NISTIR 4645

Center for Electronics and Electrical Engineering

Technical Publication Announcements

Covering Center Programs, October to December 1990, with 1991 CEEE Events Calendar

U.S. DEPARTMENT OF COMMERCE
National Institute of Standards and Technology
Center for Electronics and Electrical Engineering
Semiconductor Electronics Division
Gaithersburg, MD 20899

August 1991

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U.S. DEPARTMENT OF COMMERCE
Robert A. Mosbacher, Secretary
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INTRODUCTION TO THE CEEE TECHNICAL PUBLICATION ANNOUNCEMENTS

This is the twenty-seventh issue of a quarterly publication providing information on the technical work of the National Institute of Standards and Technology (formerly the National Bureau of Standards) Center for Electronics and Electrical Engineering. This issue of the CEEE Technical Publication Announcement covers the fourth quarter of calendar year 1990.

Organization of Bulletin: This issue contains citations and abstracts for Center publications published in the quarter. Entries are arranged by technical topic as identified in the table of contents and alphabetically by first author within each topic. Following each abstract is the name and telephone number of the individual to contact for more information on the topic (usually the first author). This issue also includes a calendar of Center conferences and workshops planned for calendar year 1991 and a list of sponsors of the work.

Center for Electronics and Electrical Engineering: Center programs provide national reference standards, measurement methods, supporting theory and data, and traceability to national standards.

The metrological products of these programs aid economic growth by promoting equity and efficiency in the marketplace, by removing metrological barriers to improved productivity and innovation, by increasing U.S. competitiveness in international markets through facilitation of compliance with international agreements, and by providing technical bases for the development of voluntary standards for domestic and international trade. These metrological products also aid in the development of rational regulatory policy and promote efficient functioning of technical programs of the Government.

The work of the Center is divided into two major programs: the Semiconductor Technology Program, carried out by the Semiconductor Electronics Division in Gaithersburg, MD, and the Signals and Systems Metrology Program, carried out by the Electricity Division in Gaithersburg and the Electromagnetic Fields and Electromagnetic Technology Divisions in Boulder, CO. Key contacts in the Center are given on the back cover; readers are encouraged to contact any of these individuals for further information.

Center sponsors: The Center Programs are sponsored by the National Institute of Standards and Technology and a number of other organizations, in both the Federal and private sectors; these are identified on page 26.

Note on Publication Lists: Guides to earlier as well as recent work are the publication lists covering the work of each division. These lists are revised and reissued on an approximately annual basis and are available from the originating division. The current set is identified in the Additional Information section, page 19.

TABLE OF CONTENTS

SEMICONDUCTOR TECHNOLOGY PROGRAM

Silicon Materials

Geist, J., Schaefer, A.R., Song, J-F., Wang, Y.H., and Zalewski, E.F., **An Accurate Value for the Absorption Coefficient of Silicon at 633 nm**, Journal of Research of the National Institute of Standards and Technology, Vol. 95, No. 5, pp. 549-558 (September-October 1990).

High-accuracy transmission measurements at an optical wavelength of 633 nm and mechanical measurements of the thickness of a 13-μm thick silicon-crystal film have been used to calculate the absorption and extinction coefficients of silicon at 633 nm. The results are 3105 $\pm$ 62 cm^{-1} and 0.01564 $\pm$ 0.00031, respectively. These results are about 15% less than current handbook data for the same quantities, but are in good agreement with a recent fit to one set of data described in the literature.
[Contact: Jon Geist, (301) 975-2066]

Mayo, S., Lowney, J.R., Roitman, P., and Novotny, D.B., **Persistent Photoconductivity in SIMOX Film Structures**, Journal of Applied Physics, Vol. 68, No. 7, pp. 3456-3460 (1 October 1990).

Photoinduced transient spectroscopy (PITS) was used to measure the persistent photoconductive (PPC) response in n-type SIMOX film resistors. A broadband, single-shot, flashlamp-pumped dye laser pulse was used to photoexcite interband electrons in the film, and the excess carrier population decay was measured at temperatures in the 60- to 200-K range. The PPC signals exhibit nonexponential character, and the conductivity transients are recorded as a function of temperature for variable periods up to 30 s. The photoconductive data are analyzed by using the Queisser and Theodorou potential barrier model, and a logarithmic time decay dependence is confirmed for the first time in SIMOX material. The hole-trap density at the conductive film-buried silica interface is calculated to be in the high 10^{15} cm^{-3} to low 10^{16} cm^{-3} range. The sensitivity of PITS is demonstrated to be appropriate for characterization of the SIMOX interface structure and for material qualification.
[Contact: Santos Mayo, (301) 975-2045]

Thurber, W.R., Ehrstein, J.R., and Lowney, J.R., **Comparison of High-Resistivity Measurements of Silicon by AC Impedance, DC Resistance, van der Pauw, and Four-Probe Methods**, Extended Abstracts, Fall Meeting of the Electrochemical Society, Seattle, Washington, October 14-19, 1990, Vol. 90-2, pp. 581-582 (1990).

Resistivity measurements by different techniques are compared for high-resistivity silicon. The ac impedance method is emphasized as it is seldom used for silicon but has certain advantages for high-resistivity material. Slices with implanted and annealed surfaces were measured by the impedance method and two-terminal dc resistance. For material with lapped surfaces, results were obtained by ac impedance, van der Pauw, and four-probe methods. The agreement was within 5% for slices and ingot sections greater than 0.1 cm in length and resistivity above 5 k$\Omega\cdot$cm.
[Contact: W. Robert Thurber, (301) 975-2067]

Analysis Techniques

Bell, M.I., and McKeown, D.A., **High-Precision Optical Reflectometer for the Study of Semiconductor Materials and Structures**, Review of Scientific Instruments, Vol. 61, No. 10, pp. 2542-2545 (October 1990).

The design and performance of a high-precision optical reflectometer are described. This instrument has been optimized for measuring the specular reflectivity of thin films and multilayer structures of interest in semiconductor technology. Its design emphasizes high spectral and spatial resolution, photometric accuracy, and stray light rejection.

Analysis Techniques (cont'd.)

Use of a spectrometer drive linear in wavenumber (energy) and a flexible data acquisition system facilitates data analysis. The performance of the reflectometer is demonstrated using a set of specimens consisting of silicon-dioxide layers on silicon substrates for which the oxide thicknesses had been determined by ellipsometry. Excellent agreement is obtained between the thicknesses derived from the reflectivity spectra and those determined ellipsometrically.
[Contact: David A. McKeown, (301) 975-3095]

Kopanski, J.J., Albers, J., Carver, G.P., and Ehrstein, J.R., **Verification of the Relation Between Two-Probe and Four-Probe Resistances as Measured on Silicon Wafers**, Journal of the Electrochemical Society, Vol. 137, No. 12, pp. 3935-3941 (December 1990).

The predicted relation between the two-probe resistance (spreading resistance) and the four-probe resistance and the dependence of the four-probe resistance on the ratio of layer thickness to probe spacing have been experimentally verified. The verified behavior is predicted from calculations, based upon the solution of Laplace's equation, of the two- and four-probe resistance for arbitrary, vertical resistivity profiles. Arrays of lithographically fabricated, geometrically well-defined contacts on silicon wafers were utilized to make the necessary precise, reproducible resistance measurements. Additional measurements using point pressure contacts were also made. For verification of the two-probe/four-probe relation, silicon that was very uniform in lateral (across the surface) resistivity was used. This ensured that the variation in spreading resistance with probe spacing was large compared to any lateral variations in resistivity. The dependence of the four-probe resistance on the ratio of layer thickness to probe spacing was verified for both the in-line and square-probe configurations. Wafers that were junction isolated or back oxidized (to approximate an insulating back boundary) and p-type wafers with a back metallization (to approximate a conducting back boundary) were used. Layer thickness-to-probe-spacing ratios were varied from 0.003 to 20. Silicon wafers with resistivities between 0.0006 and 160 Ω-cm were used.
[Contact: Joseph J. Kopanski, (301) 975-2089]

Power Devices

Hefner, Jr., A.R., **Analytical Modeling of Device-Circuit Interactions for the Power Insulated Gate Bipolar Transistor (IGBT)**, IEEE Transactions on Industry Applications, Vol. 26, No. 6, pp. 995-1005 (November/December 1990). [Also published in the Conference Record of the IEEE Industry Applications Society Annual Meeting, Pittsburgh, Pennsylvania, October 2-7, 1988, pp. 606-613 (1988).]

The device-circuit interactions of the power Insulated Gate Bipolar Transistor (IGBT) for a series resistor-inductor load, both snubbered and unsnubbered, are simulated. An analytical model for the transient operation of the IGBT, previously developed, is used in conjunction with the load circuit state equations for simulations. The simulated results are compared with experimental results for all conditions. Devices with a variety of base lifetimes are studied.

For the fastest devices studied (base lifetime = 0.3 μs), the voltage overshoot of the series resistor-induction load circuit approaches the device voltage rating (500 V) for load inductances greater than 1 μH. For slower devices, though, the voltage overshoot is much less, and a larger inductance can therefore be switched without a snubber circuit (e.g., 80 μH for a 7-μs device). In this study, the simulations are used to determine the conditions for which the different devices can be switched safely without a snubber protection circuit.

Power Devices (cont'd.)

Simulations are also used to determine the required values and ratings for protection circuit components when protection circuits are necessary.
[Contact: Allen R. Hefner, (301) 975-2071]

Hefner, Jr., A.R., **An Improved Understanding for the Transient Operation of the Power Insulated Gate Bipolar Transistor (IGBT)**, IEEE Transactions on Power Electronics, Vol. 5, No. 4, pp. 459-468 (October 1990). [Also published in the Proceedings of the 20th Annual IEEE Power Electronics Specialists Conference, PESC '89, Milwaukee, Wisconsin, June 26-29, 1989, pp. 303-313 (1989).]

It is shown that a non-quasi-static analysis must be used to describe the transient current and voltage waveforms of the IGBT. The non-quasi-static analysis is necessary because the transports of electrons and holes are coupled for low-gain, high-level injection conditions, and because the quasi-neutral base width changes faster than the base transit speed for typical load circuit conditions. To verify that both of these non-quasi-static effects must be included, the results of quasi-static and non-quasi-static models are compared with measured current and voltage switching waveforms. The comparisons are performed for different load circuit conditions and for different device base lifetimes.
[Contact: Allen R. Hefner, Jr., (301) 975-2071]

Device Physics and Modeling

Gaitan, M., Mayergoyz, I.D., and Korman, C.E., **Investigation of the Threshold Voltage of MOSFETs with Position and Potential Dependent Interface Trap Distributions Using a Fixed Point Method**, IEEE Transactions on Electron Devices, Vol. 37, No. 4, pp. 1031-1038 (April 1990).

