NAT'L INST. OF STAND & TECH
A11106 243101

NIST
PUBLICATIONS

NISTIR 4997

Electronics and Electrical
Engineering Laboratory

Technical Publication Announcements

Covering Laboratory Programs,
April to June 1992,
with 1992/1993 EEEL Events Calendar

E. J. Walters
Compiler

December 1992

33

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

QC
100
.U56
no.4997
1992

NIST

NISTIR 4997

Electronics and Electrical Engineering Laboratory

Technical Publication Announcements

Covering Laboratory Programs, April to June 1992, with 1992/1993 EEEL Events Calendar

E. J. Walters
Compiler

December 1992

33

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

U.S. DEPARTMENT OF COMMERCE
Barbara Hackman Franklin, Secretary

TECHNOLOGY ADMINISTRATION
Robert M. White, Under Secretary for Technology

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY
John W. Lyons, Director

INTRODUCTION TO THE EEEL TECHNICAL PUBLICATION ANNOUNCEMENTS

This is the thirty-third 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 second quarter of calendar year 1992.

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 1992/1993 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 four technical research Divisions: the Semiconductor Electronics and the Electricity Divisions in Gaithersburg, Md., and the Electromagnetic Fields and Electromagnetic Technology Divisions in Boulder, Colo. In 1991, the Office of Law Enforcement Standards, formerly the Law Enforcement Standards Laboratory, was transferred to EEEL. This Office conducts research and provides technical services to the U.S. Department of Justice, State and local governments, and other agencies in support of law enforcement activities. In addition, the Office of Microelectronics Programs (OMP) was established in EEEL to coordinate 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 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 19.

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 16.

TABLE OF CONTENTS

INTRODUCTION ... inside title page

FUNDAMENTAL ELECTRICAL MEASUREMENTS ... 2

SEMICONDUCTOR MICROELECTRONICS ... 3
- Compound Materials ... 3
- Analysis Techniques ... 3
- Device Physics and Modeling ... 4
- Dimensional Metrology ... 4
- Integrated-Circuit Test Structures ... 5
- Microfabrication Technology ... 5
- Plasma Processing ... 5
- Packaging ... 6
- Power Devices ... 6
- Photodetectors ... 7
- Reliability ... 7

SIGNAL ACQUISITION, PROCESSING, AND TRANSMISSION ... 7
- DC and Low-Frequency Metrology ... 7
- Waveform Metrology ... 9
- Antenna Metrology ... 10
  [Also see Electromagnetic Interference - Radiated]
- Noise Metrology ... 10
- Electromagnetic Properties ... 11
- Optical Fiber Sensors ... 12
- Electro-Optic Metrology ... 12
- Other Signal Topics ... 13

ELECTRICAL SYSTEMS ... 13
- Magnetic Materials and Measurements ... 14
- Superconductors ... 14

ELECTROMAGNETIC INTERFERENCE ... 15
- Radiated ... 15

ADDITIONAL INFORMATION ... 16
1992/1993 EEEL CALENDAR ... 19
EEEL SPONSORS ... 19
KEY CONTACTS IN LABORATORY, LABORATORY ORGANIZATION ... inside back cover

FUNDAMENTAL ELECTRICAL MEASUREMENTS

Cage, M.E., **Quantized Dissipation of the Quantum Hall Effect at High Currents**, Conference Record, Conference on Precision Electromagnetic Measurements (CPEM '92), Paris, France, June 9-12, 1992, pp. 362-363 (1992).

Quantized dissipative voltage states are observed when large currents are passed through high-quality quantized Hall resistance devices. These dissipative states are interpreted as occurring when electrons make transitions between Landau levels and then return back to the lowest-filled levels.
[Contact: Marvin E. Cage, (301) 975-4249]

Elmquist, R.E., **Detection of Leakage Errors in Cryogenic Current Comparator Bridges**, Conference Record, Conference on Precision Electromagnetic Measurements (CPEM '92), Paris, France, June 9-12, 1992, pp. 276-277 (1992).

Several tests have been developed to detect leakage currents in cryogenic current comparator (CCC) resistance ratio bridges used to measure ratios of 100:1000 Ω and 100:6453.2 Ω. The major advantage of the tests is that they can be performed in situ using the full sensitivity of the CCC bridge. In addition, the test procedures can locate the source of some leakage currents. These test results will be used to reduce the leakage errors of CCC ratio measurements linking NIST working standards to the quantized Hall resistance and to the calculable capacitor experiment.
[Contact: Randolph E. Elmquist, (301) 975-6591]

Kim, C.G., Williams, E.R., Sasaki, H., Ye, S., Olsen, P.T., and Tew, W.L., **NMR Based Current/-Voltage Source**, Conference Record, Conference on Precision Electromagnetic Measurements (CPEM '92), Paris, France, June 9-12, 1992, pp. 414-415 (1992).

A one-ampere current has been stabilized using nuclear magnetic resonance (NMR) techniques. A pair of tandem solenoids produce two uniform magnetic fields in opposite directions and these fields are not affected by external magnetic shielding. The current and background field are controlled to 0.1 parts per million in three hours.
[Contact: Edwin R. Williams, (301) 975-6555]

Martinis, J.M., Zimmerli, G., Eiles, T.M., Jensen, H.D., and William, E., **Proposed Measurement of the Fine Structure Constant Using a Coulomb-Blockade Charge Pump** [original title: New Measurement of the Fine Structure Constant Utilizing a Coulomb Blockade Charge Pump], Conference Record, Conference on Precision Electromagnetic Measurements (CPEM '92), Paris, France, June 9-12, 1992, pp. 14-15 (1992).

We propose an experiment of which a new measurement of the fine structure constant can be obtained. This measurement utilizes an electron pump device that can transfer a countable number of electrons into a capacitor which then can be compared with the calculable capacitor. We discuss key requirements of the experiment.
[Contact: John M. Martinis, (303) 497-3597]

Olsen, P.T., Tew, W.L., and Williams, E.R., **Improvements in the NIST Watt Measurement: Monitoring the Mass Stability of the Kilogram**, Conference Record, Conference on Precision Electromagnetic Measurements (CPEM '92), Paris, France, June 9-12, 1992, pp. 123-124 (1992).

Considerable progress has been made toward the two-orders-of-magnitude decrease of the experimental uncertainty of the NIST watt measurement from that previously reported. The rebuilding of the apparatus and electronics provides the automated measurement capability to obtain the statistical resolution required to study the system's behavior and the numerous possible sources of error.
[Contact: P. Thomas Olsen, (301) 975-6553]

Tew, W.L., and Williams, E.R., **A Flux Locked Current Source Reference**, Conference Record, Conference on Precision Electromagnetic Measurements (CPEM '92), Paris, France, June 9-12, 1992, pp. 70-71 (1992).

The quantization of flux in a closed superconducting circuit is used to provide a stable reference current. A 10-mA current source is coupled via a toroidal transformer to a dc SQUID input and the resulting signal fed back as an error current. The result is a net current that exhibits stability of 1×10^{-9} per hour and is quantized with a step size of 59.4 nA. This current is fed through a precision 100-Ω resistor and compared against Zener and standard cell voltage

references.
[Contact: W. L. Tew, (301) 975-6552]

Van Degrift, C.T., Yoshihiro, K., Palm, E.C., Wakabayashi, J., Kawaji, S., and Cage, M.E., **Re-Examination of Quantum Hall Plateaus**, Conference Record, Conference on Precision Electromagnetic Measurements (CPEM '92), Paris, France, June 9-12, 1992, pp. 288-289 (1992).

Even though the practical unit of electrical resistance was tied to the quantum Hall effect in 1990, our understanding of the fundamental physics of current flow, contacting, and impurity effects in quantum Hall systems remains incomplete. This paper examines some recently discovered effects which may affect quantum Hall resistance determinations.
[Contact: Craig T. Van Degrift, (301) 975-4248]

Williams, E.R., Ghosh, R.N., and Martinis, J.M., **Measuring the Electron's Charge and the Fine Structure Constant by Counting Electrons on a Capacitor**, Journal of Research of the National Institute of Standards and Technology, Vol. 97, No. 2, pp. 299-304 (March-April 1992).

The charge of the electron can be determined by simply placing a known number of electrons on one electrode of a capacitor and measuring the voltage, V_s, across the capacitor. If V_s is measured in terms of the Josephson volt and the capacitor is measured in SI units, then the fine-structure constant is the quantity determined. Recent developments involving single electron tunneling have shown how to count the electrons as well as how to make an electrometer with sufficient sensitivity to measure the charge.
[Contact: Edwin R. Williams, (301) 975-6555]

Yoshihiro, K., Van Degrift, C.T., Cage, M.E., and Yu, D., **Anomalous Behavior of a Quantized Hall Plateau in a High-Mobility Si Metal-Oxide-Semiconductor Field-Effect Transistor** [original title: Anomalous Behavior of a Quantized Hall Plateau in a High-Mobility Si-MOSFET], Physical Review B, Vol. 45, No. 24, pp. 204-214 (15 June 1992).

Measurements at 14 T and 340 mK of the i=4 quantized Hall resistances of a Si-MOSFET made with a precision of 0.005 parts per million and an accuracy of 0.015 parts per million revealed unexpected irregularities. Smooth variations of ±0.04 parts per million were observed across the plateau even though the Si-MOSFET had a mobility of 1.2 $m^2/V{\cdot}s$ and a longitudinal resistivity less than 0.002 parts per million of the plateau resistivity. Furthermore, measurements over a period of several months indicated that the plateau shape is metastable. A variety of possible causes for these phenomena are discussed, but none provides a satisfactory explanation.
[Contact: Craig T. Van Degrift, (301) 975-4248]

SEMICONDUCTOR MICROELECTRONICS

Compound Materials

Tseng, W.F., Comas, J., Steiner, B., Metze, G., Cornfeld, A., Klein, P.B., Gaskill, D.K., Xia, W., and Lau, S.S., **Growth and Characterization of Ternary and Quaternary Compounds of $In_y(Al_xGa_{1-x})_{1-y}As$ on (100) InP**, Proceedings of the Materials Research Society Symposium, Boston, Massachusetts, December 4, 1991, Vol. 240, pp. 117-122.

