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Covering Center Programs,
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with 1989 CEEE Events Calendar

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INTRODUCTION TO THE CEEE TECHNICAL PUBLICATION ANNOUNCEMENTS

This is the eighteenth 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 Announcements covers the third quarter of calendar year 1988.

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). For the information of our readership, this issue also contains, in the Additional Information section, entries covering work on DC and Low-Frequency Metrology and Fundamental Electrical Measurements. This issue also includes a calendar of Center conferences and workshops planned for calendar year 1989 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 (which includes Fast Signal Acquisition, Processing, and Transmission; Electrical Systems; and Electromagnetic Interference), carried out by the Electrosystems Division in Gaithersburg and the Electromagnetic Fields and Electromagnetic Technology Divisions in Boulder, CO. See the table of contents on the opposite page for identification of the topics covered by each program, as represented in this issue. 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 19.

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 16.

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SEMICONDUCTOR TECHNOLOGY

Dimensional Metrology

Larrabee, R.D., **Submicrometer Optical Metrology**, Proceedings of the 46th Annual Meeting of the Electron Microscopy Society of America, Milwaukee, Wisconsin, August 8-9, 1988 (San Francisco Press, 1988), pp. 50-51.

The National Institute of Standards and Technology has had a continuing program for over 10 years to develop optical feature-size standards for the integrated circuit industry. In this paper, the basic obstacles that must be overcome to achieve precision and accuracy for submicrometer feature-size measurements are surveyed, and the present (and projected future) standards for micrometer and submicrometer optical dimensional metrology are discussed.
[Contact: Robert D. Larrabee, (301) 975-2298]

Nyyssonen, D., and Kirk, C., **Optical Microscope Imaging of Lines Patterned in Thick Layers with Variable Edge Geometry: Theory** [original title: Modeling of the Optical Microscope Imaging of Lines Patterned in Thick Layers with Variable Edge Geometry], Journal of the Optical Society of America, Vol. 5, pp. 1270-1280 (August 1988).

A monochromatic, waveguide model is presented which can predict the optical microscope images of line objects with arbitrary edge geometry, patterned in thick layers, including multilayer structures with sloping, curved, and undercut edges, granular structures such as lines patterned in polysilicon, as well as asymmetric objects. The model is used to illustrate the effects of line edge structure on the optical image. Qualitative agreement with experimentally obtained optical image profiles is demonstrated. Application of the model to study the effects of variations in layer thickness and edge geometry on linewidth measurements made at different stages of manufacturing integrated circuit devices is discussed.
[Contact: Robert D. Larrabee, (301) 975-2298]

Postek, M.T., and Tiberio, R.C., **Low Accelerating Voltage SEM Magnification Standard Prototype**, Proceedings of the 46th Annual Meeting, Electron Microscopy Society of America, Milwaukee, Wisconsin, August 8-9, 1988 (San Francisco Press, 1988), pp. 198-199.

NIST has recently begun a cooperative effort with the National Nanofabrication Facility at Cornell University to fabricate a new scanning electron microscope (SEM) magnification standard by electron-beam lithography. The design of the standard is such that integrated structures in both the x- and y-directions can be used to calibrate the scans of the SEM. Structures with a nominal pitch as large as 3000 μm to as small as a nominal pitch of 0.20 μm permit calibration from the lowest magnification range to in excess of 200,000X. Prototype samples, designed both to test manufacturability and the ability to solve the present problems with SRM 484 were fabricated on semiconductor wafers. The etched silicon structures demonstrate good contrast throughout the accelerating voltage range. This paper outlines the design criteria and the work being done to produce and certify this as an SEM magnification standard.
[Contact: Michael T. Postek, (301) 975-2299]

Integrated Circuit Test Structures

Schafft, H.A., Lechner, J., Sabi, B., and Smith, R., **How Good Are Your Estimates of t_{50} and σ?**, Proceedings of the 1987 Wafer Reliability Workshop, O. D. Trapp, Ed., Lake Tahoe, California, October 25-28, 1987, pp. 165-174.

A transcript of a talk concerning statistics for electromigration testing is presented. The talk served as a forerunner of a paper published in the

IC Test Structures (cont'd.)

Proceedings of the 26th Annual Reliability Physics Symposium, April 11-14, 1988, pp. 192-202.
[Contact: Harry A. Schafft, (301) 975-2234]

FAST SIGNAL ACQUISITION, PROCESSING, AND TRANSMISSION

Waveform Metrology

Oldham, N.M., Hetrick, P.S., and Xiangren, Z., **A Calculable, Transportable Audio-Frequency AC Reference Standard**, Conference Digest of CPEM'88, 1988 Conference on Precision Electromagnetic Measurements, Tsukuba Science City, Japan, June 7-10, 1988, pp. 46-47 (IEEE, New York, New York, June 1988).

A transportable ac voltage source is described, in which sinusoidal signals are digitally synthesized in the audio-frequency range. The rms value of the output waveform may be calculated by measuring the dc level of the individual steps used to generate the waveform. The uncertainty of this calculation is typically ±10 ppm from 20 Hz to 10 kHz at the 7-V level.
[Contact: Nile M. Oldham, (301) 975-2408]

Oldham, N.M., Petersons, O., and Waltrip, B.C., **Audio-Frequency Current-Comparator Power Bridge**, Conference Digest of CPEM'88, 1988 Conference on Precision Electromagnetic Measurements, Tsukuba Science City, Japan, June 7-10, 1988, p. 48 (IEEE, New York, New York, June 1988).

A system for performing active and reactive power measurements from 50 Hz to 20 kHz is described. The technique is an extension of a power bridge based on a current-comparator capacitance bridge that was originally restricted to power frequencies. A digitally synthesized dual-channel signal source provides the required voltage and current signals.
[Contact: Nile M. Oldham, (301) 975-2408]

Souders, T.M., and Hetrick, P.S., **Accurate RF Voltage Measurements Using a Sampling Voltage Tracker**, Conference Digest of CPEM-88, 1988 Conference on Precision Electromagnetic Measurements, Tsukuba Science City, Japan, June 7-10, 1988, pp. 270-271 (IEEE, New York, New York, June 1988).

The radio-frequency (rf) voltage measurement capability of an equivalent time-sampling system is described. The frequency range investigated is 1 to 100 MHz. Over this range, the measured errors, determined by ac/dc thermal transfer, are within the stated uncertainties presently provided by NIST for thermal converter calibrations. The system offers several advantages over conventional thermal transfer techniques: ac/dc transfers are not required, loading and transmission line problems are reduced, and direct measurement of voltages from 2 V to as low as 10 mV are possible.
[Contact: T. Michael Souders, (301) 975-2406]

Cryoelectronic Metrology

Kautz, R.L., **Thermally Induced Escape: The Principle of Minimum Available Noise Energy**, Physical Review A, Vol. 38, No. 4, pp. 2066-2080 (August 15, 1988).

The average time required for thermally induced escape from a basin of attraction increases exponentially with inverse temperature in proportion to exp (E_A/kT) in the limit of low temperature. A minimum principle states that the activation energy E_A is the minimum available noise energy required to execute a state-space trajectory which takes the system from the attractor of the noise-free system to the boundary of its basin of attraction and that the minimizing trajectory is the most probable low-temperature escape path.

