST consortium aims to ensure that one means of improving manufacturing performance doesn't slip through the “cracks”—the chasm-like software incompatibilities that divide one database or computer tool from another. The cooperative effort will develop a manufacturing engineering tool kit (or METK) that includes a product data management system and accommodates various combinations of design, process planning, and simulation software. One outcome will be a virtual system for automating programming of machining operations. Emphasis will be on developing standards and interfaces that enable commercially available software tools—typically supplied by different vendors specializing in particular engineering functions—to work together. Today, overcoming conflicting file formats and a host of other application-specific peculiarities requires costly, one-of-a-kind systems integration efforts. The consortium also will focus on another high-priority need identified by companies: methods for ensuring that all manufacturing engineering data are current, complete and valid for all uses. Data errors often are at the root of problems encountered during initial production runs, resulting in rejected parts. A prototype toolkit already has been developed with manufacturers, software suppliers, universities and Department of Defense facilities that have been collaborating on the project. The next stage of the effort will refine and extend the tool kit's capabilities and performance, leading to pilot tests in the factories of consortium members. For more information, call Swee Leong at (301) 975-5426 or send an e-mail message to leong@nist.gov.

QUALITY FEDERAL PROCUREMENT POLICY RECOMMENDED

The Government and Industry Quality Liaison Panel, a group of government and industry representatives who are developing quality standards for procurement, met on June 4 with the Interagency Committee on Standards Policy to explore the possibility of developing an Office of Management and Budget Circular or Executive Order to establish a government-wide procurement policy. The panel goals are: establishing a single quality system within a contractor's facility that will have demonstrated capability for meeting both government and private industry customer needs; promoting the recognition and use of advanced quality concepts in procurement processes by both government and industry; and helping develop uniform criteria and mechanisms within government agencies whereby audits of basic quality system requirements performed by one agency

will be accepted by all others. The work of the panel was recognized recently when the participating agencies, including NIST, were presented with the National Performance Review's Golden Hammer Award.

ENTITIES SOUGHT FOR EU CONFORMITY ASSESSMENTS

NIST is seeking information on testing laboratories and other organizations interested in performing conformity assessment activities on products for export to markets in the European Union. The information is needed to support ongoing negotiations between the United States and the EU for mutual recognition agreements on the acceptance of each other's testing and certification programs in the following regulated product areas: telecommunications terminal equipment, electromagnetic capability, low voltage electrical equipment, and recreational craft. The conformity assessment areas of interest are for product testing and quality assessment, quality system registration, evaluation of technical construction files specific to the EU's Electromagnetic Compatibility directive, and product certification. Organizations are asked to submit information on scope of competence, test methods, current accreditation by a recognized national, regional or international accreditation body, and any conformity assessment activities related to relevant EU directives. Written responses should be sent to Belinda L. Collins, Office of Standards Services, Building 820, Room 282, NIST, Gaithersburg, MD 20899-0001, fax: (301) 963-2871, e-mail: belinda.collins@nist.gov.

UPGRADE TO IMPROVE TIME SIGNAL'S COVERAGE

NIST radio station WWVB, which broadcasts standard time and frequency signals on 60 kHz, is currently upgrading to more powerful equipment. A new transmitter, scheduled to be in service by September 1997, will increase the radiated power of the signal fourfold or greater. WWVB signals can be used to set clocks to a few hundredths of a second, and they provide frequency with a relative uncertainty of one part in 10^{12} . The station's present output power of 10 kW broadcasts a signal strong enough to reach most of the continental United States but requires users at great distances from the transmitter to install bulky antennas for reliable service. The WWVB improvements will increase the station's power to over 40 kW, yielding a signal strong enough to be handled by smaller antennas throughout the United States, Mexico and southern Canada. “In fact,” says a NIST spokesman “this will make it possible to build automatic-reset clocks into all kinds of

This capability will allow tailoring a sensor design to a specific application.

