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News Briefs

General Developments

Inquiries about News Briefs, where no contact person is identified, should be referred to the Managing Editor, Journal of Research, National Institute of Standards, and Technology, Building 101, Room E215, Gaithersburg, MD 20899-2500; telephone: (301) 975-3577.

NIST RESEARCHERS DEVELOP IMPROVED HIGH-RESISTANCE STANDARDS

Researchers at NIST have developed a new generation of high-resistance standards and delivered the standards to the Primary Standards Laboratories of the Army and Air Force. The new standards, with nominal resistances of 1 GΩ and 10 GΩ, have performance characteristics that are substantially better than have been demonstrated by any prior standards at these resistance levels. As a result of this superior performance, NIST was able to deliver these standards with calibration uncertainties reduced by factors of three and five, respectively, below those that can be provided for other high-resistance standards.

The improved performance characteristics will allow the Department of Defense (DoD) standards laboratories to deliver improved high-resistance measurements. Demand for improved high-resistance measurement capability has, in recent years, driven substantial improvement in the measurement instrumentation and techniques. However, performance characteristics of existing high-resistance standards did not allow electrical metrology laboratories to achieve the full potential of the improved instrumentation. A recent NIST-led international comparison of high-resistance measurement capability clearly demonstrated the potential for improved metrology with improved standards. NIST undertook development of these improved standards as a critical step required for DoD laboratories to maintain their high-resistance measurement capabilities at the necessary state-of-the-art.

The NIST standards are based on commercially available film-type resistance elements. The elements underwent heat treatment, which leads to a very large improvement in the long-term stability of their resistance. Sets of the treated elements were carefully selected to form composite standards with net resistance very close to the nominal value, and with minimal residual net drift rate. The composite elements were hermetically sealed in brass cylinders to improve their long-term stability and to mitigate the effects of environmental humidity, and then shock-mounted in aluminum enclosures using highly damped viscoelastic material. Calibrated thermistor probes were permanently mounted inside each enclosure to permit monitoring of the temperature. Mounting of the coaxial terminals on circular polytetrafluoroethylene plates allows the standards to be fully guarded, which suppresses the leakage of current to ground. The resulting stable and robust standards have excellent traveling characteristics and are suitable for use as primary resistance standards. The standards were characterized for their drift with time and for their dependence on temperature and voltage. The 1 GΩ resistance standards were found to typically exhibit temperature coefficients of 5×10^{-6}/ °C, voltage coefficients of 0.003×10^{-6}/V, and drift rates of less than 10×10^{-6}/year. The 10 GΩ resistance standards were found to typically exhibit temperature coefficients of -3×10^{-6}/ °C, voltage coefficients of 0.003×10^{-6}/V, and drift rates of less than 20×10^{-6}/year. For comparison, high-resistance standards that are presently available commercially have typical thermal coefficients that are one to 10 times larger, and voltage coefficients that are larger by a factor of 100 to 300. The observed drift is improved by a factor of three to five.

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ELASTIC MODULI DATA FOR POLYCRYSTALLINE OXIDE CERAMICS ADDED TO WEBBOOK

A major compilation of elastic moduli data (Young's modulus, shear modulus, bulk modulus, and Poisson's ratio) for oxide ceramics has been completed and

added to the online NIST Ceramics WebBook. The variation of material properties with respect to internal microstruc-tural characteristics and environmental parameters is a critical consideration in the development and application of all advanced materials. The variation of elasticity is especially important to engineering applications in which the material components experience mechanical stresses. As part of the effort to provide evaluated data for advanced ceramics, NIST researchers have conducted a detailed review of the variation of the elastic moduli of polycrystalline oxide ceramics with respect to porosity and temperature. A compilation of data for 50 oxide ceramics was constructed, and the data were analyzed in the context of a suitable model expressing the simultaneous dependence on porosity and temperature analytically. The nearly 4000 property values were extracted from publicly accessible technical literature. Data originally presented as graphs were digitized so that the entire compilation could be given in the form of tabulated numeric values. The entire collection is available in hard copy (NISTIR 6853) and online at www.ceramics.nist.gov.