Cryoelectronic Metrology (cont'd.)

This principle is applied to the problem of thermally induced escape from two attractors of the dc-biased Josephson junction, the zero-voltage state and the voltage state, to determine activation energies and most probable escape paths. These two escape problems exemplify the classical case of escape from a potential well and the more general case of escape from an attractor of a nonequilibrium system. Monte Carlo simulations are used to verify the accuracy of the activation energies and most probable escape paths derived from the minimum principle.
[Contact: Richard L. Kautz, (303) 497-3391/-3988]

Pulse Power Metrology

McKnight, R.H., **Conference Record of the Workshop on Measurement of Electrical Quantities in Pulse Power Systems II**, Gaithersburg, Maryland, March 5-7, 1986, R. H. McKnight, Ed., 101 pages (IEEE, New York, 1988).

The purpose of this workshop was to encourage the exchange of information about measurements of electrical quantities in pulse power systems between those individuals who are presently working in this area and those of the pulse power community who have a general interest in such measurements. The format of the meeting included oral presentations of papers, some of which were submitted for publication and are included in this proceedings, progress reports, and discussion sessions. Discussion sessions were recorded with the permission of the attendees, edited by the discussers and are published as part of the proceedings. Several papers were withdrawn because of difficulties in obtaining sponsor clearances, and a roundtable discussion held on the last day of the workshop has been omitted from the proceedings at the request of some of the participants. The papers have been published as submitted and the authors retain sole responsibility for the contents.
[Contact: William E. Anderson, (301) 975-2423]

Antenna Metrology

Baird, R.C., Newell, A.C., and Stubenrauch, C.F., **A Brief History of Near-Field Measurements of Antennas at the National Bureau of Standards**, IEEE Transactions on Antennas and Propagation, Vol. 36, No. 6, pp. 727-733 (June 1988).

The National Bureau of Standards (NBS) played a pioneering role in the development of practical planar near-field antenna measurement techniques. This paper presents a brief history of that role, which began with theoretical studies to determine corrections for diffraction in a microwave measurement of the speed of light. NBS contributions to the development of nonplanar near-field measurement theory and practice are also described.
[Contact: Ramon C. Baird, (303) 497-3131]

Camell, D.G., Larsen, E.B., and Anson, W.J., **NBS Calibration Procedures for Horizontal Dipole Antennas (25 to 1000 MHz)**, Symposium Record of the 1988 IEEE International Symposium on Electromagnetic Compatibility, Seattle, Washington, August 2-4, 1988, pp. 390-394 (1988).

The theoretical basis and test procedures for horizontally polarized dipole calibrations at the National Bureau of Standards are described. Two different techniques and two different test sites are used for these measurements. The standard antenna method uses the calculation of a field strength level, from the response of a simple half-wave dipole, to calibrate an antenna. This method is used at an open-field site in the frequency range 25 to 1000 MHz. The standard field method applies the theoretical gain equations of waveguides to determine the field strength level.

Antenna Metrology (cont'd.)

This latter method is used in an anechoic chamber in the frequency range 200 to 1000 MHz. Procedures for both techniques are explained and measurement setups are illustrated. Measurement uncertainties are discussed.
[Contact: Dennis G. Camell, (303) 497-3214]

FitzGerrell, R.G., **Three PC-Computer Programs for Antenna Calculations Primarily for Use Below 1000 MHz**, IEEE Antennas and Propagation Society Newsletter, Vol. 29, No. 3, pp. 30-32 (June 1987).

This article describes three computer programs used frequently by the author when working on various antenna measurement projects in the frequency range below 1000 MHz. These programs were originally written in FORTRAN 4 and run on various main-frame computers at the NIST Boulder Laboratories. During the last year, they were converted, essentially intact, to FORTRAN 77 and compiled using IBM Professional FORTRAN installed on an IBM PC/XT. As a result of this choice of compilers, a math co-processor is required (8087 for the XT) to run the *.EXE files.
[Contact: Allen C. Newell, (303) 497-3743]

FitzGerrell, R.G., **Monopole Impedance and Gain Measurements on Finite Ground Planes**, IEEE Transactions on Antennas and Propagation, Vol. 36, No. 3, pp. 431-438 (March 1988).

The purpose of the work described here is to determine if it is possible to make "acceptably accurate" input impedance and gain measurements of monopoles on a reduced ground plane. Ideally, monopoles are located on an infinite, perfectly conducting, ground plane. Practically, measurements are made on a test site with dimensions largely determined by the cost and availability of the space occupied by the site. Measured and calculated data show that the diameter of a highly conducting ground plane should be at least 4 λ, where λ = wavelength, for measuring the input impedance of 0.25-λ monopoles. At 25 MHz, the lowest frequency considered here, such a ground plane would require a space at least 48 m in diameter. Model impedance measurements and calculations presented here imply that a space only 10 m by 11 m is required by using 16 resistively loaded wire radials to extend a 3.66-m by 4.88-m rectangular aluminum ground plane. Measured insertion loss data acquired using a 1:5 scale model ground plane with resistively loaded radials indicate that it is sufficiently large for gain measurements as well. Measured and calculated monopole standing-wave ratio and insertion loss of a full-scale ground plane verify the results of the model measurements.
[Contact: Mark T. Ma, (303) 497-3800]

Francis, M.H., and Stubenrauch, C.F., **Comparison of Measured and Calculated Antenna Side Lobe Coupling Loss in the Near Field Using Approximate Far-Field Data**, IEEE Transactions on Antennas and Propagation, Vol. 36, No. 3, pp. 438-441 (March 1988).

Computer programs exist to calculate the coupling loss between two antennas provided that the amplitude and phase of the far field are available. However, for many antennas the complex far field is not known accurately. In such cases it is nevertheless possible to specify approximate far fields from a knowledge of the side lobe level of each antenna along the axis of separation, and the electrical size of each antenna. Measurements of near-field coupling loss between two moderate sized microwave antennas were taken to determine the effectiveness of using approximate side-lobe level data instead of the detailed far fields. Comparison of the measured results to those from the computer program ENVLP indicates that the use of approximate far fields gives an estimate of the coupling loss with an uncertainty of about ± 5 dB.

Antenna Metrology (cont'd.)

[Contact: Michael H. Francis, (303) 497-5873]

Hill, D.A., **Antennas for Geophysical Applications**, Antenna Handbook: Theory, Applications, and Design, Chapter 23, pp. 23-1 to 23-26, Y.T. Lo and S.W. Lee, Eds. (Van Nostrand Reinhold Co., 1988).

The use of electrical methods in geophysics has expanded greatly in the past two decades, and during the same time period an interest in subsurface communication has developed. Both geophysical prospecting and underground communication require transmission of signals into the earth and, as a result, the same antenna types are used for both applications.

Because the methods and antennas used in geophysical probing are so varied, it is not possible to attempt a comprehensive discussion in one chapter. However, if we limit the applications to deep, subsurface probing and to through-the-earth communication, then the antennas used are primarily of two types: straight-wire antennas which are grounded at the end points and wire-loop antennas. Sections 2 and 3 discuss grounded wire antennas for direct current and time-varying excitations, respectively. Section 4 discusses loop antennas. In the analysis and discussion of these antennas some applications in geophysics and underground communication are described for illustrative purposes, but many other applications cannot be mentioned for lack of space. The primary purpose of this chapter is to describe how these antennas perform in the presence of a conducting earth.

