NISTIR 5872

Electronics and Electrical Engineering Laboratory

J. M. Rohrbaugh
Compiler

Technical Publication Announcements

47

Covering Laboratory Programs,
October to December 1995,
with 1996 EEEL Events Calendar

U.S. DEPARTMENT OF COMMERCE
Technology Administration
National Institute of Standards
and Technology

NIST

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Electronics and Electrical
Engineering Laboratory
Semiconductor Electronics Division
Gaithersburg, MD 20899

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U.S. DEPARTMENT OF COMMERCE
Michael Kantor, Secretary
TECHNOLOGY ADMINISTRATION
Mary L. Good, Under
Secretary for Technology
NATIONAL INSTITUTE OF STANDARDS
AND TECHNOLOGY
Arati Prabhakar, Director

INTRODUCTION TO THE EEEL TECHNICAL PUBLICATION ANNOUNCEMENTS

This is the forty-seventh issue of a quarterly publication providing information on the technical work of the National Institute of Standards and Technology Electronics and Electrical Engineering Laboratory (EEEL). This issue of the EEEL Technical Publication Announcements covers the fourth quarter of calendar year 1995.

Organization of Bulletin: This issue contains citations and abstracts for Laboratory 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 Laboratory conferences and workshops planned for calendar year 1996 and a list of sponsors of the work.

Electronics and Electrical Engineering Laboratory: EEEL 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 Laboratory is conducted by five technical research Divisions: the Semiconductor Electronics and the Electricity Divisions in Gaithersburg, Md., and the Electromagnetic Fields, Electromagnetic Technology Divisions, and the newly formed Optoelectronics Division in Boulder, Colo. The Office of Law Enforcement Standards conducts research and provides technical services to the U.S. Department of Justice and State and local governments, and other agencies in support of law enforcement activities. In addition, the Office of Microelectronics Programs (OMP) coordinates the growing number of semiconductor-related research activities at NIST. Reports of work funded through the OMP are included under the heading "Semiconductor Microelectronics."

Key contacts in the Laboratory are given on the inside back cover; readers are encouraged to contact any of these individuals for further information. To request a subscription or for more information on the Bulletin, write to EEEL Technical Progress Bulletin, National Institute of Standards and Technology, Metrology Building, Room B-358, Gaithersburg, MD 20899 or call (301) 975-2220.

Laboratory Sponsors: The Laboratory 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 24.

Note on Publication Lists: Publication lists covering the work of each division are guides to earlier as well as recent work. 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 22.

Certain commercial equipment, instruments, or materials are identified in this paper in order to specify adequately the experimental procedures. Such identification does not imply recommendation or endorsement by the National Institute of Standards and Technology, nor does it imply that the materials or equipment identified are necessarily the best available for the purpose.

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Internet Access (World Wide Web): http://www.eeel.nist.gov

TO LEARN MORE ABOUT THE LABORATORY....

Two general documents are available that may be of interest. These are ***Measurements for Competitiveness in Electronics*** and ***EEEL 1994 Technical Accomplishments, Supporting Technology for U.S. Competitiveness in Electronics***. The first identifies measurement needs for a number of technical areas and the general importance of measurements to competitiveness issues. The findings of each chapter dealing with an individual industry have been reviewed by members of that industry. The second presents selected technical accomplishments of the Laboratory for the period October 1, 1993 through September 30, 1994. A brief indication of the nature of the technical achievement and the rationale for its undertaking are given for each example. A longer description of both documents follows:

EEEL 1995 Technical Accomplishments, Supporting Technology for U.S. Competitiveness in Electronics, NISTIR 5818 (December 1995).

The Electronics and Electrical Engineering Laboratory, working in concert with other NIST Laboratories, is providing measurement and other generic technology critical to the competitiveness of the U.S. electronics industry and the U.S. electricity-equipment industry. This report summarizes selected technical accomplishments and describes activities conducted by the Laboratory in FY 1995 in the field of semiconductors, magnetics, superconductors, low-frequency microwaves, lasers, optical fiber communications and sensors, video, power, electromagnetic compatibility, electronic data exchange, and national electrical standards. Also included is a profile of EEEL's organization, its customers, and the Laboratory's long-term goals.

EEEL is comprised of five technical divisions, Electricity and Semiconductor Electronics in Gaithersburg, Maryland, and Electromagnetic Fields, Electromagnetic Technology, and Optoelectronics in Boulder, Colorado. Through two offices, the Laboratory manages NIST-wide programs in microelectronics and law enforcement.
[Contact: JoAnne Surette, (301) 975-5267]

Measurements for Competitiveness in Electronics, NISTIR 4583 (April 1993).

Measurements for Competitiveness in Electronics identifies for selected technical areas the measurement needs that are most critical to U.S. competitiveness, that would have the highest economic impact if met, and that are the most difficult for the broad range of individual companies to address. The document has two primary purposes: (1) to show the close relationship between U.S. measurement infrastructure and U.S. competitiveness and show why improved measurement capability offers such high economic leverage, and (2) to provide a statement of the principal measurement needs affecting U.S. competitiveness for given technical areas, as the basis for a possible plan to meet those needs, should a decision be made to pursue this course.

The first three chapters, introductory in nature, cover the areas of: the role of measurements in competitiveness, NIST's role in measurements, and an overview of U.S. electronics and electrical-equipment industries. The remaining nine chapters address individual fields of electronic technology: semiconductors, magnetics, superconductors, microwaves, lasers, optical-fiber communications, optical-fiber sensors, video, and electromagnetic compatibility. Each of these nine chapters contains four basic types of information: technology review, world markets and U.S. competitiveness, goals of U.S. industry for competitiveness, and measurement needs. Three appendices provide definitions of the U.S. electronics and electrical-equipment industries.

This document is a successor to NISTIR 90-4260, *Emerging Technologies in Electronics ... and their measurement needs* [Second Edition].
[Contact: Ronald M. Powell, (301) 975-2220]

FUNDAMENTAL ELECTRICAL MEASUREMENTS

Benz, S.P., **Superconductor-Normal-Superconductor Junctions for Programmable Voltage Standards**, Applied Physics Letters, Vol. 67, No. 18, (30 October 1995). [A similar paper has appeared in the Extended Abstracts of the Fifth International Superconductive Electronics Conference, Nagoya, Japan, September 18-21, 1995, pp. 216-218.]

Series arrays of Nb-PdAu-Nb Josephson junctions were fabricated with characteristics ideally suited for application in programmable voltage standards and D/A converters with fundamental accuracy. Large arrays of junctions with applied microwave power showed constant voltage steps with current amplitudes as large as 7 mA. A novel coplanar waveguide design has enabled uniform microwave power coupling to a five-segment array of 8192 junctions, so each segment had constant voltage steps over the same bias range. The 8192-junction device generated 1.1 mA steps at 186 mV with 11 GHz power and a maximum constant voltage step of 260 mV at 15.34 GHz.
[Contact: Samuel P. Benz, (303) 497-5258]

Cage, M.E., and Lavine, C.F., **Potential and Current Distributions Calculated Across a Quantum Hall Effect Sample at Low and High Currents**, Journal of Research of the National Institute of Standards and Technology, Vol. 100, pp. 529-541 (September—October 1995).

The potential and current distributions are calculated across the width of a quantum Hall effect sample for applied currents between 0 μA and 225 μA. For the first time, both a confining potential and a current-induced charge-redistribution potential are used. The confining potential has a parabolic shape, and the charge-redistribution potential is logarithmic. The solution for the sum of the two types of potentials is unique at each current, with no free parameters. For example, the charge-depletion width of the confining potential is determined from a localization experiment by Choi, Tsui, and Alavi, and the spatial extent of the conducting two-dimensional electron gas across the sample width is obtained from the maximum electric field deduced from a high-current breakdown experiment by Cage and Lavine, and from the quantum Hall voltage. The spatial extent has realistic cut-off values at the sample sides; e.g., no current flows within 55 magnetic lengths of the sides for currents less than 215 μA. The calculated potential distribution are in excellent agreement with contactless electro-optic effect laser beam measurements of Fontein et al.
[Contact: Marvin E. Cage, (301) 975-4224]

Cage, M.E., and Lavine, C.F., **Using Quantized Breakdown Voltage Signals to Determine the Maximum Electric Fields in a Quantum Hall Effect Sample**, Journal of Research of the National Institute of Standards and Technology, Vol. 100, pp. 269-276 (May—June 1995).

We estimate the maximum values of the electric field across the width of GaAs/AlGaAs heterostructure quantum Hall effect sample at several currents when the sample is in the breakdown regime. This estimate is accomplished by measuring the quantized longitudinal voltage drops along a length of the sample and then employing a quasi-elastic inter-Landau level scattering (QUILLS) model to calculate the electric field. We also present a pictorial description of how QUILLS transitions occurring between states distributed across the sample width can be detected as voltage signals along the sample length.
[Contact: Marvin E. Cage, (301) 975-4249]

Clark, A.F., and Steiner, R.L., **Noise Characteristics Below 1 Hz of Zener Diode-Based Voltage References**, Abstracts in the Bulletin of the American Physical Society Meeting, San Jose, California, March 13-17, 1995, p. 90.

The short- and mid-term noise of voltage references based on Zener diodes are the limiting factors in the accuracy of their application as voltage standards. Although these references are relatively rugged, survive the rigors of shipping, and have predictable long-term behavior, they do have noise in the voltage output values with a time dependence about the same as the desired measurement intervals. We have characterized several of these references in the frequency range of 10^{-1} to 10^{-6} Hz (time intervals of seconds to months) by direct comparison to a Josephson array voltage standard at the 10 and 1 V with nanovolt precision. Several distinctly different regions of noise characteristics are observed. Comparisons are made with 1/f and

other expected behaviors and resulting accuracy limitations are discussed.
[Contact: Alan F. Clark, (301) 975-2139]

Clark, A.F., Zimmerman, N.M., Williams, E.R., Amar, A., Song, D., Wellstood, F.C., Lobb, C.J., and Soulen, R.J., Jr., **Application of Single Electron Tunneling: Precision Capacitance Ratio Measurements**, Applied Physics Letters, Vol. 66, No. 19, pp. 2588-2590 (8 May 1995).

A metrological application is reported of the single electron tunneling (SET) phenomena: a precise measurement of the ratio of two cryogenic capacitors. The measurement used a superconducting SET electrometer as the null detector for a capacitance bridge. A 3 ppm level of imprecision has been achieved in the measurement of the capacitance ratio from 100 to 1000 Hz. Further improvements can be made in the attempt to obtain an imprecision of 10^{-8} at lower frequencies, sufficient for the metrological measurement of capacitance or the fine-structure constant using a SET pump.
[Contact: Alan F. Clark, (301) 975-2139]

Early, E.A., Clark, A.F., and Lobb, C.J., **Physical Basis for Half-Integral Shapiro Steps in a DC SQUID**, Physica C, Vol. 245, pp. 308-320 (1995).

[See Cryoelectronic Metrology.]

