NISTIR 6020

Electronics and Electrical Engineering Laboratory

J. M. Rohrbaugh
Compiler

Technical Publication Announcements

51

Covering Laboratory Programs,
October to December 1996,
with 1997-1998 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

May 1997

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U.S. DEPARTMENT OF COMMERCE
William M. Daley, Secretary
TECHNOLOGY ADMINISTRATION
Mary L. Good, Under Secretary for Technology
NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY
Robert E. Hebner, Acting Director

INTRODUCTION TO THE EEEL TECHNICAL PUBLICATION ANNOUNCEMENTS

This is the fifty-first issue of a 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 1996.

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 years 1997 and 1998 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, and the Optoelectronics Divisions 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 Publication Announcements, 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 15.

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 13.

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 ***EEEL 1996 Technical Accomplishments, Advancing Metrology for Electrotechnology to Support the U.S. Economy*** and ***Measurements for Competitiveness in Electronics***. The first presents selected technical accomplishments of the Laboratory for the period October 1, 1995 through September 30, 1996. A brief indication of the nature of the technical achievement and the rationale for its undertaking are given for each example. The second 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. A longer description of both documents follows:

EEEL 1996 Technical Accomplishments, Advancing Metrology for Electrotechnology to Support the U.S. Economy, NISTIR 5818 (December 1996).

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.
[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.
[Contact: Ronald M. Powell, (301) 975-2220]

TABLE OF CONTENTS

FUNDAMENTAL ELECTRICAL MEASUREMENTS

Keller, M.W., Martinis, J.M., Zimmerman, N.M., and Steinbach, A.H., **Accuracy of Electron Counting Using a 7-Junction Electron Pump**, Applied Physics Letters, Vol. 69, No. 12, pp. 1804-1806 (16 September 1996).

We have operated a 7-junction electron pump as an electron counter with an error per pumped electron of 15 parts in 10^9 and an average hold time of 600 s. The accuracy and hold time are sufficient to enable a new fundamental standard of capacitance. We compare the measured accuracy of the pump as a function of pumping speed and temperature with theoretical predictions based on a model which includes stray capacitance.
[Contact: John M. Martinis, (303) 497-3597]

SEMICONDUCTOR MICROELECTRONICS

Silicon Materials

Kim, J.S., Seiler, D.G., and Ehrstein, J.R., **Determination of Densities and Mobilities of Heavy and Light Holes in P-Type Si Using Reduced-Conductivity-Tensor Analyses of Magnetic-Field Dependent Hall and Resistivity Measurements**, Journal of Applied Physics, Vol. 80, No. 8, pp. 4425-4428 (15 October 1996).

The densities and mobilities of the individual heavy- and light-hole carriers have been simultaneously determined at various temperatures (40 K to 130 K) in three p-type, single-crystal Si samples. The separation of the two-hole components is achieved by multicarrier analyses of magnetic-field-dependent Hall and resistivity measurements within the two-carrier approximation of the reduced-conductivity-tensor scheme. The explicit experimental values for the densities and mobilities of the two-hole components obtained in this work should be considered as a valuable addition to the existing database for silicon material parameters. They should also be useful to silicon device physics and modeling.
[Contact: Jin S. Kim, (301) 975-2238]

Krska, J.-H. Y., Yoon, J.U., Nee, J.T., Roitman, P., Campisi, G.J., Brown, G.A., and Chung, J.E., **A Model for SIMOX Buried-Oxide High-Field Conduction**, IEEE Transactions on Electron Devices, Vol. 43, No. 11, pp. 1956-1964 (November 1996).

[See Device Physics and Modeling.]

Compound Materials

Bennett, H.S., **Majority and Minority Electron and Hole Mobilities in Heavily Doped Gallium Aluminum Arsenide**, Journal of Applied Physics, Vol. 80, No. 7, pp. 3844-3853 (1 October 1996).

[See Device Physics and Modeling.]