In order to penetrate the earth to depths on the order of a hundred meters or more, it is necessary to employ extremely low frequencies below about 3 kHz. At such frequencies the free-space wavelength is greater than 100 km, and the antennas are electrically small even though they could be physically large (dimensions on the order of a kilometer in some cases). Consequently, the analyses in Sections 2 through 4 utilize the quasi-static assumption that neglects displacement currents in the air. However, no assumption is made regarding the antenna dimensions and separations in terms of the skin depth in the earth.

In Section 5, some other antenna types are discussed in much less detail. Many of these antennas are used for shorter ranges and higher frequencies where the quasi-static assumption is not valid. [Contact: David A. Hill, (303) 497-3472]

Kremer, D.P., and Repjar, A.G., **Calibrating Antenna Standards Using CW and Pulsed-CW Measurements and the Planar Near-Field Method**, Proceedings of the Antenna Measurement Techniques Association (AMTA), Atlanta, Georgia, September 12-16, 1988, pp. 13-21 to 13-29.

For over a decade, the National Institute of Science and Technology (formerly National Bureau of Standards) has used the planar near-field method to accurately determine the gain, polarization, and patterns of antennas either transmitting or receiving cw signals. Some of these calibrated antennas have also been measured at other facilities to determine and/or verify the accuracies obtainable with their ranges. The facilities involved have included near-field ranges, far-field ranges, and compact ranges.

Recently, NIST (NBS) has calibrated an antenna to be used to evaluate both a near-field range and a compact range. These ranges are to be used to measure an electronically-steerable antenna which transmits only pulsed-cw signals. The antenna calibrated by NIST was chosen to be similar in physical size and frequency of operation to the array and was also calibrated with the antenna transmitting pulsed-cw. This calibra-

Antenna Metrology (cont'd.)

tion included determining the effects of using different power levels at the mixer, the accuracy of the receiver in making the amplitude and phase measurements, and the effective dynamic range of the receiver. Comparisons were made with calibration results obtained for the antenna transmitting cw and for the antenna receiving cw. The parameters compared include gain, sidelobe and cross polarization levels. The measurements are described and some results are presented.
[Contact: Douglas P. Kremer, (303) 497-3732]

Lewis, R.L., and Newell, A.C., **An Efficient and Accurate Method for Calculating and Representing Power Density in the Near Zone of Microwave Antennas**, IEEE Transactions on Antennas and Propagation, Vol. 36, No. 6, pp. 890-901 (June 1988).

An efficient and reliable method has been developed for computing and exhibiting Fresnel-region fields radiated by microwave antennas, using plane-wave scattering-matrix analysis. That is, we calculate near fields by numerically integrating the complex far-field antenna pattern. The predicted near fields are exhibited as relative power-density contours lying in a longitudinal plane bisecting the antenna's aperture. With spatial-coordinate scaling, each set of contours becomes a function of the relative aperture distribution and the electrical size of the antenna. If the latter is much larger than any normalized transverse coordinate of interest, the contour set becomes invariant with respect to antenna size. Thus, coordinate normalization can produce contours applicable to any antenna with the same relative aperture distribution, regardless of antenna size.

The crux of the analysis consists of handling a numerical instability which arises from integrating discrete data. A criterion is developed for excluding highly oscillatory regions of the integrand. In turn, this leads to restrictions on the output range over which the near-field computations are considered valid. With the numerical instability problem resolved, the fast Fourier transform is used for efficient numerical integration. The predicted near fields have been compared against both measured and theoretical data, confirming that our near-field computation algorithm is capable of extremely high accuracy.
[Contact: Richard L. Lewis, (303) 497-5196]

Newell, A.C., **Error Analysis Techniques for Planar Near-Field Measurements**, IEEE Transactions on Antennas and Propagation, Vol. 36, No. 6, pp. 754-768 (June 1988).

The results of an extensive error analysis on antenna near-field planar scanning measurements are described. It provides ways for estimating the magnitude of each individual source of error and then combining them to estimate the total uncertainty in the measurement. Mathematical analysis, computer simulation, and measurement tests are all used where appropriate.
[Contact: Allen C. Newell, (303) 497-3743]

Newell, A.C., **Improved Polarization Measurements Using a Modified Three-Antenna Technique**, IEEE Transactions on Antennas and Propagation, Vol. 36, No. 6, pp. 852-854 (June 1988).

An improved three-antenna measurement of polarization that greatly reduces the uncertainty due to phase measurement errors is described. This technique is used to calibrate polarization standards and probes used in near-field antenna measurements.
[Contact: Allen C. Newell, (303) 497-3743]

Newell, A.C., and Stubenrauch, C.F., **Effect of Random Errors in Planar Near-**

Antenna Metrology (cont'd.)

Field Measurement, IEEE Transactions on Antennas and Propagation, Vol. 36, No. 6, pp. 769-773 (June 1988).

Expressions are developed which relate the signal-to-noise ratio in the near field to the signal-to-noise ratio in the far field for antenna near-field planar scanning. The expressions are then used to predict errors in far-field patterns obtained from near-field data. A technique is also given to measure the noise in the far-field pattern.
[Contact: Allen C. Newell, (303) 497-3743]

Newell, A.C., Ward, R.D., and McFarlane, E.J., **Gain and Power Parameter Measurements Using Planar Near-Field Techniques**, IEEE Transactions on Antennas and Propagation, Vol. 36, No. 6, pp. 792-803 (June 1988).

Equations are developed and measurement techniques described for obtaining gain, effective radiated power, and saturating flux density using antenna near-field planar scanning measurements. These are compared with conventional far-field techniques, and a number of parallels are evident. These give insight to the theory and help to identify the critical measurement parameters. Application of the techniques to the INTELSAT VI satellite are described.
[Contact: Allen C. Newell, (303) 497-3743]

Repjar, A.G., Newell, A.C., and Francis, M.H., **Accurate Determination of Planar Near-Field Correction Parameters for Linearly Polarized Probes**, IEEE Transactions on Antennas and Propagation, Vol. 36, No. 6, pp. 855-868 (June 1988).

The receiving patterns of two probes, for both amplitude and phase, must be known and utilized to determine accurately the complete far field of an antenna from near-field measurements. The process of incorporating the probe characteristics in the far-field computation is referred to as "probe correction." When the antenna to be measured is nominally linearly polarized, the measurements are more accurate and efficient if nominally linearly polarized probes are used. Further efficiency is obtained if only one dual-polarized probe is used to allow simultaneous measurements of both components. It should be noted, however, that a single-port probe can be rotated by 90 deg to obtain the second component. A procedure used by the National Institute of Standards and Technology for accurately determining the plane-wave receiving parameters of both single- and dual-port linearly polarized probes is described. Examples are presented and the effect of these probe-receiving characteristics in the calculation of the parameters for the antenna being measured under test is demonstrated using appropriate planar near-field theory.
[Contact: Andrew G. Repjar, (303) 497-5703]

Microwave & Millimeter-Wave Metrology

Adair, R.T., and Russell, D.H., A **Calibration Service for 30 MHz Attenuation and Phase Shift**, NBS Special Publication 250-32 (April 1988).