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NIST RELEASES SPLIT-CYLINDER RESONATOR MEASUREMENT SOFTWARE

NIST has released SplitC, an automated software program for measuring the high-frequency electrical properties of dielectric substrates using a split-cylinder resonator. With this software, developed by a NIST scientist, manufacturers of printed-wiring boards, ceramics substrates, and other low-loss dielectric materials can use the split-cylinder resonator method to non-destructively measure the dielectric constant and loss tangent over a frequency range of 5 GHz to 50 GHz. Included in this release of SplitC is a new theoretical model for the split-cylinder resonator, derived using the mode-matching method, which improves measurement accuracy and decreases computation time. In addition, SplitC incorporates a new method, recently developed by NIST staff, for measuring the resonant frequency and quality factor of resonance curves, resulting in a reduction of measurement uncertainty. This release of SplitC follows the successful test of an earlier beta version in which participants from industry and academia published meas-urement data for a wide range of dielectric materials.

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FUNDAMENTAL NOISE LIMITATIONS ON SUPERCONTINUA GENERATED IN MICROSTRUCTURE FIBER DETERMINED BY NIST

NIST recently completed a thorough study of the amplitude noise on supercontinua generated by injecting femtosecond laser pulses into microstructure fiber. Supercontinuum generation in microstructure fiber has the potential of providing an extremely broadband, very bright, spatially and phase coherent source; these supercontinua already have revolutionized the field of optical frequency metrology. Unfortunately, the supercontinuum can exhibit substantial amplitude noise that can limit its applications. Work at NIST has succeeded in identifying the origins of this amplitude noise and characterizing its dependence on the experimental parameters. This work will be useful for researchers seeking to exploit this new optical source for metrology and other applications.

Through measurement and simulations, NIST researchers identified two components to the amplitude noise: a low-frequency component, which arises from amplification of the input laser's technical noise; and a broadband component, which arises primarily from amplification of the shot noise on the input laser pulse. Because the low-frequency component of the noise is simply an amplified version of the technical noise on the input laser, it can be reduced experimentally by using a quieter laser. The broadband component is much more fundamental, since it originates from the basic quantum shot noise on the input laser pulse. Interestingly, as a result of non-linear modulation instability effects in the fiber, the initially weak shot noise is amplified by a much larger factor than the lower-frequency technical noise. Amplification of the shot noise of up to 90 dB during supercontinuum generation has been measured. In fact, under the wrong conditions, the broadband noise is high enough that the pulse-to-pulse amplitude fluctuations exceed 50 %, rendering the supercontinuum essentially useless for most applications. Fortunately, one result of this work is the determination that amplification of the shot noise is extremely dependent on the input pulse duration; for very short pulses of $\approx$ 30 fs or less, the broadband amplitude noise is reduced dramatically.

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NIST DEMONSTRATES SINGLE PHOTON SOURCE

A NIST scientist has demonstrated the emission of individual photons on demand, a major accomplishment in

the development of "single photonics," which utilizes the photon as the fundamental particle of optical metrology. A low density of InGaAs quantum dots (QDs), semiconductor nanostructures with 10 nm to 20 nm dimensions, is grown on GaAs by molecular beam epitaxy. Individual quantum dots are isolated by a mesa etch. A pulsed laser illuminates the QD sample, exciting electron-hole pairs that are captured by the QD. The electron and hole recombine in the QD, emitting exactly one photon that is incident on an intensity interferometer with a 50/50 percent beamsplitter and photon counting detectors. A histogram of start-stop time intervals is recorded. At time interval zero, there is a very small peak compared to the peaks that are observed at multiples of the excitation laser repetition rate. This is the signature that the photons are emitted one at a time (photon on demand). In contrast, when multiple QDs are excited simultaneously, the peak height at a time interval of zero is equal to that at other time intervals corresponding to the laser repetition rate.