At temperatures ranging from 200 °C to 500 °C, degrees C, conductive oxides such as SnO₂ and ZnO are known to exhibit changes in resistivity when exposed to various types of gases. To utilize this response for gas sensing, NIST researchers previously have developed the capability to micromachine silicon-based microhotplate structures consisting of suspended resistive heaters with extremely fast thermal rise times (approximately 3 ms), and top surface electrical pads for contact to the sensing film. One of the challenges in exploiting this technology for mixture analyses has been the integration of varied materials into specific locations within the array. In the present work, the ability to independently heat an individual microhotplate element is exploited to selectively deposit MOCVD films on that element, resulting in a self-lithographic fabrication process. Additional sensing films then are deposited by introducing new reactants and heating other array elements. Currently, tetramethyltin and diethylzinc are used as the precursors, successfully producing arrays of SnO₂ and ZnO thin films. Efforts are under way to add precursors for the deposition of TiO₂. Self-aligned MOCVD of metal catalysts, such as Pt and Pd, also will be used to modify the sensing properties of the oxide films. Films deposited so far have demonstrated gas sensing responses to CO, O₂, H₂, and methanol vapors, both in a constant temperature mode and in a novel pulsed heating mode made possible by the fast thermal time constant of these structures. As quantitative detection of gas concentrations in mixed atmospheres becomes increasingly important in manufacturing, environmental monitoring, and medical diagnostics, planar arrays of robust, conducting oxide thin films based on a silicon platform show promise as a relatively low cost, yet highly specific, detection technology.

NIST HOSTS WORKSHOP FOR INTERNATIONAL ATOMIC ENERGY AGENCY

NIST held a workshop for staff from the International Atomic Energy Agency (IAEA) to transfer measurement technology to aid the IAEA in accomplishing their mission of worldwide nuclear monitoring. The technology consists of automated secondary ion mass spectrometric (SIMS) measurements of the isotopic ratios for uranium particles taken from samples obtained at production or reprocessing sites of IAEA member countries. The technique allows for the rapid measurement of the ²³⁵U/²³⁸U ratio on thousands of individual particles in approximately one day, providing an isotopic fingerprint of the sample that could not be obtained by

the usual measurement techniques of bulk analysis or individual particle analysis by thermal ionization mass spectrometry (TIMS). Although TIMS is the method of choice for precision and accuracy of isotopic measurements, it is time and resource intensive, taking approximately 1 week to measure 20 to 40 individually selected particles by an extensive experimental procedure.

The NIST presentations covered sample preparation and the philosophies, theory, and application of SIMS measurements on standards and IAEA samples, respectively. This measurement technology provides the IAEA with the potential for increasing sample throughput and analyses to identify sites requiring further inspection because of potential deviations from their allowed uranium enrichment processes. Automated electron microprobe techniques also have been developed to provide a fingerprint of the chemical components of various samples with applications in determining contaminants in manufacturing steps (e.g., semiconductor or advanced materials alloys) or pollutants in the environment.

NIST HOSTS WORKSHOP ON LOW-LEVEL LIGHT STANDARDS FOR LUMINOMETRY

About 35 scientists and engineers from the clinical diagnostics manufacturing community attended the Workshop on Low-Level Light Standards for Luminometry, held at NIST in May 1996. The goal of the workshop was to plan, with the assistance of public and private-sector stakeholders, a national program to develop standards and a standards traceability scheme for low-level light measurements.

Luminescence-based assays have become very popular in clinical diagnostics because of the low detection limits and wide dynamic range that can be achieved with relatively simple instrumentation. These assays ultimately measure the light produced as a result of chemical (chemiluminescence, CL) or biological (bioluminescence, BL) reactions. Typically, CL or BL reagents are employed as labels to tag molecules for quantitative detection. With potential detection limits down to (10⁻¹⁸ mol/L) levels, CL and BL tags now are rapidly replacing fluorescent and radiochemical labels in many clinical, forensic, chemical, and biochemical test methods.

Despite the increasing popularity of luminescent techniques, there are currently no convenient, traceable standards for absolute light intensity to compare, calibrate, verify linearity, or determine wavelength-dependent responsivity of low-level light and photon-counting detectors. The NIST workshop was held in response to numerous requests to address this dearth of standards for low-level light measurements.