Simulation results are presented for a MOSFET with position- and energy- (potential) dependent interface trap distributions which may be typical for devices subjected to interface trap-producing processes such as hot-electron degradation. The interface trap distribution is modeled as a Gaussian peak in a given position along the channel, while the energy dependence is derived from C-V measurements from an MOS capacitor exposed to ionizing radiation. A new fixed-point technique is used to solve for arbitrary distributions of interface traps. A comparison of the convergence properties of the Newton and fixed-point methods is presented, and it is shown that for some important cases, the Newton technique fails to converge while the fixed-point technique converges with a geometric rate.
[Contact: Michael Gaitan, (301) 975-2070]

Insulators and Interfaces

Mattis, R.L., **SPARCOL: A Front End for the MAIN2 Program**, NISTIR 4426 (October 1990).

SPARCOL is an interactive program which serves as a front-end to the MAIN2 and MAIN2R computer programs. SPARCOL (pronounced "sparkle") stands for SPectroscopic ellipsometry And Reflectance for Characterization Of Layers. It consists of a FORTRAN-77 program and a VMS DCL command procedure. SPARCOL is used to prepare the X.DAT and X.INN files required by MAIN2 and MAIN2R, and to give these files user-defined names. Although these two files can be created using a text editor, the user may find it helpful to prepare them using SPARCOL.
[Contact: Richard L. Mattis, (301) 975-2235]

SIGNALS & SYSTEMS METROLOGY PROGRAM

FAST SIGNAL ACQUISITION, PROCESSING, AND TRANSMISSION

Waveform Metrology

Schoenwetter, H.K., **Recent Developments in Digital Oscilloscopes**, Conference

Waveform Metrology (cont'd.)

Record, IEEE Instrumentation and Measurement Technology Conference, Washington, D.C., April 27-29, 1989, pp. 154-155 (1989).

This paper reviews the latest developments in digital storage oscilloscopes (DSOs) reported in the open literature. DSOs are used to digitize and store waveforms which may be compared, analyzed, and manipulated. DSO capabilities usually include programmability, automatic waveform parameter measurement, the display of pre-trigger signal activity, and waveform averaging to reduce noise and ripple.
[Contact: Howard K. Schoenwetter, (301) 975-2412]

Souders, T.M., and Stenbakken, G.N., **A Comprehensive Approach for Modeling and Testing Analog and Mixed-Signal Devices**, Proceedings of the 1990 International Test Conference, Washington, D.C., September 10-12, 1990, pp. 169-176 (September 1990).

An approach is presented for optimizing the testing of analog and mixed-signal devices. The entire process is performed with algebraic operations on an appropriate model. The paper demonstrates how this is accomplished using simple calls with public-domain software. Examples of test results achieved using this approach are included.
[Contact: T. Michael Souders, (301) 975-2406]

DC & Low Frequency Metrology

Chang, Y.M., and Tillett, S.B., **Calibration Procedures for Inductance Standards Using a Commercial Impedance Meter as a Comparator**, NISTIR 4466 (November 1990).

Procedures are reported for calibrating customers' inductance standards using a commercial impedance meter to compare them with NIST inductance standards by a substitution method. These procedures are based on a six-month evaluation of the meter by measuring a group of six NIST inductance standards of different values at a frequency of 1 kHz. For each inductance standard, the results of measurements with the meter and the Maxwell-Wien bridge, which is used to realize the henry at NIST, are analyzed to determine the stabilities of the standards and the impedance meter as well as to estimate the random transfer uncertainty of the meter measurements. Values of inductance obtained using the Maxwell-Wien bridge are compared with corresponding values of inductance obtained with the meter by substituting customers' inductance standards with the six NIST standards over a period of six months. The statistical analyses used to assure that measurements made using such procedures are in control are described, as well as future plans to expand the substitution technique to include other values of inductance standards at various frequencies.
[Contact: Y. May Chang, (301) 975-4237]

Tong, G., Qian, Z., Xu, X., and Liu, L., **A Device for Audio-Frequency Power Measurement**, IEEE Transactions on Instrumentation and Measurement, Vol. 39, No. 3, pp. 540-544 (June 1990).

A new device for the measurement of audio-frequency power is introduced. This device can also be used to measure audio-frequency voltage and current. The full range of power factors are accommodated ($\cos \phi = 0$ to 1). Voltage and current measuring ranges are 15 to 600 V and 0.1 to 10 A, respectively. When $\cos \phi = 1$, the permissible error of the power measurement is from 50 to 150 ppm over the frequency range of 40 Hz to 10 kHz (including the line power frequency).
[Contact: Guang-Qui Tong, (301) 975-2414]

Cryoelectronic Metrology

Huber, M.E., and Cromar, M.W., **Excess Low-Frequency Flux Noise in dc SQUIDS Incorporating Nb/Al-Oxide/Nb Josephson Junctions** [original title: Initial Characterization of Excess...], Physica B, Vols. 165 & 166, pp. 77-78 (Elsevier

Cryoelectronic Metrology (cont'd.)

Science Publishers B.V., North-Holland, 1990).

We have fabricated thin-film dc SQUIDs (Superconducting QUantum Interference Devices) incorporating Nb/Al-Oxide/Nb tunnel junctions. The spectral density of the voltage noise, S_v, of stripline SQUIDs is characterized between 1 and 2000 Hz. In this frequency range, S_v is proportional to the square of the responsivity ($\partial V/\partial\Phi$) over a significant range of bias conditions with an unusual frequency dependence. In a 7 pH SQUID, the spectral density of the flux noise, S_Φ, at 1 Hz is less than 10^{-11} $\Phi_0 2$/Hz, where $\Phi_0 \equiv h/2e$. The observed noise does not appear to be environmental; also, it is independent of the value of the junction shunt resistance and whether the stripline material is a Pbln alloy or Nb. Subject to the constraint of a constant product of the junction area, critical current density, and SQUID self-inductance in the SQUIDs studied, S_Φ is inversely proportional to the junction area.
[Contact: Martin E. Huber, (303) 497-5423]

Kautz, R.L., and Martinis, J.M., **Noise-Affected I-V Curves in Small Hysteretic Josephson Junctions**, Physical Review B, Vol. 42, No. 16, pp. 9903-9937 (1 December 1990).

We investigate the noise-affected I-V curves of small-area Josephson junctions through experiment, simulation, and theory. In particular, we consider I-V curves in which two different states of finite voltage coexist at the same dc bias: a high-voltage state that corresponds to the usual quasi-particle branch and a low-voltage state that is characterized by thermally-activated phase diffusion. The observed hysteresis between the phase-diffusion and quasi-particle branches cannot be explained within the context of the simple resistively and capacitively shunted junction model but is explained by extended models in which the damping increases with frequency. Frequency-dependent damping is shown to produce a qualitative change in the attractors of the noise-free system which allows the two voltage states to be simultaneously stable. This picture is confirmed by Monte Carlo simulations which accurately reproduce the experimental I-V curves of two different samples over a wide range of temperatures. In addition, we develop analytic expressions for three key parameters of the I-V curve of junctions displaying hysteresis between the phase-diffusion and quasi-particle branches: the initial slope of the phase-diffusion branch, the bias level at which the junction switches from the phase-diffusion branch to the quasi-particle branch, and the bias levels at which it returns to the phase-diffusion branch.
[Contact: Richard L. Kautz, (303) 497-3391]

Antenna Metrology

Francis, M.H., and MacReynolds, K., **Evaluation of Dual-Port Circularly Polarized Probes for Planar Near-Field Measurements**, Proceedings of the Antenna Measurement Techniques Association Meeting and Symposium, Philadelphia, Pennsylvania, October 8-12, 1990, pp. 13-3 to 13-8 (1990).

Accurate near-field cross-polarization measurements on circularly polarized (CP) antennas at millimeter-wave frequencies require well-characterized probes with low axial ratios. We have recently obtained and calibrated dual-port CP horns for use as near-field probes at frequencies of 40 to 50 GHz. These horns have axial ratios which are 0.3 dB or less over a 10% frequency bandwidth. With these good axial ratios, the difference between vector and scalar probe correction is usually small. Additional advantages of the dual-port probes are the need for only a single alignment, more accurate knowledge of the relative phase between two ports of the same probe, and the ability to obtain both main and cross-polarized data during one scan.

Antenna Metrology (cont'd.)

The axial ratios of the dual-port CP probes are also better than those of single-port CP probes. In this paper we present some gain, axial ratio, and pattern measurements for these probes and show that they give accurate cross-polarization measurements.
[Contact: Michael H. Francis, (303) 497-5873]

Kremer, D.P., and Newell, A.C., **Alignment Fixture for Millimeter Waveguide** [original title: Millimeter Waveguide Alignment Fixture], IEEE Antennas & Propagation Magazine, Vol. 32, No. 3, pp. 45-48 (June 1990).

Millimeter-wave measurements require care in the connection and handling of the waveguide flanges and their contact surfaces. When properly connected, these flanges can provide many years of reliable and repeatable measurements. Improper use will limit the flange use to just a few connections and result in large measurement errors. These errors are especially acute in situations requiring repeated connecting and disconnecting of these flanges, such as in antenna or insertion-loss measurements. Several factors contribute to these errors, but the largest are improperly installed waveguide flanges, misalignment in flange connections, and excess strain on the waveguide or the flange. We have addressed these problems by developing a mechanical alignment fixture for the millimeter-band waveguide. Two fixtures were developed: one for small devices, such as standard-gain horns, which can be supported by the fixture and another for larger devices. These systems, along with a properly installed flange, can reduce the measurement uncertainty associated with the connection from greater than 1 decibel to a few hundredths of a decibel.
[Contact: Douglas P. Kremer, (303) 497-3732]

Muth, L.A., Newell, A.C., Lewis, R.L., Canales, S., and Kremer, D., **Experimental and Theoretical Probe Position Error Correction in Near-Field Antenna Measurements**, Proceedings of the Antenna Measurement Techniques Association Meeting and Symposium, Philadelphia, Pennsylvania, October 8-12, 1990, pp. 13-27 to 13-30 (1990).

Effects of probe-position errors in planar near-field measurements have been significantly reduced at the National Institute of Standards and Technology by accurate alignment of the scanner and an analytic error correction. Currently, the near-field range has probe-position errors greater than 0.01 cm only at the edges of the $4 \times 4\ m^2$ area, and less than that everywhere else. The position errors can be further removed by a theoretical procedure, which requires only the error-contaminated near field and the probe-position errors at the points of measurements. All necessary computations can be efficiently performed using FFTs. An explicit nth-order approximation to the ideal near field of the antenna can be shown to converge to the error-free near field. Computer simulations with periodic error functions show that this error-correction technique is highly successful even if the errors are as large as $0.2\ \lambda$, thereby making near-field measurements at frequencies well above 60 GHz more practicable.
[Contact: Lorant A. Muth, (303) 497-3603]

Wittmann, R.C., and Stubenrauch, C.F., **Spherical Near-Field Scanning: Experimental and Theoretical Studies**, NISTIR 3955 (July 1990).