The acquisition of reflection-high-energy-electron-diffraction (RHEED) oscillation information on (100) GaAs substrates is described for use in the growth of "lattice-matched" $In_y(Al_xGa_{1-x})_{1-y}As$ layers on (100) InP substrates with $0.52 \leq y \leq 0.53$ and $0.00 \leq x \leq 1.00$. The observed frequency of the RHEED oscillations on GaAs is the same as on InP; however, the measured lattice parameters of the grown layers are less than that of InP. The X-ray diffraction images show that the misfit dislocations perpendicular to the primary flats of 2-in. round (100) InP wafers are denser than the parallel ones. Photoluminescence (at 10 K) and photoreflectance (at 300 K) measurements on a composite layer structure of x=0, 0.2, 0.4, 0.6, 0.8, and 1 clearly show six distinct peaks with narrow FWHMs of less than 20 meV. The measured bandgaps increase linearly with the Al content.
[Contact: Wen F. Tseng, (301) 975-5291]

Analysis Techniques

Albers, J., **Semiconductor Measurement Technology: Version 2.0 of the TXYZ Thermal Analysis Program: TXYZ20**, NIST Special Publication 400-89 (June 1992).

The TXYZ computer program has been used for a number of years for the thermal analysis of semiconductor devices and packages. This program makes

use of the closed form, Fourier series solution of the steady-state heat flow equation for the general case of a rectangular three-layer structure with multiple heat sources on the top surface. TXYZ provides for the calculation of the temperature at any set of points in this structure and has proven useful for the determination of the steady-state temperature distribution of semiconductor chips and packages. This report presents TXYZ20 (TXYZ Version 2.0) which is a revised and updated version of the original TXYZ program. The TXYZ20 program incorporates more flexible handling of input data, assignment of positive or negative noninteger weights to the various heat sources or heat sinks, and improved evaluation of limiting forms in the code.

The first part of this report consists of a discussion of the general elements in the TXYZ code and the particular changes which have been made to it to obtain TXYZ20. The second part of the report contains a discussion of several examples of the running of the code. Several annotated input data files are presented and discussed to show both the increased flexibility of the input data and the actual use of the updated code. Running the TXYZ20 code for one of the input files provides a benchmark for several machines. The user may wish to run this example for the purpose of comparing the CPU times involved. The appendix contains an annotated, internally documented listing of the FORTRAN source code for TXYZ20.

The FORTRAN source code (total of about 21 kbytes) and sample input and output data files are available in ASCII format using a number of transfer vehicles. These include: standard 8 track magnetic tape (ASCII, density = 1600, record = 80, block = 1600), 5.25-in. (360-kbyte and 1.2-Mbyte) DOS-formatted floppy disks, and electronic mail over the Internet. The sample input and output data files are included so that the user can check the program for proper operation as well as to become acquainted with the setup and use of the code. Users of the TXYZ code will find the updated TXYZ20 code easy to use and should benefit from the more flexible input and the more general treatment of heat sources and heat sinks.
[Contact: John Albers, (301) 975-2075]

Device Physics and Modeling

Tomizawa, M., Ishibashi, T., Bennett, H.S., and Lowney, J.R., **Effects of Heavy Doping on Numerical Simulations of Gallium Arsenide Bipolar Transistors,** [original title: Verification of Effective Intrinsic Carrier Concentrations for Numerical Simulations of Gallium Arsenide Bipolar Transistors], Solid-State Electronics, Vol. 35, No. 6, pp. 865-874 (1992).

Knowing how the effective intrinsic carrier concentrations vary with doping and carrier densities is essential for predictive numerical simulations of advanced, high performance GaAs transistors. Theoretical calculations for the effective intrinsic carrier concentrations, n_{ie}, of GaAs at 300 K have been verified experimentally for the first time by measurements on devices. Two GaAs homojunction bipolar transistors with heavily doped bases and emitters that have widths between 0.05 μm and 0.45 μm were fabricated to compare measured and predicted current-voltage characteristics and dc common emitter gains. The theoretical data for n_{ie} were implemented into a two-dimensional, drift-diffusion simulator for these transistors. The predicted gain of eight for one of the transistors agreed very well with its measured gain of nine. Without using the new theoretical data for n_{ie}, the predicted gain would have been four. The predicted gain of 25 for the other transistor also agreed well with its measured gain of 22. Without using the theoretical data, the predicted gain for the second transistor would have been 14. Sensitivity analyses on mobilities, lifetimes, and n_{ie} show that correct n_{ie} values are very important for predictive simulations of GaAs bipolar transistors.
[Contact: Herbert S. Bennett, (301) 975-2079]

Dimensional Metrology

Geist, J., Belzer, B.J., Miller, M.L., and Roitman, P., **Optical Calibration of a Submicrometer Magnification Standard**, Journal of Research of the National Institute of Standards and Technology, Vol. 97, No. 2, pp. 267-272 (March-April 1992).

The calibration of a new submicrometer magnification standard for electron microscopes is described. The new standard is based on the width of a thin thermal-oxide film sandwiched between a silicon single-crystal substrate and a polysilicon capping layer. The calibration is based on an ellipsometric measurement of the oxide thickness before the polysilicon layer is deposit-

ed on the oxide. The uncertainty in the derivation of a thickness for the layer from the ellipsometric parameters is also derived.
[Contact: Jon Geist, (301) 975-2066]

Integrated-Circuit Test Structures

Allen, R.A., Cresswell, M.W., and Buck, L.M., **A New Test Structure for the Electrical Measurement of the Width of Short Features with Arbitrarily Wide Voltage Taps**, IEEE Electron Device Letters, Vol. 13, No. 6, pp. 322-324 (June 1992).

Accurate determination of the linewidth of a narrow, conducting film for VLSI applications using electrical test structure metrology has required that the length of the line be many times its width to minimize geometric error due to finite width voltage taps. However, long lines obscure important local effects such as nonuniformities in the film. Shorter lines highlight such effects. This paper describes a method of measuring the width of a short line having taps of arbitrary width. The effect of the taps is measured and used in the extraction of the linewidth allowing the confident determination of local linewidth variations.
[Contact: Richard A. Allen, (301) 975-5026]

Mattis, R.L., **Test Structures at NIST**, SRC Newsletter, Vol. 10, No. 4, pp. 4-5 (April 1992).

Some historical background introduces a description of the work in test structures being conducted by the Semiconductor Electronics Division of NIST. The three directions of the current work are (1) to accommodate the shrinking geometries of today's integrated circuit chips, (2) to interpret the large volume of test structure data using expert system and neural network techniques, and (3) to use test structures to evaluate device reliability.
[Contact: Richard L. Mattis, (301) 975-2235]

Microfabrication Technology

Marshall, J.C., Parameswaran, M., Zaghloul, M., and Gaitan, M., **Methodology for the Computer-Aided Design of Silicon-Micromachined Devices in a Standard CMOS Process**, NISTIR 4845 (May 1992). [Also to be published in the IEEE Circuits and Devices Magazine.]

The methodology for implementing the design of silicon-micromachined devices in a standard CMOS foundry process is discussed, and a modified Magic technology file is introduced. The modified technology file is used to design silicon-micromachined devices and circuits that are fabricated using a standard CMOS foundry through the MOSIS service. An additional maskless etch in EDP is required to realize the micromechanical structures once chips are delivered. The modified technology file implements a layer that we call "open" that consists of a combination of active area, contact cut, via, and glass opening. This open area exposes the silicon surface for an anisotropic etch procedure that creates suspended bridges of polysilicon or metal encapsulated in SiO_2. Results from fabricated chips are included.
[Contact: Michael Gaitan, (301) 975-2070]

Tseng, W.F., Pellegrino, J.G., Kim, J.S., Thurber, W.R., Comas, J., Papanicolou, N., and Prokes, S., **Reduction of DX Centers in Superlattice Alloy-Like Material High Electron Mobility Transistors**, Journal of the Electrochemical Society, Vol. 139, No. 4, pp. 1219-1222 (April 1992).

The substitution of selectively Si-doped short-period (4 by 2 and 2 by 1 monolayer(s)) GaAs/AlAs superlattice alloy-like material (SLAM) for Si-doped AlGaAs layers in conventional high electron mobility transistor (HEMT) structures has been demonstrated. Such a short period SLAM HEMT still preserves its field effect transistor characteristics as compared with the conventional HEMT. The shifts of threshold voltages and amounts of DX centers were found to depend on the layer thickness of the superlattices and the positions of Si-dopants within the GaAs layers.
[Contact: Wen F. Tseng, (301) 975-5291]

Plasma Processing

Olthoff, J.K., Roberts, J.R., Van Brunt, R.J., Whetstone, J.R., Sobolewski, M.A., and Djurovic, S., **Mass Spectrometric and Optical Emission Diagnostics for rf Plasma Reactors**, Proceedings of SPIE (The International Society for Optical Engineering, P.O. Box 10, Bellingham, Washington 98227-0010), Process Module Metrology, Control, and Clustering, Vol. 1594, pp. 168-178 (1992).