Applications of the single photon turnstile are envisioned for the development of high-accuracy, quantum-based radiometry, in which laser power and energy measurements are calibrated by counting photons. Single photon sources are also critical components of quantum cryptography, or quantum key distribution, an ultra-secure form of communication.
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NIST USES HIGH-FREQUENCY NOISE TO CHARACTERIZE COMMERCIAL RECORDING HEADS

A NIST researcher has completed a study of high-frequency magnetic noise in commercial magneto-resistive recording heads. The study was done in collaboration with two private U.S. companies involved in the manufacture of disk drives and recording heads. The magnetic noise in the read sensors was measured over a frequency range from 0.1 GHz to 8 GHz. Magnetic noise is the component of noise due to thermal fluctuations of the magnetic layers used to sense the fields from data bits. These fluctuations scale inversely with the sensor size and, as the sensor dimensions shrink below 100 nm, can become the dominant source of noise. The peak magnetic noise level in 200 nm devices in modern disk drives is 0.2 $nV/Hz^{0.5}$, which is on the same order as the Johnson noise.

The magnetic noise is measured by subtracting a reference spectrum, in which the magnetization is saturated with a large field, from the noise spectrum This subtraction allows the magnetic noise to be separated from other noise sources and gives a noise floor of 5 $pV/Hz^{0.5}$. The noise was measured as a function of both current through the sensor and a magnetic field applied in a direction to simulate the bit fields. Because electromagnetic pickup from the environment can be considerably larger than the intrinsic noise signal, the high-frequency magnetic noise was measured in a special low-noise environment.

The noise spectra show several resonant peaks. The largest, near 5 GHz, is due to the uniform rotation of the magnetization near the center of the devices. Additional peaks are observed due to magnetic fluctuations at the ends of the devices, which are more strongly pinned by abutted permanent-magnet thin films. Other higher-frequency peaks are observed that may be due to non-uniform modes in the center of the device. A low-frequency noise component, indicative of non-ideal magnetization structure and domain wall motion, varied considerably from head to head. The strength of the peaks, and to a lesser extent, the frequency positions of the peaks, also varied from head to head.

The NIST researcher compared these noise measurements on recording heads with his earlier noise measurements on specially prepared magnetoresistive structures fabricated at NIST. The NIST devices were designed to allow precise measurement of the high-frequency magnetic noise in magnetoresistive sensors. As a function of temperature and bias field, those noise spectra fit theoretical models. Commercial recording heads, however, are considerably more complicated. The microwave properties of the interconnect structures are less ideal, and the magneto-resistive sensor is surrounded by permanent-magnet and shield films that may alter the noise spectra in complex ways. When the noise spectra are fully understood, they will provide a powerful diagnostic of the magnetic structure of the sensors.
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BROADLY TUNABLE MICROWAVE REFERENCE OSCILLATOR DEVELOPED

The measurement of phase-modulation (PM) noise and amplitude-modulation (AM) noise of clocks and oscillators presumes the availability of stable, low-noise reference oscillators at the desired measurement frequencies. However, it is too expensive and cumbersome to maintain dedicated reference oscillators for each measurement frequency.

NIST researchers have developed a novel reference-oscillator system with broad tunability, which advances

the art of PM and AM noise measurement. Previously, methods for synthesizing offsets from stable, fixed-frequency oscillators had been extremely complex. The problem is that frequency-offset synthesis generally creates unacceptable levels of noise. In the traditional approach, a synthesized offset is added to a stabilized oscillator. The noises of these two signals are independent and additive.

The innovation of the new system is in the placement of the offset synthesizer inside a servo control loop used to stabilize a high-Q microwave cavity. The frequencies of the two oscillators, the reference signal and the offset, must add up to the fixed reference frequency of the cavity. Therefore, the reference-signal frequency will be changed in a direction opposite to changes in the synthesized offset frequency. The system suppresses the total noise on the reference signal.

The concept was experimentally demonstrated using a high-Q microwave cavity with a resonance frequency of 10.6 GHz, a dielectric resonant oscillator, and a digital offset-frequency synthesizer. The results demonstrated the addition of tunability without substantially adding to the noise.

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REPRODUCIBILITY OF OPTICAL FREQUENCY STUDIED

The mercury-ion optical-frequency standard has the potential for an accuracy surpassing that of the cesium-fountain standard by two or more orders of magnitude. With a Q factor greater than 10^{14} and a transition that is relatively insensitive to environmental factors, the potential uncertainty for the standard is as small as 1 aHz/Hz (0.001 fHz/Hz, or 1×10^{-18}).