Device Physics and Modeling

Bennett, H.S., **Majority and Minority Electron and Hole Mobilities in Heavily Doped Gallium Aluminum Arsenide**, Journal of Applied Physics, Vol. 80, No. 7, pp. 3844-3853 (1 October 1996).

The majority electron and minority hole mobilities have been calculated in $Ga_{1-y}Al_yAs$ for donor densities between 10^{16} cm^{-3} and 10^{19} cm^{-3}. Similarly, the majority hole and minority electron mobilities have been calculated for acceptor densities between 10^{16} and 10^{20} cm^{-3}. The mole fraction of AlAs, y, varies between 0.0 and 0.3 in these calculations. All the important scattering mechanisms have been included. The ionized impurity and carrier-carrier scattering processes were treated with a quantum-mechanical, phase-shift analysis. These calculations are the first to use a phase-shift analysis for minority carriers scattering from majority carriers in ternary compounds such as $Ga_{1-y}Al_yAs$. The results are in good agreement with experiment for majority mobilities and predict that at high-dopant densities, minority mobilities should increase with increasing dopant density for a short range of densities. This effect occurs because of the reduction of plasmon scattering and the removal of carriers from carrier-carrier scattering because of the Pauli exclusion principle. These calculations do not treat the density-of-state modifications due to heavy doping, which should have only a small effect on the mobility at room temperature. The results are important for device modeling because of the need to have physically reasonable values for minority

mobilities when simulating the electrical behavior of heterojunction bipolar transistors.
[Contact: Herbert S. Bennett, (301) 975-2079]

Bennett, H.S., **Report on the International Conference on Simulation of Semiconductor Processes and Devices**, [On-Line] Available: <<http://tcad.stanford.edu/tcad-journal/reports/sispad96.html>>

The International Conference on Simulation of Semiconductor Processes and Devices (SISPAD) provided an open forum for presentations of the latest results and trends in process and device simulation. The number of registered attendees set a record with over 212 attendees. This SISPAD96 was the first unified conference from the three preceding conferences, namely, the International Workshop on Numerical Modeling of Processes and Devices (NUPAD), the International Workshop on VLSI Process and Device Modeling (VPAD); and the International Conference on Simulation of Semiconductor Devices and Processes (SISDEP), which had been held in the U.S., Japan, and Europe, respectively. SISPAD is now the leading forum for Technology for Computer-Assisted Design (TCAD). The strong international nature of SISPAD96 was reflected in its program of seven invited papers, 46 accepted papers for oral presentations, and 29 poster papers. Authors from 20 countries had submitted 126 papers for consideration by the SISPAD96 Program Committee. Of the papers, 26 were from the U.S., 14 from Japan, and the remainder from Austria, Belgium, France, Germany, Italy, Korea, Russia, Switzerland, Taiwan, and the United Kingdom. The conference had eight sessions on the following topics: Transport Models, Process Modeling, Impurity Modeling, Future Device Models, Advanced Silicon Device Models, Equipment and Topography Modeling, TCAD Applications, and Mesh Generation and Circuit Models. New topics were added. They included equipment modeling, new measurement techniques, and the use of the INTERNET for electronic publications and for remote collaborations. The Proceedings of this conference (ISBN Number 0-7803-2745-4) are available upon request and may be purchased from either the Business Center for Academic Societies Japan or the IEEE Service Center Single Publications Sales Unit.
[Contact: Herbert S. Bennett, (301) 975-2079]

Kim, J.S., Seiler, D.G., and Ehrstein, J.R., **Determination of Densities and Mobilities of Heavy and Light Holes in P-Type Si Using Reduced-Conductivity-Tensor Analyses of Magnetic-Field Dependent Hall and Resistivity Measurements**, Journal of Applied Physics, Vol. 80, No. 8, pp. 4425-4428 (15 October 1996).

[See Silicon Materials.]

Krska, J.-H. Y., Yoon, J.U., Nee, J.T., Roitman, P., Campisi, G.J., Brown, G.A., and Chung, J.E., **A Model for SIMOX Buried-Oxide High-Field Conduction**, IEEE Transactions on Electron Devices, Vol. 43, No. 11, pp. 1956-1964 (November 1996).