Mass spectrometric and optical emission studies have been performed on argon discharges in a parallel-

plate rf reactor. Ion energy distributions exhibit structure for ions produced in the sheath region, while ions produced in the bulk plasma exhibit narrow energy distribution indicative of the sheath potential. The addition of small amounts of O_2 to an argon discharge significantly alters the observed ion energy distributions. Optical emission studies indicate increasing spatial nonuniformity in the plasma at higher pressures. Time-resolved optical emission studies indicate a varying relationship between the applied rf voltage and the time-varying optical emission with changing pressure and position between the electrodes.
[Contact: James K. Olthoff, (301) 975-2431]

Packaging

Harman, G.G., **Wire Bonding--Towards 6σ Yield and Fine Pitch**, 1992 Proceedings of the 42nd Electronic Components and Technology Conference, San Diego, California, May 18-20, 1992, pp. 903-910.

The leading edge of semiconductor manufacturing is the high-yield production of semiconductor devices with high I/O counts and fine pitch. The packaging of these chips has become as challenging as the silicon manufacturing itself. The object of this paper is to describe the problems as well as the solutions required to wire bond these high I/O chips to their packages at the required high yields. The elements of achieving 6σ wire bond yield can be summarized as follows: (1) the choice of metallization on the chip as well as on the package is critical; (2) an appropriate cleaning procedure (which in some circumstances may be at the wafer level) and/or special storage and shipping containers are necessary; (3) factorial bonder setup and proper bond test methods are required; (4) uniform, reproducible wire and bonding machine characteristics are essential; and (5) both the chip bond pads and the package pads must be designed with full awareness of the limitations and tolerances of the chosen bonder and its bonding method.

Wafer testing probe cards currently limit the minimum wire bond pad pitch on high-end devices to about 100 μm. However, 75-μm pitch wedge bonding can be performed with current (modified) autobonders, and 40-μm pitch bonding has been reported. Almost every aspect of fine pitch bonding requires more planning and coordination and is more expensive to achieve than bonding at normal pitch.

[Contact: George G. Harman, (301) 975-2097]

Power Devices

Hefner, A.R., Jr., **Semiconductor Measurement Technology: INSTANT — IGBT Network Simulation and Transient ANalysis Tool**, Special Publication 400-88 (June 1992).

The IGBT (Insulated Gate Bipolar Transistor) is a power semiconductor device that has gained acceptance among power electronic circuit design engineers for motor driver and power converter applications, due to its efficient voltage gate drive requirements and due to its high current density capability. These devices have the best features of both power MOSFETs and power bipolar transistors. When designing the circuits and systems that utilize IGBTs, circuit simulations are needed to examine the behavior of the IGBTs within the circuit. However, the semiconductor device models available in most circuit simulators were originally intended to describe microelectronic devices and cannot adequately describe the characteristics of power devices.

In this publication, a compact IGBT model suitable for incorporation in circuit simulators is described, and a circuit simulation program called INSTANT is presented that simulates the dynamic behavior of IGBTs within any external drive, load, and feedback circuit configuration. The INSTANT simulator solves the systems of differential equations (state equations) that describe each component of the circuit, where the equations for the individual components are coupled by the circuit configuration. The INSTANT software package is designed to provide the flexibility to change the external circuit configuration and model equations. The device and circuit parameters are also readily accessible, and the graphics output provides a real-time display of the waveforms as they are calculated.

This publication also describes the automated measurement methods developed to extract the IGBT device model parameters from terminal electrical measurements. It is shown that unlike parameter extraction for microelectronic devices, the dynamic characteristics must be used to characterize the IGBTs and to extract the model parameters. This occurs because the devices exhibit non-quasi-static behavior and because the dynamic waveforms contain

many features that isolate different physical mechanisms, whereas the physical mechanisms are convoluted in the relatively simple steady-state characteristics. The unique features of the IGBT electrical characteristics are explained using the model, and the procedures used to verify the IGBT model are given.
[Contact: Allen R. Hefner, Jr., (301) 975-2071]

Photodetectors

Geist, J., Luther, J.E., Novotny, D.B., and Vahakangas, J., **Simple, Low-Contrast Thermal-Resolution Test Target**, Applied Optics, Vol. 31, No. 16, pp. 2978-2980 (1 June 1992).

An easily constructed, thermal resolution test target for low-contrast applications is described. The calibration of the target need not be obtained by reference to some other radiometric standard, but can be obtained directly from the mechanical dimensions of the device and the thermal conductivity of fused silica.
[Contact: Jon Geist, (301) 975-2066]

Phelan, R.J., Jr., Lehman, J.H., and Larson, D.R., **Reference Detectors for Spectral Responsivity Measurements**, Proceedings of the 1991 Measurement Science Conference, Anaheim, California, January 31-February 1, 1991, pp. 1-8.

This paper presents a view of the need, use, design, and evaluation of detectors to be used for spectral responsivity measurements. The emphasis is on a design that is easy to use and for which the spectral responsivity can be understood and confirmed by the user.
[Contact: Robert J. Phelan, Jr., (303) 497-3696]

Reliability

Schafft, H.A., and Suehle, J.S., **The Measurement, Use, and Interpretation of the Temperature Coefficient of Resistance of Metallizations**, Solid-State Electronics, Vol. 35, No. 3, pp. 403-410 (1992).

The accurate measurement of the temperature coefficient of resistance (TCR) of thin-film, aluminum-based interconnects has many important applications for the reliability of microelectronics. The TCR is used to determine the metallization temperature in electromigration accelerated stress tests, a key element in characterizing the metallization. It can be used as a monitor for metal impurities and changes in structure that may have an impact on the reliability of the metal film. The resistance-versus-temperature behavior can be used to detect process variations that result in changes in cross-sectional areas of interconnect lines and residual resistivity. Also, the TCR permits metal lines to be used as temperature sensors that provide useful data for characterizing thermal environments and for thermal modeling that, again, impact reliability.

To permit the effective use of TCR for these applications, this paper describes the measurement, use, and interpretation of the temperature dependence of thin-film interconnects in ways that will help avoid many pitfalls and problems involved in the measurement and use of TCR. This paper is also intended to complement the JEDEC Standard in preparation on the temperature coefficient of resistance of metallization lines.
[Contact: Harry A. Schafft, (301) 975-2234]

SIGNAL ACQUISITION, PROCESSING, AND TRANSMISSION

DC and Low-Frequency Metrology

Avramov, S., Oldham, N.M., Jarrett, D.G., and Waltrip, B.C., **Automatic Inductive Voltage Divider Bridge for Operation From 10 Hz to 100 kHz**, Conference Record, Conference on Precision Electromagnetic Measurements (CPEM '92), Paris, France, June 9-12, 1992, pp. 67-68.

An automatic bridge to calibrate inductive voltage dividers from 10 Hz to 100 kHz is described. The bridge is based on a programmable 30-bit binary inductive voltage divider with terminal linearity of 0.1 parts per million (ppm) at 400 Hz (linearity degrades 10 ppm at frequency extremes). Measurements of programmable test dividers can be completely automated via General Purpose Interface Bus (GPIB, also known as IEEE 448 bus standard) using software developed to align the bridge components and perform an auto balance.
[Contact: Nile M. Oldham, (301) 975-2408]

Boynton, P.A., **An Automated System for the Measurement of High-Valued Resistors**, Conference Record, Conference on Precision Electromagnetic Measurements (CPEM '92), Paris, France, June 9-

12, 1992, pp. 278-279.

An automated method for measuring high-valued resistors is described. It is based on a loss-of-charge method, involving the discharge of a standard capacitor through an unknown resistor. This system is intended to calibrate standards ranging from $10^{10}\ \Omega$ to $10^{14}\ \Omega$.
[Contact: Paul A. Boynton, (301) 975-4241]

Dziuba, R.F., and Elmquist, R.E., **Improvements in Resistance Scaling at NIST Using Cryogenic Current Comparators**, Conference Record, Conference on Precision Electromagnetic Measurements (CPEM '92), Paris, France, June 9-12, 1992, pp. 284-285.

Cryogenic current comparators (CCCs) are being used at NIST to verify Hamon-type resistance scaling techniques from the 1-Ω level to the 100-Ω, 1-kΩ, 6453.20-Ω, and 10-kΩ resistance levels. Measurements comparing the 100/1 ratio of a CCC to that of a Hamon transfer standard agree to within 0.01 ppm - the practical limit of accuracy for a Hamon standard. The higher ratio accuracies and higher sensitivities of CCC bridges will make it possible to lower the uncertainties associated with resistance scaling at NIST by a factor of two or more.
[Contact: Ronald F. Dziuba, (301) 975-4239]

Jarrett, D.G., and Dziuba, R.F., **Automated AC Bridge for the Measurement of Resistors Over the Frequency Range 10 Hz to 10 kHz**, Conference Record, Conference on Precision Electromagnetic Measurements (CPEM '92), Paris, France, June 9-12, 1992, pp. 87-88.

An automated, guarded ac Kelvin bridge has been developed for measuring the frequency dependence of precision resistors from the 1-Ω to the 1-MΩ level over the frequency range of 10 Hz to 10 kHz. The main ratio arms consist of two-stage 30-bit binary inductive voltage dividers. A guard inductive voltage divider drives a RC network to provide a known phase compensation to balance the quadrature component of the bridge. A bridge substitution technique is used in which the unknown is compared to a standard of known impedance. The bridge resolution is better than 0.1 parts per million for the in-phase and quadrature components.
[Contact: Dean G. Jarrett, (301) 975-4240]

Kinard, J.R., Huang, D.X., and Novotny, D.B., **Multilayer Thin-Film Thermal Converters**, Conference Record, Conference on Precision Electromagnetic Measurements (CPEM '92), Paris, France, June 9-12, 1992, pp. 56-57.

Multilayer, thin-film multijunction thermal converters (MJTCs) are being produced at NIST. This paper describes the thermal and physical designs and materials chosen to reduce ac-dc differences. Experimental results on prototype converters are also given.
[Contact: Joseph R. Kinard, (301) 975-4250]

Kinard, J.R., Knight, R.B.D., Martin, P., Klonz, M., de Vreede, J., and Dessens, J., **Intercomparison of NIST, NPL, PTB, and VSL Thermal Voltage Converters from 100 kHz to 1 MHz**, Conference Record, Conference on Precision Electromagnetic Measurements (CPEM '92), Paris, France, June 9-12, 1992, pp. 318-319.