The reproducibility of this standard relative to the present cesium standard (NIST-F1) was studied over a 2 year period by NIST. Measurements were referenced to NIST-F1 through the intermediary of a hydrogen maser. The short-term stabil-ity of the mercury standard is superior to that of NIST-F1, so the maser played a key role in the comparisons. The variation in the frequency of the S-D optical transition relative to NIST-F1 was found to be less than ±10 fHz/Hz over the 2 years.

The uncertainty of the absolute measurement (at this same level) is the most accurate measurement ever made of an optical frequency, and is a very encouraging result, since no significant effort had been made to control systematic frequency shifts. The largest of these shifts is expected to be the atomic quadrupole shift, which depends on the orientation of the applied magnetic field relative to ambient, static electric-field gradients. Concepts for determining and controlling this and other smaller shifts have been developed, but further studies are needed to test them. To evaluate the systematic effects, a second mercury-ion standard has been constructed. Changes in operating parameters on one of these two mercury standards should readily reveal any perturbative shift in the frequency of the optical clock transition when the frequencies of the two standards are compared.

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GEOMETRICAL-PHASE QUANTUM-LOGIC GATE DEMONSTRATED

The recent demonstration of a novel, two-qubit, geometrical-phase quantum-logic gate significantly advances prospects for quantum computation. This new gate appears to have features that overcome a number of difficulties identified earlier.

In this device, rather than manipulating the direction of the spin states, NIST researchers control the phases of the spin states using optical dipole forces. An important advantage of this change is that the requirements on control of the laser phase are signficantly reduced. For gates of the sort the researchers demonstrated and reported 2 years ago in *Nature*, the laser phase had to be kept constant relative to the qubit phase during the gate operation. For the new gate, only the phase of the dipole force relative to the motion needs to be maintained constant. In general, this is much easier to do.

The geometrical-phase gate also shares many of the positive attributes of the earlier gate. It is a one-step gate. Also, individual-ion addressing is not required. In fact, we want to illuminate the ions simultaneously. This means that careful laser focusing is not needed. Finally, motional eigenstates are not required as long as the ions are tightly contained and within the Lamb-Dicke limit.

The new gate is particularly well-suited to application in multiplexed trap systems, a design approach that will provide for scaling to larger logic systems. For example, there is no requirement for maintaining equal laser couplings to each ion as in the previous, two qubit gate. This means that sympathetic cooling can be used in more complex systems without introducing difficulties in maintaining specific laser-beam couplings to the ions. The additional phases accumulated on individual qubits from unequal coupling can be removed in software by changing the phase of subsequent applied operations rather than applying correction pulses to the ions themselves.

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PATHWAY PROVIDED TO SCALABLE QUANTUM ARCHITECTURES WITH NON-LOCAL QUANTUM GATES

One of the basic requirements for building a scalable quantum computer is the need to interact arbitrary pairs of qubits (quantum bits) within the computer. However, most quantum interactions have only a short range, limiting interactions between qubits to those that are nearest neighbors. A chain of interactions between neighboring qubits would be required to connect distant qubits, which would be a burdensome communication cost.

In a recently submitted paper, three NIST scientists have shown how one can efficiently solve this quantum communication problem by using a set of ancillary quantum bits to create a distant pair of entangled qubits. This entangled pair of atoms, or quantum resource, then can be used to efficiently perform or teleport a non-local quantum gate between any two distant qubits. The paper shows that this concept is robust even in the presence of quantum noise and decoherence.

This new concept effectively provides a means of building a quantum bus, a concept very similar to the classical bus connecting the basic architectural elements of the von Neumann computer. Together with the key building blocks of a quantum computer, the quantum bus provides a pathway to a scalable quantum architecture using non-local interactions.