Elmquist, R.E., and Dziuba, R.F., **A High-Temperature Superconductor Cryogenic Current Comparator**, IEEE Transactions on Instrumentation and Measurement, Vol. 44, No. 2, pp. 262-264 (April 1995). [Also published in Digest of the 1994 Conference on Precision Electromagnetic Measurements, Boulder, Colorado, June 27—July 1, 1994, pp. 136-137.]

[See DC and Low-Frequency Metrology.]

Jeffrey, A., Elmquist, R.E., and Cage, M.E., **Precision Tests of a Quantum Hall Effect Device DC Equivalent Circuit Using Double-Series and Triple-Series Connections**, Journal of Research of the National Institute of Standards and Technology, Vol. 100, pp. 677-685 (November—December 1995).

[See DC and Low-Frequency Metrology.]

Kautz, R.L., **Shapiro Steps in Large-Area Metallic-Barrier Josephson Junctions**, Journal of Applied Physics, Vol. 78, No. 9, pp. 5811-5819 (November 1995).

The current amplitudes of Shapiro steps in large-area metallic-barrier Josephson junctions, both with and without a ground plane, are investigated with the goal of optimizing junction parameters for programmable voltage standards. Using the resistively shunted junction model without capacitance, we calculate maximum step amplitudes as a function of reduced frequency and junction dimension for both one- and two-dimensional junctions. For junctions without a ground plane, we conclude that step amplitudes on the order of 10 mA are practical, but significantly larger amplitudes require excessive microwave power.
[Contact: Richard L. Kautz, (303) 497-3391]

Lee, K.C., **Bonding Wires to Quantized Hall Resistors**, IEEE Transactions on Instrumentation and Measurement, Vol. 44, No. 2, pp. 249-252 (April 1995).

Three different techniques for attaching wires to quantized Hall resistors with gold-germanium-nickel alloyed contacts were evaluated. The best quality and most robust samples were made by evaporating bonding pads that overlapped the alloyed contacts and the substrate, so that bonds could be made over the substrate rather than over the heterostructure.
[Contact: Kevin C. Lee, (301) 975-4236]

SEMICONDUCTOR MICROELECTRONICS

Seiler, D.G., and Shaffner, T.J., **Report on International Workshop on Semiconductor Characterization: Present Status and Future Needs**, Journal of Research of the National Institute of Standards and Technology, Vol. 100, pp. 711-715 (November—December 1995).*

The International Workshop on Semiconductor Characterization: Present Status and Future Needs was held at the National Institute of Standards and Technology from January 30 to February 2, 1995. This comprehensive, "world-class" workshop was

dedicated to summarizing major issues and giving critical reviews of important semiconductor characterization techniques that are useful to the semiconductor industry. Because of the increasing importance of in-line and in-situ characterization methods, the workshop placed a strong emphasis on these methods.

Specific goals of the workshop were: (1) to provide a forum in which measurements and technical issues of current and future interest to the semiconductor industry could be reviewed, discussed, critiqued, and summarized; (2) to demonstrate and review important applications for diagnostics, manufacturing, and in-situ monitoring and control in real-time environments; (3) to provide a silicon integrated circuit process and materials-based view of requirements for off-line, in-line, and in-situ analysis and metrology; (4) to focus attention on the critical and unique requirements related to compound semiconductor materials and devices; and (5) to act as an important stimulus of new progress in the field by providing new perspectives.

The workshop provided a concise and effective portrayal of industry characterization needs and the problems that must be addressed by industry, government, and academia to continue the dramatic progress in semiconductor technology. The workshop proceedings will be published by the American Institute of Physics.
[Contact: David G. Seiler, (301) 975-2054]
*See Announcements under Additional Information.

Compound Materials

Kim, J.S., Seiler, D.G., Lancaster, R.A., and Reine, M.B., **Electrical Characterization of Narrow Gap n-type Bulk HgCdTe Single Crystals by Variable-Magnetic-Field Hall Measurements and Reduced-Conductivity-Tensor Measurements**, Extended Abstracts of the 1995 U.S. Workshop on the Physics and Chemistry of Mercury Cadmium Telluride and Other IR Materials, Baltimore, Maryland, October 10-12, 1995, pp. 31-32.

Variable-magnetic-field-Hall measurements (0 to 1.5 T) are performed on very-narrow-gap bulk-grown HgCdTe single crystals ($0.16 \leq x \leq 0.2$) at various temperatures (10 K to 300 K). The electron densities and mobilities are obtained within the one-carrier (electrons) approximation of the reduced-conductivity-tensor scheme. A definitive, pronounced peak is observed when the electron mobility at 10 K is plotted against the alloy composition x-value which has been predicted due to the effective-mass minimum at the bandgap-crossing ($E_g \approx 0$). The observed position ($x \approx 0.164$), height ($\approx 4 \times 10^2$ m^2/Vs), and width (≈ 0.1 in x) of the mobility-peak can be explained by a simple simulation involving only the ionized-impurity scattering. A lower bound of the effective mass is introduced as a fitting parameter to be consistent with the finiteness of the observed electron mobility and found to be of the order of 10^{-4}.
[Contact: Jin S. Kim, (301) 975-2238]

Analysis and Characterization Techniques

Bullis, W.M., Perkowitz, S., and Seiler, D.G., ***Semiconductor Measurement Technology*: Survey of Optical Characterization Methods for Materials, Processing, and Manufacturing in the Semiconductor Industry**, NIST Special Publication 400-98 (December 1995).

Contactless, nondestructive optical methods are used to characterize many critical properties of materials, processes, and devices in the semiconductor industry. To determine the extent of use and the relative importance of various optical methods in the industry, the Semiconductor Electronics Division of the National Institute of Standards and Technology conducted a survey of this field. The survey also sought to identify both advantages and limitations of these techniques as well as future requirements for and anticipated use of optical characterization methods within the semiconductor industry. Data from 42 firms were analyzed to show the impact of the methods, what they measure, their range and precision, and their cost. A significant finding of the study is the need expressed by many industrial users for improved standards and test methods for optical characterization, especially in the area of film thickness and composition.
[Contact: David G. Seiler, (301) 975-2054]

Device Physics and Modeling

Hefner, A.R., Jr., **Modeling Buffer Layer IGBT's**

for Circuit Simulation, IEEE Transactions on Power Electronics, Vol. 10, No. 2, pp. 111-123 (March 1995).

[See Power Devices.]

Lowney, J.R., **Use of Monte Carlo Modeling for Interpreting Scanning Electron Microscope Linewidth Measurements**, Scanning, Vol. 17, pp. 281-286 (1995).

[See Dimensional Metrology.]

Dimensional Metrology

Linholm, L.W., Allen, R.A., Cresswell, M.W., Ghoshtagore, R.N., Mayo, S., Schafft, H.A., Kramar, J.A., and Teague, E.C., **Measurement of Patterned Film Linewidth for Interconnect Characterization**, Proceedings of the IEEE International Conference on Microelectronic Test Structures, Nara, Japan, March 22-25, 1995, pp. 23-26.

[See Integrated-Circuit Test Structures.]

Linholm, L. W., Allen, R. A., and Cresswell, M. W, **Microelectronic Test Structures for Overlay Metrology**, Nikkei Microdevices, pp. 63-65 (1995) (in Japanese).

[See Integrated-Circuit Test Structures.]

Lowney, J.R., **Use of Monte Carlo Modeling for Interpreting Scanning Electron Microscope Linewidth Measurements**, Scanning, Vol. 17, pp. 281-286 (1995).

A scanning electron microscope (SEM) can be used to measure the dimensions of the microlithographic features of integrated circuits. However, without a good model of the electron-beam/specimen interaction, accurate edge location cannot be obtained. A Monte Carlo code has been developed to model the interaction of an electron beam with one or two lines lithographically produced on a multi-layer substrate. The purpose of the code is to enable one to extract the edge position of a line from SEM measurements. It is based on prior codes developed at NIST, but with a new formulation for the atomic scattering cross sections and the inclusion of a method to simulate edge roughness or rounding. The code is currently able to model the transmitted and backscattered electrons, and the results from the code have been applied to the analysis of electron transmission through gold lines on a thin silicon substrate, such is used in an X-ray lithographic mask. Significant reductions in backscattering occur because of the proximity of a neighboring line.
[Contact: Jeremiah R. Lowney, (301) 975-2048]

Mayo, S., and Schafft, H.A., **Electrical Characterization of Integrated Circuit Metal Line Thickness**, Solid-State Electronics, Vol. 38, No. 12, pp. 1993-2000 (1995).

[See Reliability.]

Integrated-Circuit Test Structures

Linholm, L.W., Allen, R.A., Cresswell, M.W., Ghoshtagore, R.N., Mayo, S., Schafft, H.A., Kramar, J.A., and Teague, E.C., **Measurement of Patterned Film Linewidth for Interconnect Characterization**, Proceedings of the IEEE International Conference on Microelectronic Test Structures, Nara, Japan, March 22-25, 1995, pp. 23-26.

Test results from high-quality electrical and physical measurements on the same cross-bridge resistor test structure with approximately vertical sidewalls have shown differences in linewidth as great as 90 nm for selected conductive films. These differences were independent of design linewidth. As dimensions become smaller, the accurate measurement of the patterned conductor width is necessary to assure predictable timing performance of the interconnect system as well as control of critical device parameters.
[Contact: Loren W. Linholm, (301) 975-2052]

Linholm, L.W., Allen, R.A., and Cresswell, M.W, **Microelectronic Test Structures for Overlay Metrology**, Nikkei Microdevices, pp. 63-65 (1995) (in Japanese).

Control of image placement has been and is expected to remain one of the most important challenges required in the manufacturing of advanced microelectronic devices. By the year

2001, it is anticipated that level-to-level overlay requirements will be approximately 60 nm. The metrology to monitor and evaluate the performance of lithographic tools with those capabilities is lagging. Electrical test structures provide low-cost, post-patterning metrology for overlay that is routinely available during the advanced stages of process development and during manufacturing.
[Contact: Loren W. Linholm, (301) 975-2052]

Mayo, S., and Schafft, H.A., **Electrical Characterization of Integrated Circuit Metal Line Thickness**, Solid-State Electronics, Vol. 38, No. 12, pp. 1993-2000 (1995).

[See Reliability.]

Microfabrication Technology

Yentis, R., Jr., Zincke, C., Zaghloul, M.E., and Gaitan, M., **Micromachined Display Output for a Cellular Neural Network**, Proceedings of the 1995 IEEE International Symposium on Circuits and Systems, Seattle, Washington, April 30—May 3, 1995, pp. 660-663.

A major problem with current Cellular Neural Networks is that the size of the network is partially limited by the number of input/output pins. This paper addresses this issue by combining a thermal pixel with the output of each cell. The output of all of the cells can then be seen in parallel with the aid of a thermal camera or other device located off chip. The layout for the cell is given and discussed. The chip was fabricated through the MOSIS service.
[Contact: Michael Gaitan, (301) 975-2072]

Zincke, C.A., Gaitan, M., and Zaghloul, M.E., **CMOS Circuit Design for Controlling Temperature in Micromachined Devices**, Proceedings of the 37th Midwest Symposium on Circuits and Systems, Lafayette, Louisiana, August 3-5, 1994, pp. 183-186 (1995).