Coaxial, thermal voltage converters (TVCs) were hand-carried between NIST, NPL, PTB, and VSL for intercomparison of ac-dc difference from 100 kHz to 1 MHz. This paper briefly describes the methods and underlying principles on which ac-dc difference determinations are based in each laboratory, describes the transfer standards used, and gives the results of the intercomparisons.
[Contact: Joseph R. Kinard, (301) 975-4250]

Kinard, J.R., Rebuldela, G., Zhen, Z., Janik, D., Huang, D-X., and de Vreed , J., **Intercomparison of Thermal Converters at NIM, NIST, PTB, SIRI, and VSL from 10 to 100 MHz**, Conference Record, Conference on Precision Electromagnetic Measurements (CPEM '92), Paris, France, June 9-12, 1992, pp. 320-321.

Coaxial, thermal voltage converters have been intercompared between NIM, NIST, PTB, SIRI, and VSL in the frequency range from 10 to 100 MHz. The intercomparisons were made from 1988 through 1990. This paper briefly describes the methods and underlying principles on which rf-dc difference determinations are based in each laboratory, describes the transfer standards used, and gives the results of the intercomparisons.
[Contact: Joseph R. Kinard, (301) 975-4250]

Oldham, N.M., Petersons, O., and Waltrip, B.C., **Automatic Impedance Bridge for Calibrating Standard Inductors,** Conference Record, Conference on Precision Electromagnetic Measurements (CPEM '92), Paris, France, June 9-12, 1992, pp. 419-420.

An impedance bridge that compares standard inductors to characterized resistors is described. A dual channel digitally synthesized source that is adjustable in amplitude and phase is used to balance the bridge. Uncertainties of less than ±100 parts per million are possible in low audio frequency range for inductors from 10 μH to 10 H.
[Contact: Nile M. Oldham, (301) 975-2408]

Steiner, R.L., Early, E.A., and Kiser, C., **Voltage Ratio Measurements of a Zener Reference Using a Digital Voltmeter** [original title: 1:10 Volt Ratio Measurements of a Zener Reference Using a Digital Voltmeter], Conference Record, Conference on Precision Electromagnetic Measurements (CPEM '92), Paris, France, June 9-12, 1992, pp. 300-301.

A high-precision digital voltmeter can be used to measure the ratio of 1 V to 10 V very accurately. Preliminary tests of calibrating 10-V zener references from a 1-V Josephson array standard indicate that an accuracy with an uncertainty of several parts in 10^8 is possible.
[Contact: Richard L. Steiner, (301) 975-4226]

Steiner, R.L., and Stahley, S., **Zener Reference Transfers Between 10-V Josephson Array Systems,** Conference Record, Conference on Precision Electromagnetic Measurements (CPEM '92), Paris, France, June 9-12, 1992, pp. 366-367.

A multi-zener reference standard was measured at seven metrology laboratories which operate 10-V Josephson array standard systems. Six laboratories agreed with the NIST-measured voltage to within 0.02 parts per million with typical random uncertainties of less than 0.015 parts per million (1σ). One laboratory had a 0.11 ± 0.012 parts per million difference.
[Contact: Richard L. Steiner, (301) 975-4226]

Waveform Metrology

Oldham, N.M., and Hetrick, P.S., **Characterized Generator Extends Phase Meter Calibrations from 50 kHz to 20 MHz,** Conference Record, Conference on Precision Electromagnetic Measurements (CPEM '92), Paris, France, June 9-12, 1992, pp. 352-353.

A phase angle standard generator made by phase locking two function generators is described. The generator produces two sine waves that are programmable in phase (0 to 360°), amplitude (0 to 40 V rms), and frequency (< 1Hz to 20 MHz). The phase linearity is characterized from ±50 to ±250 mdeg over the frequency range without external phase standards.
[Contact: Nile M. Oldham, (301) 975-2408]

Stenbakken, G. N., and Dolev, A., **High-Accuracy Sampling Wattmeter,** Proceedings of the IEEE Instrumentation and Measurement Technology Conference, Secaucus, New Jersey, May 12-14, 1992, pp. 568-572. [A slightly revised version will appear in a special issue of IEEE Transactions on Instrumentation and Measurement (IMTC/92).]

A high-accuracy sampling wattmeter was developed at the National Institute of Standards and Technology (NIST) to investigate the feasibility of using waveform-sampling techniques for making very accurate power measurements at frequencies from 50 Hz to 1000 Hz. The prototype instrument is not portable, but was used to demonstrate the accuracy achievable with the sampling method. The goal of this development was to build an instrument with an uncertainty of less than ±50 parts per million over these frequencies. The new high-accuracy sampling wattmeter was built around a previous wideband instrument developed earlier at NIST.

The new wattmeter uses 16-bit converters and includes a two-stage current transformer in one of the modules. This wattmeter, as the previous wattmeter, operates with asynchronous sampling. The high accuracy is achieved by approximately synchronizing the interval over which samples are taken with the period of the input signal. Special care was taken to design input stages with a flat frequency response and low-temperature sensitivity. The wattmeter has been calibrated using the NIST Audio-Frequency Power bridge. The two instruments agreed to better than ±50 parts per million of full scale over the 50-Hz to 1000-Hz frequency range at all power factors.
[Contact: Gerard N. Stenbakken, (301) 975-2440]

Waltrip, B.C., Parker, M.E., Oldham, N.M., and Bell,

B.A., **A Sampling Technique for Calibrating Phase Angle Generators from 1 Hz to 100 kHz,** Conference Record, Conference on Precision Electromagnetic Measurements (CPEM '92), Paris, France, June 9-12, 1992, pp. 421-422.

A method of calibrating phase angle generators from 1 Hz to 100 kHz is described. A commercial dual-channel waveform sampler is used to digitize both waveforms of the generator. The phase relationship between the two signals is resolved to <1 mdeg using a four-parameter sine fit. The uncertainty in phase linearity is 1 to 10 mdeg over the frequency range.
[Contact: Bryan C. Waltrip, (301) 975-2438]

Antenna Metrology
[Also see Electromagnetic Interference - Radiated]

Muth, L.A., **Probe-Position Error Correction in Planar Near Field Measurements at 60 GHz: Experimental Verification,** Journal of Research of the National Institute of Standards and Technology, Vol. 97, No. 2, pp. 273-297 (March-April 1992).

This study was conducted to verify that the probe-position error-correction technique can be successfully applied to real data obtained on a planar near-field range, where the probe-position errors are known. Since probe-position error correction is most important at high frequencies, measurements were made at 60 GHz. Six planar scans at z positions separated by 0.03λ were obtained. The correction technique was applied to an error-contaminated near-field measurement constructed out of the six scans according to a discretized periodic error functions. The results indicate that probe-position errors can be removed from real near-field data as successfully as from simulated data; some residual errors, which are thought to be due to multiple reflections, residual drift in the measurement system, and residual probe-position errors in all three coordinates are observed.
[Contact: Lorant A. Muth, (303) 497-3603]

Noise Metrology

Estin, A.J., Juroshek, J.R., Marks, R.B., Clague, F.R., and Allen, J.W., **Basic rf and Microwave Measurements: A Review of Selected Programs** [original title: Basic rf and Microwave Measurements: A Review of Selected Programs at NIST], Metrologia, Vol. 29, pp. 135-151 (1992).

This paper summarizes the principles, historical background, and present status of three primary areas of rf and microwave measurements and standards: circuit parameter measurement, power measurement, and noise generation and measurement. Both the reference standards and the techniques of measurement and of transfer to secondary standards are addressed. An extensive bibliography is provided to enable the interested reader to pursue areas to greater depth, and brief discussions to indicate likely directions of current and future work are included.
[Contact: John R. Juroshek, (303) 497-5362]

Microwave and Millimeter-Wave Metrology

Estin, A.J., Juroshek, J.R., Marks, R.B., Clague, F.R., and Allen, J.W., **Basic rf and Microwave Measurements: A Review of Selected Programs** [original title: Basic rf and Microwave Measurements: A Review of Selected Programs at NIST], Metrologia, Vol. 29, pp. 135-151 (1992).

This paper summarizes the principles, historical background, and present status of three primary areas of rf and microwave measurements and standards: circuit parameter measurement, power measurement, and noise generation and measurement. Both the reference standards and the techniques of measurement and of transfer to secondary standards are addressed. An extensive bibliography is provided to enable the interested reader to pursue areas to greater depth, and brief discussions to indicate likely directions of current and future work are included.
[Contact: John R. Juroshek, (303) 497-5362]

Marks, R.B., **Comments on "Rapid Pulsed Microwave Propagation,"** IEEE Microwave and Guide Wave Letters, Vol. 2, No. 5, p. 204 (May 1992).

This letter discusses a recently published paper which reports experimental evidence of electromagnetic pulses propagating faster than the speed of light. It argues that such results contradict Maxwell's equations. Limitations of the experiment are examined.
[Contact: Roger B. Marks, (303) 497-3037]

Reeve, G.R., **Millimeter Wave Metrology at the National Institute of Standards and Technology,** Proceedings of the National Conference of Standards Laboratories, 1991 Workshop and Symposium,

Albuquerque, New Mexico, August 18-22, 1991, pp. 183-195.