A new model for SIMOX buried-oxide (BOX) high-field conduction which incorporates the role of silicon islands and BOX nonstoichiometry is presented. For single-implant SIMOX BOX high-field conduction, the onset E-field for both positive and negative applied bias is much lower than the expected onset E-field for that of thermal oxide. In addition, the onset E-field for injection from the substrate is lower than for injection from the top-silicon.

We propose that conduction by electron injection from the top interface is due to Fowler-Nordheim tunneling with oxide-nonstoichiometry-induced modification of the effective barrier height. Conduction by electron injection from the bottom interface is due to a two-step Fowler-Nordheim tunneling mechanism with cathode E-field enhancement caused by the presence of silicon islands located near the oxide-substrate interface of single-implant SIMOX. These mechanisms were verified using numerical simulation, electrical, and physical measurements.

A modified Fowler-Nordheim equation can be used to model BOX conduction through the addition of three parameters, k_c, K_α, and ϕ_{BOX}. The E-field enhancement factors (k_c and k_α) can be directly correlated to silicon island shape, location and density, while the effective barrier-height (ϕ_{BOX}) can be correlated to BOX nonstoichiometry. Monitoring these parameters has potential use as a simple

method for SIMOX BOX quality control.
[Contact: Peter Roitman, (301) 975-2077]

Marchiando, J.F., **On Calculating the Reflectance and Transmittance of Light for a Simple Thick Grating Structure**, Journal of Modern Optics, Vol. 43, No. 12, pp. 2493-2501 (1996).

This paper presents a formulation for calculating the reflectance and transmittance of classical light for a simple structure that contains a rectangularly shaped line grating layer that lies atop a thick transparent or weakly absorbing substrate layer. It is assumed that the substrate thickness is sufficiently large and non-uniform that when the light traverses it is averaged over a large surface area, the averaged field is considered as losing phase coherence and intensities can be added. It is assumed that the optical properties of the media in the various homogeneous regions of the structure are complex, local, linear, isotropic, and non-magnetic. This kind of structure has important applications in the metrology of linewidths for the semiconductor integrated circuit industry.
[Contact: Jay F. Marchiando, (301) 975-2088]

Dimensional Metrology

Allen, R.A., and Marshall, J.C., **Critical Dimension Metrology for MEMS Processes Using Electrical Techniques**, Proceedings of the SPIE (The International Society for Optical Engineering), Microlithography and Metrology in Micromachining II, Vol. 2880, pp. 152-157 (1996).

Electrical critical dimension (ECD) test structures have been adapted for use in a surface micromachining environment and fabricated alongside various MicroElectroMechanical Systems (MEMS) structures. These freestanding ECD test structures, which are exposed to air on all surfaces (that is, no encompassing oxide), provide the ability to measure two key metrological process parameters, sheet resistance and feature width that can affect the threshold at which released fixed-fixed beam MEMS structures experience deflection due to residual compression strain.
[Contact: Richard A. Allen, (301) 975-5026]

Microfabrication Technology

Allen, R.A., and Marshall, J.C., **Critical Dimension Metrology for MEMS Processes Using Electrical Techniques**, Proceedings of the SPIE (The International Society for Optical Engineering), Microlithography and Metrology in Micromachining II, Vol. 2880, pp. 152-157 (1996).

[See Dimensional Metrology.]

Marshall, J.C., Read, D.T., and Gaitan, M.G., **Analysis of Fixed-Fixed Beam Test Structures**, Proceedings of the SPIE (The International Society for Optical Engineering, P.O. Box 10, Bellingham, Washington 98227-0010), 1996 Symposium on Microlithography and Metrology in Micromachining II, Vol. 2880, pp. 46-55 (1996).