We present a CMOS circuit used for controlling the temperature of a CMOS-compatible micro-heating element, known as a thermal pixel. The circuit uses nonlinear compensation to maintain constant power over large variation in the resistance. An external analog voltage controls the power delivered to the thermal pixel. This circuit was designed and fabricated through the MOSIS service foundry. Measurements are presented that verify the design and performance of the circuit.
[Contact: Christian A. Zincke, (301) 975-2073]

Plasma Processing

Christophorou, L.G., Van Brunt, R.J., and Olthoff, J.K., **Fundamental Processes in Gas Discharges**, Proceedings of the XIth International Conference on Gas Discharges and Their Applications, Tokyo, Japan, September 11-15, 1995, pp. I-536—I-548.

[See Power Systems Metrology.]

Olthoff, J.K., and Greenberg, K.E., **The Gaseous Electronics Conference RF Reference Cell—An Introduction**, Journal of Research of the National Institute of Standards and Technology, Vol. 100, pp. 327-339 (July—August 1995).

This paper provides an introduction to the Gaseous Electronics Conference (GEC) RF Reference Cell, and to the articles published in this Special Issue of the Journal of Research of the National Institute of Standards and Technology. A brief summary of the history and purpose of the Reference Cell concept is presented, and recent changes to the GEC Cell design are documented. The paper concludes with highlights of research performed on GEC Cells, and with an appendix of all known publications that present research performed on GEC Cells.
[Contact: James K. Olthoff, (301) 975-2431]

Olthoff, J.K., Van Brunt, R.J., and Radovanov, S.B., **Studies of Ion Kinetic-Energy Distributions in the Gaseous Electronics Conference RF Reference Cell**, Journal of Research of the National Institute of Standards and Technology, Vol. 100, pp. 383-400 (July—August 1995).

A review is presented of kinetic-energy distribution measurements for ions striking grounded surfaces in a Gaseous Electronics Conference (GEC) rf Reference Cell. Two experimental arrangements that have been used to measure ion energies in the GEC Cell are described, and a comparison of their performance under different operating conditions is presented. Significant results from ion-energy analysis in the Reference Cell are highlighted,

including evidence of effects due to surface conditions on ion sampling, verification of electrical behavior of the cell, inferences about ion-molecule reactions indicated by the shapes of measured ion kinetic-energy distributions (IEDs), and the use of measured IEDs for the validation of theoretical models. The paper concludes with a detailed study of IEDs measured for rf plasmas generated in mixtures of argon and oxygen, using both experimental arrangements.
[Contact: James K. Olthoff, (301) 975-2431]

Van Brunt, R.J., Olthoff, J.K., and Radovanov, S.B., **Kinetic-Energy Distributions of Ions Sampled from Radio-Frequency Discharges in Helium, Nitrogen, and Oxygen**, Proceedings of the Eleventh International Conference on Gas Discharges and Their Applications, Tokyo, Japan, September 11-15, 1995, Vol. 1, pp. I-486—I-489.

Mass-resolved ion kinetic energy distributions are measured for radio-frequency (rf) discharges sustained in helium, nitrogen, and oxygen in a parallel-plate plasma reactor. The dominate ions for each of the gases are observed to be the parent ions He^+, N_2^+, and O_2^+, respectively, over a wide range of pressures (1.3 to 67 Pa) with an applied rf voltage of 200 V. Ion kinetic-energy distributions at the grounded electrode were measured for these ions, as well as for less abundant ions, such as He_2^+, N^+, N_2H^+, N_3^+, N_4^+, O^+, and O_3^+.
[Contact: Richard J. Van Brunt, (301) 975-2425]

Packaging

Marks, R.B., and Williams, D.F., **Accurate Electrical Characterization of High-Speed Interconnections**, Proceedings of the 1994 International Society for Hybrid Microelectronics, Boston, Massachusetts, November 14-17, 1994, pp. 96-101.

[See Microwave and Millimeter-Wave Metrology.]

Power Devices

Hefner, A.R., Jr., **Modeling Buffer Layer IGBT's for Circuit Simulation**, IEEE Transactions on Power Electronics, Vol. 10, No. 2, pp. 111-123 (March 1995).

The dynamic behavior of commercially available buffer layer IGBT's is described. It is shown that buffer layer IGBT's become much faster at high voltages than nonbuffer layer IGBT's with similar low voltage characteristics. Because the fall times specified in manufacturers' data sheets do not reflect the voltage dependence of switching speed, a new method of selecting devices for different circuit applications is suggested. A buffer layer IGBT model is developed and implemented into the Saber circuit simulator, and a procedure is developed to extract the model parameters for buffer layer IGBT's. It is shown that the new buffer layer IGBT model can be used to describe the dynamic behavior and power dissipation of buffer layer IGBT's in user-defined application circuits. The results of the buffer layer IGBT model are verified using commercially available IGBT's.
[Contact: Allen R. Hefner, Jr., (301) 975-2071]

Reliability

Mayo, S., and Schafft, H.A., **Electrical Characterization of Integrated Circuit Metal Line Thickness**, Solid-State Electronics, Vol. 38, No. 12, pp. 1993-2000 (1995).

Resistance measurements of thin aluminum-silicon alloy lines 10 and 30 μm wide, were made at various temperatures in the 9.2 to 295.5 K range. Deviations from Matthiessen's rule were observed over the whole temperature range. At temperatures near room ambient data for these lines are in good agreement with those reported for aluminum-copper alloy wires. A formalism was developed to calculate line thickness and cross-sectional area from electrical resistance data. Line thickness calculation are in good agreement with thickness data measured via scanning electron microscopy. The stress distributions in these lines were modeled by using finite element stress analysis. The results show large stress gradients localized at the line edge region, whereas at the central part of the line there is high stress value and a low stress gradient. In submicrometer lines the whole line body is under large stress gradients.
[Contact: Santos Mayo, (301) 975-2045]

SIGNAL ACQUISITION, PROCESSING, AND TRANSMISSION

DC and Low-Frequency Metrology

Avramov-Zamurovic, S., Stenbakken, G.N., Koffman, A.D., Oldham, N.M., and Gammon, R.W., **Binary vs Decade Inductive Voltage Divider Comparison and Error Decomposition**, IEEE Transactions on Instrumentation and Measurement, Vol. 44, No. 4, pp. 904-908 (August 1995).

[See Waveform Metrology.]

Dziuba, R.F., **Automated Resistance Measurements at NIST**, Proceedings of the 1995 National Conference of Standards Laboratories Workshop and Symposium, Dallas, Texas, July 16-20, 1995, pp. 189-195.

NIST provides a calibration service for dc standard resistors over 17 decades of resistance from 10^{-4} Ω to 10^{12} Ω using seven independent measurement systems. Four measurement systems are completely automated for calibrating resistors from 1 Ω to 1 MΩ. A fifth system for high-resistance measurements is semi-automated. Plans are underway to fully automate this system, along with the remaining two measurement systems. The primary consideration to automate a measurement system is to improve the quality of measurements, and not simply to relieve the operator from tedious repetitive measurements. This paper describes the extent and future plans of resistance measurement automation at NIST.
[Contact: Ronald F. Dziuba, (301) 975-4239]

Elmquist, R.E., **Progress on the Quantized Hall Resistance Recommended Instrinsic/Derived Standards Practice**, Proceedings of the National 1995 Conference of Standards Laboratories Workshop and Symposium, Dallas, Texas, July 16-20, 1995, pp. 647-653.

The quantized Hall resistance (QHR) standard requires characterization tests which determine if and how a particular QHR device should be used as an intrinsic standard. The initial characterization at a qualified QHR laboratory would provide the following: 1) verification that the device resistance was approximately equal to that of other QHR devices under prescribed conditions, 2) assurance that the QHR device meets recognized quality construction standards, 3) determination of the effect of temperature in the range below 1.5 K, and 4) determination of the approximate magnetic flux density which must be applied to measure the QHR standard. The device could then be used as a standard in another laboratory, which would be expected to characterize the device using procedures which are given in the Recommended Intrinsic/Derived Standards Practice. Some of the laboratory procedures are described.
[Contact: Randolph E. Elmquist, (301) 975-6591]

Elmquist, R.E., and Dziuba, R.F., **A High-Temperature Superconductor Cryogenic Current Comparator**, IEEE Transactions on Instrumentation and Measurement, Vol. 44, No. 2, pp. 262-264 (April 1995). [Also published in Digest of the 1994 Conference on Precision Electromagnetic Measurements, Boulder, Colorado, June 27—July 1, 1994, pp. 136-137.]

NIST is developing a cryogenic current comparator (CCC) to operate at 77 K, using high-temperature superconductor (HTS) ceramic shielding material and an HTS-based superconducting quantum interference device detector. HTS materials appear sufficient for use in a high-accuracy CCC. A measurement of current-linkage error, a figure of merit for CCC devices, is made for one type of HTS CCC. The design of a second HTS CCC which uses improved magnetic shielding is described.
[Contact: Randolph E. Elmquist, (301) 975-6591]

Jarrett, D.G., **Constant Temperature and Humidity Chamber for Standard Resistors**, Proceedings of the 1995 National Conference of Standards Laboratories Workshop and Symposium, Dallas, Texas, July 16-20, 1995, pp. 501-505.

An environmental chamber has been developed for housing standard resistors under controlled temperature and humidity conditions during calibration in air. Temperature is controlled at 23 ± 0.02 °C by a proportional, integral, and derivative (PID) processor which provides proportional heating. The input circuitry to the PID is a Wheatstone bridge using thermistors in two opposing arms for added sensitivity. Constant cooling is provided by a convection Peltier air conditioning unit. Relative humidity is maintained at 35 ± 5% relative humidity by aqueous salt solutions.

The design allows sufficient space for standard resistors to be housed in a volume of 0.25 cubic meters with 16 pairs of coaxial connectors feeding through the chamber wall to the lab environment. The box is of double-walled construction with the inner box electrically and thermally insulated from the outer box. Improved insulation and control circuitry along with added volume are some of the improvements this new air chamber has over other chambers previously used for calibrating standard resistors at NIST.
[Contact: Dean G. Jarrett, (301) 975-4240]

Jeffrey, A., Elmquist, R.E., and Cage, M.E., **Precision Tests of a Quantum Hall Effect Device DC Equivalent Circuit Using Double-Series and Triple-Series Connections**, Journal of Research of the National Institute of Standards and Technology, Vol. 100, pp. 677-685 (November—December 1995).

Precision tests verify the dc equivalent circuit used by Ricketts and Kemeny to describe a quantum Hall effect device in terms of electrical circuit elements. The tests employ the use of cryogenic current comparators and the double-series and triple-series connection techniques of Delahaye. Verification of the dc equivalent circuit in double-series and triple-series connections is a necessary step in developing the ac quantum Hall effect as an intrinsic standard of resistance.
[Contact: Randolph E. Elmquist, (301) 975-6591]

Kile, L.L., **Programmable Guarded Coaxial Connector Panel**, to be published in the Proceedings of the 1995 National Conference of Standards Laboratories Workshop and Symposium, Dallas, Texas, July 16-20, 1995, pp. 285-289.