Discussions at the workshop established that two general requirements for standards exist: instrument manufacturers desire the development of standards for low-level light measurements that are traceable to SI units for the factory calibration of their instrumentation, while manufacturers of clinical diagnostic test kits and end users of these products want standards that are linked to the CL or BL chemistries employed in their assays. To address both of these needs, a two-phase program was proposed involving: (1) the development of a national reference instrument at NIST and a glowing artifact transfer standard traceable to the national instrument for use mostly by instrument manufacturers to calibrate detectors; and (2) research and evaluation of suitable luminescent chemistries to determine the feasibility of developing "field" calibration standards that could be employed by diagnostic kit manufacturers and end users alike to test instruments and the entire assay procedure.

HIGHLY CHARGED IONS PUT TO USE

Ion beams have many industrial uses. However, most applications have used weakly charged ions, each ion carrying approximately 10 eV of internal Coulomb energy. These ions often must be accelerated to high velocities to be useful. However, the NIST Electron Beam Ion Trap (EBIT) produces highly charged ions, such as heavy atoms with 44 electrons removed. These have thousands of times more internal energy than their weakly charged cousins, and ongoing research shows that beams of these ions produce important effects without the need for high velocities.

The recent construction of a beamline at EBIT allows the delivery of record numbers of highly charged ions onto surfaces in a controlled manner, so that the physical processes can be studied carefully. The beam currents available are orders of magnitude greater than previously reported from such devices. The studies cut across traditional disciplinary boundaries and range from fundamental physics to applied biology. Researchers in the Harvard University Chemistry Department are collaborating to determine the effect of these beams on organic polymer films. A Cooperative Research and Development Agreement with a consortium of companies and institutions devoted to the commercialization of ion beam lithography involves the production of quantum-regime dots on surfaces. Additional collaborations are invited.

COLOR DISPLAY CALIBRATION STANDARD

Have you ever gazed at a wall of televisions at the department store, and wondered why their colors all looked different? Even if colorimeters were used during

their manufacture, it is often difficult to calibrate these instruments correctly. This problem is more significant in the computer industry, which puts a premium on correctly calibrating the appearance of computer displays. When showing merchandise, photographs, medical data, or scientific images, it is important that computer screens consistently display what is intended, perhaps before the operator commits the image to paper. NIST and the American Society for Testing and Materials (ASTM) have completed revision of ASTM Standard E 1455, on the color measurement of displays. When compatible tristimulus colorimeters, as defined in the standard, are calibrated and used according to the standard, these relatively simple and inexpensive instruments achieve an accuracy comparable to that of more complicated and expensive spectro-radiometers. Standard E 1455, thereby, allows the wider and more consistent use of color calibration instruments. The improvement is achieved by the computation and the application of a calibration matrix that allows each color detector (e.g., red, green, or blue) to contribute in the appropriate proportion to all of the color coordinates.

INDUSTRIAL COLLABORATION RESULTS IN AWARD

A research team from NIST and a private company received the Best Paper Award from the Society of Plastics Engineers' Engineering Properties and Structure Division at the society's annual meeting in May 1996.

The paper, "Morphology of Syndiotactic Polystyrene as Examined by Small Angle X-ray Scattering," described use of NIST SAXS facilities to unravel the microstructure of syndiotactic polystyrene (sPS), a novel isomeric form of polystyrene with potential commercial significance. Polymer scientists from the private company entered into a Cooperative Research and Development Agreement to obtain NIST assistance in elucidating the structure and mechanical properties of sPS made by a new synthetic process. Modern instrumentation has made x-ray scattering, a classic technique for determining crystal structure of materials, more informative while significantly reducing measurement times. This has permitted new types of measurements to be made.

The sPS studied in this work is unusual in that the difference in density between the amorphous and crystalline phases is very small at temperatures below the glass temperature of the material. The small density difference makes conventional x-ray measurements difficult because of the low contrast in electron densities between amorphous and crystalline phases. Measurements of SAXS patterns recorded at temperatures both

above and below the glass temperature allowed the researchers to identify three distinct phases: a strongly disordered phase exhibiting behaviors typical of amorphous polymers, a crystalline phase, and a density deficient grain boundary phase.