This paper presents recent NIST MicroElectroMechanical Systems fixed-fixed beam test structure data and analysis. These test structures show the most promise in measuring the compressive strain due to simplicity of the test structure design, simplicity of test and analysis, ability to isolate compressive strain values as a function of geometry, and most importantly, capability to record process variability data.
[Contact: Janet C. Marshall, (301) 975-2049]

Milanović, V., Gaitan, M., Bowen, E.D., and Zaghloul, M.E., **Micromachined Coplanar Waveguides in CMOS Technology**, IEEE Microwave and Guided Wave Letters, Vol. 6, No. 10, pp. 380-382 (October 1996).

Coplanar waveguides were fabricated in standard complementary metal-oxide semiconductor with post-processing micromachining. ICs were designed with commercial CAD tools, fabricated through the MOSIS service, and subsequently suspended by maskless top-side etching. Absence of the lossy silicon substrate after etching results in significantly improved insertion loss characteristics, dispersion characteristics, and phase velocity. Measurements were performed at frequencies from 1 to 40 GHz, before and after micromachining. These show improvement in loss characteristics of orders of magnitude. For the micromachined line, loss does not exceed 4 dB/cm. Before etching, loss as high as 38 dB/cm is measured. Phase velocity $v_p \approx 0.8 \cdot c$ is achieved for the micromachined line.
[Contact: Michael Gaitan, (301) 975-2070]

Milanović, V., Gaitan, M., Marshall, J.C., and Zaghloul, M.E., **CMOS Foundry Implementation of Schottky Diodes for RF Detection**, IEEE Transactions on Electron Devices, Vol. 43, No. 12, pp. 2210-2214 (December 1996).

Schottky diodes for rf power measurement were designed and fabricated using a commercial n-well CMOS foundry process through the MOSIS service. The Schottky diodes are implemented by modifying the SCMOS technology file of the public-domain graphics layout editor, MAGIC, or by explicitly implementing the appropriate Caltech Intermediate Form layers. The modifications allow direct contact of first-layer metal to the low-doped substrate. Current-voltage measurements showed that only the n-type devices had rectifying properties with a barrier height of 0.78 eV. The *I-V* results were verified by performing capacitance-voltage measurements on diodes of different contact-areas. The diodes were tested in an rf detector circuit. The cut-off frequency of the detector was shown to be 600 MHz.
[Contact: Michael Gaitan, (301) 975-2070]

Read, D.T., and Marshall, J.C., **Measurements of Fracture Strength and Young's Modulus of Surface-Micromachined Polysilicon**, Proceedings of the SPIE (The International Society for Optical Engineering), Microlithography and Metrology in Micromachining II, Vol. 2880, pp. 46-55 (1996).

Polycrystalline silicon (polysilicon) is widely used as a mechanical layer in MicroElectroMechanical Systems (MEMS). Mechanical elements within MEMS structures are, by design, microscopic in size. Because the thickness of the polysilicon layer is typically around 2 μm and the width and length of the freed area is a few to hundreds of micrometers, standard techniques and apparatus for measurements of mechanical properties are not applicable. Furthermore, the deposition techniques for polysilicon cannot be adapted to make specimens big enough to test by conventional techniques. Therefore, special structures were designed to facilitate measurements of Young's modulus and fracture strength: cantilever beams and dog-bone tensile specimens. Here, we report first experiences with these structures. These experiences include successes and failures in manipulating and testing the special structures. While no definitive results for either fracture strength or Young's modulus are reported here, some plausible values for both quantities were obtained. Test methods and preliminary results to date are discussed.
[Contact: David T. Read, (303) 497-3853]

Plasma Processing

Rao, M.V.V., Van Brunt, R.J., and Olthoff, J.K., **Resonant Charge Exchange and the Transport of Ions at High Electric-Field to Gas-Density Ratios (*E/N*) in Argon, Neon, and Helium**, Physical Review E, Vol. 54, No. 5, pp. 5641-5656 (November 1996).