A programmable guarded connector panel using coaxial connectors has been specifically designed for an automated measurement system for the comparison of four-terminal resistors. A computer-controlled XYZ positioning system is used to move a four-connector Z arm over a panel of 72 coaxial connectors mounted in the XY plane. This provides for 30 four-terminal channels. The outer shields of the connectors are electrically isolated from one another to allow the shields to be driven at guard voltages to suppress errors caused by leakage currents. The resistance repeatability of the plug-socket connections including resistance variations of 12 m of AWG 12 connecting cable is typically 10 $\mu\Omega$. Variations of thermoelectric voltages over a 10-min measurement period of the plug-socket connections are typically less than 10 nV. This automatic switching system may be useful for other types of precision measurements where guarding, contact resistances, and thermoelectric voltages are critical factors.
[Contact: Lisa L. Kile, (301) 975-4241]

Lee, K.C., **Bonding Wires to Quantized Hall Resistors**, IEEE Transactions on Instrumentation and Measurement, Vol. 44, No. 2, pp. 249-252 (April 1995).

[See Fundamental Electrical Measurements.]

Waveform Metrology

Avramov-Zamurovic, S., Stenbakken, G.N., Koffman, A.D., Oldham, N.M., and Gammon, R.W., **Binary vs Decade Inductive Voltage Divider Comparison and Error Decomposition**, IEEE Transactions on Instrumentation and Measurement, Vol. 44, No. 4, pp. 904-908 (August 1995).

An automatic Inductive Voltage Divider (IVD) characterization method that can measure linearity by comparing IVDs with different structures is suggested. Structural models are employed to decompose an error vector into components that represent each divider. Initial tests at 400 Hz show that it is possible to assign independent errors due to the binary and decade structures with a 2σ uncertainty of 0.05 parts per million at the measured ratio values.
[Contact: Nile M. Oldham, (301) 975-2408]

Cryoelectronic Metrology

Benz, S.P., **Superconductor-Normal-Superconductor Junctions for Programmable Voltage Standards**, Applied Physics Letters, Vol. 67, No. 18, (30 October 1995). [A similar paper has appeared in the Extended Abstracts of the Fifth International Superconductive Electronics Conference, Nagoya, Japan, September 18-21, 1995, pp. 216-218.]

[See Fundamental Microelectronics.]

Booi, P.A.A., and Benz, S.P., **High-Power, High-Frequency Oscillators Using Distributed Josephson-Junctions Arrays**, Extended Abstracts of the Fifth International Superconductive Electronics Conference, September 18-21, 1995, pp. 513-515.

We present experimental results showing emission that is coupled from distributed series arrays of wide, resistively-shunted tunnel junctions to on-chip 50 Ω loads. We have detected power output of 0.85 mW near 240 GHz and power >100 μm at most frequencies in the range 100 to 300 GHz are detected.
[Contact: Samuel P. Benz, (303) 497-5258]

Early, E.A., Clark, A.F., and Lobb, C.J., **Physical Basis for Half-Integral Shapiro Steps in a DC SQUID**, Physica C, Vol. 245, pp. 308-320 (1995).

The dynamics of a dc superconducting quantum interference device is analogous to the classical dynamics of a particle subject to conservative, damping, and driving forces in two dimensions. The equations of motion define a trajectory on a potential-energy surface derived from the conservative forces, the components of which correspond to different forms of stored energy in the SQUID. In the presence of a periodic driving force, half-integral Shapiro steps are possible when the trajectory follows a zig-zag path between minima of the potential surface. This description of the dynamics in terms of a potential surface provides an intuitive, physical basis for previous simulation results on half-integral Shapiro steps in a dc superconducting quantum interference device.
[Contact: Edward A. Early (301) 975-4228]

Elmquist, R.E., and Dziuba, R.F., **A High-Temperature Superconductor Cryogenic Current Comparator**, IEEE Transactions on Instrumentation and Measurement, Vol. 44, No. 2, pp. 262-264 (April 1995). [Also published in Digest of the 1994 Conference on Precision Electromagnetic Measurements, Boulder, Colorado, June 27—July 1, 1994, pp. 136-137.]

[See DC and Low-Frequency Metrology.]

Kautz, R.L., Shapiro Steps in Large-Area Metallic-Barrier Josephson Junctions, Journal of Applied Physics, Vol. 78, No. 9, pp. 5811-5819 (November 1995).

[See Fundamental Microelectronics.]

Ono, R.H., Vale, L.R., Reintsema, C.D., and Kunkel, G., **Controlling the Critical Current Density of High-Temperature SNS Josephson Junctions**, Extended Abstracts of the 5th International Superconductive Electronics Conference, Nagoya, Japan, September 18-21, 1995, pp. 114-116.

High-T_c Josephson junctions have been made using a step-edge superconductor-normal-superconductor (SNS) process where the critical current density has been controlled by the geometric length of the N region. We discuss techniques for controlling the critical currents while simultaneously adjusting the normal resistances.
[Contact: Ronald H. Ono, (303) 497-3762]

Antenna Metrology

Francis, M.H., **A Comparison of K-Correction and Taylor-Series Correction for Probe-Position Errors in Planar Near-Field Scanning**, Proceedings of the 17th Annual Meeting and Symposium, Antenna Measurement Techniques Association, Williamsburg, Virginia, November 13-17, 1995, pp. 341-347.

We investigated two methods of probe-position error correction to determine how well the corrected results compare to the uncorrupted far field: the k-correction method and the Taylor-series method. For this investigation, we measured a 1.2 m dish at 4 GHz and a 1.2 m by 0.9 m phased array at 2.2 GHz. Measurements were made first without position errors and then with deliberate z-position errors. We performed probe-position error correction using both methods and compared the results to the error-free far field. For errors up to $\lambda/4$, the fifth-order implementation of the Taylor-series correction was slightly better than the k-correction. For errors of $\lambda/2$, the k-correction was better than the Taylor-series correction.
[Contact: Michael H. Francis, (303) 497-5873]

Francis, M.H., Newell, A.C., Grimm, K.R., Hoffman,

J., and Schrank, H.E., **Comparison of Ultralow-Sidelobe Antenna Far-Field Patterns Using the Planar-Near-Field Method and the Far-Field Method**, IEEE Antennas and Propagation Magazine, Vol. 37, No. 6, pp. 7-15 (December 1995).

The development of very-low-sidelobe antennas raises the question of whether or not the planar-near-field can be used to accurately measure these antennas. Recently, scientists at several organizations showed that data taken and processed with the planar-near-field methodology, including probe correction, can be used to accurately measure the sidelobes of very-low-sidelobe antennas. This can be done to levels of -55 dB to -60 dB, relative to the main-beam peak. This paper highlights these results, including a comparison of the far-field range. The test antenna for this study was a slotted-waveguide array, the low sidelobes for which were known. The near-field measurements were conducted on the NIST planar-near-field facility.
[Contact: Michael H. Francis, (303) 497-5873]

Muth, L.A., **General Order N Analytic Correction of Probe-Position Errors in Planar Near-Field Measurements**, Proceedings of the 17th Annual Meeting and Symposium, Antenna Measurement Techniques Association, Williamsburg, Virginia, November 13-17, 1995, pp. 331-340.

An analytic technique recently developed at NIST to correct for probe position errors in planar near-field measurements has been implemented to arbitrary accuracy. The nth-order correction scheme is composed of an mth-order ordered expansion and a n-m higher-order approximation, where both n and m are arbitrary. The technique successfully removes very large probe position errors in the near-field, so the residual near-field probe position errors are substantially below levels that can be measured on a near-field range. Only the error-contaminated near-field measurements and an accurate probe position error function are needed for implementation of the correction technique. The method also requires the ability to obtain derivatives of the error-contaminated near-field defined on an error-free regular grid with respect to the coordinates. In planar geometry the derivatives are obtained using FFTs, giving an approximate operation count of $(3 \cdot 2^{m-1} - 1 + (n-m))\ N \log N$, where N is the number of data points. Efficient computer codes have been developed to demonstrate the technique. The results of simulations are more accurate than those obtained using the well-known k correction, which can correct for position errors in some direction in k space, but further contaminates the sidelobe levels.
[Contact: Lorant A. Muth, (303) 497-3603]

Muth, L.A., Lewis, R.L., and Wittmann, R.C., **Polarimetric Calibration of Reciprocal-Antenna Radars**, Proceedings of the 17th Annual Meeting and Symposium, Antenna Measurement Techniques Association, Williamsburg, Virginia, November 13-17, 1995, pp. 3-8.

We discuss how RCS target depolarization enhances cross-polarization contamination, and we present a graphical study of measurement error due to depolarization by an inclined dihedral reflector. Error correction requires complete polarimetric RCS measurements. We present a simple polarimetric calibration scheme that is applicable to reciprocal calibration scheme that is applicable to reciprocal antenna radars. This method uses a dihedral calibration target mounted on a rotator. Because the calibration standard can be rotated, there is no need to mount and align multiple separate standards, and clutter and noise may be rejected by averaging over rotation angle.
[Contact: Lorant A. Muth, (303) 497-3603]

Noise Metrology

Clark, A.F., and Steiner, R.L., **Noise Characteristics Below 1 Hz of Zener Diode-Based Voltage References**, Abstracts in the Bulletin of the American Physical Society Meeting, San Jose, California, March 13-17, 1995, p. 90.

[See Fundamental Electrical Measurements.]

Kirschenbaum, L.S., Rogers, C.T., Russek, S.E., and Sanders, S.C., **Telegraph Noise in Silver-Permalloy Giant Magnetoresistance Test Structures**, IEEE Transactions on Magnetics, Vol. 31, No. 6, pp. 3943-3945 (November 1995).

[See Magnetic Materials and Measurements.]

Microwave and Millimeter Wave Metrology

DeGroot, D.C., and Marks, R.B., **Optimizing Time-Domain Network Analysis**, Proceedings of the 46th Automatic Radio Frequency Techniques Group, Scottsdale, Arizona, November 30—December 1, 1995, pp. 19-28.

In this work, we demonstrate how changes is sample density, time-window size, and waveform averaging affect the accuracy and acquisition time of calibrated time-domain network analysis. One of the key results from this study is that accuracy can be enhanced by eliminating the incident step-edge signal from the time-domain reflection waveform before maximizing the instrument's vertical scale. This study identifies the trade-offs between accuracy and measurement speed and examines other trends to provide general guidance in establishing reliable and efficient time-domain network analysis measurements for a variety of rf and microwave applications.
[Contact: Donald C. DeGroot, (303) 497-7212]

Jargon, J.A., **Coaxial Line-Reflect-Match Calibration**, Proceedings of the 1995 Asia-Pacific Microwave Conference, Taejon, Korea, October 10-13, 1995, pp. 86-89.

We describe a coaxial line-reflect-match calibration that corrects for imperfections in the load used as a match standard. The method provides a practical means of obtaining accurate, wideband calibrations with compact coaxial standard sets. When our load model is valid, the load may be characterized using an additional line of moderate length.
[Contact: Jeffrey A. Jargon, (303) 497-3596]

Jargon, J.A., and Marks, R.B., **Two-Tier Multiline TRL for Calibration of Low-Cost Network Analyzers**, Proceedings of the 46th Automatic Radio Frequency Techniques Group, Scottsdale, Arizona, November 30-December 1, 1995, pp. 1-8.