Moreover, the characteristics of the microstructure were found to depend on processing conditions in a rather subtle manner as observed by examining specimens that were injected into molds maintained above and below the glass temperature of the sPS.

Results from morphological studies of this kind are used to guide processing decisions such as melt temperatures, mold conditions, and the need for additives. The presence of the grain boundary phase may have significant implications for the chemical resistance and mechanical durability of products made from the polymer.

UNRAVELING ANISOTROPIC MICROSTRUCTURES IN PLASMA-SPRAYED CERAMIC DEPOSITS

Researchers at NIST, in collaboration with scientists from the State University of New York at Stony Brook, and using facilities at NIST's research reactor, have applied small-angle neutron scattering (SANS) to characterize the voids within plasma-sprayed deposits. The void fraction in these materials is a major factor in determining their mechanical and thermal properties, which are key elements in establishing their industrial performance.

The microstructure of plasma-sprayed ceramic deposits typically includes pores between the splat layers, which are preferentially oriented parallel to the substrate, and cracks formed within the splats mostly during cooling, which are preferentially oriented perpendicular to the substrate. The SANS results have made it possible, for the first time, to unravel the orientational significance of the cracks and the pores and have made it possible to relate these to fabrication and processing parameters. The SANS results indicate that (1) the orientation of intralamellar cracks is a function of the spray angle, whereas the orientation of the interlamellar pores is not; (2) a significant fraction of the voids in grey-alumina deposits is in the form of cracks, whereas cracks are only a small fraction of voids in partially stabilized zirconia deposits; (3) thermal-shock (heat treatment) of the zirconia deposits results in the removal of most of the cracks in the as-deposited material; (4) the total specific surface area within

grey-alumina deposits decreases with increasing total porosity along different monotonic curves for increasing spray distance and angle. Taken together, the SANS results indicate it is possible to predict the deposit morphology from microstructure models involving accessible spray processing parameters.

EVALUATION OF CORROSION FATIGUE RESISTANCE OF ALLOYS USED IN THE PULP AND PAPER INDUSTRY

NIST scientists initiated a research project based on a Cooperative Research and Development Agreement with a private company to study corrosion fatigue of duplex stainless steels used in the manufacture of paper. The company is a leading manufacturer of the large and complex suction roll shells used in the paper making process and is the only U.S.-based supplier. Because of the corrosive nature of the process liquids, corrosion fatigue poses a serious threat to the integrity of the shells, and this necessitates the development of specialized alloys and heat treatments. The problem would be exacerbated by changes in the liquids resulting from proposed tightening of environmental requirements. This research program is designed to develop improved measurement techniques for determining crack length in laboratory tests and to generate more accurate models to predict crack propagation rates in practice. The results will permit the company to modify its alloys and manufacturing methods to optimize corrosion fatigue resistance of these components.

NIST HOSTS CONCEPT PLANNING WORKSHOP FOR A CONSTRUCTION TECHNOLOGY EXTENSION PROGRAM (CTEP)

A concept planning workshop for a Construction Technology Extension Program (CTEP) was held in March 1996 at NIST. The event was sponsored jointly by NIST and the Civil Engineering Research Foundation (CERF).

CTEP is intended to be modeled on the NIST administered Manufacturing Extension Partnership (MEP) and will seek to increase the competitiveness and productivity of the U.S. construction industry through widespread and accelerated deployment of new and/or improved technologies, standards, and practices. This will enable the nearly 1 million small establishments in construction to contribute to achievement of the

National Construction Goals developed by the President's National Science and Technology Council with strong endorsement by the industries of construction. The goals are focused on improving (1) the life-cycle quality of constructed facilities; and (2) the health and safety of the construction workforce.

Industry segments represented at the workshop included materials and equipment; design and consulting; construction; and operation, maintenance, and repair. Forty participants from trade and professional organizations, education and training institutions, labor, standards and codes organizations, technology evaluation centers, small firms, information service firms, and other federal agencies attended, including groups such as the Associated General Contractors of America, the American Public Works Association, and the National Association of Home Builders.