Over the past several years, there has been an increased interest in the use of millimeter waves for such diverse applications as wide-band satellite communications, short-range radar and vehicle traffic control, and a much expanded cellular personal telephone service. Recent developments in gallium arsenide fabrication and MMIC devices promise low-cost, high-performance circuits. Over the past five years, the National Institute of Standards and Technology has been engaged in a program to expand its measurement services in this region of the spectrum. This paper describes the additions that have been made to these services and some of the technical challenges that were encountered during the process. [Contact: Gerome R. Reeve, (303) 497-3557]

Williams, D.F., and Marks, R.B., **Frequency-Dependent Transmission Line Parameters** [original title: Frequency-Dependent Transmission Line Parameters of Interconnects Determined from Microwave Measurements], Proceedings of the IEEE Topical Meeting on Electrical Performance of Electronic Packaging, Tucson, Arizona, April 22-24, 1992, pp. 125-127 (1992).

New results in microwave circuit and measurement theory are applied to the problem of determining the equivalent circuit parameters of quasi-TEM transmission lines. The effects of field penetration into the conductors gives rise to a frequency-dependent inductance and resistance. The behavior of the equivalent circuit parameters is exploited to determine relationships between the characteristic impedance and readily measurable quantities. This allows the application of microwave measurement techniques to a comprehensive characterization of these lines. [Contact: Dylan F. Williams, (303) 497-3138]

Electromagnetic Properties

Baker-Jarvis, J.R., Janezic, M.D., Grosvenor, J.H., Jr., and Geyer, R.G., **Transmission/Reflection and Short-Circuit Line Methods for Measuring Permittivity and Permeability** [original title: Transmission/Reflection and Short-Circuit Line Methods for Permittivity and Permeability Determination], NIST Technical Note 1355 (May 1992).

The transmission/reflection and short-circuit line methods for measuring complex permittivity and permeability of materials in waveguides and coaxial lines are examined. Equations for complex permittivity and permeability are developed from first principles. In addition, new formulations for the determination of complex permittivity and permeability independent of reference plane position are derived. For the one-sample transmission/reflection method and two-position short-circuit line measurements, the solutions are unstable at frequencies corresponding to integral multiples of one-half wavelength in the sample. For two-sample methods the solutions are unstable for frequencies where both samples resonate simultaneously. Criteria are given for sample lengths to maintain stability. An optimized solution is also presented for the scattering parameters. This solution is stable over all frequencies and is capable of reducing scattering parameter data on materials with higher dielectric constant. An uncertainty analysis for the various techniques is developed and the results are compared. The errors incurred due to the uncertainty in scattering parameters, length measurement, and reference plane position are used as inputs to the uncertainty models. [Contact: James R. Baker-Jarvis, (303) 497-5621]

Gans, W.L., Geyer, R.G., and Klemperer, W.K., **Quantifying Standard Performance of Electromagnetic-Based Mine Detectors**, NISTIR 3982 (October 1991).

This is a final report to the sponsor on work performed by National Institute of Standards and Technology (NIST) personnel from January 1, 1985 to December 31, 1990. An overview of the theory of the electromagnetic (EM) properties of soils is presented, along with a brief review of existing technologies for the detection of buried objects using electromagnetics. The critical electromagnetic performance factors for portable EM mine detectors that NIST has identified are presented, along with a discussion of measurement systems for measuring the constitutive properties of soil and mine-like materials. Recommendations are then presented for a measurement system configuration that should meet most of the Army's requirements. A recommended mine detector testing strategy is then presented along with a set of instructions for specific tests and an algorithm for comparatively scoring the performance of detectors. The tests and the scoring algorithm are as specific and as detailed as

is possible at this stage of development. Last, a section is included that contains NIST's recommendations for the test data that should be archived.
[Contact: William L. Gans, (303) 497-3538]

Hill, D.A., **Gradiometer Antennas for Tunnel Detection**, NISTIR 3990 (June 1992).

The use of gradiometer antennas for detection of long conductors and detection of empty tunnels is analyzed. For reception in vertical boreholes, the gradiometer consists of two vertical electric or magnetic dipoles with a vertical separation. Both sum and difference responses are useful, but the difference response has the potential advantage of suppressing the primary field and making the scattered field easier to detect. The difference response is most effective in suppressing the primary field for a parallel scan where the transmitting antenna and receiving gradiometer are always at the same height. Gradiometers are most advantageous at low frequencies where the scattered field is small compared to the primary field.
[Contact: David A. Hill, (303) 497-3472]

Optical Fiber Sensors

Deeter, M.N., and Williams, P.A., **Magneto-Optic Characterization of Iron Garnet Crystals Using Photoelastic Modulation**, 1992 Digest of INTERMAG Conference, St. Louis, Missouri, April 13-16, 1992, p. JQ-02 (April 1992).

Depolarization phenomena in demagnetized bulk iron garnet crystals are investigated with the aid of a photoelastic modulator. An experimental configuration which simultaneously measures Faraday rotation and depolarization as functions of applied magnetic field is described. The technique is demonstrated with samples of SF-57 glass, which exhibits no measurable depolarization, and bulk yttrium iron garnet, which shows pronounced depolarization in the demagnetized state.
[Contact: Merritt N. Deeter, (303) 497-5400]

Electro-Optic Metrology

Phelan, R.J., Jr., Lehman, J.H., and Larson, D.R., **Reference Detectors for Spectral Responsivity Measurements**, Proceedings of the 1991 Measurement Science Conference, Anaheim, California, January 31-February 1, 1991, pp. 1-8.

This paper presents a view of the need, use, design, and evaluation of detectors to be used for spectral responsivity measurements. The emphasis is on a design that is easy to use and for which the spectral responsivity can be understood and confirmed by the user.
[Contact: Robert J. Phelan, Jr., (303) 497-3696]

Digital Imaging

Fenimore, C., and Field, B.F., **An Analysis of Frame Interpolation in Video Compression and Standard Conversion**, Proceedings of the Data Compression Conference, Snowbird, Utah, March 25-27, 1992, p. 381 (April 1992).

The interpolation of frames into a video stream is a problem common to the design of video compression techniques and of conversion schemes for the transfer between various video standards and formats, such as frame rate conversion and de-interlacing. This study considered the metrics which are used for assessing the quality of an interpolation scheme. Recently, it has been suggested that the L1 norm is a preferred metric in the comparison of images. We applied both the time-averaged L1 and L2 norms to video, processed according to each of two interpolation schemes. These norms were compared for their ability to detect various levels of interpolation error. The L2-based norm discriminated between low and high levels of interpolation error more effectively that did the L1-based norm. Short sequences of interpolation video were generated and viewed in real time to provide a comparison. The study was carried out on a real-time video supercomputer, the Princeton Engine at NIST.
[Contact: Charles Fenimore, (301) 975-2428]

Other Signal Topics

Gans, W.L., Geyer, R.G., and Klemperer, W.K., **Quantifying Standard Performance of Electromagnetic-Based Mine Detectors**, NISTIR 3982 (October 1991).

This is a final report to the sponsor on work performed by National Institute of Standards and Technology (NIST) personnel from January 1, 1985 to December 31, 1990. An overview of the theory of the electromagnetic (EM) properties of soils is presented, along with a brief review of existing technologies for

the detection of buried objects using electromagnetics. The critical electromagnetic performance factors for portable EM mine detectors that NIST has identified are presented, along with a discussion of measurement systems for measuring the constitutive properties of soil and mine-like materials. Recommendations are then presented for a measurement system configuration that should meet most of the Army's requirements. A recommended mine detector testing strategy is then presented along with a set of instructions for specific tests and an algorithm for comparatively scoring the performance of detectors. The tests and the scoring algorithm are as specific and as detailed as is possible at this stage of development. Last, a section is included that contains NIST's recommendations for the test data that should be archived.
[Contact: William L. Gans, (303) 497-3538]

ELECTRICAL SYSTEMS

Power Systems Metrology

Misakian, M., **An Evaluation of Instrumentation Used to Measure AC Power System Magnetic Fields** [original title: An Evaluation of Instrumentation Used to Measure Power Line Magnetic Fields], IEEE Transactions on Power Delivery, Vol. 6, No. 1, pp. 373-383 (January 1991).

A workshop was organized by the IEEE AC Fields Working Group for the purpose of evaluating instrumentation designed for measuring power system magnetic fields. The instruments tested varied from simple single axis survey meters to microcontroller-based instruments designed for long-term data collection and analysis. The working group designed a series of tests which were used to evaluate each instrument. These included calibration and harmonic response tests, tests of susceptibility to high 60-Hz electric fields and electromagnetic interference and the measurement of fields typical of transmission line, appliance, substation and office/shop environments. Results for each of these tests are presented and discussed. With some minor exceptions, the performance of all instruments was satisfactory.
[Contact: Martin Misakian, (301) 975-2426]

Van Brunt, R.J., **Discussion on paper entitled "Digital Techniques for Partial Discharge Measurements,"** [original title: Discussion on Paper Entitled "Digital Techniques for Partial Discharge Measurement," A Report on the Activities of the Working Group on Digital Analysis of Partial Discharges], IEEE Transactions on Power Delivery, Vol. 7, No. 2, p. 447 (April 1992).

This is a brief discussion that points out inherent limitations to reliable and meaningful interpretation of data from phase-resolved measurements of partial-discharge pulse-height and phase-of-occurrence distributions currently being developed for investigation of aging phenomena in electrical insulation and for evaluation of insulation integrity. These limitations are due to memory propagation effects that cause the phenomenon to be susceptible to nonstationary behavior. It is pointed out that these limitations can be at least partly overcome by measuring various conditional partial-discharge pulse height and phase distributions.
[Contact: Richard J. Van Brunt, (301) 975-2425]

Van Brunt, R.J., **Partial Discharge Pulse-Height Analysis - Promises and Limitations**, Proceedings of the International Symposium on Digital Techniques in High-Voltage Measurements, Toronto, Canada, October 28-30, 1991, pp. 2-12 to 2-16 (October 1991).