We compare calibrations for use on three-sampler vector network analyzers which do not allow the direct application of some advanced error-correction schemes such as TRL (thru-reflect-line). Here, we compare various alternatives, including an approximate version of TRL that has been introduced commercially and two-tier multiline TRL using external software. We consider both coaxial and coplanar open-short-load-thru calibrations for the first tier, showing that the latter can lead to inaccuracies. Finally, we investigate the stability of the load reflection terms to show that the first tier calibration need not be frequently repeated.
[Contact: Jeffrey A. Jargon, (303) 497-3596]

Marks, R.B., DeGroot, D.C., and Jargon, J.A., **High-Speed Interconnection Characterization Using Time Domain Network Analysis**, Advancing Microelectronics, Vol. 22, No. 6, pp. 35-39 (November/December 1995).

Time domain network analysis (TDNA), has become a realistic competitor to conventional automatic network analyzers. Off-line processing of data from fast digital sampling oscilloscopes can provide measurements of network parameters with an accuracy that is acceptable for many packaging and interconnect problems at frequencies from dc to over 10 GHz. Since many packaging laboratories have ready access to the required instruments, TDNA brings many advanced measurement capabilities into the hands of engineers to whom a conventional network analyzer is unavailable.
[Contact: Roger B. Marks, (303) 497-3037]

Marks, R.B., Jargon, J.A., Pao, C.K., and Wen, C.P., **Electrical Measurements of Microwave Flip-Chip Interconnections**, Proceedings of the 1995 International Symposium on Microelectronics, Los Angeles, California, October 24-26, 1995, pp. 424-429.

We apply custom calibration standards and software to the accurate on-wafer measurement of components on flip-chip coplanar-waveguide monolithic microwave integrated circuits. We characterize transmission lines, metal insulator metal capacitors, and spiral inductors and develop equivalent-circuit models. The results are applicable to the development of an accurate computer-aided design database.
[Contact: Roger B. Marks, (303) 497-3037]

Marks, R.B., and Williams, D.F., **Accurate Electrical Characterization of High-Speed Interconnections**, Proceedings of the 1994 International Society for Hybrid Microelectronics,

Boston, Massachusetts, November 14-17, 1994, pp. 96-101.

A program at the National Institute of Standards and Technology supports the electrical characterization of electronic packaging and interconnections in terms of scattering parameters, impedances, and transmission line. This paper reviews the basic methodology, including its origins in the characterization of monolithic microwave integrated circuits, and describes the resulting calibration and measurement methods that have been developed.
[Contact: Roger B. Marks, (303) 497-3037]

Pucic, S.P., and Daywitt, W.C., **Single-Port Technique for Adaptor Efficiency Evaluation**, Proceedings of the 45th Automatic Radio Frequency Techniques Group, Orlando, Florida, May 19, 1995, pp. 113-118.

The "single-port adaptor efficiency evaluation" (SPAEE) technique uses swept-frequency measurements to evaluate broadband efficiency of low-loss, reciprocal two-ports, including noninsertable devices such as adaptors. The two-port is terminated in two reflective terminations, a shielded open and a short. The value of the intrinsic efficiency as a function of frequency is extracted from the automatic network analyzer S_{11} data. The frequency range is limited only by the availability of the two reflective terminations. The major advantages of the SPAEE technique are its simplicity, speed, and accuracy. The expanded uncertainty (k = 2) is typically about 1.5%.
[Contact: Suchana P. Pucic, (303) 497-3546]

Electromagnetic Properties

Baker-Jarvis, J.R., and Jones, C.A., **Dielectric Measurements on Printed-Wiring and Circuit Boards, Thin Films, and Substrates: An Overview**, Proceedings of the Materials Research Society, San Francisco, California, April 18, 1995, Vol. 381 pp. 153-164.

A review of the most common methods of permittivity measurements on thin films, printed-wiring and circuit boards, and substrates is presented. Transmission-line techniques, coaxial apertures, open-resonators, surface-wave modes, and dielectric resonators methods are examined. The frequency range of applicability and typical uncertainties associated with each method are summarized.
[Contact: James R. Baker-Jarvis, (303) 497-5621]

Ceremuga, J., Krupka, J., Geyer, R.G., and Modelski, J., **Influence of Films' Thickness and Air Gaps in Surface Impedance Measurements of High Temperature Superconductors Using the Dielectric Resonator Technique**, IEICE Transactions on Electronics, Vol. E78-C, No. 8, pp. 1106-1110 (August 1995).

The dielectric resonator technique is commonly used for microwave surface resistance measurements of High-Temperature superconducting (HTS) films. Thickness of superconductors and its impact on measurement results has not been taken into consideration so far. A theoretical mode-matched solution analysis of TE_{011} 10 GHz sapphire resonator was performed. The results of this analysis demonstrate that the thickness of the films under test can significantly affect the resonannt frequencies (f_{res}) and quality factor (Q) of the resonant system, particularly when the thickness is less than three times the penetration depth (λ) of the films at the operating temperature. In such cases, the microwave properties of the substrate affect f_{res} and Q. For HTS films' thickness relatively small as compared to λ, measured quality factors and resonant frequency may also be affected by substrate thickness and the conductivity of the backing plates of the system. The presence of air gaps between the sapphire resonator and the HTS films does not significantly influence surface resistance from which the penetration depth is calculated.
[Contact: Richard G. Geyer, (303) 497-5533]

Hill, D.A., **Electric Dipole Excitation of a Long Conductor in a Lossy Medium**, Electromagnetics, Vol. 15, pp. 301-319 (1995).

[See Radiated EMI.]

Weil, C., **The NIST Metrology Program on Electromagnetic Characterization of Materials**, Proceedings of the Symposium on Materials and Progress for Wireless Communication, Boston, Massachusetts, November 15-16, 1994, pp. 35-48 (1995).

The Electromagnetic Properties of Materials Program at the National Institute of Standards and Technology (NIST) is described, including an outline of the current goals of the project and details of measurement techniques being used at NIST for characterizing dielectric and magnetic materials of importance in wireless communications in the RF spectrum of interest.
[Contact: Claude M. Weil, (303) 497-5305]

Optical Fiber/Waveguide Sensors

Rochford, K.B., and Rose, A.H., **Simultaneous Laser-Diode Emission and Detection for Fiber-Optic Sensor Applications**, Optics Letters, Vol. 20, No. 20, pp. 2105-2107, October 15, 1995.

The simultaneous emission and detection of radiation with a semiconductor laser is investigated. Measured signal-to-noise ratios of up to 56 dB demonstrate that self-detecting devices are adequate for sensor applications with discrete measurands. We observed a strong polarization dependence, which can cause response fluctuations, and suggest methods to minimize these fluctuations. This technique could be used for lower-cost sensors without splitter and detectors.
[Contact: Kent B. Rochford, (303) 497-5170]

ELECTRICAL SYSTEMS

Power Systems Metrology

Christophorou, L.G., and Van Brunt, R.J., **SF_6 Insulation: Possible Greenhouse Problems and Solutions**, NISTIR 5685 (July 1995).

Sulfur hexafluoride (SF_6) is the most common insulating gas used in enclosed electrical systems to date. It has been identified, however, as a potent greenhouse gas and thus, its use could impact environmental costs, regulations, and restrictions, in spite of its current low levels in the environment. This potential problem and current efforts in the search for short-term and long-term solutions are briefly outlined and discussed in this report. Limiting the release of SF_6 in the environment, recycling SF_6, and limiting its use, are among the elements of an emerging consensus effort for the short run. A long-term solution may include the search for alternative high-voltage insulants, such as high-pressure gaseous dielectrics (e.g., N_2 and N_2/SF_6 mixtures), and would require accurate measurements and reference data to quantify their physical, chemical, and dielectric properties.
[Contact: Loucas G. Christophorou, (301) 975-2432]

Christophorou, L.G., and Van Brunt, R.J., **SF_6/N_2 Mixtures: Basic and High-Voltage-Insulation Properties**, IEEE Transactions on Dielectrics and Electrical Insulation, Vol. 2, No. 5, pp. 952-1003 (October 1995).

The widespread use of SF_6 by the electric power and other industries has led to increased concentrations of SF_6 in the atmosphere. This causes concern as to possible effects on global warming because SF_6 is a potent greenhouse gas. This paper first touches on this issue and then documents the behavior of high-pressure gases such as N_2 and SF_6/N_2 mixtures that can be realistically considered as acceptable intermediate or long-term replacements for pure SF_6 in some high-voltage applications. The possible use of dilute SF_6/N_2 mixtures as an alternative to pure SF_6 for some of industry's insulation needs (albeit at higher pressure) is documented, and existing knowledge on these mixtures and on the individual components (N_2 and SF_6), both basic and applied, is compiled. A guide to existing literature is provided.
[Contact: Loucas G. Christophorou, (301) 975-2432]

Christophorou, L.G., Van Brunt, R.J., and Olthoff, J.K., **Fundamental Processes in Gas Discharges**, Proceedings of the XIth International Conference on Gas Discharges and Their Applications, Tokyo, Japan, September 11-15, 1995, pp. I-536—I-548.

Recent aspects of fundamental processes in gas discharges are discussed. These include the effect of internal energy excitation of atoms and molecules on their interactions with slow electrons, the effect of temperature on electron attachment and detachment processes, photodissociation of molecules and photodetachment of anions, and interactions involved in discharge byproduct formation and discharge diagnostics. Reference is also made to fundamental processes in gas discharge materials used in plasma processing.

[Contact: Richard J. Van Brunt, (301) 975-2425]

Hüecker, T., von Glahn, P.G., Kranz, H.-G., and Okamoto, T., **A Standardised Computer Data File Format for Storage, Transport, and Off-Line Processing of Partial Discharge Data**, Proceedings of the Ninth International Symposium on High Voltage Engineering, Graz, Austria, August 28—September 1, 1995, pp. 5613-1—5613-4.

We present an overview of a proposed data file format for digitised partial discharge data. The proposed format will permit investigators at different institutions to exchange PD data and collaborate on the analysis and understanding of the PD phenomenon. We include an example in which investigators at all three institutions evaluated the same data record and report their analysis results.
[Contact: Peter G. von Glahn, (301) 975-2427]

Martzloff, F.D., **Classified Bibliography - Insulation Condition Monitoring Methods, 1989-1995**, NISTIR 5760 (November 1995).

This bibliography covers the period 1989-1995, that includes reference listings and abstracts, organized in six categories: General Reviews and Tutorials; Experimental Partial Discharge Measurements; Partial Discharge Modeling and Analysis; Other Test Methods; Dielectric Properties Measurements; and Aging Effects.
[Contact: François D. Martzloff, (301) 975-2409]

Martzloff, F.D., **Keeping Up with the Reality of Today's Surge Environment**, Proceedings of the 1995 Power Quality/Mass Transit Conference, Ventura, California, September 11-15, 1995, pp. 246-252.

[See Conducted EMI.]