The workshop identified the most important services that should be provided, including assistance with information technologies; workforce training and education; standards, codes, conformance assessment, and product approval; technical and business practices; and clearing-house functions.

Alternative delivery mechanisms (adding construction expertise to MEP centers versus creating a separate extension network for construction) as well as the role of information technology were discussed extensively. Recognizing that ease and speed of service accessibility by small firms are critical, some combination of the two delivery mechanisms may emerge as the most effective. In either case, CTEP would need to be established as a distinct but integral part of MEP. Also, participants felt that a combined high-tech (information technology) low-tech (field agents) approach would be best for construction.

NEW EDITION OF LIFE-CYCLE COSTING HANDBOOK FOR BUILDINGS AND BUILDING SYSTEMS

Handbook 135, a guide to understanding and practicing life-cycle-cost (LCC) evaluations of energy and water conservation projects in federally owned and leased buildings, has been revised extensively. Organized around the key steps in a life-cycle cost analysis, it explains how to discount future amounts to present value, how to calculate net savings, savings-to-investment ratio, adjusted internal rate of return, and discounted payback, and how to use these measures to select the economically optimal project alternative. The explanations and examples integrate the assumptions and criteria that apply to economic evaluations under the Federal Energy Management Program with standard methods of life-cycle cost analysis. Handbook 135 and

its associated supplements and computer software are used by about 6000 engineers and architects, energy analysts, and managers of federal, state, local, and privately owned facilities throughout the United States. To obtain the new (1995) edition, call 1-800-DOE-EREC.

NIST STAFF FIND EFFECTIVE FIRE RETARDANT

Nearly all polymer products must meet flammability requirements in addition to satisfying the performance desires of consumers. For most polymers, fire performance is met with fire retardant additives, many of which are based on bromine and chlorine. Because of possible environmental and recycling requirements, the search for alternatives to halogenated fire retardants is a subject of high concern to the plastics industry. Two NIST scientists and a scientist from the Russian Academy of Sciences have been studying mechanisms for reducing the burning rate of polymers. They have now found that the combination of silica gel and potassium carbonate, two common chemicals, is an effective fire retardant for a wide range of high-use polymers, including nylon, polypropylene, and cellulose. The rate of heat release, the most important property in determining fire hazard, is reduced by up to a factor of three, with no significant increase in smoke or carbon monoxide production. Further research is under way to understand better how this formulation affects such a wide range of materials. The results have been presented to the Society for the Advancement of Material and Process Engineering.

FLICKERING FLAMES DOCUMENTED BY NIST SCIENTISTS

Fire spread is dominated by flame radiation, whose intensity depends on the soot concentration in the flame and its optical properties. The flames in fires are both diffusion-controlled (the fuel vapors and air are not initially well mixed) and turbulent in nature. However, most soot measurements and studies of soot formation mechanisms have been conducted in steady, laminar diffusion flames. A team of NIST scientists has been bridging this gap by making comprehensive measurements on periodically flickering diffusion flames. Using nonintrusive laser optical techniques, the scientists have determined temperature and soot concentration profiles and performed full Mie analyses of the soot volume fraction results. In the process, they have developed the technique of laser-induced ionization for quantitative applications. They have found significant differences in the structure of the soot fields and in the roles of soot

inception, growth, and oxidation for different hydrocarbon fuels. Working with a scientist from the Naval Research Laboratory, they find good agreement with a computational model of the flames. The results have been submitted to *Combustion and Flame*.

NIST SCIENTIST ADVANCES KNOWLEDGE IN FIELD OF CRYSTAL GROWTH

A NIST scientist, together with two university scientists, have recently addressed the intriguing question of what shape a water droplet, at rest on a chilled surface, takes when it is solidified. They discovered that the water droplet, whose shape was that of a spherical cap, solidified into a shape with a cusp-like peak. Their mathematical modeling showed that this curious form resulted from a dynamical relation between the angles at which the water/ice, air/ice, and air/water interfaces met during the solidification process.