An alternative approach to measurement of the phase-resolved stoachastic properties of partial-discharge pulses is described which can be used to unravel significant phase-to-phase memory propagation effects that give rise to nonstationary behavior in the observed pulse-height or phase-of-occurrence distributions. Examples are shown of data obtained using a point-to-dielectric discharge gap.
[Contact: Richard J. Van Brunt, (301) 975-2425]

Van Brunt, R.J., Cernyar, E.W., von Glahn, P., and Las, T., **Variations in the Stochastic Behavior of Partial-Discharge Pulses with Point-to-Dielectric Gap Spacing**, Conference Record of the 1992 IEEE International Symposium on Electrical Insulation, Baltimore, Maryland, June 7-10, 1992, pp. 349-353 (June 1992).

The stochastic behavior of ac-generated partial-discharge pulses in a point-to-dielectric air gap has been thoroughly characterized from direct measurements of various conditional and unconditional phase-restricted pulse-height and phase-of-occurrence distributions. The results reveal significant pulse-to-

pulse and phase-to-phase memory propagation at all gap spacings. The observed memory effects are seen to be important in controlling the initiation and growth probabilities of partial-discharge pulses at any given phase of the applied voltage.
[Contact: Richard J. Van Brunt, (301) 975-2425]

Van Brunt, R.J., Olthoff, J.K., and Shah, M., **Rate of S_2F_{10} Production from Negative Corona in Compressed SF_6**, Conference Record of the 1992 IEEE International Symposium on Electrical Insulation, Baltimore, Maryland, June 7-10, 1992, pp. 328-331 (June 1992).

Using a mass spectrometer-gas chromatograph capable of detecting S_2F_{10} concentrations in SF_6 down to the parts-per-billion level, the rates of S_2F_{10} production from dc glow-type negative point-plane corona discharges in pressurized SF_6 have been measured at different absolute gas pressures in the range of 100 to 500 kPa (1 to 5 atm) and at different constant discharge currents in the range 2 to 80 μA. The charge rate-of-production for S_2F_{10} is observed to drop with decreasing discharge current, and the yield curves exhibit nonlinearities in the early stages of the discharge that appear to be associated with "conditioning" of the point electrode. The nonlinearities become more pronounced with increasing gas pressure. The results are found to be quite reproducible and suggest the possibility of using this type of corona discharge as a reliable method for preparing reference gas samples that contain predictable trace quantities of S_2F_{10} in SF_6.
[Contact: Richard J. Van Brunt, (301) 975-2425]

Magnetic Materials and Measurements

Deeter, M.N., and Williams, P.A., **Magneto-Optic Characterization of Iron Garnet Crystals Using Photoelastic Modulation,** 1992 Digest of INTERMAG Conference, St. Louis, Missouri, April 13-16, 1992, p. JQ-02 (April 1992).

Depolarization phenomena in demagnetized bulk iron garnet crystals are investigated with the aid of a photoelastic modulator. An experimental configuration which simultaneously measures Faraday rotation and depolarization as functions of applied magnetic field is described. The technique is demonstrated with samples of SF-57 glass, which exhibits no measurable depolarization, and bulk yttrium iron garnet, which shows pronounced depolarization in the demagnetized state.
[Contact: Merritt N. Deeter, (303) 497-5400]

Goldfarb, R.B., **Demagnetizing Factors,** Concise Encyclopedia of Magnetic & Superconducting Materials, pp. 103-104 (Pergamon Press Ltd., Great Britain, 1992).

Demagnetizing factors for ellipsoids of revolution and right circular cylinders are reviewed.
[Contact: Ronald B. Goldfarb, (303) 497-3650]

Superconductors

Bray, S.L., and Ekin, J.W., **Critical-Current Degradation in Nb_3Sn Composite Wires Due to Locally Concentrated Transverse Stress,** Advances in Cryogenic Engineering (Materials), Vol. 38, Part B, pp. 643-646, (Plenum Press, New York, 1992). [Proceedings of the Ninth International Cryogenic Materials Conference, Huntsville, Alabama, June 11-14, 1991.]

The superconducting wires in an energized magnet coil are subjected to mechanical stresses caused by the Lorentz force. Previous measurements have shown that either axial tensile stress or transverse compressive stress, the two dominant stresses on the wire, can cause substantial degradation in the superconductor's critical current. The previous transverse stress measurements were made with uniformly applied stress; however, many superconductor applications employ cables where the strands experience stress concentrations at the points where they cross one another. For this study, a single stress concentration point was simulated by applying transverse stress to two Nb_3Sn wires, which were crossed over each other at an angle, while measuring the critical current of one of the wires at magnetic fields up to 9 T. A comparison between the cross-over-transverse-stress measurements and the uniform-transverse-stress measurements shows a critical-current degradation at equivalent loads that is significantly greater for the cross-over situation due to the reduced area. However, these preliminary data indicate that the concentration effect can be simply predicted because the degradation in critical current is comparable at equivalent stress.
[Contact: Steven L. Bray, (303) 497-5631]

Goodrich, L.F., and Srivastava, A.N., **Comparison of**

Transport Critical Current Measurement Methods, Advances in Cryogenic Engineering (Materials), Vol. 38, Part B, pp. 559-566 (Plenum Press, New York, 1992). [Proceedings of the Ninth International Cryogenic Materials Conference, Huntsville, Alabama, June 11-14, 1991.]

The critical current (I_c) of a superconductor can be measured using a variety of measurement systems and techniques. The measurement system should be chosen based upon several considerations including accuracy, the number of samples to be measured, and measurement environment. The system may vary in complexity from a simple analog recorder to a sophisticated computerized data acquisition system that monitors several different experimental parameters. Various measurement techniques are available for measuring I_c, including the dc, pulse, and ac methods. Each technique, along with its advantages and disadvantages, is discussed.
[Contact: Loren F. Goodrich, (303) 497-3143]

Kucera, J.T., Rubin, L.M., Uwai, K., Perkins, J.D., Graybeal, J.M., Orlando, T.P., Vander Sande, J.B., Roshko, A., and Moreland, J., **Fabrication of Nanometer Smooth $Bi_2Sr_2CaCu_2O_{8+\delta}$ Films by Reactive Co-Sputtering from Elemental Targets with Pure Ozone,** Physica C, Vol. 192 (Elsevier Science Publishers B.V., North-Holland, 1992) pp. 23-30.

We describe the fabrication of superconducting $Bi_2Sr_2CaCu_2O_{8+\delta}$ thin films having root-mean-square surface roughness of less than 5 nm as determined by scanning tunneling microscopy. Films are deposited "in-situ" by rf and dc triode magnetron sputtering from elemental metallic targets in the presence of pure ozone. As deposited, these films have transition temperatures as high as 68 K and zero-field critical current densities exceed 10^6 A/cm^2 at 4.2 K. The transition temperatures can be increased to 80 K by post-deposition annealing with only a slight increase in surface roughness.
[Contact: Alexana Roshko, (303) 497-5420]

ELECTROMAGNETIC INTERFERENCE

Radiated

Hill, D.A., Crawford, M.L., Kanda, M., and Wu, D.I., **Aperture Coupling to Shielded Transmission Lines: Theory and Experiment,** NISTIR 3988 (April 1992).

Coupling through circular apertures in the shields of a coaxial air line and a TEM cell is studied theoretically and experimentally. Polarizability theory is used to compute the effective dipole moments that excite the transmission lines in the internal region. Measurements of shielding effectiveness of both structures were made in a reverberation chamber over wide frequency ranges. Agreement between theory and measurements is generally within $\pm$10 dB. Recommendations for improvements in the measurements and theory are made for achieving closer agreement that would be desirable for an artifact standard for shielding effectiveness measurements.
[Contact: David A. Hill, (303) 497-3472]

Kanda, M., and Ondrejka, A.R., **Ultra-Broadband and Nondispersive Sensor for the Measurement of Time-Domain Signals,** Proceedings of the Symposium on Electromagnetic Security for Information Protection, Rome, Italy, November 21-22, 1991, pp. 65-78.

This paper reviews the ultra broadband and nondispersive antenna for the measurements of time-domain signals. The resistively-loaded TEM horn with the active cross-over network has a nearly constant amplitude and phase response from 2 kHz to 800 MHz. The upper frequency response, up to 1 GHz, is limited by the active cross-over network. The antenna transfer function is on the order of -22 dB relative to 1 V output 0 for 1 V/m.
[Contact: Motohisa Kanda, (303) 497-5320]

Ma, M.T., **EMC Standards and Regulations: A Brief Review,** NISTIR 3989 (May 1992).

Important current regulations and standards regarding electromagnetic compatibility (EMC) measurements are reviewed. These regulations and standards have been either enforced by U.S. Government agencies such as the Federal Communications Commission and Department of Defense or incorporated in voluntary industrial practice. The specific methods and configurations of measurement required in some of these standards are assessed from a technical basis to see whether or not they are adequate and appropriate. Technical deficiencies and potential problems, if any, are pointed out together with recommendations of alternative and better methods of measurements. Concurrently, the EMC measurement capability at the

National Institute of Standards and Technology is evaluated and appraised for the purpose of planning new metrology activities or programs responsive to the needs of U.S. industry.
[Contact: Mark T. Ma, (303) 497-3800]

Masterson, K.D., and Kanda, M., **Broadband, Photonic Electric Field Sensors for EMP and HPM** [original title: Broadband, Photonic Electric Field Sensors for EMP and HPM Applications], Proceedings of the Fifth National Conference on High Power Microwave Technology, West Point, New York, June 10-15, 1990, pp. 388-391.