Ramboz, J.D., and Martzloff, F.D., **The Technical Impact of the NIST Calibration Service for Electrical Power and Energy**, NISTIR 5564 (December 1995).

The National Institute of Standards and Technology (NIST) has by law the mandate to provide for industry access to a system of uniform and consistent measurements. Important measurements within the electric utilities include energy measurements for revenue billing to customers, other measurements for the control of the utility systems, and measurements for determination equipment efficiency. The principal instrument used to measure the electric energy flowing throughout the utility systems and ultimately to the consumer is the watthour meter. Thus, the watthour meter is, indeed, the "cash-register" of every electric utility.

The initial purpose of this impact study was to assess qualitatively and quantitatively the technical and economic impacts of power and energy metrology and the NIST calibration services for electrical power and energy on the U.S. electrical power industry and supporting measurement community. As described in this report, the economic data obtained from respondents did not provide enough basis for firm conclusions, so that the final scope if this report is limited to technical impacts. For a historical and anecdotal perspective, some discussions are included on attempts at collecting economic data and the limited results obtained in that area.

A separate study of economic benefits was conducted on the impact of these services, which is documented in a companion report. The results of the present study on the technical impact, as well as the results of the companion economic impact study, will be used to guide improved NIST calibration services and research programs to respond effectively to present and future industry and laboratory needs.
[Contact: François D. Martzloff, (301) 975-2409]

Van Brunt, R.J., **Physics and Chemistry of Partial Discharge and Corona - Recent Advances and Future Challenges**, Proceedings of the 1994 Conference on Electrical Insulation and Dielectric Phenomena, Arlington, Texas, October 23-26, 1994, pp. 29-70 (1995). [Also published in IEEE Transactions of Dielectrics and Electrical Insulation, Vol. 1, No. 5, pp. 761-784 (October 1994).]

Results of recent research on physical and chemical processes in partial discharge (PD) phenomena are reviewed. The terminology used to specify different types or modes of PD are discussed in light of a general theory of electrical discharges. The limitations and assumptions inherent to present

theoretical models are examined. The influence of memory propagation effects in controlling the stochastic behavior of PD is shown. Examples of experimental results are presented that demonstrate the nonstationary characteristics of PD which can be related to permanent or quasi-permanent discharge-induced modifications (aging) of the site where the PD occur. Recommendations for future research are proposed.
[Contact: Richard J. Van Brunt, (301) 975-2425]

Van Brunt, R.J., and von Glahn, P.G., **Continuous Recording and Stochastic Analysis of PD**, IEEE Transactions on Dielectrics and Electrical Insulation, Vol. 2, No. 4, pp. 590-601 (August 1995).

We describe the design and use of a digital partial discharge (PD) data recording system capable of continuous real-time recording of PD pulse trains. The recording system consists of a custom two-channel PD digitizer coupled to a personal computer via a 16-bit parallel interface. The digitizer is under software control with the resulting data being stored in binary files on the computer's hard disk. The stored data subsequently are subjected to stochastic analysis using appropriate computer software. Because all data are retained and the computer provides the desired stochastic analysis of data files, the new system is well suited to investigate non-stationary PD behavior such as encountered in aging studies. By way of illustration, the new system was used to determine the time-varying stochastic behavior of ac-generated PD from point-to-dielectric gaps in air where the insulation material was cast epoxy with aluminum oxide filler. The results confirm and extend previous measurements made with an analog stochastic analyzer. With these sample results, we demonstrate how the system allows detailed stochastic analyzes not possible with data obtained from existing conventional PD measurement systems.
[Contact: Richard J. Van Brunt, (301) 975-2425]

von Glahn, P.G., **Comments on the Digital Processing of Partial Discharge Signals**, IEEE Transactions on Dielectrics and Electrical Insulation, Vol. 2, No. 4, pp. 692-694 (August 1995).

This paper is a discussion by Peter Osvath. Osvath's paper describes some design issues for digital partial discharge instrumentation. This discussion highlights potential problems with Osvath's approach and presents some thoughts on future directions for partial discharge instrumentation design.
[Contact: Peter G. von Glahn, (301) 975-2427]

von Glahn, P.G., and Van Brunt, R.J., **Behavior of Surface Partial Discharge on Aluminum Oxide Dielectrics**, Proceedings of the 1995 IEEE Conference on Electrical Insulation and Dielectric Phenomena, Virginia Beach, Virginia, October 22-25, 1995, pp. 365-371.

Partial discharge (PD) was generated with alternating voltage applied to a point electrode touching the surfaces of aluminum oxide (Al_2O_3) dielectrics of different purity in air. The amplitudes and phases of all pulsating PD events that occurred during voltage application periods up to 35 min. were recorded, and the results were analyzed to reveal details of the time- and voltage-dependent stochastic behavior of the discharge. It was discovered that the characteristics of PD exhibit rapid changes with time that depend significantly on voltage and the purity of the Al_2O_3 sample. Examples are shown of statistical data for individual positive and negative pulses in a voltage cycle that are much more refined than data that can be obtained from conventional PD measurement systems. The results presented here illustrate the advantages of using continuous data records in the investigation and characterization of pulsating PD phenomena.
[Contact: Peter G. von Glahn, (301) 975-2427]

Pulse Power Metrology

Van Brunt, R.J., Nelson, T.L., and Firebaugh, S.L., **Early Streamer Emission Lightning Protection Systems - Literature Survey and Technical Evaluation**, NISTIR 5621 (January 1995).

This report has been prepared by the National Institute of Standards and Technology at the request of the National Fire Protection Research Foundation for the purpose of providing information needed to perform a technical evaluation of lightening protection systems based on the early

streamer emission (ESE) concept. Included in this document is an annotated bibliography of over 300 publications that were found to be directly or indirectly relevant to ESE technology. Each publication is listed, together with an abstract and/or commentary that describes the nature of the work, and each article in the bibliography has been rated according to its perceived importance. Also included is a discussion derived from an examination of the literature cited in the bibliography about the state of knowledge concerning the operation and effectiveness of ESE devices that identifies issues and areas of controversy. The report concludes with recommendations for research that may be needed to resolve remaining issues.
[Contact: Richard J. Van Brunt, (301) 975-2425]

Magnetic Materials and Measurements

Cross, R.W., Oti, J.O., Russek, S.E., and Silva, T., **Magnetoresistance of Thin-Film NiFe Devices Exhibiting Single-Domain Behavior**, IEEE Transactions on Magnetics, Vol. 31, No. 6, pp. 3358-3360 (November 1995).

Rectangular NiFe stripes as small as 1 x 5 μm were fabricated and characterized as a function of film thickness. Gold current leads were sputtered and patterned onto the stripes so that magnetoresistance measurements could be performed. A uniform in-plane magnetic field was applied transverse to the stripe length and at various angles from the perpendicular direction. For film thicknesses greater than 10 nm, the magnetoresistance for all of the devices had large jumps and hysteresis due to domain formation. As the thickness of the film decreased below 10 nm, the domain structure disappeared for stripe heights 2 μm or less. Theoretical calculations of the magnetization reversals were obtained using a numerical implementation of the Stoner-Wohlfarth model for the switching of a single-domain ellipsoidal particle. The calculations were used to predict the switching field where the magnetization reaches an unstable threshold, causing a jump in the magnetization and magnetoresistance. The model was in close agreement with experimental results for various field orientations.
[Contact: R. William Cross, (303) 497-5300]

Kim, Y.K., Sanders, S.C., and Russek, S.E., **Low Magnetostriction in Annealed NiFe/Ag Giant Magnetoresistive Multilayers**, IEEE Transactions on Magnetics, Vol. 31, No. 6, pp. 3964-3966 (November 1995). [Also published in the Digest of the 1995 International Magnetics Conference, San Antonio, Texas, April 18-21, 1995, p. EC-10.]

We have measured the saturation magnetostriction for NiFe/Ag multilayer thin films exhibiting giant magnetoresistance. Zero magnetostriction concurrent with high magnetoresistance ratio ($\Delta R/R$ = 5%) and field sensitivity [7.5%/(kA/m) (0.6%/Oe)] was observed for NiFe/Ag films having an optimal multilayer configuration and annealing temperature. This combination of zero-magnetostriction and high-magnetoresistive response makes the NiFe/Ag multilayer system potentially useful for high-performance magnetic recording read heads.
[Contact: Steven C. Sanders, (303) 497-5096]

Kirschenbaum, L.S., Rogers, C.T., Russek, S.E., and Sanders, S.C., **Telegraph Noise in Silver-Permalloy Giant Magnetoresistance Test Structures**, IEEE Transactions on Magnetics, Vol. 31, No. 6, pp. 3943-3945 (November 1995).

We report noise data for discontinuous $Ni_{82}Fe_{18}$/Ag multilayer test structures. Examination of the noise data for this material indicates that random telegraph fluctuator (RTF) noise of the resistance is the predominant noise source. Analysis of the RTF noise in these structures presents an opportunity to estimate magnetic domain or magnetic cluster strengths and the domain-domain interactions.
[Contact: Stephen E. Russek, (303) 497-5097]

Kosobukin, V.A., **Theory of the Magneto-Optic Kerr Effect In the Near-Field**, Proceedings of SPIE (The International Society for Optical Engineering, P.O. Box 10, Bellingham, Washington 98227-0010), Near-Field Optics, Vol. 2535, pp. 9-15 (1995).

A theory is developed for the magneto-optic Kerr effect (MOKE) excited via an optical near field. The model under consideration includes a semi-infinite ferromagnet and a small non-magnetic metal particle which is located nearby and possesses a long-living surface plasmon. A multiple-scattering formulation of the problem is given. Considering

the Rayleigh scattering of light and the magneto-optical light polarization conversion as elementary events, all the essential optical processes are classified, and those which contribute to the near-field MOKE are treated separately. An effective particle polarizability, responsible for a near-field excitation, is treated self-consistently to all orders in light-matter interaction, and the magneto-optical interaction is described in the first order approximation of perturbation theory. The scattered light-field is discussed with special emphasis on the change of optical polarization due to MOKE.
[Contact: Ronald B. Goldfarb (303) 497-3650]

Russek, S.E., Cross, R.W., Sanders, S.C., and Oti, J.O., **Size Effects in Submicron NiFe/Ag GMR Devices**, IEEE Transactions on Magnetics, Vol. 31, No. 6, pp. 3939-3942 (November 1995).

We have measured the magnetoresistive response of submicrometer NiFe/Ag giant magnetoresistive (GMR) devices as a function of current density and field angle. In addition to magnetostatic broadening, we observe large jumps in the magnetoresistive response (Barkhausen jumps) due to domain switching. These effects lead to irregular device-specific magnetoresistive response curves. The large Barkhausen jumps are more pronounced at low-current density, while at high-current densities, the response is smoother due to self-field stabilization. The detailed structure of the Barkhausen jumps is very sensitive to angle of the applied magnetic field. These effects are general properties of a wide class of GMR materials that rely on incoherent reversal of many small magnetic domains. We compare the experimental data with a phenomenological GMR transport model. The model qualitatively describes the experimental data and provides insight into the detailed micromagnetic behavior of these films.
[Contact: Stephen E. Russek, (303) 497-5097]

Silva, T.J., and Kos, A.B., **Dependence of Contrast on Probe/Sample Spacing with the Magneto-Optic Kerr-Effect Scanning Near-Field Optical Microscope (MOKE-SNOM)**, Proceedings of SPIE (The International Society for Optical Engineering, P.O. Box 10, Bellingham, Washington 98227-0010), Near-Field Optics, Vol. 2535, pp. 2-8 (1995).