This report documents the evaluation of spherical near-field scanning algorithms and computer code developed at the National Institute of Standards and Technology. The experimental work is primarily a comparison of probe-compensated spherical and planar near-field measurement results for a common test antenna. Theoretical work is largely supportive of the experimental effort, but some peripheral topics are developed: For example, (1) application of spherical near-field

Antenna Metrology (cont'd.)

measurements to the determination of incident fields in compact ranges, and (2) spherical-wave expansions for the fields of a uniformly excited circular aperture (to facilitate the creation of analytic test data).
[Contact: Ronald C. Wittmann, (303) 497-3326]

Microwave & Millimeter-Wave Metrology

Clague, F.R., **Power Measurement System for 1 mW at 1 GHz**, NIST Technical Note 1345 (November 1990).

An automated measurement system designed to measure power accurately at the level of 1 mW and at the frequency of 1 GHz is described. The system consists of commercial IEEE Std-488 bus-controlled instruments, a computer controller, and software. The results of a series of measurements are output to the computer CRT and, optionally, to a printer. The results are the mean of the measurement series and an estimate of the systematic and random uncertainty. The total estimated uncertainty for the average of six consecutive measurements of a nominal 1-mW, 1-GHz source is typically less than 1%. The system can measure any power from 0.1 to 10 mW at any microwave frequency by making appropriate changes to the software and, possibly, the hardware.
[Contact: Fred R. Clague, (303) 497-5778]

Daywitt, W.C., **First-Order Symmetric Modes for a Slightly Lossy Coaxial Transmission Line**, IEEE Transactions on Microwave Theory and Techniques, Vol. 38, No. 11, pp. 1644-1650 (November 1990).

A complete set of solutions for Maxwell's equations to first order in the normalized surface impedance z_s of the coaxial conductors is found. The resulting characteristic admittance and distributed line parameters are calculated; the distributed line resistance is significantly different from other calculations found in the literature.
[Contact: William C. Daywitt, (303) 497-3720]

Kremer, D.P., and Newell, A.C., **Alignment Fixture for Millimeter Waveguide** [original title: Millimeter Waveguide Alignment Fixture], IEEE Antennas & Propagation Magazine, Vol. 32, No. 3, pp. 45-48 (June 1990).

Millimeter-wave measurements require care in the connection and handling of the waveguide flanges and their contact surfaces. When properly connected, these flanges can provide many years of reliable and repeatable measurements. Improper use will limit the flange use to just a few connections and result in large measurement errors. These errors are especially acute in situations requiring repeated connecting and disconnecting of these flanges, such as in antenna or insertion-loss measurements. Several factors contribute to these errors, but the largest are improperly installed waveguide flanges, misalignment in flange connections, and excess strain on the waveguide or the flange. We have addressed these problems by developing a mechanical alignment fixture for the millimeter-band waveguide. Two fixtures were developed: one for small devices, such as standard-gain horns, which can be supported by the fixture and another for larger devices. These systems, along with a properly installed flange, can reduce the measurement uncertainty associated with the connection from greater than 1 decibel to a few hundredths of a decibel.
[Contact: Douglas P. Kremer, (303) 497-3732]

Marks, R.B, and Phillips, K.R., **Wafer-Level ANA Calibrations at NIST**, 34th ARFTG Conference Digest, Automatic RF Techniques Group, Ft. Lauderdale, Florida, November 30-December 1, 1989, pp. 11-25 (March 1990).

The National Institute of Standards and Technology (NIST) has begun a program supporting on-wafer scattering parameter

Microwave & Millimeter-Wave (cont'd.)

measurements. In contrast to many previous NIST endeavors, this program seeks to transfer methodology into industrial measurement laboratories. The subject of this paper is the development of calibration techniques and algorithms, rather than physical standards, for the measurement of on-wafer scattering parameters. In particular, we discuss a TRL-based method which uses transmission lines as standards but includes redundant measurements to improve calibration accuracy and bandwidth.
[Contact: Roger B. Marks, (303) 497-3037]

Reeve, G.R., Marks, R.B., and Blackburn, D.L., **MMIC Related Metrology at the National Institute of Standards and Technology**, IEEE Transactions on Instrumentation and Measurement, Vol. 39, No. 6, pp. 958-961 (December 1990). [Also published in the Conference Record, IEEE Instrumentation and Measurement Technology Conference, San Jose, California, February 13-15, 1990, pp. 196-199 (1990).]

This paper describes how the National Institute of Standards and Technology (NIST) has chosen to interact with the GaAs community and the Defense Advanced Research Projects Agency MIMIC initiative. The organization of a joint industry and government laboratory consortium for MMIC-related metrology research is described, along with some of the initial technical developments at NIST done in support of the consortium.
[Contact: Gerome R. Reeve, (303) 497-3557]

Williams, D.F., **On-Wafer Microwave Standards at NIST** [original title: Development of On-Wafer Microwave Standards at NIST], 34th ARFTG Conference Digest, Automatic RF Techniques Group Conference, Ft. Lauderdale, Florida, November 30-December 1, 1989, pp. 5-10, (March 1990).

The National Institute of Standards and Technology has begun a program to develop standards and calibration services for microwave wafer-level probing systems. The program objectives, organization, and plans are discussed.
[Contact: Dylan F. Williams, (303) 497-3138]

Optical Fiber Metrology

Tang, D., and Day, G.W., **Progress in the Development of Miniature Optical Fiber Current Sensors**, Conference Proceedings of the 1988 LEOS (IEEE Lasers and Electro-Optics Society) Annual Meeting, Santa Clara, California, November 2-4, 1988, p. 306 (1990).

Recent improvements in fiber annealing technology have allowed us to substantially reduce the size and increase the number of turns of fiber current-sensing coils. Coils as small as 7 mm in diameter have been successfully annealed. Coils with more than 100 turns and diameters of 1 or 3 cm are routinely produced. The linear birefringence of such coils is small enough that Faraday rotation is not measurably diminished. Increased loss as a result of annealing is minimal.
[Contact: Gordon W. Day, (303) 497-5204]

Young, M., **Standards for Optical Fiber Geometry Measurements**, (Technical Digest, Symposium on Optical Fiber Measurements, Boulder, Colorado, September 11-12, 1990), NIST Special Publication 792, pp. 129-133 (1990).

This publication is a preliminary report on NIST efforts to develop a standard of optical fiber diameter. We are developing a contact micrometer and a scanning confocal microscope in order to measure a diameter precisely within 0.1 μm or less. We have studied video microscopy and concluded that we can make measurements with enough precision, but that a small correction will have to be effected to get the required accuracy.
[Contact: Matt Young, (303) 497-3223]

Electro-Optic Metrology

Craig, R.M., and Phelan, Jr., R.J., **Low-Temperature, Electrically Calibrated SOS Bolometer for Power and Energy Measurements**, Proceedings of the Measurement Science Conference, Anaheim, California, February 8-9, 1990, pp. 3A-1 to 3A-11 (1990).

A system has been constructed to allow absolute, electrically calibrated radiometry of low-power (pW/$\sqrt{\text{Hz}}$) and low-energy (pJ) beams. The detector is based on an adaptation of silicon-on-sapphire (SOS) technology with an integral absorber/heater for real-time electrical substitution. Cooling is provided by a custom closed-cycle helium liquefaction system built inside an optical access Dewar. Convenient control and data analysis are provided by use of the GPIB bus and a computer. This arrangement will allow routine laser measurements and detector calibrations at 1% to 5% accuracy across the 0.4-μm to 15-μm wavelength range.
[Contact: Rex M. Craig, (303) 497-3359]

Day, G.W., **Recent Advances in Faraday Effect Sensors**, Springer Proceedings in Physics, Vol. 44, pp. 250-254 (Springer-Verlag Berlin, Heidelberg 1989). (Proceedings of the International Conference on Optical Fiber Sensors, Paris, France, September 18-20, 1989).

This paper reviews recent developments in the application of the Faraday effect to electric current and magnetic field sensing. Progress toward smaller, faster, more sensitive, and more stable devices is emphasized.
[Contact: Gordon W. Day, (303) 497-5204]

Hickernell, R.K., Veasey, D.L., and Aust, J.A., **Spatial Resolved Measurement of High Attenuation in Integrated Optical Polarizers**, (Technical Digest, Symposium on Optical Fiber Measurements, Boulder, Colorado, September 11-12, 1990), NIST Special Publication 792, p. 63 (September 1990).

We present a method for measuring high attenuation in integrated optic polarizers made by depositing absorbing overlayers on channel waveguides. Based on the photothermally induced deflection of a probe laser beam, the technique permits in-situ probing along the length of a single guide to measure attenuation on the order of 1000 dB/cm. High spatial resolution of loss variation is achieved. The measurement is not limited by their irreproducibility of input coupling and is minimally affected by depolarization in the coupling optics. We fabricated both TE- and TM-pass polarizers by depositing a layer of hydrogenated amorphous silicon on ion-exchanged glass waveguides and etching to the proper thickness. Loss as high as 760 dB/cm was measured for TM-polarized input at a wavelength of 632.8 nm. We also report the measurement of loss in metal-clad titanium-indiffused lithium niobate waveguide polarizers.
[Contact: Robert K. Hickernell, (303) 497-3455]

Patterson, R.L., Rose, A.H., Tang, D., and Day, G.W., **A Fiber-Optic Current Sensor for Aerospace Applications**, Proceedings of the Intersociety Energy Conversion Engineering Conference, Reno, Nevada, August 12-17, 1990, Vol. 1, pp. 500-504 (American Institute of Chemical Engineers, New York, 1990) and NASA Technical Memorandum 103152 (1990).

A robust, high-accuracy, broad-banded, alternating current sensor using fiber optics is being developed for space applications at power frequencies as high as 20 kHz. It can also be used in low- and high-voltage 60-Hz terrestrial power systems and in 400-Hz aircraft systems. It is intrinsically EMI immune and has the added benefit of excellent isolation. The sensor uses the Faraday effect in optical fiber and standard polarimetric measurement techniques to sense electrical current. The primary component of the sensor is a specially treated coil of single-mode optical fiber, through which the current-carrying conductor passes. Improved precision is

Electro-Optic Metrology (cont'd.)

accomplished by temperature compensation via signals from a novel fiber-optic temperature sensor embedded in the sensing head. This paper reports on the technology contained in the sensor and also relates the results of precision tests conducted at various temperatures within the wide operating range. It also shows the results of early EMI tests.
[Contact: Allen H. Rose, (303) 497-5599]

Rose, A.H., Deeter, M.N., Tang, D., and Day, G.W., **Performance and Limitations of Faraday Effect Sensors**, Extended Abstracts, Electrochemical Society Fall Meeting, Seattle, Washington, October 14-19, 1990, Vol. 90-2, p. 1093 (1990).