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NIST RESEARCHES EUV RADIATION SOURCE FOR ELECTRONICS MANUFACTURING

Integrated-circuit manufacturers require increasingly shorter wavelength radiation in order to print increasingly smaller features on semiconductor wafers. Near-term development is focused on systems employing excimer-laser radiation at 193 nm and 157 nm. However, in the longer term, industry research is focused on systems employing 13 nm extreme ultraviolet (EUV) radiation, for which multilayer mirrors are particularly efficient. The technology roadmap calls for a radiation source based upon 10-times ionized xenon gas (Xe^{10+}), which has strong emission at 13 nm. However, in previous studies using low-resolution instruments, its true spectrum in this region was not well measured.

NIST scientists have used the NIST 10.7 m grazing-incidence spectrograph to record the first high-resolution spectrum of Xe^{10+}. The spectra were obtained by puffing a small amount of xenon into a low-inductance vacuum spark. In the observed spectrum, fine details of the many-lined spectrum were revealed for the first time. The most prominent of the individual spectral lines were analyzed and classified as to their origins in the energy levels of the Xe^{10+} ion. The data should be of great help for modeling and optimization of an effective EUV lithography source.

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NIST RELEASES UPDATED SOFTWARE REFERENCE DATA SET FOR USE BY COMPUTER FORENSICS COMMUNITY

NIST recently released Version 2.1 of the National Software Reference Library (NSRL) Reference Data Set (RDS) to the computer forensics community. The RDS is a resource for law enforcement, corporate, and other organizations investigating crimes involving computers. It contains over 15 million file profiles from software, including operating systems, database management systems, word processing packages, graphics applications, utilities, image libraries, font libraries, and many others. These profiles can be used to "fingerprint" known files on computer systems and either remove or include them automatically in reviewing files for probative content. The RDS also is being used for digital library management and to support intrusion detection.

The NSRL is supported by the U.S. Department of Justice's National Institute of Justice; the Federal Bureau of Investigation; the National Archives and Records Administration; and NIST.

The RDS is available on CD-ROM from NIST's Standard Reference Data Office. Annual subscription ordering information can be found at www.nist.gov/srd/nistsd28.htm. Ongoing information about the project can be found at www.nsrl.nist.gov.

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M^3 WRITES LINE PATTERNS

Using the NIST-developed Molecular Measuring Machine (M^3), nanoscale lines have been accurately drawn on a silicon substrate. The writing method is based on scanning probe oxidation lithography, previously developed at NIST. The substrate is a hydrogen-

terminated Si(111) surface. Recent work at NIST has elucidated means of consistently preparing high quality H-Si(111) surfaces. The M^3 probe tip is guided over the surface under interferometer-based control to accurately position the written features. A high tunneling bias voltage of up to 10 V was used for writing. The initial features drawn were lines and concentric boxes with 100 nm line spacings. The lines were 10 nm to 20 nm wide and about 4 nm high. By varying the writing voltage, similarly sized trenches could also be written. These features were imaged after writing by using M^3, operating at a lower, non-writing, bias voltage. The writing and imaging were done in vacuum. The features were then confirmed in measurements done by a NIST researcher, imaging with an atomic force microscope in air. The initial results demonstrate the possibility of making unique calibration artifacts that can be used for intercomparison between tools within NIST, and for the dissemination of length at the nanoscale.

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CD-SEM SHAPE-SENSITIVE LINEWIDTH MEASUREMENT FINAL REPORT SUBMITTED

The final report for a one-year project to apply a model-based library (MBL) method to measurements performed with critical dimension scanning electron microscopes (CD-SEMs) has been submitted to International SEMATECH. CD-SEM images of linewidth test patterns were analyzed to determine the lines' widths and the angles of their edges. The patterns were subsequently cross-sectioned and imaged again. Comparison of the MBL and cross section results revealed differences of approximately 6 nm for widths and 1° for sidewall angles. These differences are considered small enough that they may be accounted for by line edge roughness and uncertainty in matching the location of the cross section to the location of the CD-SEM image.