A calibration service currently being offered by NIST (formerly NBS) for attenuation and phase shift at 30 MHz is described. The service offers measurements on coaxial attenuators that are either fixed (standard attenuation) or variable for incremental (step) attenuation. Waveguide-below-cutoff variable attenuators with coaxial connectors are also calibrated for incremental attenuation. Ranges of capabilities and estimated limits of systematic and random uncertainty are presented.

Calibration of phase shifters which provide fixed (insertion) phase shift and those with variable phase shift (phase shift difference) are described.

Microwave & Millimeter-Wave (cont'd.)

Ranges of phase shift and estimated limits of uncertainty are given in degrees. However, a smaller portion of this document is devoted to this calibration service since it is requested only infrequently.

Definitions, capabilities of the system, and techniques of calibration are given. The standards, measurement accuracies, results from intercomparisons, quality assurance, and statistical control of the system are discussed and analyzed. Representative reports of calibration are also included.
[Contact: Daved H. Russell, (303) 497-3148]

Counas, G.J., and Yates, B.C., **Measurement of Adapter Loss, Mismatch, and Efficiency Using the Dual Six-Port**, NBSIR 88-3096 (July 1988).

A noise measurement system is being developed for the Air Force which uses coaxial cryogenic and ambient noise temperature standards to determine the noise temperature of the device under test. When the device under test has a different connector than those on the noise standards, an adapter has to be used. Adapter loss and complex reflection coefficient must be compensated for, or noise measurement accuracy is affected. A technique has been developed which uses a dual six-port measurement system to determine the mismatch, loss, and ultimately the efficiency of the adapter used. This enables correction of measurement results and allows measurements to be made with an adapter with no degradation of accuracy. The method of evaluating adapters is described, and instructions for its use are provided.
[Contact: George J. Counas, (303) 497-3664]

Optical Fiber Metrology

Scace, R.I., **Optical Communication**, ASTM Standardization News, pp. 30-32 (Sept. 1988).

A new communication medium with exciting capabilities is being put into service around the world. It exploits the astonishing transparency to infrared light of high purity silica (fused quartz) fibers to carry extremely high quantities of information long distances at low cost. Much has been made of optical fibers in advertising telephone services, but these ads deal with only the beginning of a communication revolution.
[Contact: Robert I. Scace, (301) 975-2220]

Other Fast Signal Topics

Capobianco, T.E., and Vecchia, D.F., **Coil Parameter Influence on Eddy Current Probe Sensitivity**, Review of Progress in Quantitative Nondestructive Evaluation, Vol. 7A, D.O. Thompson and D.E. Chimenti, Eds. (Plenum Publishing Corporation, 1988), pp. 487-492.

Results of a study undertaken to quantify causes of sensitivity variations found in commercial eddy current probes are reported. Electrical parameter measurements made on a number of commercially produced coils indicate that coil reproducibility is not a major problem in the probe construction process. On the other hand, commercial probes designed for a particular inspection can have sensitivities differing by almost an order of magnitude. It appears that while individual probe manufacturers can produce many identical probes, the choice of coil design parameters can lead to flaw-detectability variations in eddy current probes obtained from different sources.

This study evaluates the effects on sensitivity of changes in the physical parameters of small ferrite core coils. Among the parameters studied were wire gauge, number of wire turns, coil aspect ration, ferrite permeability, and operating frequency. The criteria used

Other Fast Signal Topics (cont'd.)

to gauge probe sensitivity are the impedance changes observed on applying the coils to four semi-elliptical electrical-discharged-machined notches in aluminum and to aluminum and titanium test blocks. The results indicate that coils with similar electrical characteristics but different physical parameters can have significant differences in sensitivity.
[Contact: Thomas E. Capobianco, (303) 497-3141]

Fickett, F.R., and Capobianco, T.E., **Conductors for Advanced Energy Systems**, Conductors for Advanced Energy Systems Annual Report, INCRA Project #321B (International Cooper Research Association, Inc., New York, NY, October 1987).

In this report we present the results of extensive mechanical-properties tests on a large number of oxygen-free copper samples representing a range of producers and wire tempers. Tests at both room temperature and liquid-helium temperature (4 K) are reported. A specialized apparatus developed for the low-temperature tests is described. Results of the many tests are presented in graphical and tabular form. The most interesting of the results is that it appears possible to predict the strength of oxygen-free copper wires at low temperatures by the measurement of the residual resistance ratio (RRR), the ratio of the room temperature resistance to that measured at 4 K. This result is of great importance in applications, since many laboratories are able to measure RRR, but few can do low-temperature mechanical properties tests.
[Contact: Fred Fickett, (303) 497-3785]

Hill, D.A., **Electromagnetic Scattering by Buried Objects of Low Contrast**, IEEE Transactions on Geoscience and Remote Sensing, Vol. 26, No. 2, pp. 195-203 (March 1988).

The Born approximation is used to derive the plane-wave scattering matrix for objects of low dielectric contrast. For general shapes, a numerical integration over the volume of the scatterer is required, but analytical expressions are derived for a sphere, a circular cylinder, and a rectangular box (parallelepiped). Plane-wave, scattering-matrix theory is used to account for the air-earth interface. Numerical results are presented for the scattered near field and far field for plane-wave excitation. The scattered fields are weak for low-contrast objects, but the near-field results have application to electromagnetic detection of buried objects.
[Contact: David A. Hill, (303) 497-3472]

ELECTRICAL SYSTEMS

Power Systems Metrology

Anderson, W.E., **A Calibration Service for Voltage Transformers and High-Voltage Capacitors**, NBS Special Publication 250-33 (June 1988).

The National Institute of Standards and Technology calibration service for voltage transformers and high-voltage capacitors is described. The service for voltage transformers supports the measurement of ratio correction factors and phase angles at primary voltages up to 170 kV and secondary voltages as low as 10 V at 60 Hz. Calibrations at frequencies from 50 to 400 Hz are available over a more limited voltage range. The service for high-voltage capacitors supports the measurement of capacitances and dissipation factors at applied voltages ranging from 100 V to 170 kV at 60 Hz depending on the nominal capacitance. Calibrations over a reduced voltage range at other frequencies are also available. As in the case with voltage transformers, these voltage constraints are determined by the facilities at the National Institute of Standards and Technology.
[Contact: William E. Anderson, (301) 975-2423]

Power Systems Metrology (cont'd.)

Moore, W.J.M., So, E., Miljanic, P.N., Oldham, N.M., and Bergeest, R., **An International Comparison of Power Meter Calibrations Conducted in 1987**, Conference Digest of CPEM'88, 1988 Conference on Precision Electromagnetic Measurements, Tsukuba Science City, Japan, June 7-10, 1988, pp. 341-342 (IEEE, New York, New York, June 1988).