Sensors that use the Faraday effect to measure electric current and magnetic fields are becoming more prevalent because of their sensitivity, bandwidth, stability, and ability to operate in the presence of high voltage or EMI. They are now routinely used to measure large current pulses and are becoming available to the power industry. They can measure currents from milliamperes to mega-amperes and magnetic fields in the nanotesla range. Their size has been reduced and stability increased. Their speed is limited by material effects or transit time, but often extends to hundreds of megahertz.
[Contact: Allen Rose, (303) 497-5599]

Schlager, J.B., Hale, P.D., and Franzen, D.L., **Subpicosecond Pulse Compression and Raman Generation Using a Mode-Locked Erbium-Doped Fiber Laser-Amplifier**, IEEE Photonics Technology Letters, Vol. 2, No. 8, pp. 562-564 (August 1990).

Pulses of 20-ps duration from a 1536-nm erbium-doped fiber laser mode-locked at 10 MHz are soliton-compressed in a 1-km fiber to 1.5 ps. The pulses are then amplified in an erbium-doped fiber amplifier and compressed in a second fiber to less than 300 fs. Pulses give rise to stimulated Raman scattering in fibers; the direct output from the erbium fiber laser-amplifier has sufficient peak power to pump fiber Raman lasers.
[Contact: John B. Schlager, (303) 497-3346]

Electromagnetic Properties

Baker-Jarvis, J.R., **Transmission/Reflection and Short-Circuit Line Permittivity Measurement Methods**, NIST Technical Note 1341 (July 1990).

The transmission/reflection and short-circuit line methods for measuring complex permittivity are examined. Equations for permittivity are developed from first principles. New robust algorithms that eliminate the ill-behaved nature of the commonly used transmission/reflection method at frequencies corresponding to integer multiples of one-half wavelength in the sample are presented. These allow measurements to be made on samples of any length. An uncertainty analysis is presented which yields estimates of the errors incurred due to the uncertainty in scattering parameters, length measurement, and reference plane position. The equations derived here indicate that the minimum uncertainty for transmission/reflection measurements of nonmagnetic materials occurs at integer multiples of one-half wavelength in the material. In addition, new equations for determining complex permittivity independent of reference plane position and sample length are derived. New equations are derived for permittivity determination using the short-circuit line allow positioning the sample arbitrarily in the sample holder.
[Contact: James R. Baker-Jarvis, (303) 497-5621]

Baker-Jarvis, J., Vanzura, E.J., and Kissick, W.A., **Improved Technique for Determining Complex Permittivity with the Transmission/Reflection Method**, IEEE Transactions on Microwave Theory and Techniques, Vol. 38, No. 8, pp. 1096-1103 (August 1990).

Electromagnetic Properties (cont'd.)

The transmission/reflection method for complex permittivity and permeability determination is studied. The special case of permittivity measurement is examined in detail. New robust algorithms for permittivity determination that eliminate the ill-behaved nature of the commonly used procedures at frequencies corresponding to integer multiples of one-half wavelength in the sample are presented. An error analysis is presented which yields estimates for the errors incurred due to the uncertainty in scattering parameters, length measurement, and reference plane position. In addition, new equations are derived for determining complex permittivity independent of reference plane position and sample length.
[Contact: James R. Baker-Jarvis, (303) 497-5621]

Other Fast Signal Topics

Capobianco, T.E., Splett, J.D., and Iyer, H.K., **Eddy Current Probe Sensitivity as a Function of Coil Construction Parameters** [original title: Relationship of Coil Construction to Eddy Current Probe Sensitivity for Single-Coil Ferrite Core Probes], Research in Nondestructive Evaluation, Vol. 2, pp. 169-186 (Springer-Verlag New York Inc., 1990).

We report the results of the first phase of a study designed to quantify the relationship between eddy current coil construction and the performance of these coils used in nondestructive evaluation inspections. The ferrite core coils wound for this study are small but typical of the sizes commonly used in commercially manufactured eddy current probes. Coil diameters range from 1 mm to 7 mm with lengths of 0.5 mm to 4 mm. Seven parameters were studied and included ferrite diameter, ferrite permeability, coil aspect ratio, number of turns, distance of the windings from the inspection end of the ferrite, wire gauge, and length of the ferrite beyond the end of the windings. Additionally, the coil set was designed to provide some indication of the repeatability of identical constructions, what we have called winding inhomogeneity. The coils were incorporated into surface probes for scanning defects in flat plate specimens. The measure of sensitivity was the change of probe impedance (ΔZ) as the probe was scanned from an unflawed area to the flawed area of the test specimen. Measurements were also made of the component of ΔZ perpendicular to the liftoff vector ($\Delta Z(\perp)$).
[Contact: Thomas E. Capobianco, (303) 497-3141]

Hill, D.A., **Quasi-Static Analysis of a Two-Wire Transmission Line Located at an Interface**, Radio Science, Vol. 25, No. 4, pp. 435-440 (July-August 1990).

Simple quasi-static expressions have been derived for the propagation constant, the characteristic impedance, and the field distribution of a two-wire transmission line located at the air-earth interface. Both the complex permittivity and the complex permeability of the earth are allowed to differ from the free-space values, and a numerical solution of the mode equation shows that quasi-static approximation is valid when the wire separation is much less than a free-space wavelength. The quasi-static approximation can be used to determine both the complex permittivity and the complex permeability of the earth from measurements of the propagation constant and the characteristic impedance of the transmission line.
[Contact: David A. Hill, (303) 497-3472]

ELECTRICAL SYSTEMS

Power Systems Metrology

Field, B.F., **National Institute of Standards and Technology (NIST) Informational Poster on Power Quality**, NIST Special Publication SP768A (October 1990).

Power Systems Metrology (cont'd.)

A poster prepared by the NIST Power Quality Committee informs users of sensitive equipment about problems with and solutions to protecting their equipment from power disturbances. The poster contains: 1) Answers to seven common questions about power quality that should help you pinpoint problems and solutions related to power disturbances; 2) a chart describing the types of power disturbances, the equipment affected, and a brief summary of the types of protection equipment that is effective against the disturbance; and 3) a glossary of common power terms.
[Contact: Bruce F. Field, (301) 975-4230]

Herron, J.T., and Van Brunt, R.J., **Zonal Model for Corona Discharge-Induced Oxidation of SF_6 in $SF_6/O_2/H_2O$ Gas Mixtures**, Symposium Proceedings of the Ninth International Symposium on Plasma Chemistry, Vol. 1, Pugnochiuso, Italy, September 4-8, 1989, pp. 257-262.

A chemical kinetics model for oxidation of SF_6 in negative glow-type corona discharges is proposed. The model is applied to highly localized dc, point-plane negative corona discharges in SF_6/O_2 mixtures containing water vapor, and resulting predictions for oxidation by-product yields are compared with recent data on rates for SOF_2, SOF_4, SO_2F_2, SO_2, and S_2F_{10} formation from corona discharges in SF_6 and SF_6/O_2 mixtures.
[Contact: Richard J. Van Brunt, (301) 975-2425]

Kulkarni, S.V., Van Brunt, R.J., and Lakdawala, V., **Transition from Trichel-Pulse Corona to Dielectric Barrier Discharge**, 1990 Annual Report, Conference on Electrical Insulation and Dielectric Phenomena, Pocono Manor, Pennsylvania, October 29-31, 1990, pp. 267-274 (IEEE, Piscataway, New Jersey, 1990).

Experiments are conducted to investigate the conditions under which the transition from negative corona to dielectric barrier-controlled discharge occurs. A negative point-plane electrode (covered with polytetrafluoroethylene dielectric) geometry is studied using a newly developed partial discharge detection technique. At a critical gap distance, an abrupt transition from a rapid pulsating behavior to a widely distributed random pulse behavior is observed. The critical distance increases with increasing diameter of the solid dielectric and decreases with increase in applied voltage. The influence of dielectric surface charging on the Trichel pulse behavior is manifested by the measured pulse-height and time-separation distributions. As the influence of dielectric charging increases, the pulse separation distribution begins to broaden significantly, and the corresponding pulse-height distribution becomes narrower. The previously observed strong correlation between pulse height and time separation from the previous pulse is also persistent under all conditions of experimentation. The expected behavior can be attributed to the perturbation of applied field at the tip of the cathode due to surface charging of the solid dielectric. Once the Trichel-pulse behavior ceases, the rate of discharge pulsation becomes controlled by the rate of the surface charge dissipation on the dielectric.
[Contact: Richard J. Van Brunt, (301) 975-2425]

Misakian, M., and Kaune, W.T., **Optimum Experimental Design for In Vitro Studies Using ELF Magnetic Fields**, Bioelectromagnetics (Brief Communications), Vol. 11, pp. 251-255 (1990).

An experimental arrangement is described that maximizes the dosimetric information that can be obtained during in vitro studies with extremely-low-frequency (ELF) magnetic fields. The arrangement enables researchers to distinguish between a purely magnetic-field effect and one that also involves the electric fields and currents induced by the magnetic field.

Power Systems Metrology (cont'd.)

[Contact: Martin Misakian, (301) 975-2426]

Olthoff, J.K., Van Brunt, R.J., Wang, Y., Doverspike, L.D., and Champion, R.L., **Collisional Electron-Detachment and Ion-Conversion Processes in SF_6**, Nonequilibrium Effects in Ion and Electron Transport, pp. 229-244 (Plenum Press, New York, 1990). (Proceedings of the Sixth International Swarm Seminar, Glen Cove, New York, August 2-5, 1989.)

In this report we summarize results from the first direct measurements of absolute cross sections for electron-detachment and ion-conversion processes involving interactions of SF_6, SF_5, and F^- with SF_6. These cross sections are used to calculate electron-detachment and ion-conversion reaction coefficients as functions of electric field-to-gas density ratios for various reactions. We then discuss the relevance of these results to the interpretation of data from uniform-field drift-tube measurements and measurements of electrical-discharge initiation processes.
[Contact: James K. Olthoff, (301) 975-2431]

Van Brunt, R.J., **Preface to book entitled, Nonequilibrium Effects in Ion and Electron Transport.** (Plenum Press, New York, 1990). (Proceedings of the Sixth International Swarm Seminar, August 2-5, 1989, Glen Cove, New York, 1989).