A magneto-optic Kerr-effect scanning near-field optical microscope is used to image a stripe domain wall in a Co/Pt multilayer sample. The microscope is an improved version of a type previously reported, which uses light scattering from surface plasmons in 20 to 40 nm Ag particles as a near-field probe. Data are presented for both the probe intensity and polarization contrast as a function of probe/sample spacing. Oscillatory behavior in both sets of data is reasonably explained with a simplified model of optical interference.
[Contact: Thomas J. Silva, (303) 497-5619]

Superconductors

Ceremuga, J., Krupka, J., Geyer, R.G., and Modelski, J., **Influence of Films' Thickness and Air Gaps in Surface Impedance Measurements of High Temperature Superconductors Using the Dielectric Resonator Technique**, IEICE Transactions on Electronics, Vol. E78-C, No. 8, pp. 1106-1110 (August 1995).

[See Electromagnetic Properties.]

Goodrich, L.F., and Srivastava, A.N., **Critical Current Measurement Methods: Quantitative Evaluation**, Cryogenics, VAMAS Supplement, pp. S19—S23 (1995).

This paper reports the important elements of the methodology that need to be considered in order to obtain low variability in critical current measurements in Nb_3Sn conductors. The critical current of these superconductors is a strong function of the strain state. Thus, the choice of reaction and measurement mandrel, as well as the measurement technique used to determine the critical current become important factors in the variability of the measurement. VAMAS conducted two international interlaboratory comparisons of critical current measurements. The results of these experiments indicated that a standardized methodology outlining procedures for reaction, mounting, and measuring the sample would yield a lower variability.
[Contact: Loren F. Goodrich, (303) 497-3143]

Goodrich, L.F., and Srivastava, A.N., Thermal Contraction of Materials Used in Nb_3Sn **Critical Current Measurements**, Cryogenics, VAMAS

Supplement, pp. S29—S32 (1995).

It is typical for Nb_3Sn-Cu superconductor specimens to be wound into coils on tubular measurement mandrels for critical current measurements. If the thermal contraction of the mandrel is different from that of the specimen, either tensile or compressive axial strain could develop upon cooling from room temperature to liquid helium temperature, thus affecting the measured critical current I_c. The amount of strain depends on the magnitude of the different contraction, the relative strength of the specimen and mandrel, and the mechanical coupling between the specimen and its mandrel. For coil specimens that are mounted on the surface of cylindrical mandrels, the strain is predominantly along the axis of the specimen. Thermal contraction became apparent as a measurement variable in the recent VAMAS interlaboratory comparative measurements of the critical current of Nb_3Sn.

The literature contains considerable data on the compressive prestrain of Nb_3Sn filaments caused by differential thermal contraction between the filaments and the matrix material. However, very few data on the overall thermal contraction of Nb_3Sn-Cu wires are presently available. The thermal contraction of a Nb_3Sn-Cu cable is reported previously; however, the conductor had a tungsten core that significantly reduced its thermal contraction. Consequently, the thermal contraction of Nb_3Sn wires used in the recent VAMAS comparison was measured.
[Contact: Loren F. Goodrich, (303) 497-3143]

ELECTROMAGNETIC INTERFERENCE

Conducted EMI

Martzloff, F.D., **Keeping Up with the Reality of Today's Surge Environment**, Proceedings of the 1995 Power Quality/Mass Transit Conference, Ventura, California, September 11-15, 1995, pp. 246-252.

The paper proposes to establish a program for characterizing surge events by the capability of a surge event to deliver a surge current through the power system in end-user facilities. Two approaches are proposed: (1) Using a metal-oxide varistor with the lowest possible voltage to "attract" surges away from other SPDs connected in the facility, and then recording the surge current waveform in the varistor; and (2) Gathering data on field failures attributable to surges or swells of all types of electrical appliances and then attempting to replicate the failure mode in the laboratory.
[Contact: François D. Martzloff, (301) 975-2409]

Radiated EMI

Hill, D.A., **Electric Dipole Excitation of a Long Conductor in a Lossy Medium**, Electromagnetics, Vol. 15, pp. 301-319 (1995).

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 either ungrounded or grounded conductors.
[Contact: David A. Hill, (303) 497-3472]

Hill, D.A., **Spatial Correlation Function for Fields in a Reverberation Chamber**, IEEE Transactions on Electromagnetic Compatability, Vol. 37, No. 1, p. 1 (February 1995).

In a recent paper, we described random fields in a reverberation chamber by an integral representation of plane waves over all real angles. A physical interpretation of the random field in a reverberation chamber is that each member of the ensemble corresponds to a different stirrer (tuner) position. The plane-wave spectrum representation has been found useful for providing a mathematical description for the response of a receiving antenna or other test object in a reverberation chamber and for calculating the quality factor (Q) for reverberation chambers of arbitrary geometries. The purpose of this correspondence is to show that the plane-wave spectrum representation can also be used to provide a simple derivation for the spatial correlation function of the fields.
[Contact: David A. Hill, (303) 497-3472]

PRODUCT DATA SYSTEMS

Stewart, S.L., and St. Pierre, J.A., **Roadmap for the Computer Integrated Manufacturing Application Framework**, NISTIR 5679 (June 1995).

This is the final report for the first year of a joint project between the National Institute of Standards and Technology (NIST) and SEMATECH under a Cooperative Research and Development Agreement (CRADA) between the two organizations. The results of work on generalization, standardization, and promotion, conformance testing, and certification are covered in this report. This report includes a roadmap to adoption, use, standardization, testing, and certification of the Computer Integrated Manufacturing Application Framework (CIM Framework) developed by SEMATECH.
[Contact: James A. St. Pierre, (301) 975-4124]

VIDEO TECHNOLOGY

Bechis, D.J., Grote, M.D., Bortfeld, D.P., Hammer, L.H., Polak, M.J., Kelley, E.F., Jones, G.R., and Boynton, P.A., **Display-Measurement Round-Robin**, Society for Information Display, International Symposium, Digest of Technical Papers, Orlando, Florida, May 23-25, 1995, pp. 641-644.

Display measurement procedures intended for use by other laboratories and by industry for measuring, analyzing, and reporting the performance of display monitors are tested through the round-robin process in preparation for acceptance of the procedures as a standard. The National Information Display Laboratory and NIST results presented here show much quantitative agreement in support of the measurement procedures. Interpretation of the few discrepancies will be the subject of a later report, along with any attendant proposed refinements to the measurement and reporting procedures.
[Contact: Edward F. Kelley, (301) 975-3842]

Fenimore, C., **The National Information Infrastructure and Advanced Digital Video**, Proceedings of the 1994 International Symposium of Digital Imagery, Tokyo, Japan, October 20, 1994, pp. 1-17 (1995).

The U.S. Administration regards the development of a National Information Infrastructure (NII) as a way of putting vast amounts of information at the fingertips of users in America and around the world. The NII is expected to be a principal engine for economic growth in the 21st century. It must be capable of connecting networks on a global scale. While it is to be developed and deployed in the U.S. by the private sector, government will have an essential role in this process. This role will include: funding long-term research and development; supporting projects which demonstrate information services for schools, libraries, hospitals, and other non-profit institutions; providing government information services; and creating the telecommunications and information policies that will promote the deployment of the NII. Digital video services are likely to be the most technically demanding NII service. Recognizing this, the National Institute of Standards and Technology, the Technology Policy Working Group, and several industrial organizations sponsored a workshop to: (1) define a vision of the role of digital video in the NII; (2) identify the architectural, scaling, and performance issues in realizing this vision; and (3) recommend the research, experiments, and other steps to be taken to resolve these issues. At the Workshop, it was broadly agreed that the NII will be an amalgam of networks, information appliances, and services in which any company may provide any service to any user. This heterogeneous system will necessarily be modular, with an extensible architecture. The components of the NII will require publicly identified reference points and interfaces. The development of High Definition Television (HDTV) will be a powerful force driving the development of NII applications. It was the sense of the Workshop that the Grand Alliance proposal for HDTV is the best available alternative for HDTV transmission in the U.S. Additional standards for advanced digital video will be required to meet the diverse needs of the NII.
[Contact: Charles Fenimore, (301) 975-2428]

Kelley, E.F., Jones, G.R., Boynton, P.A., Grote, M.D., and Bechis, D.J., **A Survey of the Components of Display-Measurement Standards**, Society for Information Display, International Symposium, Digest of Technical Papers, Orlando, Florida, May 23-25, 1995, pp. 637-640.

Several display standards are reviewed and distinctive elements are compared. With flat-panel displays becoming more common and the CRT displays being so well established, the associated standards activities can be somewhat bewildering, even overwhelming. This paper attempts to identify complementary and inconsistent elements of related display standards.
[Contact: Edward F. Kelley, (301) 975-3842]

ADDITIONAL INFORMATION

Announcements

Characterization Workshop Proceedings Published

The Proceedings of the International Workshop on Semiconductor Characterization: Present Status and Future Needs is now available through AIP Press. The book *Semiconductor Characterization* covers the unique characterization requirements of both silicon IC development and manufacturing and compound semiconductor materials, devices, and the National Technology Roadmap for Semiconductors. Additional sections discuss technology trends and future requirements for compound semiconductor applications. Recent developments in characterization, including in-situ, in-FAB, and off-line analysis methods are also highlighted. The book provides useful insights on the capabilities of different characterization techniques, gives perspectives on industrial metrology requirements, and explores critical needs and issues in semiconductor metrology research. This book will serve as a base-line reference in this rapidly growing field for the next decade.

In the foreword, **Craig Barrett**, Chief Operating Officer at Intel, and **Arati Prabhakar**, Director of NIST, stated that "characterization and modeling of semiconductors are increasingly becoming a crucial part of semiconductor manufacturing. This book provides a concise and effective portrayal of industry characterization needs and the problems that must be addressed by industry, government, and academia to continue the dramatic progress in semiconductor technology."

The work is based on papers given at the International Workshop, held the week of January 30, 1995 at NIST in Gaithersburg, Maryland. Sponsors were: The Advanced Research Projects Agency, SEMATECH, the National Institute of Standards and Technology, The Army Research Office, the U.S. Department of Energy, the National Science Foundation, Semiconductor Equipment and Materials International (SEMI), the Manufacturing Science and Technology Division of the American Vacuum Society, and the Working Group on Electronic Materials of the Committee on Civilian Industrial Technologies.

For additional information, or to order the Proceedings, call the American Institute of Physics toll free at 1-800-809-2247.

Lists of Publications

Bradford, A.G., **Metrology for Electromagnetic Technology: A Bibliography of NIST Publications**, NISTIR 5040 (September 1995).