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STANDARD BULLETS PROJECT FEATURED IN *SCIENCE NEWS*

The Jan. 11, 2003, edition of *Science News* featured an article entitled "A Shot in the Light," about the Standard Bullets Project led by a NIST researcher. The article discussed the automated image analysis systems and databases for linking bullets and casings recovered from different crime scenes with each other and with bullets and casings from suspect weapons. The role of the developing National Integrated Ballistics Information Network in this process also was discussed, along with the project at NIST to develop reproducible standard bullets to verify the operation of the image analysis systems. The manufacture of the first 20 bullets was discussed, along with the development of the NIST measurement and analysis system for demonstrating their reproducibility.

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NIST RESEARCHERS STUDY IMAGING AT THE INTERFACE OF MATERIALS SCIENCE WITH BIOLOGY

NIST scientists have designed and built a multimodal optical coherence microscope (OCM) that they have dedicated to *in vitro* tissue engineering metrology. This OCM with a collinear confocal fluorescence microscope (OCM/CFM) was constructed to provide dual mode, high-resolution imaging of the structure and functions within materials.

Researchers have demonstrated that the OCM/CFM can volumetrically image the structure of a polymeric scaffold and, at the same time, visualize the functioning of cells within the scaffold though the detection of fluorescent markers. Polymeric tissue engineering scaffolds such as these can cause cells to grow into and speed the beginnings of new tissues and organs, thereby holding the promise to repair functionality destroyed by injury, disease, and aging.

The near-term plan for this project is to add the capability to perform Coherent Anti-Stokes Raman Spectroscopy to this system for three-dimensional characterization of chemical functionality within the scaffold. The ultimate goal is to develop an integrated metrology that will provide the user with the capability of correlating biological activity, chemical functionality, mechanical properties, and physical structure over a wide range of dimensions in complex systems, such as these scaffolds, for engineered tissue.

For further information, visit the Web site at www.nist.gov/polymers and under Search Polymers Web space, enter "OCM."

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PAPER ON MEASUREMENT OF THE NANOMECHANICAL PROPERTIES OF THIN FILMS USING AFAM RECEIVES RECOGNITION

NIST researchers are developing atomic force acoustic microscopy (AFAM) methods to quantitatively determine the elastic properties of thin films. The AFAM technique measures the frequencies of an atomic force microscope (AFM) cantilever's first two flexural resonances while in contact with a material. The indentation modulus, *M,* of an unknown or test material can then be obtained by comparing the resonant spectra of the test material to those of a reference material. To examine metrology issues for this emerging technique, AFAM results have been compared with those obtained by other methods, such as instrumented indentation. The results show that better agreement may be achieved by averaging results from two different reference materials, providing better insight into using AFAM methods to attain reliable, accurate measurements of elastic properties on the nanoscale.

A conference paper on this subject, entitled "Quantitative Elastic-Property Information with Acoustic AFM: Measurements and Modeling," by NIST's Donna Hurley and Paul Rice, Joseph Turner (University of Nebraska-Lincoln) and Joshua Wiehn (former Nebraska graduate student), was recently awarded Second Best Paper for the SPIE 2002 Symposium on NDE and Health Monitoring. The topic was also the subject of an invited colloquium at the Fraunhofer Institute for Nondestructive Testing (Saarbruecken, Germany) last autumn.

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MICROWAVE MEASUREMENT TECHNIQUE DEVELOPED BY NIST RESEARCHER ADOPTED BY COMMERCIAL INSTRUMENT MANUFACTURER

A measurement method developed by a NIST researcher is now being widely used in the microwave industry. The method for measuring equivalent source match, published in the October 1997 issue of *Microwave Journal*, enables more accurate power measurements. The method has been adopted by a number of national laboratories and companies. The most recent example is an application note published by a manufacturer of microwave equipment that describes the technique in detail. The application note points out that the uncertainty in the calibration of power meters can be reduced by one order of magnitude when the technique is used to correct for source and power meter mismatches.