Photonic sensors offer the potential to measure high-power electromagnetic fields more accurately than has been available in the past. This is primarily due to their immunity from interference generated by such fields, the high information capacity of optical fibers, and the minimal perturbation of the field by an all-dielectric sensor. An overview of system design based on transfer functions for the individual components is presented with particular emphasis placed on the electro-optic modulator. Using this approach, we summarize the characteristics of two measurement systems that have been fabricated at the National Institute of Standards and Technology, and we design a measurement system based on a Mach-Zender interferometric modulator that would be applicable to HPM measurements. When operating with a 1-GHz detection bandwidth, we estimate that the probe could measure field levels from 200 V/m to over 1 MV/m and operate over a frequency range from 0.5 to over 10 GHz. This would cover much of the region of interest for HPM.
[Contact: Keith D. Masterson, (303) 497-3756]

ADDITIONAL INFORMATION

Lists of Publications

DeWeese, M.E., **Metrology for Electromagnetic Technology: A Bibliography of NIST Publications,** NISTIR 3972 (August 1991).

This bibliography lists the publications of the personnel of the Electromagnetic Technology Division of NIST in the period from January 1970 through publication of this report. A few earlier references that are directly related to the present work of the Division are included.
[Contact: Annie Smith, (303) 497-3678]

Lyons, R.M., and Gibson, K.A., **A Bibliography of the NIST Electromagnetic Fields Division Publications,** NISTIR 3973 (August 1991).

This bibliography lists publications by the staff of the National Institute of Standards and Technology's Electromagnetic Fields Division for the period from January 1970 through August 1991. Selected earlier publications from the Division's predecessor organizations are included.
[Contact: Kathryn A. Gibson, (303) 497-3132]

Palla, J.C., and Meiselman, B., **Electrical and Electronic Metrology: A Bibliography of NIST Electricity Division's Publications, NIST List of Publications 94** (January 1992).

This bibliography covers publications of the Electricity Division, Center for Electronics and Electrical Engineering, NIST, and of its predecessor sections for the period January 1968 to December 1991. A brief description of the Division's technical program is given in the introduction.
[Contact: Jenny C. Palla, (301) 975-2220]

Walters, E.J., **Semiconductor Measurement Technology, 1990-1991, NIST List of Publications 103** (April 1992) and **Semiconductor Measurement Technology, 1962-1989, NIST List of Publications 72** (March 1990).

The bibliography provides information on technology transfer in the field of microelectronics at NIST for the calendar years 1990 and 1991. Publications from groups specializing in semiconductor electronics are included, along with NIST-wide research now coordinated by the NIST Office of Microelectronics Programs which was established in 1991. Indices by topic area and by author are provided. Earlier reports of work performed during the period from 1962 through December 1989 are provided in NIST List of Publications 72.
[Contact: E. Jane Walters, (301) 975-2050]

Continuing Production-Expanded Capability Standard Reference Materials

The Semiconductor Electronics Division announces

the continuing production of three thicknesses and the addition of two new thicknesses for the Standard Reference Material (SRM) for **ellipsometrically derived thickness and refractive index of a silicon dioxide film on silicon.** For sale to the public through the NIST Standard Reference Material Program [(301) 975-6776], the following three individual oxide thicknesses continue to be available: 50 nm (SRM 2531), 100 nm (SRM 2532), and 200 nm (SRM 2533). Recently, two new thicknesses, 25 nm (SRM 2534) and a limited number of 14-nm prototypes (SRM 2535), were added to the availability list.

SRMs 2531, 2532, and 2533, originally released as SRM 2530-1, 2530-2, and 2530-3, were developed in response to the industry's need to evaluate the accuracy of ellipsometers and other thin-film thickness-monitoring instruments. The scope of these SRMs has now expanded with the recent issuance of the 25-nm and 14-nm oxide thicknesses so they have application as thickness standards for use in research as well as in semiconductor fabrication production lines.

Each SRM unit, consisting of a 76-mm (3-in) diameter silicon wafer on which a uniform silicon dioxide layer has been grown, is individually measured and certified over a 5-mm diameter area in the center of the wafer for the ellipsometric parameters delta, Δ, and psi, ψ, at the vacuum wavelength $\lambda = 633.0$ nm using the High-Accuracy Ellipsometer built at NIST. Each SRM is also certified for the derived values for the thicknesses and indices of refraction of both layers of a two-layer optical model of an oxide film on a single-crystal silicon substrate.
[Contact: Barbara J. Belzer, (301) 975-2248]

Standard Reference Materials Issued Within Past Year

The Microelectronics Dimensional Metrology Group of the Precision Engineering Division announces the release of two Standard Reference Materials (SRMs) for calibrating optical microscopes used to measure linewidths on photomasks. Each SRM consists of a 63.5 × 63.5 × 1.5 mm (2.5 × 2.5 × 0.060 in) photomask patterned with chromium lines of widths in the range of 0.9 to 10.8 µm. SRM 475, patterned with antireflecting chromium on a quartz substrate, is being reissued after being out of production for almost four years. SRM 476, a new SRM, is patterned with bright chromium on a borosilicate substrate.

In addition to isolated opaque lines on a clear background and isolated clear lines on an opaque background, these SRMs contain opaque line pairs for calibrating the length scale of optical microscopes, adjacent clear and opaque lines of approximately equal widths for setting the line-to-space ratio (contrast) on video image-scanning instruments, and features with 10 approximately equally spaced opaque lines for checking the linearity of measurement systems (e.g., the magnification as a function of position over the field of view).

The certified linewidth and spacing values were determined from measurements made with the NIST automated linewidth measurement system. The uncertainty of the linewidth measurements is 0.081 µm or less for SRM 475 and 0.064 µm or less for SRM 476. The dominant contribution to this uncertainty is the nonvertical geometry of the line edges, and finding a source of photomasks with better edge geometry would lead to considerable improvement in the calibration uncertainty.
[Contact: James Potzick, (301) 975-3481 or Robert Larrabee, (301) 975-2298]

Emerging Technologies in Electronics ... and Their Measurement Needs, Second Edition

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

Transfer of Pulse Waveform Measurements Services to NIST, Gaithersburg, MD

The responsibility for the Special Test Services Provided by NIST for pulse waveform measurements has now been officially transferred to the Electricity Division, Electronic Instrumentation and Metrology Group (811.02) in Gaithersburg, MD. These services include:

Test Number	Description of Services
65100S	Impulse Generator Spectrum Amplitude (50 Ohm)
65200S	Fast Repetitive Broadband Pulse Parameters (50 Ohm)
65300S	Network Impulse Response (S_{21}) of Coaxial Networks
65400S	Pulse Time Delay through Coaxial Transmission Lines

Service for test number 65400S is already available; it is anticipated that the equipment and software necessary for bringing the other waveform measurement services on line will also become available by June 30, 1992. Please direct specific technical questions concerning these services to Mr. William L. Gans, (301) 975-2502.

Information Notice to Purchasers of Specified Sets of NIST SRM 1522, Silicon Power Device Level Resistivity Standard

This notice applies only to the use of 180-Ω·cm slices of certain sets of Standard Reference Material 1522, Silicon Power Device Level Resistivity Standard, identified below by set and slice number. These slices were certified for resistivity determined at the center of each slice as stated in the certificate; the certified values are valid.

The introduction of resistivity measuring equipment that measures over a larger area than the center may lead some users to attempt to calibrate these instruments with SRM 1522 slices. A recent review of data for SRM 1522 suggests that possible resistivity variations for some of the slices provided as part of the SRM 1522 sets may provide misleading results when used as a basis for calibrating areal-responding instruments. As a service to industry, NIST is prepared to provide replacement slices for the slices identified below. With each replacement slice, NIST will provide a new certificate and instructions for incorporating the slice into the SRM 1522 set. The slices will be certified for center values of resistivity as before, but the resistivity variations will be reduced to values typical of the production run of SRM 1522 180-Ω·cm slices.

If you have a set assigned one of the following set numbers or a 180-Ω·cm slice assigned one of the following slice numbers, please contact James R. Ehrstein (telephone: (301) 975-2060; fax: (301) 948-4081; mailing address: National Institute of Standards and Technology, Bldg. 225, Rm. A305, Gaithersburg, MD 20899).

SRM 1522

Set #	Slice #
301	341
302	342
303	343
305	371
307	375
314	384
315	386
316	390
317	377
318	403
319	395
320	393
321	394
322	388
325	401
326	389
327	402
328	398
329	404
330	405
331	355
333	345
335	356
336	351
337	347
338	348
339	346
340	358
342	359
R10	373

1992/1993 EEEL CALENDAR

Ion Implant Users Group Meeting.

January 28, 1993 (Gaithersburg, Maryland)

The topic for discussion at this tenth meeting of the Ion Implant Users Group will be High-Energy Implantation. Also to be presented is a Summary of the SEMATECH Workshop on Charging.
[Contact: John Albers, (301) 975-2075]

9th Annual IEEE Semiconductor, Thermal Measurement and Management Symposium (SEMI-THERM).