The results of an intercomparison of power meter calibrations conducted during 1987 between the National Research Council, Ottawa (Canada), the National Bureau of Standards, Gaithersburg (U.S.A.), and the Physikallsch-Technische Bundesanstalt, Braunschweig (Federal Republic of Germany), using a time-division multiplier watt-converter developed at the Institut Mihailo Pupin, Belgrade (Yugoslavia), are described. The measurements were made at 120 V, 5 A, 50 and 60 Hz, at power factors of 1.0, 0.5 lead and lag, and 0.0 lead and lag. An agreement between laboratories of better than 20 parts in a million is indicated.
[Contact: Nile H. Oldham, (301) 975-2408]

Olthoff, J.K., Van Brunt, R.J., Wang, Y., Champion, R.L., and Doverspike, L.D., **Collisional Electron Detachment Cross Sections for SF_6^-, SF_5^-, and F^- in SF_6: Implication for Interpretations of Existing Ion Transport and Breakdown Probability Data**, Proceedings of IX International Conference on Gas Discharges and Their Applications, Venice, Italy, September 19-23, 1988, pp. 363-366 (Bennetton Editore, Padova, Italy, 1988).

Collisional electron-detachment cross sections for SF_6^-, SF_5^-, and F^- on SF_6 target gas have been measured for relative (center-of-mass) energies in the range of 3 to 250 eV. Apparent thresholds for direct detachment are observed at 90 eV for SF_6^- and SF_5^-, and at 8 eV for F^-. Cross sections for ion-conversion processes that compete with detachment are reported and indicate the necessity to re-examine ion-conversion rates determined in SF_6 from drift-tube data. The measured cross sections are used in a theoretical model which invokes detachment from long-lived, energetically unstable states of collisionally excited SF_6^- to explain the pressure dependence of previously measured detachment coefficients and the high detachment thresholds implied by analysis of breakdown-probability data for SF_6. The model indicates that at high pressure, measured detachment coefficients appear to depend primarily upon ion-conversion and direct detachment rates for processes involving F^-.
[Contact: James K. Olthoff, (301) 975-2427]

Van Brunt, R.J., and Kulkarni, S.V., **Stochastic Properties of Negative Corona (Trichel) Pulses in SF_6/O_2 Mixtures**, Proceedings of the 9th International Conference on Gas Discharges and Their Applications, Venice, Italy, September 19-23, 1988, pp. 227-230 (Bennetton Editore, Padova, Italy, 1988).

The statistical probability distributions of discharge pulse amplitude, $p_o(q)$, pulse time interval, $p_o(\Delta t)$, and pulse amplitude for a given time separation, Δt, from the previous pulse, $p_1(q|\Delta t)$ have been measured for Trichel-type negative point-plane corona in SF_6/O_2 gas mixtures as functions of point-to-plane voltage and mixture ratio. The results reveal significant, previously unrecognized correlations among the amplitudes and time intervals of successive discharge pulses which are consistent current theoretical descriptions of the phenomenon. As the SF_6 content in SF_6/O_2 mixtures is increased, the growth of negative corona pulses diminishes as reflected in lower mean pulse amplitudes and the pulses appear more randomly in time; i.e., there is a broadening of the pulse time-interval distributions.
[Contact: Richard J. Van Brunt, (301) 975-2425]

Power Systems Metrology (cont'd.)

Van Brunt, R.J., and Siddagangappa, M.C., **Identification of Corona Discharge-Induced SF_6 Oxidation Mechanisms Using SF_6-$^{18}O_2$-$H_2{}^{16}O$ and SF_6-$^{16}O_2$-$H_2{}^{18}O$ Gas Mixtures**, Plasma Chemistry and Plasma Processing, Vol. 8, No. 2, pp. 207-223 (Plenum Publishing Corporation, June 1988).

The absolute yields of gaseous oxyfluorides SOF_2, SO_2F_2, SOF_4, from negative, point-plane corona discharges in pressurized gas mixtures of SF_6 with O_2 and H_2O enriched with $^{18}O_2$ and $H_2{}^{18}O$ have been measured using a gas chromatograph-mass spectrometer. The predominant SF_6 oxidation mechanisms have been revealed from a determination of the relative ^{18}O and ^{16}O isotope content of the observed oxyfluoride by-products. The results are consistent with previously proposed production mechanisms and indicate that SOF_2 and SO_2F_2 derive oxygen predominantly from H_2O and O_2, respectively, in slow, gas-phase reactions involving SF_4, SF_3, and SF_2 that occur outside of the discharge region. The species SOF_4 derives oxygen from both H_2O and O_2 through fast reactions in the active discharge region involving free radicals or ions such as HO and O, with SF_5 and SF_4.
[Contact: Richard J. Van Brunt (301) 975-2425]

Van Brunt, R.J., Sieck, L.W., Sauers, I., and Siddagangappa, M.C., **Transfer of F^- in the Reaction of SF_6^- with SOF_4: Implications for SOF_4 Production in Corona Discharges** [original title: Transfer of F^- in SF_6^- + SOF_4 Collisions and Its Influence on SOF_4 Yield from Corona Discharges in Gases Containing SF_6], Plasma Chemistry and Plasma Processing, Vol. 8, No. 2, pp. 225-246 (Plenum Publishing Corporation, June 1988).

The temperature (T) and electric field-to-gas pressure (E/P) dependences of the rate constant k for the reaction $SF_6^- + SOF_4 \rightarrow SOF_5^- + SF_5$ have been measured. For $T < 270$ K, k approaches a constant of 2.1×10^{-9} cm^3/s, and for 433 K > T > 270 K, k decreases with T according to $k(cm^3/s) = 0.124 \exp(-3.3\ \ell n\ T(k))$. For $E/P < 60$ V/cm·torr, k has a constant value of about 2.5×10^{-10} cm^3/s, and for 130 V/cm·torr, the rate is approximately given by $k(cm^3/s) \approx 7.0 \times 10^{-10} \exp(-0.022\ E/P)$. This reaction is shown to be important in controlling the yield of SOF_4 from corona discharges in gas mixtures containing SF_4 amd at least trace amounts of O_2 and H_2O. The observed behavior of SOF_4 production rates for negative, point-plane corona discharges is analyzed using k in a chemical kinetics model of the ion-drift region in the discharge gap, and it is shown that competing reactions not involving SOF_4 are effective in deactivating SF_6^-.
[Contact: Richard J. Van Brunt, (301) 975-2425]

Superconductors

Ekin, J.W., **Relationships Between Critical Current and Stress in NbTi** [original title: Critical Current vs Stress Relationships in NbTi Superconductors], IEEE Transactions on Magnetics, Vol. MAG-23, No. 2, pp. 1634-1637 (March 1987).

The effects of various types of stress on the critical current of a multifilamentary NbTi superconductor are reported. Degradation of critical current due to axial tension applied at 4 K, transverse compression applied at 4 K, and hairpin bending strain applied at room temperature has been measured. The degradation from axial tension is much greater than from transverse compression in many practical cases because the soft copper matrix limits the buildup of transverse compression. The degradation from typical levels of transverse compression is only about 4% at 8 T, for example. For axial tension, on the other hand, higher stresses can occur that will degrade the critical current by 24%, for example, at 7 T and

Superconductors (cont'd.)

2.7% strain. Both the axial-tensile and the transverse-compressive stress effects are about 98% reversible; thus the degradation will be seen only when the conductor is under operational stress. The results indicate that a primary origin of the critical current degradation in NbTi is a stress-induced reversible decrease in the upper critical field.
[Contact: John W. Ekin, (303) 497-5448]

Ekin, J.W., Larson, T.M., Bergren, N.F., Nelson, A.J., Swartzlander, A.B., Kazmerski, L.L., Panson, A.J., and Blankenship, B.A., **High T_c Superconductor/Noble-Metal Contacts with Surface Resistivities in the 10^{-10} $\Omega \cdot cm^2$ Range**, Applied Physics Letters, Vol. 52, No. 21, pp. 1819-1821 (May 23, 1988).