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PROPOSED NIST DISTRIBUTED TESTBED FOR FIRST RESPONDERS

Over the past several months, NIST has been working on novel communications and networking technologies for first responders at disaster sites. The goal of the NIST Distributed Testbed for First Responders is to save lives during natural or man-made emergencies by equipping first responders with highly capable systems and gear, based on the latest technological advances. Research in the Advanced Network Technologies Division has contributed to the NIST Distributed Testbed for First Responders in the following ways:

• NIST researchers built a wireless ad hoc network (WANET) consisting of Compaq iPAQ Personal Digital Assistants (PDAs) running on the Linux operating system and equipped with IEEE 802.11b wireless local area network (WLAN) cards. The network demonstrates how first responders could communicate with each other and with those outside of their WANET at an emergency site. Requiring no prior infrastructure, the network self-organizes once the first responders converge on a disaster site. It reorganizes automatically every time a node leaves the network (perhaps due to destruction or to the physical departure of the person carrying the associated radio/handheld terminal). As such, the network is resilient to node and link failures, and its performance degrades gracefully in the face of such events.

The network uses multihop communications to carry all sorts of traffic, such as full-duplex voice, video, text, and sensor data. Any message to be transmitted from node A to node B may go through several intermediary nodes. This helps conserve the battery power at each node, reducing interference for other communications taking place throughout the network and increasing the traffic-carrying capacity of the network. ITL's use of the IEEE 802.11b technology in the testbed is for proof-of-concept purposes. Future standards for first responder communications and networking will be based on other varieties of wireless technology.

• NIST developed a method by which the WANET could determine the locations of all assets of interest, such as the first responders themselves and any civilians trapped at the disaster site, at any given time. While the Global Positioning System (GPS) provides that functionality in an outdoor environment where one has line-of-sight (LOS) communication with GPS satellites, other solutions are needed for the much harder indoor localization problem. ITL's system relies

on a number of stationary IEEE 802.11b WLAN nodes with known locations to determine the locations of the mobile nodes. This allows tracking and knowledge of the location of first responders during an emergency, facilitating the management of the disaster.

• NIST researchers carried out some experimentation with smart sensor networks based on WANET concepts. This includes work on collaborative signal processing algorithms that combine data from sensors of different types (heat, smoke, chemical, etc.) to arrive at more detailed information about the disaster and its evolution than can be obtained from single sensors, such as today's smoke detectors.

These components, along with ongoing work in BFRL and MEL, will be integrated in the NIST Distributed Testbed for First Responders in the next several months. The Web site is http://w3.antd.nist.gov. CONTACT: Nader Moayeri, (301) 975-3767; nader.moayeri@nist.gov.

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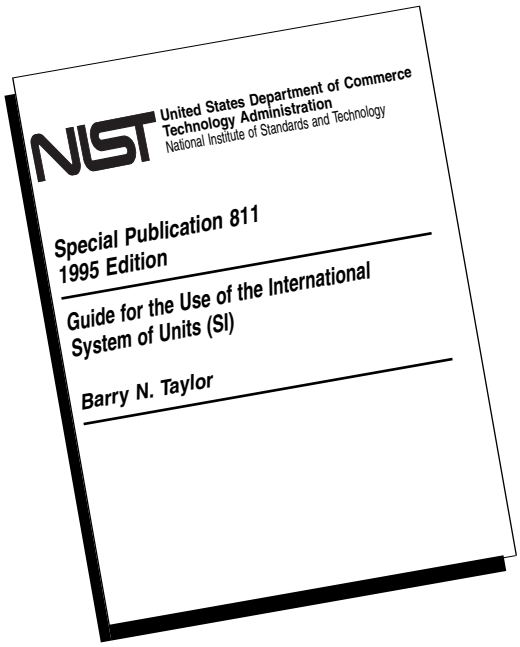
The International System of Units (SI)

A Guide for the Use of the Modern Metric System

NIST Special Publication 811, 1995 Edition



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 NIST SP 811, 1995 Edition, may be obtained by contacting the NIST Metric Program, 100 Bureau Drive, Stop 2000, Gaithersburg, MD 20899-2000; telephone: 301-975-3690; fax: 301-948-1416; email: metric_prg@nist.gov. NIST SP 811 is also available online at the NIST Web site entitled “NIST Reference on Constants, Units, and Uncertainty,” physics.nist.gov/cuu.

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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 Institute of Physics (AIP). Subscription orders and renewals are available from AIP, P.O. Box 503284, St. Louis, MO63150-3284.

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.

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