February 2-4, 1993 (Austin, Texas)

Sponsored by IEEE CHMT and NIST, SEMI-THERM is the premier forum for the exchange of information on thermal management of electronics systems between the academic and industrial communities. The program will address the following topics: analytical and computational modeling; measurement techniques including temperature, fluid flow, and thermal-mechanical properties; and thermal reliability screening and testing.
[Contact: David Blackburn, (301) 975-2053]

EEEL SPONSORS

National Institute of Standards and Technology
Executive Office of the President
U.S. Air Force
  Hanscom Field; McClelland AFB; Newark Air Force Station; Rome Air Development Center; Space & Missile Organization; Wright-Patterson Air Force Base; CRDEC; SAF/FMBMB, Pentagon
U.S. Army
  Fort Belvoir; Fort Huachuca; Harry Diamond Laboratory; Materials & Mechanics Research; Strategic Defense Command; AVRADCOM (Aviation)
Department of Commerce
  NOAA; Census
Department of Defense
  Advanced Research Projects Agency; Defense Nuclear Agency; Combined Army/Navy/Air Force (CCG); National Security Agency
Department of Energy
  Energy Systems Research; Fusion Energy; Basic Energy Sciences; Oak Ridge National Laboratory
Department of Justice
  Law Enforcement Assistance Administration; FBI
U.S. Navy
  Naval Sea Systems Command; Weapons Support Center/Crane; Office of Naval Research; Naval Air Systems Command; Naval Air Engineering Center; Naval Surface Warfare Center; Naval Research Laboratory; Naval Ocean Systems Center
National Aeronautics and Space Administration
  NASA Headquarters; Goddard Space Flight Center; Lewis Research Center
Nuclear Regulatory Commission
Department of Transportation
  National Highway Traffic Safety Administration
MIMIC Consortium
  Various Federal Government Agencies

NIST-114
(REV. 9-92)
ADMAN 4.09

U.S. DEPARTMENT OF COMMERCE
NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY

MANUSCRIPT REVIEW AND APPROVAL

(ERB USE ONLY)	
ERB CONTROL NUMBER: W93-0369	DIVISION: 812
PUBLICATION REPORT NUMBER: NISTIR 4997	CATEGORY CODE
PUBLICATION DATE: December 1992	NUMBER PRINTED PAGES: 24

INSTRUCTIONS: ATTACH ORIGINAL OF THIS FORM TO ONE (1) COPY OF MANUSCRIPT AND SEND TO: THE SECRETARY, APPROPRIATE EDITORIAL REVIEW BOARD.

TITLE AND SUBTITLE (CITE IN FULL)

Electronics and Electrical Engineering Laboratory Technical Publication Announcements Covering Laboratory Programs, April to June 1992, with 1992/1993 EEEL Events Calandar

CONTRACT OR GRANT NUMBER

TYPE OF REPORT AND/OR PERIOD COVERED

April to June 1992

AUTHOR(S) (LAST NAME, FIRST INITIAL, SECOND INITIAL)

Walters, E. J.

PERFORMING ORGANIZATION (CHECK (X) ONE BOX)

- [X] NIST/GAITHERSBURG
- [ ] NIST/BOULDER
- [ ] JILA/BOULDER

LABORATORY AND DIVISION NAMES (FIRST NIST AUTHOR ONLY)

Walters, E. J.

SPONSORING ORGANIZATION NAME AND COMPLETE ADDRESS (STREET, CITY, STATE, ZIP)

U.S. Department of Commerce
National Institute of Standards and Technology
Electronics and Electrical Engineering Laboratory

RECOMMENDED FOR NIST PUBLICATION

- [ ] JOURNAL OF RESEARCH (NIST JRES)
- [ ] J. PHYS. & CHEM. REF. DATA (JPCRD)
- [ ] HANDBOOK (NIST HB)
- [ ] SPECIAL PUBLICATION (NIST SP)
- [ ] TECHNICAL NOTE (NIST TN)
- [ ] MONOGRAPH (NIST MN)
- [ ] NATL. STD. REF. DATA SERIES (NIST NSRDS)
- [ ] FEDERAL INF. PROCESS. STDS. (NIST FIPS)
- [ ] LIST OF PUBLICATIONS (NIST LP)
- [X] NIST INTERAGENCY/INTERNAL REPORT (NISTIR)
- [ ] LETTER CIRCULAR
- [ ] BUILDING SCIENCE SERIES
- [ ] PRODUCT STANDARDS
- [ ] OTHER ______

RECOMMENDED FOR NON-NIST PUBLICATION (CITE FULLY) [ ] U.S. [ ] FOREIGN

PUBLISHING MEDIUM

- [ ] PAPER
- [ ] CD-ROM
- [ ] DISKETTE (SPECIFY) ______
- [ ] OTHER (SPECIFY)

SUPPLEMENTARY NOTES

ABSTRACT (A 1500-CHARACTER OR LESS FACTUAL SUMMARY OF MOST SIGNIFICANT INFORMATION. IF DOCUMENT INCLUDES A SIGNIFICANT BIBLIOGRAPHY OR LITERATURE SURVEY, CITE IT HERE. SPELL OUT ACRONYMS ON FIRST REFERENCE.) (CONTINUE ON SEPARATE PAGE, IF NECESSARY.)

This is the thirty-third issue of a quarterly publication providing information on the technical work of the National Institute of Standards and Technology, Electronics and Electrical Engineering Laboratory. This issue of the EEEL Technical Publication Announcements covers the second quarter of calendar year 1992. Abstracts are provided by technical area for paper published this quarter.

KEY WORDS (MAXIMUM 9 KEY WORDS; 28 CHARACTERS AND SPACES EACH; ALPHABETICAL ORDER; CAPITALIZE ONLY PROPER NAMES)

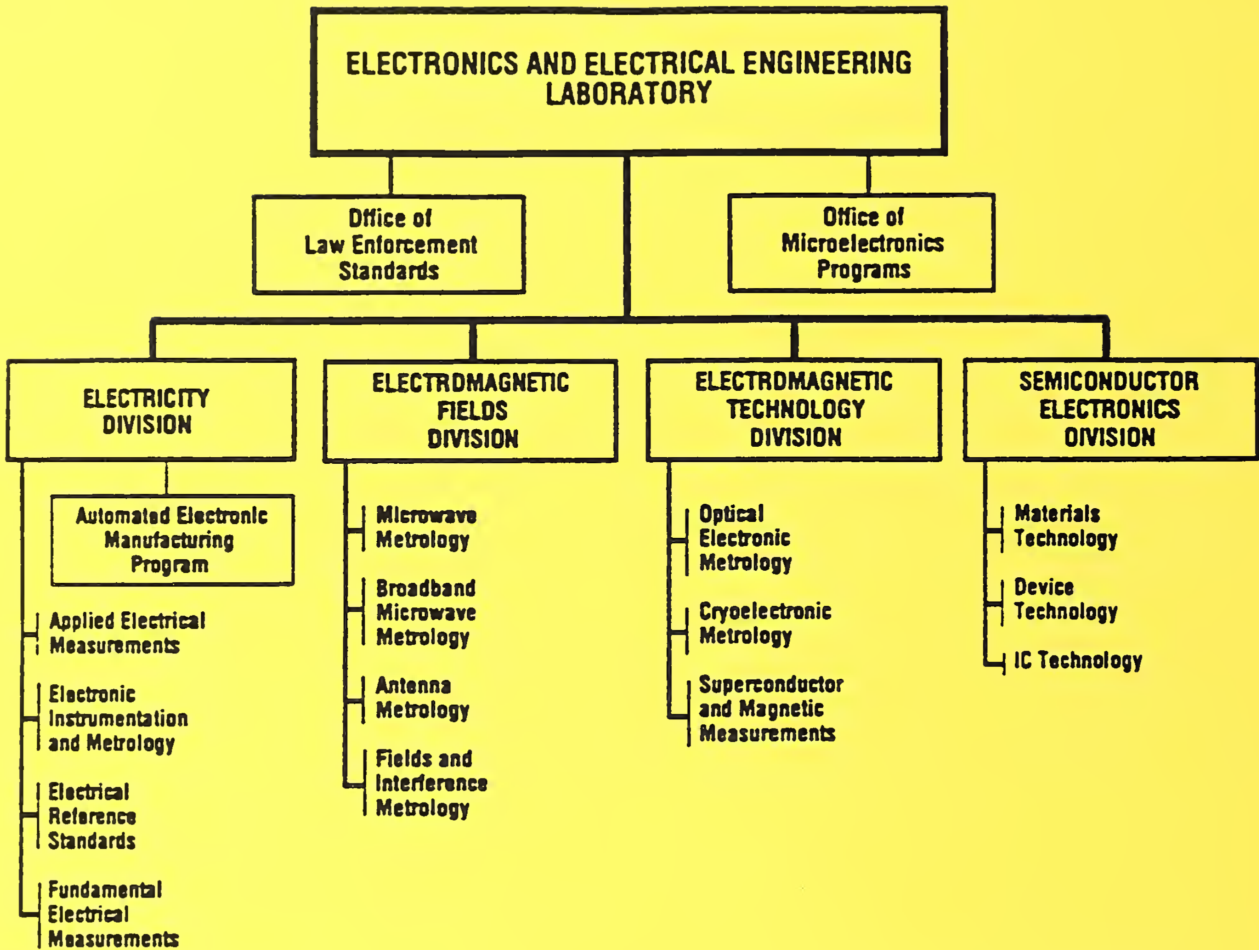
antennas; electrical engineering; electrical power; electromagnetic interference; electronics; instrumentation; laser; magnetics; microwave; optical fibers; semiconductors; superconductors

AVAILABILITY

- [X] UNLIMITED
- [ ] FOR OFFICIAL DISTRIBUTION. DO NOT RELEASE TO NTIS.
- [ ] ORDER FROM SUPERINTENDENT OF DOCUMENTS, U.S. GPO, WASHINGTON, D.C. 20402
- [X] ORDER FROM NTIS, SPRINGFIELD, VA 22161

NOTE TO AUTHOR(S) IF YOU DO NOT WISH THIS MANUSCRIPT ANNOUNCED BEFORE PUBLICATION, PLEASE CHECK HERE. [ ]

ELECTRONIC FORM



KEY CONTACTS

Laboratory Headquarters (810)	Director, Mr. Judson C. French (301) 975-2220
	Deputy Director, Dr. Robert E. Hebner (301) 975-2220
Office of Microelectronics Programs	Director, Mr. Robert I. Scace (301) 975-4400
Office of Law Enforcement Standards	Director, Mr. Lawrence K. Eliason (301) 975-2757
Electricity Division (811)	Chief, Dr. Oskars Petersons (301) 975-2400
Semiconductor Electronics Division (812)	Chief, Mr. Frank F. Oettinger (301) 975-2054
Electromagnetic Fields Division (813)	Chief, Mr. Allen C. Newell (303) 497-3131
Electromagnetic Technology Division (814)	Chief, Dr. Robert A. Kamper (303) 497-3535

INFORMATION:

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

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