Contact surface resistivities (product of contact resistance and area) in the 10^{-10} $\Omega \cdot cm^2$ range have been obtained for both silver and gold contacts to high-T_c superconductors. This is a reduction by about eight orders of magnitude from the contact resistivity of indium-solder connections, low enough to be considered for interconnect applications. The contacts were formed by sputter depositing either silver or gold at low temperatures (<100°C) on a clean surface of $YBa_2Cu_3O_{7-\delta}$ (YBCO) and later annealing the contacts in oxygen. Annealing temperature characteristics show that for bulk-sintered YBCO samples, there is a sharp decrease in contact resistivity after annealing silver/YBCO contacts in oxygen for 1 h at temperatures above ~500°C and gold/YBCO contacts for 1 h above ~600°C. Oxygen annealing for longer times (8 h) did not reduce the contact resistivity of silver contacts as much as annealing for 1 h. Auger microprobe analysis shows that indium/YBCO contacts contain a significant concentration of oxygen in the indium layer adjacent to the YBCO interface. Silver and gold contacts, on the other hand, contain almost no oxygen and have favorable interfacial chemistry with low oxygen affinity. Silver also acts as a "switchable" passivation buffer, allowing oxygen to penetrate to the YBCO interface at elevated temperatures, but protecting the YBCO surface at room temperature.
[Contact: John W. Ekin, (303) 497-5448]

Kamper, R.A., and Clark, A.F., **Superconductivity: Challenge for the Future**, Journal of Research of the National Bureau of Standards, Vol. 92, No. 6, pp. 391-392 (November-December 1987).

This is a brief report on the Federal Conference on Commercial Applications of Superconductivity, Washington, DC, July 28-29, 1987.
[Contact: Robert A. Kamper, (303), 497-3535]

Moreland, J., Beall, J.A., Ono, R.H., and Clark, A.F., **Recent Tunneling Measurements of 90 K Superconductors at NBS**, Proceedings of Materials Research Society Spring Meeting, Symposium K, High-T_c Superconductors, Reno, Nevada, April 5-9, 1988, (Materials Research Society, Pittsburgh, Pennsylvania, 1988), pp. 351-353.

Several tunneling measurements on oxide superconductors have been made at NBS in the last year. These include break junction tunneling measurements of the energy gap, break junction superconducting point contacts, and the operation of a break junction point contact radio-frequency superconducting quantum interference device (SQUID) above 77 K. Until recently, these tunneling experiments have been limited to bulk samples cut from sintered pellets and a few small single crystals. We present here further results on thin films of $YBa_2Cu_3O_x$ (YBCO) using squeezable electron tunneling (SET) junctions. In contrast to the break junction tunneling experiments on bulk samples, where quite often tunneling spectra are without energy gap features, the spectra for thin-film SET junctions are rich with

Superconductors (cont'd.)

structure.
[Contact: John Moreland, (303) 497-3641]

Moreland, J., Clark, A.F., Damento, M.A., and Gschneider, K.A., Jr., **Single Crystal $HoBa_2Cu_3O_x$ Break Junctions**, Physics C, Proceedings of the International Conference on High Temperature Superconductors - Materials and Mechanisms of Superconductivity, Interlaken, Switzerland, February 29-March 4, 1988 (North-Holland Physics Publishing Division, North-Holland, Amsterdam, 1988), pp. 1383-1384.

Tunneling spectra of $HoBa_2Cu_3O_x$ single crystals using the break junction method show energy gap features. These features are variable from junction to junction possibly due to an anisotropic gap function. The I-V curves show the peculiar square law dependence of the current on voltage seen in many tunneling measurements of polycrystalline samples of 90-K superconductors. This may be an indication of an inherent "granularity" built into the superconducting matrix of a single crystal.
[Contact: John Moreland, (303) 497-3641]

Moreland, J., Goodrich, L.F., Ekin, J.W., Capobianco, T.E., and Clark, A.F., **Break Junctions I**, NBSIR 88-3090 (May 1988).

Measurements of the tunneling current-voltage characteristics of break junctions in conventional superconductors can be used to determine their superconducting energy gap as a function of energy. These results agree with those previously obtained using traditional oxide tunneling barriers. Break junctions in some exotic superconductors, on the other hand, have anomalous current-voltage characteristics compared to BCS theory predictions. Energy gaps and the Josephson effect measurement for the new high T_c materials YBaCuO (T_c = 93 K) and LaSrCuO (T_c = 36 K) indicate that the samples are inhomogeneous with varying gap functions depending on the location of the tunneling contact within the break junction fracture. Break junction data for these materials are within the strong coupling limits of BCS theory.
[Contact: John Moreland, (303) 497-3641]

ELECTROMAGNETIC INTERFERENCE

Radiated Electromagnetic Interference

Crawford, M.L., and Ladbury, J.M., **Mode-Stirred Chamber for Measuring Shielding Effectiveness of Cables and Connectors, An Assessment of MIL-STD-1344A Method 3008**, Proceedings of the 1988 IEEE International Symposium on Electromagnetic Compatibility, Seattle, Washington, August 2-4, 1988, pp. 30-36 (1988).

The mode-stirred method for measuring the shielding effectiveness (SE) of cables and connectors as specified in MIL-STD-1344A Method 3008 is examined. Problems encountered in applying the method are identified and recommendations are provided to improve the measurement results. These include chamber design, type and placement of transmitting and reference receiving antenna, determination and correction for VSWR of the reference antenna and equipment under test, and the measurement approach to use at specified test frequencies. Design and measurement setups for a small mode-stirred chamber suitable for performing SE measurements in the frequency range from 1 to 18 GHz with dynamic ranges up to 130 dB are given along with SE measurement results of some sample equipment.
[Contact: Myron L. Crawford, (303) 497-5497]

Ma, M.T., **Understanding Reverberating Chambers as an Alternative Facility for EMC Testing**, Journal of Electromagnetic Waves and Applications, Vol. 2, Nos. 3/4, pp. 339-351 (1988).

Radiated EMI (cont'd.)

A relatively new facility called a reverberating chamber designed for electromagnetic compatibility (EMC) testing is described. The purpose is to create a statistically uniform electric field inside a metal enclosure for testing radiated susceptibility or immunity of equipment. Design criteria in terms of the number of cavity modes, mode density, and composite quality factor are presented in detail in order to understand the physical insight and to enhance interpretations of measurement results. Recent experimental data are included to illustrate the underlying principle.
[Contact: Mark T. Ma, (303) 497-3800]

Wilson, P.F., Ondrejka, A.R., and Ma, M.T., **Fields Radiated by Electrostatic Discharges**, Proceedings of the IEEE International Symposium on Electromagnetic Compatibility, Seattle, Washington, August 2-4, 1988, pp. 179-183 (1988).