This volume presents the contributions of the participants in the Sixth International Swarm Seminar, held August 2-5, 1989 at the Webb Institute in Glen Cove, New York. The Swarm Seminars are traditionally held as relatively small satellite conferences of the International Conference on the Physics of Electronic and Atomic Collisions (ICPEAC) which occurs every two years. The 1989 ICPEAC took place in New York City prior to the Swarm Seminar. The focus of the Swarm Seminars has been on basic research relevant to understanding the transport of charged particles, mainly electrons and ions, in weakly ionized gases. This is a field that tends to bridge the gap between studies of fundamental binary atomic and molecular collision processes and studies of electrical breakdown or discharge phenomena in gases. Topics included in the 1989 seminar ranged the gamut from direct determinations of charged-particle collision cross sections to use of cross sections and swarm parameters to model the behavior of electrical gas discharges. Although the range of subjects covered was in many respects similar to that of previous seminars, there was an emphasis on certain selected themes that tended to give this seminar a distinctly different flavor. There was, for example, considerable discussion on the meaning of "equilibrium" and the conditions under which nonequilibrium effects become important in the transport of electrons through a gas. It is evident from work presented here that under certain gas discharge or plasma conditions nonequilibrium effects can be significant; therefore, application of swarm or transport parameters determined under equilibrium conditions to the modeling of such discharges or plasmas must be considered questionable. The discussions at this seminar, as represented by several of the invited papers, has helped to remove some of the confusion about the applicability of equilibrium assumptions and provided guidance for attempts to deal with nonequilibrium situations. The seminar also included discussions about the meaning and determination of higher order "diffusion coefficients" in electron transport and limitations on the range of validity of "modified effective range theory." Interesting new developments on both topics were presented. Several of the invited papers were concerned with the peculiarities of ion transport in sulfur hexafluoride, a gas that has become increasingly important because of use in plasma processing of electronic materials and as a gaseous dielectric in electrical power systems. An attempt was made for the first time to include papers

Power Systems Metrology (cont'd.)

on electron transport in dense media, namely high-pressure gases and liquids.

The 1989 Swarm Seminar was sponsored jointly by the Polytechnic University of New York, the National Institute of Standards and Technology, and the Naval Surface Warfare Center. Financial support for the seminar was also provided by the U.S. Air Force Office of Scientific Research.
[Contact: Richard J. Van Brunt, (301) 975-2425]

Van Brunt, R.J., and Kulkarni, S.V., **Stochastic Properties of Trichel-Pulse Corona: A Non-Markovian Random Point Process**, Physical Review A, Vol. 42, No. 8, pp. 4908-4932 (15 October 1990).

The stochastic properties of a negative, point-to-plane, Trichel-pulse corona discharge are completely characterized in terms of a set of measured conditional and unconditional discharge pulse-amplitude and pulse-time-separation distributions. The Trichel-pulse phenomenon is shown to be a clear example of a non-Markovian, marked random point process in which memory effects play an important role. Strong correlations are shown to exist among the amplitudes and time separations of successive discharge pulses that indicate how initiation and growth of a discharge pulse are affected by the presence of residual ion space charge and metastable species from previous pulses. The analysis required to assess consistency among the various measured probability distributions is discussed and used to interpret observed variations in distribution profiles. Because of the observed dependence of discharge pulse amplitude on both the amplitude of and time separation from the previous pulse, memory can propagate indefinitely back in time. The experimental limitations to verifying the extent of memory propagation are analyzed.
[Contact: Richard Van Brunt, (301) 975-2425]

Superconductors

Goodrich, L.F., and Bray, S.L., **Integrity Tests for High-T_c and Conventional Critical-Current Measurement Systems**, Advances in Cryogenic Engineering (Materials), Vol. 36, Part A, pp. 43-50 (Plenum Press, New York, 1990). (Proceedings of the Eighth International Cryogenic Materials Conference, Los Angeles, California, July 24-28, 1989.)

Critical-current measurement systems must be extremely sensitive to the small differential voltage that is present across the test specimen as it changes from the zero-resistance state to the flux-flow resistance state. Consequently, these measurement systems are also sensitive to interfering voltages. Such voltages can be caused by ground loops and by common-mode signals. Specific methods for testing the sensitivity of critical-current measurement systems and for detecting the presence of interfering voltages are discussed. These include a simple procedure that simulates the zero-resistance state and the use of an electronic circuit that simulates the flux-flow resistance state.
[Contact: Loren F. Goodrich, (303) 497-3143]

Goodrich, L.F., Bray, S.L., and Stauffer, T.C., **Thermal Contraction of Fiberglass-Epoxy Sample Holders Used for Nb_3Sn Critical-Current Measurements**, Advances in Cryogenic Engineering (Materials), Vol. 36, Part A, pp. 117-124 (Plenum Press, New York, 1990). (Proceedings of the Eighth International Cryogenic Materials Conference, Los Angeles, California, July 24-28, 1989.)

It is typical for Nb_3Sn-Cu superconductor specimens to be wound into coils on tubular specimen holders for critical-current measurements. If the thermal contraction of the holder is different than that of the specimen, axial strain may be applied to the specimen upon cooling from room to liquid-helium temperature. This strain can affect the measured critical current. The thermal

Superconductors (cont'd.)

contraction was measured for three different Nb_3Sn-Cu superconductors. Also, the thermal contraction was measured for several different specimen holders, all of which were made from fiberglass-epoxy composites. The specimen holder measurements were made using an electrical-resistance strain-gage technique, and they were confirmed by direct mechanical measurements. The tubes varied in diameter, wall thickness, and fabrication technique. Some of the tubes were made directly from tube stock, and others were machined from plate stock. The results of these measurements show that the thermal contraction of tube stock is strongly dependent on the ratio of its wall thickness to its radius, while the contraction of tubes machined from plate stock is relatively independent of these dimensions. Critical-current measurements of Nb_3Sn-Cu specimens mounted on these various holders show that the presence of differential thermal contraction between the specimen and its holder can significantly affect the measured critical current.
[Contact: Loren F. Goodrich, (303) 497-3143]

Goodrich, L.F., and Srivastava, A.N., **Software Techniques to Improve Data Reliability in Superconductor and Low-Resistance Measurements**, Journal of Research of the National Institute of Standards and Technology, Vol. 95, No. 5, pp. 575-589 (September-October 1990).

Software techniques have been developed to take low-amplitude data in various patterns, assign a figure of merit to a set of data readings, edit data for erroneous readings (or other experimental variations), and to alert the experimenter if the detected errors are beyond the scope of the software. Erroneous voltage readings from digital voltmeters, intermittent electrical connections, and an array of similar variations in data have been detected through the use of a data editor. The fixed-limit data editor removes readings that are inconsistent with the distribution of the majority of the data readings. The frequency of erroneous readings from a particular digital voltmeter ranges from 1 error per 100,000 readings to 1 error per 100 readings. The magnitude of the error can be as large as 3% of full scale with a zero volt input to the voltmeter. It may be necessary to have multiple meters measuring voltages in the same circuit in order to generate these erroneous readings. A systematic study was performed on the occurrence of the internally-generated erroneous voltmeter readings, and it was determined that the amount that a reading was in error scaled with one of a few parameters. The software techniques described here have been used in a variety of measurements, such as resistance-versus-temperature measurements made on cryoconductors or superconductors, and voltage-versus-current measurements made on superconductors to determine the critical current.
[Contact: Loren F. Goodrich, (303) 497-3143]

Moreland, J., Chiang, C.K., and Swartzendruber, L.J., **Break Junction Tunneling Spectroscopy of Single-Crystal Bismuth Based High Temperature Superconductors**, Advances in Cryogenic Engineering (Materials), Vol. 36, Part A, pp. 619-625 (Plenum Press, New York, 1990). (Proceedings of the Eighth International Cryogenic Materials Conference, Los Angeles, California, July 24-28, 1989.)

We have measured the tunneling spectra of some high-temperature superconducting crystal break junctions at 4 K. The samples were thin plates of $Bi_2SrCa_2Cu_2O_8$ compound. The tunneling spectra (conductance versus voltage) were not typical of Bardeen-Cooper-Schrieffer superconductor tunneling electrodes. The spectra of higher-resistance break-junction settings ($R > 1$ MΩ) show a tunneling gap on top of a linearly increasing conductance background signal. "Harmonic" dip features in the spectra of lower resistance break-junction settings ($R < 1$ MΩ) indicated tunneling between multiple particles in the vicinity

Superconductors (cont'd.)

of the primary (highest resistance) contact of the junction. The dips occurred at about the same current but shifted in voltage when the resistance of the break junction was continuously adjusted to new settings.
[Contact: John Moreland, (303) 497-3641]

Moreland, J., Li, Y.K., Ekin, J.W., and Goodrich, L.F., **Possible "Proximity Matrix" Route to High Current Conductors**, Advances in Cryogenic Engineering (Materials), Vol. 36, Part A, pp. 413-421 (Plenum Press, New York, 1990). (Proceedings of the Eighth International Cryogenic Materials Conference, Los Angeles, California, July 24-28, 1989.)

The conductance of point contacts between the surfaces of superconducting $YBa_2Cu_3O_{7-\delta}$ thin films is very low. This is probably due to a native insulating surface layer. The conductance of these point contacts can be markedly increased by vacuum depositing and subsequently annealing a thin layer of Ag into the surface of the films. We believe that what might be described as a normal-metal superconducting "proximity matrix" is formed at the surface of the Ag-coated $YBa_2Cu_3O_{7-\delta}$ films. In this paper, we describe our efforts to adapt this method to $YBa_2Cu_3O_{7-\delta}$ powder. In particular, we have developed a procedure for vacuum deposition of very thin Ag coatings onto the surface of $YBa_2Cu_3O_x$ powder grains. The Ag-treated powder is then pelletized, sintered, annealed, and cut to form small conducting bars for electrical transport testing.
[Contact: John Moreland, (303) 497-3641]

Peterson, R.L., and Ekin, J.W., **Critical-Current Diffraction Patterns of Grain-Boundary Josephson Weak Links** [original title: Critical-Current Diffraction Patterns in Superconductor Weak-Links], Physical Review B, Vol. 42, No. 13, pp. 8014-8018 (1 November 1990).

We discuss the characteristics of the critical current as a function of magnetic field in grain-boundary Josephson barriers. Diffraction patterns occur not just for SIS junctions but for all types of Josephson links, including SNS junctions, which may be present at grain boundaries in high-T_c superconductors. We discuss the generality of the Airy diffraction pattern, which is expected to characterize most grain-boundary barriers in bulk material more accurately than the Fraunhofer pattern. The transport critical-current density in many bulk, granular high-T_c superconductors has a power-law dependence on very low magnetic fields, characteristic of averaged diffraction patterns, and cannot be fitted by an exponential magnetic-field dependence, which may result from the material properties of the barriers.
[Contact: Robert L. Peterson, (303) 497-3750]

Magnetic Materials & Measurements

Deeter, M.N., Rose, A.H., and Day, G.W., **High Speed Magnetic Field Sensors Based on Iron Garnets**, Proceedings of the AFCEA Department of Defense Fiber Optics Conference '90, McLean, Virginia, March 20-23, 1990, pp. 423-424 (1990).