The freezing droplet problem represents a simple system, both experimentally and mathematically, that mimics more complicated systems used in industrial casting and crystal growth applications where shape changes can have dramatic effects on the quality of the solidified product. These applications include containerless casting processes in which the melt/crystal system is open to the surrounding vapor and laser surface treatments where portions of a surface are melted with strong laser pulses and the resulting pool of molten material re-solidified. The freezing droplet model identifies the appropriate conditions at three-phase junctions required to predict accurately shape changes in more complicated systems. A detailed article describing the work will appear in the *Journal of Crystal Growth*.

NIST BEGINS TESTING OF AUTOMATED SOFTWARE TEST GENERATION METHODS

NIST has initiated a project to investigate the effectiveness of using automated software test generation methods to develop conformance tests for specifications of software standards. Traditionally, conformance tests have been developed by manually coding the test source code and testing that source code. The project compares the performance of selected automated methods both with each other and with the traditional approach. The first phase of the project compares the performance of the automated Assertion Definition Language, developed by a private company with the traditional approach, both approaches being applied to the same set of specifications. To this end, a collection of metrics has been developed to compare the development time, quality, and coverage of the test code produced by the two techniques. A web page for this project has been set up at <http://speckle.ncsl.nist.gov/~goldfine/autogen.htm>.

MINIMUM INTEROPERABILITY SPECIFICATION FOR PKI COMPONENTS

NIST has established Cooperative Research and Development Agreements (CRADAs) with several major vendors of public key infrastructure (PKI) products to develop a Minimum Interoperability Specification for PKI components that will be broadly accepted and easily implemented in products. The PKI will support the use of digital signatures in distributed information environments. Interoperability is essential to enable large, diverse use of digital signature technology.

NIST will administer the CRADA program and write the specification using input from work with the Federal PKI Technical Working Group and hands-on experience with various commercial products supplied by the CRADA partners. The CRADA partners will help identify implementation problems, compatibility problems, and other issues that affected interoperability in a PKI. The group plans to complete the specification by October 1996.

REPORT INTRODUCES NEW PARALLEL PROGRAM PERFORMANCE TOOL

NISTIR 5789, *Using S-Check Alpha Release 1.0*, introduces a new tool that gives the programmer useful performance information and is portable across machines as well as architectures. S-Check automates the techniques of synthetic perturbation screening (SPS) that determine performance sensitivities of selected program code segments. The resulting sensitivity analysis serves as a basis for performance evaluations.

Standard Reference Materials

HUMAN SERUM SRM NOW NEW AND IMPROVED

A new and improved version of NIST's Standard Reference Material for human serum will help ensure accuracy in clinical laboratory blood analyses. For years, this popular SRM has been used widely as a reference standard for some of the most common indicators of human health, such as cholesterol, glucose, sodium and potassium levels in blood. The new version, SRM 909b, includes for the first time certified values for triglycerides. Also added are "elevated" values for several compounds. Certified values are now offered for 13 organic and inorganic blood constituents. Non-certified values also are provided for seven other constituents. The SRM contains six bottles of freeze-

dried serum, three with “normal” levels and three with “elevated” levels, and six bottles of high-purity water. SRM 909b is available for \$342 from the NIST Standard Reference Materials Program, Room 204, Engineering Mechanics Building, Gaithersburg, MD 20899-0001, (301) 975-6776, fax: (301) 948-3730, e-mail: srminfo@enh.nist.gov.

STANDARD REFERENCE MATERIAL (SRM) 1249—INCONEL 718

Nickel base superalloys are among the vital high-temperature materials used by the aerospace and electrical power generation industries. These alloys have a wide range of applications where high strength is needed in high-temperature, corrosive environments. In power generation plants, nickel base superalloys are used for superheater tubing, ash-handling systems, and stack gas scrubbers. But their greatest applications are in the aerospace industry where they are used in the construction of rocket engines and for aircraft gas turbine parts such as blades, disks, rings, shafts, and various compressor and diffuser components. SRM 1249, Inconel 718, is certified for the following 13 elements whose concentrations are critical to aircraft and aerospace component performance: aluminum, carbon, chromium, cobalt, copper, manganese, molybdenum, nickel, niobium, phosphorus, silicon, titanium, and vanadium. The SRM is in disk form and intended primarily for use with optical emission and x-ray spectrometric methods of analysis.