Electrostatic discharge (ESD) can be a serious threat to electronic equipment. To date, metrology efforts have focused primarily on ESD-associated currents in order to develop test simulators. Significantly less work has been done on the ESD-radiated fields. This paper examines the fields problem, both theoretically and experimentally. Measurements indicate that the electric fields can be quite significant (>150 V/m at a distance of 1.5 m), particularly for relatively low voltage sparks (<6 kV). A theoretical dipole model for the ESD spark is developed to compute the radiated fields if the required current waveform can be modeled based on measurements. The agreement between theory and experiment is good. The model may be used to predict the fields for a wide range of possible discharge configurations.
[Contact: Mark T. Ma, (303) 497-3800]

Conducted Electromagnetic Interference

Martzloff, F.D., **Surge Testing: Don't Kid Yourself, Don't Kill Yourself**, EMC Technology and Interference Control News, Vol. 7, No. 5, pp. 35-38 (July-August 1988).

Increasing awareness of the sensitivity of electronics to surge effects has led to a proliferation of surge suppressors on the market. Confronted with a difficult choice, some users are evaluating the performance of these devices by surge testing. However, the techniques involved in these tests are different from typical electromagnetic compatibility (EMC) testing because of the single-shot nature of the event and because of the potential personal hazards involved in surge testing. This article presents a brief overview of surge testing, focusing on the techniques required in performing valid tests under safe conditions.
[Contact: Francois D. Martzloff, (301) 975-2409]

Martzloff, F.D., and Leedy, T.F., **Electrical Fast Transient Tests: Applications and Limitations**, Proceedings of the IEEE Industrial Applications Society 35th Annual Petroleum & Chemical Industry Conference, Dallas, Texas, September 12-14, 1988 (Institute of Electrical and Electronics Engineers, Inc., New York, New York, September 1988), pp. 1-8.

The Technical Committee TC 65 of the International Electrotechnical Commission (IEC) has promulgated a new document (IEC 801-4) requiring demonstration of the immunity of industrial process control equipment to fast transients occurring in power and data lines. These fast transients contain high-frequency components, intuitively expected to suffer greater attenuation than the lower-frequency components as they propagate along the lines. Quantifying this intuitive expectation provides a perspective on the severity of the situation and helps in defining realistic test requirements. To that end, this paper describes specific

Conducted EMI (cont'd.)

measurements conducted for typical low-voltage power line configurations; modeling of the attenuation provides a tool for understanding the significance of the line parameters and extends the usefulness of results to general cases. [Contact: Francois D. Martzloff, (301) 975-2409]

ADDITIONAL INFORMATION

DC & Low Frequency Metrology

Field, B.F., and Ruimin, L., **An Improvement in the Reliability of Standard Cell Enclosures**, Journal of Research of the National Bureau of Standards, Vol. 93, No. 4, pp. 533-537 (July-August 1988).

We describe the design of a new temperature-regulation circuit, which is used as an outer oven controller for new standard cell enclosures, with the emphasis on improving the reliability of the temperature control. A redundant protection circuit is used to prevent loss of temperature control caused by component failures in the controller. The temperature control of the outer oven of the enclosure is better than 0.4 mK per °C change in ambient temperature. When used with the additional inner controller, the sensitivity of the cell temperature to the ambient temperature is improved to 20 μK/°C. This paper describes in detail the new circuit, summarizes the enclosure construction, and presents data on the performance of the system. [Contact: Bruce F. Field, (301) 975-4230]

Peterson, R.L., and Oldham, N.M., **Josephson ac Voltmeter**, Journal of Applied Physics, Vol. 63, No. 10, pp. 4804-4810 (May 15, 1988).

A technique for accurate measurement of ac voltages with Josephson junctions is described. Based on the counting of pulses generated by a Josephson junction, the method may be capable of precision at the ppm level for frequencies less than 100 kHz. [Contact: Robert L. Peterson, (303) 497-3750]

Turgel, R.S., Mulrow, J.M., and Vecchia, D.F., **NBS Phase Angle Calibration Services**, NBS Special Publication 250-26 (May 1988).

The National Institute of Standards and Technology/NIST (formerly National Bureau of Standards/NBS) offers a calibration service for audio-frequency phase meters. The calibrations are based on a phase angle standard developed at NIST that generates two sinusoidal signals displaced relative to each other by a precisely known phase angle over a frequency range of 2 Hz to 50 kHz. The signal amplitudes are independently adjustable on each channel from 0.5 to 100 V. The angular resolution is better than 0.002° at the low end of the frequency range and decreases to 0.005° at the high end. The uncertainty of the phase angle between the two signals generated by the standard varies from 0.005° to 0.04°, depending on frequency and amplitude.

Using the phase angle standard, phase meter readings are obtained at selected test points. From the calibration data, the phase meter response characteristic is determined and is compared to that of an ideal meter having a linear characteristic. If the phase meter response conforms to the linear model, a straight-line calibration curve is derived from the data and serves to calculate corrected readings. From the statistical parameters associated with the calibration curve, it is possible to estimate the limits of offset between the calibrated meter and the calibration standard. By extension, the uncertainty of readings of the phase meter in the user's laboratory can be estimated. [Contact: Raymond S. Turgel, (301) 975-2420]

Lists of Publications

Reidy, A.M., and Gibson, K.A., **A Bibliography of the NIST Electromagnetic Fields Division Publications**, NISTIR 88-3900 (September 1988).

This bibliography lists publications by the staff of the National Bureau of Standards' Electromagnetic Fields Division for the period from January 1970 through August 1988. Selected earlier publications from the Division's predecessor organizations are included.
[Contact: Kathryn A. Gibson, (303) 497-3132]

Kline, K.E., and DeWeese, M.E., **Metrology for Electromagnetic Technology: A Bibliography of NBS Publications**, NBSIR 87-3074 (June 1987).

This bibliography lists the publications of the personnel of the Electromagnetic Technology Division of NBS in the period from January 1970 through December 1986. A few earlier references that are directly related to the present work of the Division are included.
[Contact: Sarabeth Moynihan, (303) 497-3678]

Palla, J.C., and Meiselman, B., **Electrical and Electronic Metrology: A Bibliography of NBS Electrosystems Division Publications, NBS List of Publications 94** (January 1988).

This bibliography covers publications of the Electrosystems Division, Center for Electronics and Electrical Engineering, NBS, and of its predecessor sections for the period January 1963 to January 1988. 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, NBS List of Publications 72** [a bibliography of NBS publications concerning semiconductor measurement technology for the years 1962-1987] (March 1988).