We characterize magnetic field sensors based on the Faraday effect in ferrimagnetic iron garnets in terms of their sensitivity and frequency response. Signal-to-noise measurements at 80 Hz on a sample of yttrium iron garnet yield noise equivalent magnetic fields of 10 nT/Hz. Frequency response measurements exhibit virtually flat response to approximately 700 MHz.
[Contact: Merritt N. Deeter, (303) 497-5400]

Thompson, C.A., and Fickett, F.R., **Magnetoresistance of Multifilament Al/Al-Alloy Conductors**, Advances in Cryogenic Engineering (Materials), Vol. 36, Part A, pp. 663-669 (Plenum Press, New York, 1990). (Proceedings of the Eighth International Cryogenic Materials Conference, Los Angeles, California, July

Magnetic Matls. & Meas. (cont'd.)

24-28, 1989.)

Previously, we have shown that composite monofilament conductors consisting of very pure aluminum confined in an Al-Fe-Ce alloy sheath show an anomalously high magnetoresistance compared to pure aluminum. Some monofilament conductors showed values of $\Delta R/R$ in excess of 50 at 4 K in fields of 10 T, whereas pure aluminum values are usually an order of magnitude smaller. Concerns that similar anomalous behavior might occur in multifilament wires of the same materials prompted this study. Multifilamentary conductors with pure aluminum filaments contained in an Al-Fe-Ce matrix have been investigated.
[Contact: Curtis A. Thompson, (303) 497-5206]

ELECTROMAGNETIC INTERFERENCE

Radiated Electromagnetic Interference

Adams, J.W., Wu, D., and Budlong, A., **Measurement of Electric Field Strength Near Higher Powered Personal Transceivers**, NISTIR 90-3938 (May 1990). [Also to be published as a National Institute of Justice Report, Technology Assessment Program.]

Electric field strengths were measured at a number of points near 5-W personal transceivers. The points were located on cylinders of revolution around the antenna with radii of 7, 9.5, 12, 14.5, 17, and in some cases, 27, 37, and 47 cm. At shorter distances, these measured values exceeded the exposure limits suggested in ANSI Guide C95.1-1982.
[Contact: John W. Adams, (303) 497-3328]

Crawford, M.L., Ma, M.T., Ladbury, J.M., and Riddle, B.F., **Measurement and Evaluation of a TEM/Reverberating Chamber**, NIST Technical Note 1342 (July 1990).

This report summarizes the measurement and evaluation of a 1/10 scaled model TEM/reverberating chamber developed as a single, integrated facility for testing radiated electromagnetic compatibility/vulnerability (EMC/V) of large systems over the frequency range, 10 kHz to 40 GHz. The facility consists of a large shielded enclosure configured as a transverse electromagnetic (TEM), transmission line-driven, reverberating chamber. TEM mode test fields are generated at frequencies below multimode cutoff, and mode-stirred test fields are generated at frequencies above multimode cutoff. Both the chamber's cw and pulsed rf characteristics are measured and analyzed. The report also discusses the basis for such a development including the theoretical concepts, the advantages and limitations, the experimental approach for evaluating the operational parameters, and the procedures for using the chamber to perform EMC/V measurements. A full-scale chamber that will provide a test volume of 8 m x 16 m x 30 m is proposed. Some projections of the full-scale chamber's estimated characteristics and operational parameters are also given.
[Contact: Myron L. Crawford, (303) 497-5497]

Hill, D.A., **Near-Field and Far-Field Excitation of a Long Conductor in a Lossy Medium**, NISTIR 3954 (September 1990).

Excitation of currents on an infinitely long conductor is analyzed for horizontal electric dipole or line sources and for a plane-wave, far-field source. Any of these sources can excite strong currents which produce strong scattered fields for detection. Numerical results for these sources indicate that long conductors produce a strong anomaly over a broad frequency range. The conductor can be either insulated or bare to model ungrounded or grounded conductors.
[Contact: David A. Hill, (303) 497-3472]

Hill, D.A., **Quasi-Static Analysis of a Two-Wire Transmission Line Located at an Interface**, Radio Science, Vol. 25, No. 4, pp. 435-440 (July-August 1990).

Radiated EMI (cont'd.)

Simple quasi-static expressions have been derived for the propagation constant, the characteristic impedance, and the field distribution of a two-wire transmission line located at the air-earth interface. Both the complex permittivity and the complex permeability of the earth are allowed to differ from the free-space values, and a numerical solution of the mode equation shows that quasi-static approximation is valid when the wire separation is much less than a free-space wavelength. The quasi-static approximation can be used to determine both the complex permittivity and the complex permeability of the earth from measurements of the propagation constant and the characteristic impedance of the transmission line.
[Contact: David A. Hill, (303) 497-3472]

Kanda, M., **A Microstrip Patch Antenna as a Standard Transmitting and Receiving Antenna**, Symposium Digest, 1989 International Symposium on Electromagnetic Compatibility, Nagoya, Japan, September 8-10, 1989, pp. 460-462. [Also published in IEEE Transactions on Electromagnetic Compatibility, Vol. 32, No. 1, pp. 5-8 (February 1990) and to be published in the Digest of the International Symposium on Electromagnetic Metrology (ISEM '89), Beijing, China, August 16-19, 1989.]

This paper discusses the possibility of employing a microstrip patch antenna as a standard transmitting and receiving antenna. The intrinsic properties of the substrate used for the antenna are determined by careful impedance measurements. The experimental results indicate that the transmitting characteristics of a microstrip antenna can be theoretically determined from its geometry. The microstrip patch antenna discussed here is physically small (20-cm^2 for 450 MHz) and can be well matched to a power delivery system (standing-wave ratio = 1.17).
[Contact: Motohisa Kanda, (303) 497-5320]

Randa, J.P., **Theoretical Considerations for a Thermo-Optic Microwave Electric-Field-Strength Probe**, Journal of Microwave Power and Electromagnetic Energy, Vol. 25, No. 3, pp. 133-140 (1990).

The theoretical background for the design of a microwave electric-field probe is presented. The design uses a fiber-optic thermometer to measure the temperature rise of a resistive sphere or spherical shell in an electromagnetic field. Design parameters are chosen to optimize sensitivity and frequency response for the 1- to 10-GHz range. These parameters also result in good frequency response well into the millimeter-wave range. Advantages of the design are that it is small, nonperturbing, and can be used in high electromagnetic fields.
[Contact: James P. Randa, (303) 497-3150]

ADDITIONAL INFORMATION

Lists of Publications

Lyons, R.M., and Gibson, K.A., **A Bibliography of the NIST Electromagnetic Fields Division Publications**, NISTIR 3945 (August 1990).

This bibliography lists publications by the staff of the National Institute of Standards and Technology's Electromagnetic Fields Division for the period from January 1970 through August 1989. Selected earlier publications from the Division's predecessor organizations are included.
[Contact: Kathryn A. Gibson, (303) 497-3132]

DeWeese, M.E., **Metrology for Electromagnetic Technology: A Bibliography of NIST Publications**, NISTIR 3946 (August 1990).

This bibliography lists the publications of the personnel of the Electromagnetic Technology Division of NIST in the period from January 1970 through publication of this report. A few earlier references that are directly related to the present work of the Division are included.

Additional Information (cont'd.)

[Contact: Sarabeth Moynihan, (303) 497-3678]

Palla, J.C., and Meiselman, B., **Electrical and Electronic Metrology: A Bibliography of NIST Electricity Division's Publications, NIST List of Publications** 94 (January 1990).

This bibliography covers publications of the Electricity Division, Center for Electronics and Electrical Engineering, NIST, and of its predecessor sections for the period January 1968 to December 1989. A brief description of the Division's technical program is given in the introduction.
[Contact: Jenny C. Palla, (301) 975-2220]

Walters, E.J., **Semiconductor Measurement Technology, NIST List of Publications 72** [a bibliography of NIST publications concerning semiconductor measurement technology for the years 1962-1989] (March 1990). Also LP72 Supplement (May 1991).

This bibliography contains reports of work performed at the National Institute of Standards and Technology in the field of Semiconductor Measurement Technology in the period from 1962 through December 1989. An index by topic area and a list of authors are provided. LP72 Supplement lists publications for the calendar year 1990 and includes other NIST publications in the field of microelectronics.
[Contact: E. Jane Walters, (301) 975-2050]

NEW CALIBRATION SERVICES OFFERED

The explosive growth of optical fiber use in the communications industry has resulted in a demand for calibration services. NIST's Boulder, Colorado, laboratory now offers **measurements of optical laser power and energy at wavelengths and power levels of interest to fiber optic producers and users.** Measurements are based on a standard reference instrument called the C-series calorimeter. An electrically calibrated pyroelectric radiometer (ECPR) is calibrated against the calorimeter and is then used to calibrate optical power meters at wavelengths of 850, 1300, and 1550 nm. To improve calibration capabilities, NIST is preparing test measurement systems for detector linearity, detector uniformity, and detector spectral responsivity. These systems should be available in 6 months. For a paper outlining NIST's optical power measurement capabilities, contact Fred McGehan, Div. 360, NIST, 325 Broadway, Boulder, Colorado 80303. For more information on calibration services, contact Thomas R. Scott, Div. 724, same address, or phone (303) 497-3651.

NEW NIST RESEARCH MATERIAL

NIST has announced the availability of **Research Material 8458**, a well-characterized artificial flaw used as an artifact standard in eddy current nondestructive evaluation (NDE). The new Research Material (RM) is the outcome of work carried out by the Division to address the need for calibration standards for eddy-current NDE, for example as used to detect fatigue cracks in aircraft structures. The RM flaw is produced in an annealed aluminum alloy block by first indenting the block and then compressively deforming the resulting notch until it is tightly closed. The next operation is to restore a flat finish to the block face, after which the block is heat treated to the original temper. The controlled flaw has been named the "CDF notch," after its inventors (listed on patent application) Thomas E. Capobianco (Electromagnetic Technology Division), William P. Dube (Division 583), and Ken Fizer (Naval Aviation Depot, NAS Norfolk, Virginia).

In the past, the challenge has been to manufacture artificial flaws that closely simulate the mechanical properties of fatigue cracks. Currently used artifacts include electrical-discharge-machined and saw-cut notches, both of which are

Additional Information (cont'd.)

relatively poor representations of fatigue cracks as their widths are too great. The Division-developed method provides notches that can be made controllably in a variety of geometries, have know dimensions, with widths that are narrow enough to provide an acceptable representation of fatigue cracks.