STANDARD REFERENCE MATERIAL (SRM) 2433—TITANIUM BASE ALLOY 8Al-1Mo-1V

The issuance of SRM 2344—Ti 8Al-1Mo-1V completes a series of nine titanium base alloy SRMs made available by the NIST SRM Program. These alloys have wide application within the aircraft and aerospace industries where they are used in the production of commercial jet aircraft components. Titanium 8-1-1, in particular, is used for aircraft structural components (primarily fuselage skin) and turbine parts such as compressor disks, plates, and hubs, and other applications where low-density, high-strength, highly weldable materials are required. SRM 2433 is in the form of chips sized between 0.05 mm and 1.18 mm sieve openings (35 mesh and 16 mesh) and is certified for four elements whose concentrations are critical to the performance of the alloy. These elements are aluminum, iron, molybdenum, and vanadium.

Standard Reference Data

ATOMIC-SCALE SURFACE STRUCTURE DATABASE EXPANDED

An important resource for scientists and researchers in materials, physics and chemistry has been expanded with information on nearly 400 new structures. Standard Reference Database 42, NIST Surface Structure Database, Version 2.0, for PCs, is the only complete critical compilation of reliable information on surface crystallographic structures available. It is a powerful tool for analyzing the surface structures of materials in electronics and semiconductors and for high-performance ceramic coatings. The database brings instant access to detailed text and graphical displays of nearly 1000 experimentally determined atomic-scale structural analyses obtained from low-energy electron diffraction and other experiments. Information is included on a wide variety of materials of scientific and technological interest, including catalysts. The database contains three-dimensional color graphics that permit the visual inspection of all surface structures. The structures can be rotated and magnified, and the distance between atoms can be determined easily. SRD 42, Version 2.0, is available for \$390 (updates \$100) from the Standard Reference Data Program, Building 820, Room 113, NIST, Gaithersburg, MD 20899-0001, (301) 975-2208, fax: (301) 926-0416, e-mail: srdata@nist.gov.

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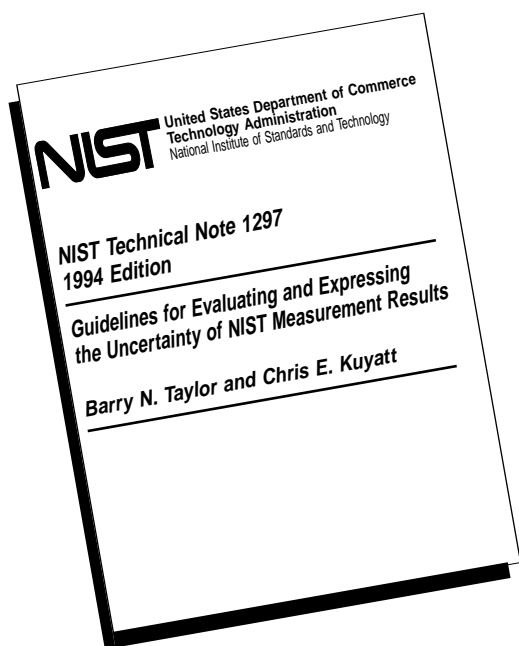
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Evaluating and Expressing the Uncertainty of Measurement Results



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.

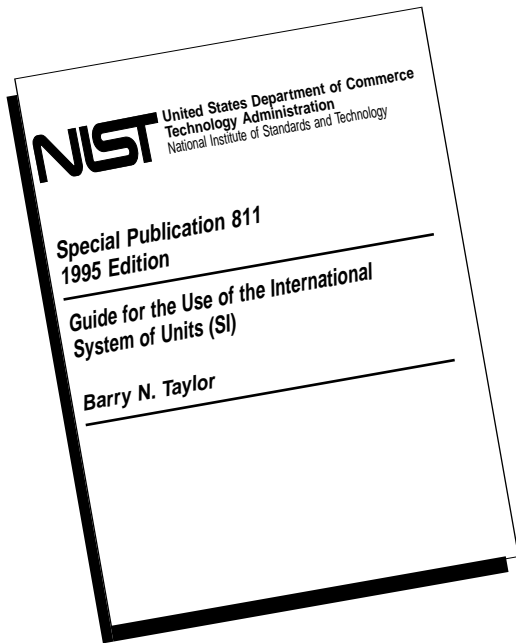
It is expected that the 1994 edition of TN 1297 will be even more useful than its immediate predecessor, the 1993 edition, of which 10 000 copies were distributed worldwide.