This bibliography lists the publications of the personnel of the Electromagnetic Technology Division of NIST during 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 also included. This edition of the bibliography is the first since the Electromagnetic Technology Division split into two Divisions, and it includes publications from the areas of cryoelectronic metrology and superconductor and magnetic measurements. The optical electronic metrology section found in earlier editions is now being produced separately by the new Optoelectronics Division of NIST. That companion bibliography to this publication is NISTIR 4041.
[Contact: Ann G. Bradford, (303) 497-3678]

Lyons, R.M., **A Bibliography of the NIST Electromagnetic Fields Division Publications**, NISTIR 5039 (August 1995).

This bibliography lists the publications by the staff of the National Institute of Standards and Technology's Electromagnetic Fields Division for the period January 1970 through July 1995. It supersedes NISTIR 5028 which listed the publications of the Electromagnetic Fields Division from January 1970 through July 1994. Selected earlier publications from the Division's predecessor organizations are

Dr. David G. Seiler Appointed Chief of NIST's Semiconductor Electronics Division

On September 1, 1995, David G. Seiler assumed the responsibilities of Chief of the Semiconductor Electronics Division, Electronics and Electrical Engineering Laboratory, at the National Institute of Standards and Technology. Dr. Seiler has been with the Division as leader of the Materials Technology Group since 1988, with an assignment as a NIST Program Office analyst for the past year. Prior to coming to NIST, Seiler was a Regents Professor of Physics at the University of North Texas, had served as a solid state physics program officer in the Division of Materials Research at the National Science Foundation (1985-86), and spent a year's sabbatical at the M.I.T. Francis Bitter National Magnet Laboratory (1980-81). Seiler has made significant contributions to the characterization of various semiconductors and has published over 100 papers on their electrical, optical, and nonlinear optical properties. He also has organized a number of international conferences and workshops on semiconductors and has been the editor of several semiconductor books.

The Semiconductor Electronics Division provides measurement-related infrastructure needed by the semiconductor industry in the areas of semiconductor materials, processing, and integrated circuits. Seiler wants the division to continue to make a significant impact on the semiconductor industry with respect to silicon, through achieving goals outlined in the 1994 Semiconductor Industry Association National Technology Roadmap for Semiconductors. With respect to compound semiconductors, he wants to help industry develop an assessment of the measurement infrastructure required for advances in compound semiconductors, and then help to respond to this assessment.

included.
[Contact: Ruth Marie Lyons, (303) 497-3132

Schmeit, R.A., **Electrical and Electronic Metrology: A Bibliography of NIST Electricity Division's Publications, NIST List of Publication 94** (July 1995).

This bibliography covers publications of the Electricity Division (and predecessor organizational units), Electronics and Electrical Engineering Laboratory, National Institute of Standards and Technology, for the period of January 1968 through December 1994. A brief description of the Division's technical program is given in the introduction.
[Contact: Ruth A. Schmeit, (301) 975-2401]

Smith, A.J., and Derr, L.S., **A Bibliography of Publications of the NIST Optoelectronics Division**, NISTIR 5041 (September 1995).

This bibliography lists publications of the staff of the Optoelectronics Division and its predecessor organizational units from 1970 through the date of this report.
[Contact: Annie J. Smith, (303) 497-5342]

Walters, E.J., **NIST List of Publications 103, National Semiconductor Metrology Program and the Semiconductor Electronics Division, 1990-1995**. (March 1996).

This List of Publications includes all papers relevant to semiconductor technology published by NIST staff, including work of the National Semiconductor Metrology Program, and the Semiconductor Electronics Division, and other parts of NIST having independent interests in semiconductor metrology. Bibliographic information is provided for publications from 1990 through 1995. Indices by topic area and by author are provided. Earlier reports of work performed by the Semiconductor Electronics Division (and its predecessor divisions) during the period from 1962 through December 1989 are provided in NIST List of Publications 72.
[Contact: E. Jane Walters, (301) 975-2050]

1996 Calendar of Events

May 6-7, 1996 (Baveno, Italy)

IEEE Workshop on VLSI and Microsystem Packaging Techniques and Manufacturing.

The Workshop is co-sponsored by NIST and IEEE, in cooperation with the European Communities, ESPRII DGIII-Industry, NETPACK (the Network in Microelectronic System Integration Packaging), and the JESSI Organization. Topics to be addressed are: the design and implementation of first-level electronic packaging and the technologies, materials, and equipment for the manufacture of multichip and single-chip packages for VLSI and the new emerging domain of microsensors and microsystems.
[Contact: George G. Harman, (301) 975-2097]

July 16-18, 1996 (San Francisco, California)

SEMICON/West '96, Moscone Center. The NIST National Semiconductor Metrology Program will continue its government-industry liaison support role by exhibiting at SEMICON/West in 1996. For over 40 years, NIST and its predecessor, the National Bureau of Standards, have provided expertise on semiconductor-related issues to industry, government agencies, and academia. Since SEMICON/-West's inception 26 years ago, NIST personnel have provided the same expertise to the show's attendees. NIST's booth is located in Hall 4, Booth 6547. Please stop by and see us!
[Contact: Alice Settle-Raskin, (301) 975-4400]

October 1-3, 1996 (Boulder, Colorado)

Symposium on Optical Fiber Measurements. This Symposium, held at NIST in Boulder, provides a forum for reporting the results of recent measurement research in the area of lightwave communications, including optical fibers. Aspects of optical fiber metrology will be discussed, including attenuation, dispersion, geometry, reflectometry, and connectors; integrated optic devices; laser diode sources and detectors; and system measurements.
[Contact: Douglas L. Franzen, (303) 497-3346]

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NIST SILICON RESISTIVITY SRMs

The Semiconductor Electronics Division of NIST provides Standard Reference Materials (SRMs) for bulk silicon resistivity through the NIST Standard Reference Materials Program. The existing SRMs (on 50 mm wafers) shown in the table below will be augmented with an improved set (on 100 mm wafers) during CY 96-97. NIST efforts to produce the new SRMs have recently received increased emphasis. The earlier set will continue to be available until the supply is exhausted.

The new SRMs have similar values of nominal resistivity as the earlier set, but offer improved uniformity and substantially reduced uncertainty of certified values due both to material and procedural improvements. While it is expected that these wafers will offer considerable utility in calibrating contactless gauges, certification has been performed solely with four-point probe methods. Technical insights presented by the rigorous certification process will be presented in a NIST Special Publication. Individual data for each wafer will be supplied along with the SRM Certificate.

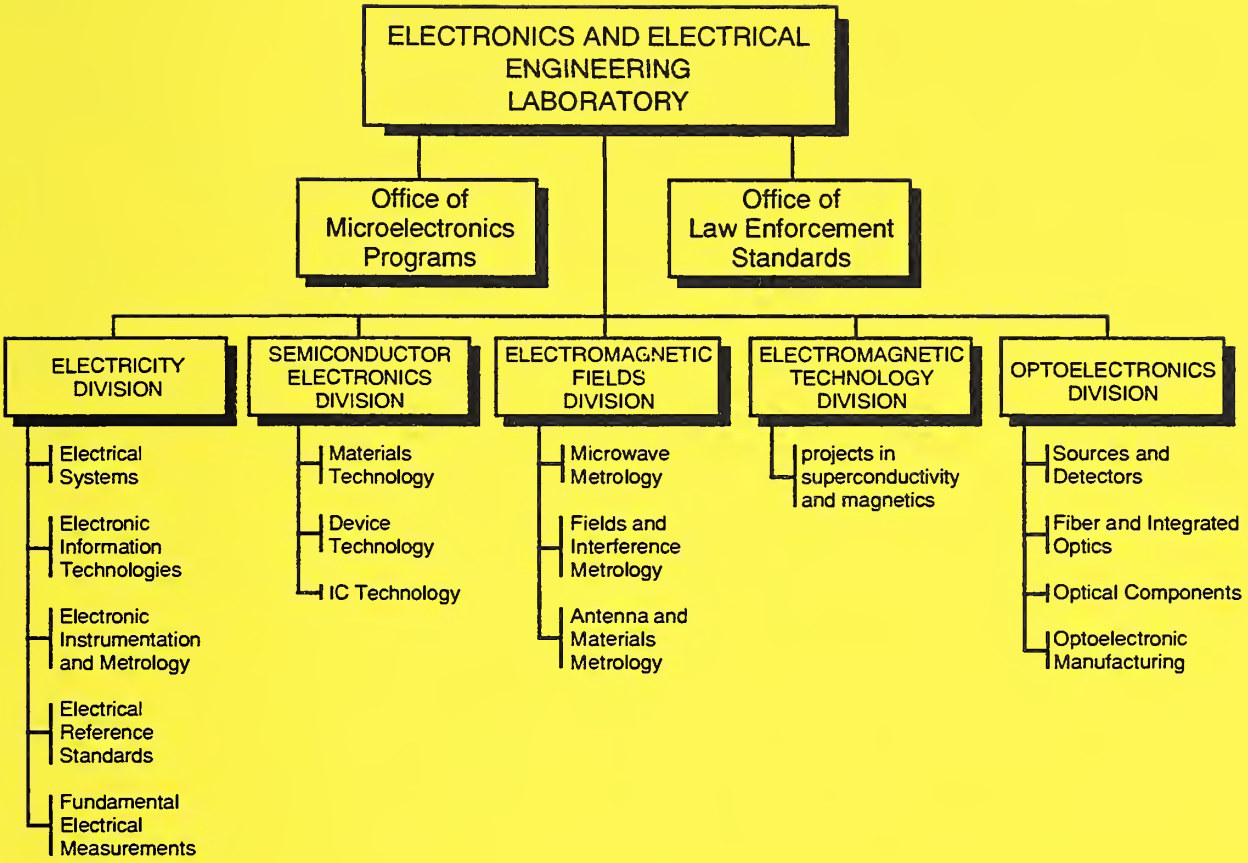
It is expected that the higher resistivity SRMs (2547, 2546) will be available first during CY 96 and be followed closely by SRM 2545. The low resistivity material (SRMs 2542, 2541) is expected to be available by year end. A limited number of SRM 2543 may also be available by year end, with the remainder in early CY 97. Technical issues associated with SRM 2544 will preclude its availability until CY 97.

NIST SILICON BULK RESISTIVITY STANDARD REFERENCE MATERIALS

DATE UPDATED: 23 JANUARY 1996

NOMINAL RESISTIVITY (ohm · cm)	OLD SRMs	AVAILABILITY	NEW SRMs (ohm · cm)	ANTICIPATED AVAILABILITY
0.01	1523 (one of set of two wafers)	limited supply	2541	CY 96
0.1	1521 (one of set of two wafers)	limited supply	2542	CY 96
1	1523 (one of set of two wafers)	limited supply	2543	CY 96-97
10	1521 (one of set of two wafers)	limited supply	2544	CY 97
25	1522	set of three wafers no longer available	2545	CY 96
75	1522		2546 (100)	CY 96
180	1522		2547 (200)	CY 96

The above table will be updated in future issues to reflect changes in availability. Every effort will be made to provide accurate statements of availability; NIST sells SRMS on an as-available basis. For technical information, contact James R. Ehrstein, (301) 975-2060; for ordering information, call the Standard Reference Materials Program Domestic Sales Office: (301) 975-6776.



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