An NIST Research Material is not certified by NIST, but meets the International Standards Organization definition of "a material or substance one or more properties of which are sufficiently well established to be used in the calibration of an apparatus, the assessment of a measurement method, or for assigning values to materials." The documentation issued with RM 8458 is a "Report of Investigation." Contact: technical information -- Fred Fickett, (303) 497-3785; order information -- Office of Standard Reference Materials, (301) 975-6776.

EMERGING TECHNOLOGIES IN ELECTRONICS...AND THEIR MEASUREMENT NEEDS, SECOND EDITION

This report assesses the principal measurement needs that must be met to improve U.S. competitiveness in emerging technologies within several fields of electronics; semiconductors, superconductors, magnetics, optical fiber communications, optical fiber sensors, lasers, microwaves, video, and electromagnetic compatibility. The report seeks feedback from industry and Government agencies on the assessment. The feedback will guide the development of NIST programs that provide U.S. industry with new documented measurement methods, new national reference standards to assure the accuracy of those measurement methods, and new reference data for electronic materials. Copies may be obtained by ordering Report No. PB90-188087/AS ($23.00 hard copy, $11.00 microfiche) from the National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22161, (703) 487-4650.

JAN. 1, 1990 CHANGES IN THE U.S. ELECTRICAL UNITS

Effective January 1, 1990, the U.S. as-maintained (i.e., "practical") units of voltage and resistance were increased by 9.264 ppm and 1.69 ppm, respectively. The increases in the U.S. legal units of current and of electrical power will be about 7.57 ppm and 16.84 ppm, respectively. These changes result from efforts by the major national standardizing laboratories, including the National Institute of Standards and Technology (NIST), formerly the National Bureau of Standards (NBS), to re-evaluate their as-maintained units in terms of the International System of Units (SI). The consequence of this activity has been the introduction of standards representing the SI units of voltage and resistance by the International Committee of Weights and Measures, an international body created by the Treaty of the Meter.[1] The use of these standards world-wide beginning January 1, 1990, will result in international consistency of electrical measurement as well as coherence among the practical units of length, mass, electricity, time, etc., inherent in the definitions of the SI.

Implementation of Changes at NIST

These changes have been instituted in the U.S. by NIST using the new, internationally-adopted constants K_{J-90} = 483 597.9 GHz/V exactly and R_{K-90} = 25 812.807 Ω exactly with the Josephson and quantum Hall effects to establish representations of the SI volt and ohm, respectively. The representation of the SI volt is attained by using K_{J-90} in the formula

[1]Note that the SI Units have not been redefined; rather, they have been realized more accurately and a quantum physics representation of the ohm has been introduced, thus leading to the changes in magnitude of the practical or as-maintained units.

Additional Information (cont'd.)

$$U_J(n) = \frac{f}{K_J} \qquad n = 1,2,3,\ldots$$

to give the voltages $U_J(n)$ of the steps produced by the ac Josephson effect at a frequency f. The past value, K_{J-72}, was 483 593.42 GHz/V(NBS-72), thus leading to the 9.264 ppm change. Likewise, R_{K-90} is used in the following formula for the resistance of the i^{th} plateau of a quantum Hall effect device,

$$R_H(i) = \frac{R_K}{i} \qquad (R_K = R_H(1))$$

to realize a representation of the SI ohm. The most recent past national unit of resistance, $\Omega(\text{NBS-48})_t$, was based on a group of five Thomas one-ohm standards and had an uncompensated drift rate of approximately -0.053 ppm per year. Since the quantum Hall effect is used as the national standard, the U.S. representation of the ohm has no drift. (The past unit of voltage, V(NBS-72), was based on the Josephson effect since 1972, and accordingly had a zero drift rate.)

Reassignments to Non-adjustable Standards

Since the U.S. practical volt and ohm units increased on January 1, 1990, the changes must be implemented in non-adjustable standards calibrated in terms of V(NBS-72) and/or Ω(NBS-48) only by **reducing** the values assigned to them proportionally. The examples given below show how to do this for a standard cell and a standard resistor.

Sample Adjustments of Values of Standards

Standard cell:

"Old" emf 1.0180564 V(NBS-72)

Multiply "Old" emf by 0.999990736 to get emf in terms of the present volt representation 1.01804697 ≈ 1.0180470 V

Standard resistor:

"Old" resistance value
$9999.976\ \Omega(\text{NBS-48})_{01/01/90}$

Multiply "Old" resistance by 0.99999831 to get the resistance in terms of the present ohm representation
9999.9591 ≈ 9999.959 Ω

In the above, "Old" refers to the value of the standard which would have been in use on January 1, 1990, had the changes not been made; i.e., if a correction curve based on its past assigned values has been employed to obtain the currently-used value for a standard, the above represents a downward shift of the curve starting January 1, 1990. For resistance, the slope of the curve also changed (slightly) since Ω(NBS-48) has a drift rate and Ω(NIST-90) does not.

Do not send your standards to NIST for recalibration on January 1, 1990, unless they are normally due then. The changes are accurately known and corrections to existing standards may be applied.

Adjustment of Instrumentation

An assigned or calibrated value of a standard is merely a label giving the magnitude of the parameter embodied in the standard. The actual emf or resistance of a standard did not change on January 1, 1990; only what it is called should have changed. In the same sense, meter readings are labels giving the magnitudes of the parameters being measured. **Readings taken after January 1, 1990 using unadjusted meters will be too large in magnitude.** Adjustments to meters must have the effect of reducing the amplitudes of readings for fixed emf's or resistances.

Adjustable voltage and current sources or adjustable resistors for which nominal output is desired, on the other hand, must have their outputs **increased** propor-

Additional Information (cont'd.)

tionally by the above amounts. DVM calibrators are probably the largest class of this type of instrument.

Guidelines

The National Conference of Standards Laboratories (NCSL) and NIST have formed NCSL *ad hoc* Committee 91.4, Changes in the Volt and Ohm to assist industry and government laboratories in coming into compliance with the changes. A major responsibility of the committee is the generation and publication of a set of guidelines which describes unambiguous methods for adjusting standards and instruments, or their values, and delineates other types of problems which may arise, e.g., voltage values called out explicitly in maintenance procedures, values imbedded in software, and the like. These guidelines have been published as NIST Technical Note 1263, "Guidelines for Implementing the New Representations of the Volt and Ohm Effective January 1, 1990." This document is available at no charge through the NIST Electricity Division. To receive a copy, contact Sharon Fromm at 301-975-4222.

For further information, contact Norman B. Belecki (301-975-4223), Ronald F. Dziuba (301-975-4239), Bruce F. Field (301-975-4230), or Barry N. Taylor (301-975-4220).

U.S. REPRESENTATIONS OF ELECTRICAL POWER AND ENERGY

Watt, Var, Volt-Ampere
Joule, Watthour, Varhour
Volt-Ampere-hour, and Q-hour

Background

By international agreement, starting on January 1, 1990, the U.S. put into place new representations of the volt and ohm based, respectively, on the Josephson and Quantum Hall effects and which are highly consistent with the International Systems of Units (SI). Implementation of the new volt and ohm representations in the U.S. required that on January 1, 1990, the value of the present national volt representation maintained by the National Institute of Standards and Technology (NIST, formerly the National Bureau of Standards) be increased by 9.264 parts per million (ppm) and that the value of the national ohm representation be increased by 1.69 ppm (1 ppm = 0.0001%). The resulting increase in the national representation of the ampere is 7.57 ppm. The resulting increase in the national representations of the electrical quantities of power, namely the watt, var, and volt-ampere, and the quantities of energy, namely the joule, watthour, varhour, volt-ampere-hour, and Q-hour is 16.84 ppm.

The adjustment for electrical power and energy is generally very small compared to revenue metering measurement uncertainties (typically greater than ±0.1%) and therefore are not likely to have a significant effect. Adjustments do not need to be applied in the above instances. However, for the highest accuracy calibrations of power and energy standards having uncertainties less than ±0.020%, adjustments should be made. Accordingly, all Reports of Calibration and Reports of Test issued by NIST after January 1, 1990, reflect the appropriate changes.

For instruments calibrated prior to January 1, 1990, adjustments to the calibration values due to the change in the volt and ohm can be made without instrument recalibration. The adjustments are exact and, if properly applied, will not introduce any errors. Examples given below will illustrate proper procedures for applying the new adjustments.

Adjustments for Wattmeters, Varmeters, and Volt-Ampere Meters

Calibrations of wattmeters, varmeters, and volt-ampere meters at NIST provide customers with corrections and uncer-

Additional Information (cont'd.)

tainties given in units of watts, vars, or volt-amperes, as appropriate. Applying the appropriate adjustment due to the new representations of the volt and ohm for power measuring instruments (i.e., wattmeters for "real power" and varmeters for quadrature or imaginary power) requires minor calculations. First, it is necessary to assess the magnitude of the calibration uncertainty in percent and then decide if applying adjustments for the change in the volt and ohm are required. To determine the percentage uncertainty, simply divide the uncertainty in watts, vars, or volt-amperes by the product of the applied voltage and current times the power factor (the real power) and multiply that quantity by 100, as

$$U\% = [(U_w,\ U_v,\ \text{or}\ U_va)/(V_a \times I_a \times PF)] \times 100,$$

where

$U\%$ is the uncertainty in percent,
U_w is the calibration uncertainty in watts,
U_v is the calibration uncertainty in vars,
V_{va} is the calibration uncertainty in volt-amperes,
V_a is the applied voltage in volts,
I_a is the applied current in amperes, and
PF is the power factor (including its sign).

For example, if the uncertainty is stated on a Report of Calibration as ±0.060 watts for the calibration of a wattmeter at an applied voltage of 120 V and an applied current of 5 A at unity power factor, then

$$\text{Percent Uncertainty} = U\% = [(\pm 0.060\ \text{W})/(120\ \text{V} \times 5\ \text{A} \times 1)] \times 100 = \pm 0.010\%.$$

If the percentage uncertainty, as calculated above, is less than ±0.020%, (as it is in the above example), then it is recommended that an adjustment of 0.0017% (0.001684% rounded to four significant decimal places) due to the new representations of the volt and ohm be applied.