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.

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.

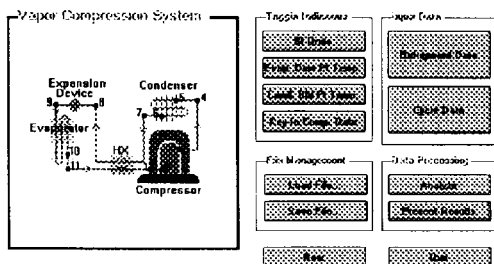
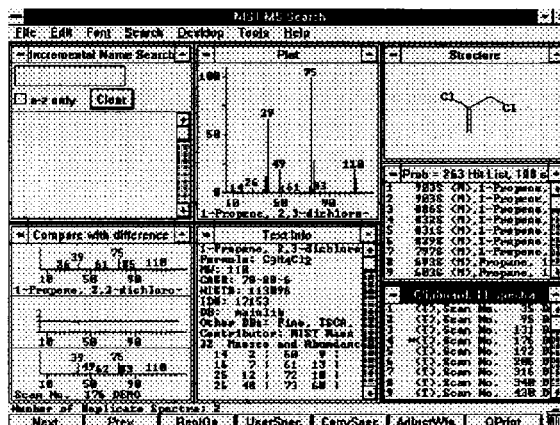
The topics covered by SP 811 include:

- 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.

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NIST Technical Publications

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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.

National Standard Reference Data Series—Provides quantitative data on the physical and chemical properties of materials, compiled from the world's literature and critically evaluated. Developed under a worldwide program coordinated by NIST under the authority of the National Standard Data Act (Public Law 90-396). NOTE: The Journal of Physical and Chemical Reference Data (JPCRD) is published bimonthly for NIST by the American Chemical Society (ACS) and the American Institute of Physics (AIP). Subscriptions, reprints, and supplements are available from ACS, 1155 Sixteenth St., NW, Washington, DC 20056.

Building Science Series—Disseminates technical information developed at the Institute on building materials, components, systems, and whole structures. The series presents research results, test methods, and performance criteria related to the structural and environmental functions and the durability and safety characteristics of building elements and systems.

Technical Notes—Studies or reports which are complete in themselves but restrictive in their treatment of a subject. Analogous to monographs but not so comprehensive in scope or definitive in treatment of the subject area. Often serve as a vehicle for final reports of work performed at NIST under the sponsorship of other government agencies.

Voluntary Product Standards—Developed under procedures published by the Department of Commerce in Part 10, Title 15, of the Code of Federal Regulations. The standards establish nationally recognized requirements for products, and provide all concerned interests with a basis for common understanding of the characteristics of the products. NIST administers this program in support of the efforts of private-sector standardizing organizations.

Order the following NIST publications—FIPS and NISTIRs—from the National Technical Information Service, Springfield, VA 22161.

Federal Information Processing Standards Publications (FIPS PUB)—Publications in this series collectively constitute the Federal Information Processing Standards Register. The Register serves as the official source of information in the Federal Government regarding standards issued by NIST pursuant to the Federal Property and Administrative Services Act of 1949 as amended, Public Law 89-306 (79 Stat. 1127), and as implemented by Executive Order 11717 (38 FR 12315, dated May 11, 1973) and Part 6 of Title 15 CFR (Code of Federal Regulations).

NIST Interagency Reports (NISTIR)—A special series of interim or final reports on work performed by NIST for outside sponsors (both government and nongovernment). In general, initial distribution is handled by the sponsor; public distribution is by the National Technical Information Service, Springfield, VA 22161, in paper copy or microfiche form.

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