This bibliography contains reports of work performed at the National Bureau of Standards in the field of Semiconductor Measurement Technology in the period from 1962 through December 1987. An index by topic area and a list of authors are provided.
[Contact: E. Jane Walters, (301) 975-2050]

R&D 100 AWARD WINNER

Image-Preserving Optical Delay

Edward F. Kelley of the Electrosystems Division is the recipient of an R&D 100 Award in 1988 for developing the first practical optical system capable of providing high-quality images with significant delays and applied it to the analysis of nanosecond-scale electrical discharge events. The delay system uses one 0.3-m diameter concave mirror and a special array of smaller mirrors located about 4 m from the concave mirror to provide a delay of up to 390 ns, based on the travel time of light reflected some thirty times between the mirrors. Diffraction and astigmatism effects make it impractical to achieve such a delay in an image-preserving system with either a single-reflection system with the mirrors widely spaced or a conventional folded-beam mirror arrangement. While others have demonstrated single-pass image-preserving optical systems providing short delays, the Division believes that the NIST system is the first to provide useful delays of over 100 ns. The system is part of new apparatus for examining the onset of nonosecond-scale electrical discharges. The challenge is akin to that of taking picutres of lightning with only a fast shutter speed available: you don't know when the lightning discharge will occur. In this case, the shutter speed is as fast as 1/100,000,000 of a second. In collaboration with a team from the University of Tennessee (UT), the Division has developed a system for taking pictures of these very fast

R&D 100 Award Winner (cont'd.)

discharge events as they develop. The UT team designed a special amplifier that detects the initial rise in current as the discharge begins. By the time the discharge is detected, it is too late to actuate even the very fast Pockels-cell camera shutter designed by Division Guest Worker, M. Nehmadi. The delay system solves this problem by storing the image long enough to allow the camera to record it. The Division believes the delay system will have wide applicability in the study of randomly occurring nanosecond- and subnanosecond-scale events and has applied for a patent.
[Contact: Robert E. Hebner, (301) 975-2659]

RECENTLY ISSUED
STANDARD REFERENCE MATERIALS

The Semiconductor Electronics Division announces the release of a new Standard Reference Material (SRM) for **ellipsometrically derived thickness and refractive index of a silicon dioxide film on silicon**. Available for sale to the public through the NIST Office of Standard Reference Materials [for orders, (301) 975-6776], SRM 2530 is separately available for three oxide thicknesses: 50 nm (2530-1), 100 nm (2530-2), and 200 nm (2530-3).

This SRM was developed to respond to industry needs to evaluate the accuracy of ellipsometers, but may also be used as aid in the calibration of various other optical and mechanical thickness monitoring instruments.

Each SRM consists of a 76-mm (3-in.) diameter silicon wafer on which a uniform silicon dioxide layer was grown, patterned, and partially covered with chromium. The certified values were determined from measurements made using the highly accurate ellipsometer developed in the Division and are the ellipsometric parameters delta, Δ, and psi, ψ, at a wavelength of λ = 632.8 nm. The SRMs are also certified for the derived values of thickness and refractive index of its silicon dioxide layer determined by using a two-layer model consisting of a silicon dioxide layer on a thin silicon-rich oxide interlayer. [Contact: Deane Chandler-Horowitz, (301) 975-2084]

1989 CEEE CALENDAR

June 12-15, 1989 (Gaithersburg, MD)

International Conference on Narrow Gap Semiconductors and Related Materials. Jointly sponsored by the National Institute of Standards and Technology, the U.S. Air Force Office of Scientific Research, the American Physical Society, National Science Foundation, the U.S. Office of Naval Research, Texas Instruments, and the University of North Texas, this conference is the first in the narrow gap field since 1981. The scope of the conference includes such topics as crystal growth and new materials; two-dimensional physics; surfaces and interfaces; superlattices and heterostructures; transport; impurities and defects; optical properties; nonlinear optical effects; device physics; lattice properties; and hot or nonequilibrium carrier effects.
[Contact: David G. Seiler, (301) 975-2081]

September 11-13, 1989 (Garmisch-Partenkirchen, FDR)

VLSI and GaAs Chip Packaging Workshop. The IEEE CHMT Society and the National Institute of Standards and Technology are co-sponsoring the Eighth VLSI Packaging Workshop. Topics to be discussed include VLSI package design; integrated package design; multichip module design; WSI packaging; package thermal design; package electrical design; GaAs IC packaging; VLSI package interconnection options; VLSI package materials and die-attach solutions; and failure mechanism and quality of VLSI packages. All attendees are expected to be specialists working in the field and

CEEE Calendar (cont'd.)

to participate in discussions. [Contact: George G. Harman, (301) 975-2097]

December 10-11, 1989 (Gaithersburg, MD)

Power Semiconductor Devices Workshop. This Workshop, sponsored jointly by IEEE and NIST, is intended to bring together for interactive participation those actively working in the field of power semiconductor devices. It will be held in conjunction with the 1989 IEEE International Electron Devices Meeting in Washington, DC. Four specific topic areas have been selected: power and high voltage integrated circuits, discrete devices, device and circuit simulation, and packaging. In addition, a special panel on power electronics education will be held. This year's Workshop will specifically solicit attendance from device and circuit users as well as device researchers. Attendees are expected to be prepared to contribute to the development of responses to specific questions that arise in the context of the particular topic areas; a final schedule should be available at the end of October. [Contact: David L. Blackburn, (301) 975-2068]

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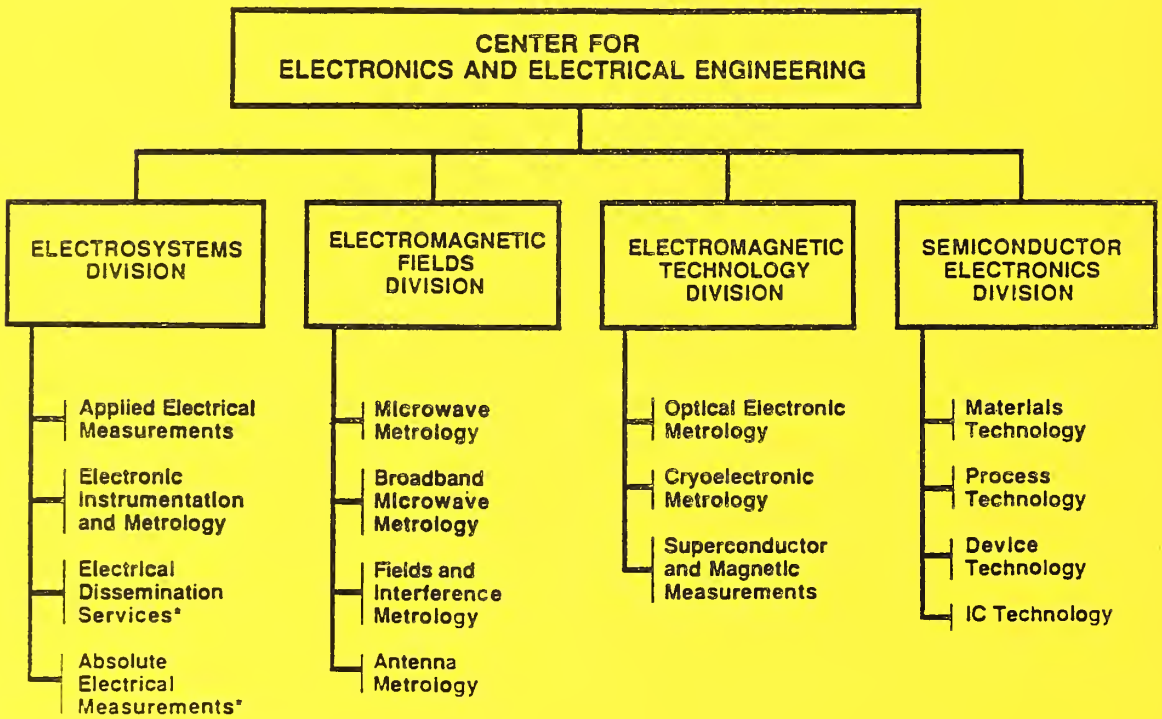

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