The second step is the calculation of how large the adjustment will be (in units of watts, vars, or volt-amperes, as appropriate), due to the reassignment of the volt and ohm. For the same example given above, if the calibration correction was given in a Report of Calibration as +0.052 watts, then the adjustment due to the change in the volt and ohm may be calculated by multiplying the product of the applied voltage and current times the power factor by 0.000017 (0.0017% expressed in proportional parts), as

$$\text{Adjustment} = (V_a \times I_a \times PF) \times 0.000017$$
$$\text{Adjustment} = (120\ \text{V} \times 5\ \text{A} \times 1) \times 0.000017 = 0.010\ \text{watts}.$$

The resulting product should be rounded to the same number of significant decimal places as the old calibration correction was given. This result is then subtracted from the old calibration correction, as in the following example:

Old Calibration Correction (prior to 1/1/90)	=	(+0.052 watts)
less 0.000017 x Applied Volt-amperes x PF	=	-(+0.010 watts)
New Calibration Correction (after 1/1/90)	=	(+0.042 watts)

If the old calibration correction (prior to 1/1/90) at test conditions of 120 V, 5 A, and at a power factor of 0.5 lag, happened to be a negative quantity, for example, -0.031 watts, then the old calibrations correction would be decreased (made more negative) by 0.0017% of the applied volt-ampere product times the power factor, as in the following example:

Old Calibration Correction (prior to 1/1/90)	=	(-0.031 watts)
less 0.000017 x Applied Volt-amperes x PF	=	-(+0.005 watts)
New Calibration Correction (after 1/1/90)	=	(-0.036 watts)

Additional Information (cont'd.)

The process of making the corresponding change for the varmeter corrections is identical to that show above. For volt-ampere meters, the adjustment is made independent of the power factor (i.e., a value of PF = 1 may be used). However, most varmeter and volt-ampere meter calibrations have stated uncertainties greater than ±0.020%, and hence, would not require an adjustment.

Adjustments for Joule, Watt-, Var-, Volt-Ampere- and Q-Hour Meters

Applying adjustments to electric energy measuring instruments (i.e., joule, watthour, varhour, volt-ampere-hour, and Q-hour meters) for changes in the representation of the volt and ohm, is more straightforward because the common calibration constant for energy metering is expressed as a "percentage registration." The amount the registration is to be adjusted can be subtracted directly as a percentage, regardless of power factor.

For example, if a watthour meter has a registration of 100.015% before January 1, 1990, then after that date, the new assigned registration would be decreased by 0.0017% (rounded from 0.001684%) as

Old percentage registration (prior to 1/1/90)	=	100.015%
less amount due to change in volt and ohm	=	-0.0017%
New percentage registration (after 1/1/90)	=	100.0133%
Rounded to three significant decimal places	=	100.013%

The process of making the corresponding changes for the joule, varhour, volt-ampere-hour and Q-hour meters are identical to that shown above. If the associated uncertainty of the calibration is greater than ±0.020%, no adjustments are necessary, as stated in the instances for wattmeters, varmeters, and volt-ampere meters. The uncertainties for varhour, volt-ampere-hour, and Q-hour meters are seldom less than ±0.020%, and hence adjustments generally do not need to be made.

Reference

N. B. Belecki, R. F. Dziuba, B. F. Field, and B. N. Taylor, Guidelines for Implementing the New Representations of the Volt and Ohm Effective January 1, 1990, NIST Tech. Note 1263, June, 1989.

Copies of the above document are available at no cost from:

National Institute of Standards and Technology
Electricity Division, MET B146
Gaithersburg, MD 20899
Telephone: (301) 975-4222

For Further Information

For further information concerning the above information, contact either John D. Ramboz (301) 975-2434 or Thomas L. Nelson (310) 975-2427, or write:

National Institute of Standards and Technology
Electricity Division, MET B344
Gaithersburg, MD 20899

NEW BROCHURE FOR SEMICONDUCTOR SRMs

Standard Reference Materials for Semiconductor Manufacturing Technology lists a series of SRMs for use in characterizing semiconductor materials and processes. The SRMs include a series of silicon resistivity materials for calibrating four-probe and eddy-current test equipment [Technical Contact: James R. Ehrstein, (301) 975-2060]; sizing materials for calibrating optical microscopes [Technical Contact: Robert D. Larrabee, (301) 975-2298]; SRMs for optical measurements [Technical Contact: Jon Geist, (301) 975-2066]; and sizing materials for calibrating scanning electron microscopes, SRMs for mechanical testing, X-ray and photographic films, X-ray diffraction, and the chemical analysis of materials [General Contact: Office of

Additional Information (cont'd.)

Standard Reference Materials, Cindy Leonard, (301) 975-2023].

Office of Microelectronics Programs Featured at Trade Show. This new office, which came into existence early in 1991 and which is headed by Robert I. Scace, Director, coordinates microelectronics efforts within NIST and helps NIST respond to the needs of industry. To this end, the OMP and the Office of Standard Reference Materials will be featured at the NIST booth, #7282 in Pavilion 4, at SEMICON/West in San Mateo, CA, May 21-23, 1991. SEMICON/West, North America's premier trade show for the semiconductor equipment and materials industry, hosts over 1,000 worldwide product exhibits and is attended by 50,000 industry professionals. More complete information on the Office of Microelectronics Programs will appear in the Technical Progress Bulletin for the period January 1 to March 31, 1991. Contact: Jane Walters, (301) 975-2050.

1991 CEEE CALENDAR

September 8-11, 1991 (Research Triangle Park, NC)

Third Workshop on Radiation-Induced and/or Process-Related Electrically Active Defects in Semiconductor-Insulator Systems. This workshop is sponsored by the Microelectronics Center of North Carolina (MCNC), North Carolina State University, and the University of North Carolina at Charlotte, in cooperation with the Semiconductor Research Corporation, the IEEE Electron Devices Society, and the National Institute of Standards and Technology. Some areas of interest are: relationships between processing and electrically active defect densities, measurement methods, theoretical modeling of electrically active defects, process control of the sensitivity of insulators to ionizing radiation, removal of radiation damage, controlled radiation standard sources, and memory effects. [Contact: Jeremiah R. Lowney, (301) 975-2048]

September 29 and October 1-2, 1991 (Scottsdale, AZ)

Eleventh VLSI and GaAs Packaging Workshop. This 11th annual workshop is co-sponsored by the IEEE CHMT Society and the National Institute of Standards and Technology. Topics to be discussed include: VLSI package design, integrated package design, multichip module design, package thermal and electrical design, GaAs IC packaging, VLSI package interconnection options, VLSI package materials and die-attach solutions, and failure mechanism and quality of VLSI packages. Contact: George G. Harman, (301) 975-2097.

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This is the twenty-seventh issue of a quarterly publication providing information on the technical work of the National Institute of Standards and Technology (formerly the National Bureau of Standards) Center for Electronics and Electrical Engineering. This issue of the Center for Electronics and Electrical Engineering Technical Publication Announcements covers the fourth quarter of calendar year 1990. Abstracts are provided by technical area for papers published this quarter.

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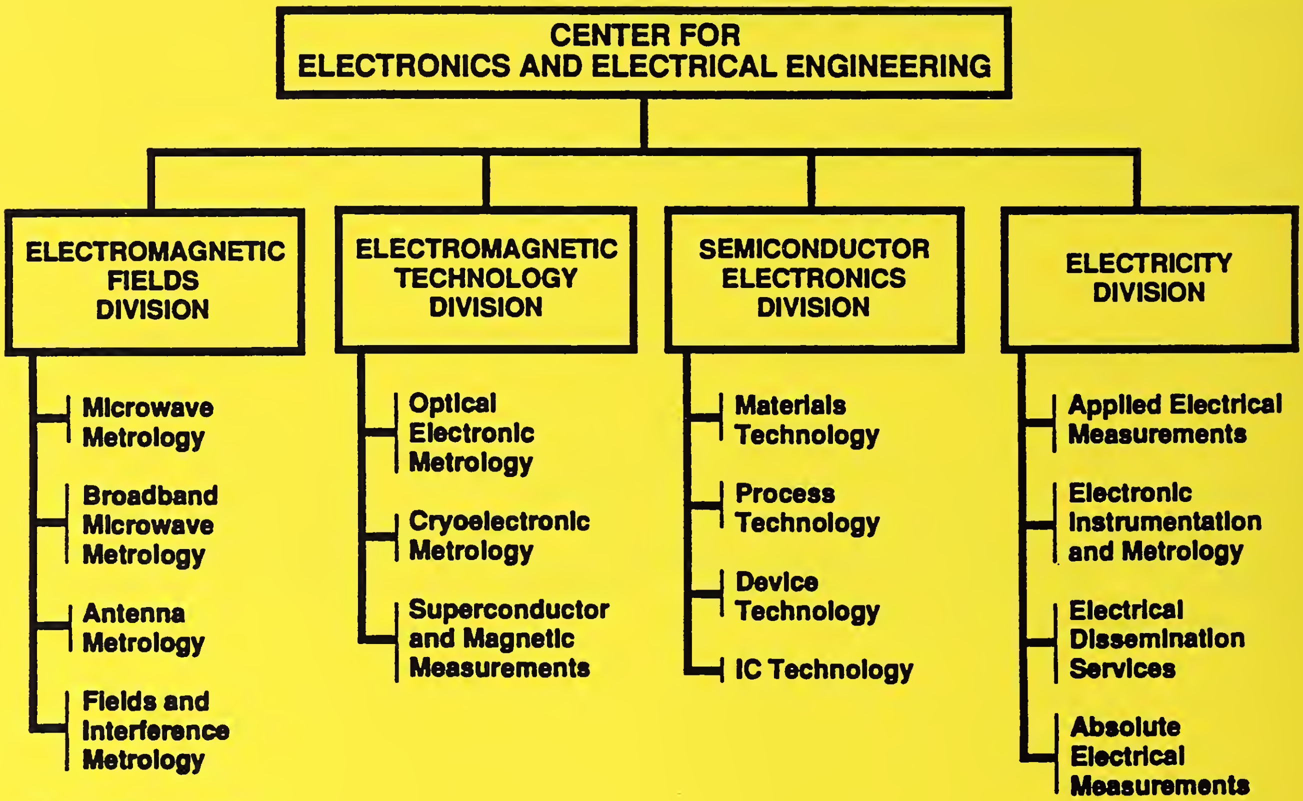

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KEY CONTACTS

Center Headquarters (720)	Director, Mr. Judson C. French (301) 975-2220
	Deputy Director, Mr. Robert I. Scace (301) 975-2220
Electromagnetic Fields Division (723)	Chief, Dr. Ramon C. Baird (303) 497-3131
Electromagnetic Technology Division (724)	Chief, Dr. Robert A. Kamper (303) 497-3535
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Electricity Division (728)	Chief, Dr. Oskars Petersons (301) 975-2400

INFORMATION:

For additional information on the Center for Electronics and Electrical Engineering, write or call:

Center for Electronics and Electrical Engineering
National Institute of Standards and Technology
Metrology Building, Room B-358
Gaithersburg, MD 20899
Telephone (301) 975-2220