Translational kinetic-energy distributions of singly and doubly charged ions have been measured at high electric-field to gas-density ratios (*E/N*) up to 5.0 x 10^{-17} V m^2 (50 kTd) in diffuse, parallel-plate Townsend discharges in Ar, Ne, and He using an ion energy analyzer-mass spectrometer. For Ar^+ in Ar and Ne^+ in Ne when E/N <2.0 x 10^{-17} V m^2, and for He^+ in He when E/N <1.0 x 10^{-17} V m^2, the energy distributions are Maxwellian and consistent with predictions based on the assumption that resonant symmetric charge exchange is the dominant ion-neutral-species collision process. At higher *E/N* values, the kinetic-energy distributions for Ar^+, Ne^+, and He^+ show departures from the Maxwellian form that are indicative of deviations from the charge-transfer model. The mean ion energies (effective ion temperatures) are consistent in the low *E/N* range with the available drift-velocity data and in the case of Ar^+ with recent results of Radovanov et al. from Townsend discharge experiments. The charge-exchange cross sections derived from Maxwellian fits to the energy distribution data for Ar^+ + Ar, Ne^+ + Ne, and He^+ + He agree with available data. The relative contributions of the doubly charged ions Ar^{2+}, Ne^{2+}, and He^{2+} to the total ion flux were found to be small (less than 3%) and tend to decrease initially with increasing *E/N*. The mean energies of the doubly charge ions are higher than those for the corresponding singly charged ions, and the results suggest that double charge transfer could be the dominant process affecting the transport of Ar^{2+} and Ne^{2+} for *E/N* below about 1.5 × 10^{-17} V m^2. The observed He^{2+} kinetic-energy distributions are not

consistent with a charge-transfer model.
[Contact: Richard J. Van Brunt, (301) 975-2425]

Packaging

Harman, G.G., **Critical Issues in Wire-Bonded Chip Interconnections to the Year 2001**, Proceedings of the Second International Symposium on Electronic Packaging Technology, Shanghai, China, December 9-12, 1996, pp. 79-84.

The current and future issues of materials, reliability, and yield of wire bonded interconnections used in microelectronics are described. Many of the critical issues affecting wire bonding over the next five years are discussed. These include the thrust towards fine pitch (towards 70 μm for ball bonding), lack of a quantitative understanding of the ultrasonic bonding mechanism, the use of high frequency for US bondings, new metallizations for bond pads, and the need for high yield and reliability for MCM production.
[Contact: George G. Harman, (301) 975-2097]

Power Devices

Berning, D.W., and Hefner, A.R., **IGBT Half-Bridge Shoot-Through Characterization for Model Validation**, Proceedings of the 1996 IEEE Industry Applications Society Meeting, San Diego, California, October 5-10, 1996, pp. 1491-1499.

A circuit is described for making a variety of measurements on half-bridge Insulated Gate Bipolar Transistor (IGBT) pairs for validating IGBT models. The circuit incorporates two robust isolated gate drives for the IGBTs. Each IGBT is driven with an eight-cycle square-wave burst with a long dead-time between bursts so that heat-sinking requirements are greatly reduced. The circuit incorporates a delay for one of the gate drives so that a variable amount of gate overlap or dead-time can be obtained. Switching events are studied that contain intervals where one IGBT is turned on before the other is turned off, as well as intervals where one is turned off before the other is turned on. The former situation applies to shoot-through faults and also emulates IGBT turn-on with diode recovery, while the latter situation represents desirable transition of current between devices. Results are related to suggested model validation procedures.
[Contact: David W. Berning, (301) 975-2069]

Photodetectors

Berkowitz, S.J., Hirahara, A.S., Char, K., and Grossman, E.N., **Low Noise High-Temperature Superconducting Bolometers for Infrared Imaging**, Applied Physics Letters, Vol. 69, No. 14, pp. 2125-2127 (30 September 1996).

[See Cryoelectronic Metrology.]

Hale, P.D., Wang, C.M., Park, R., and Lau, W.I., **A Transfer Standard for Measuring Photoreceiver Frequency Response**, Journal of Lightwave Technology, Vol. 14, No. 11, pp. 2457-2466 (November 1996).

[See **OPTOELECTRONICS**.]

Park, R., and Hale, P.D., **Frequency Response Measurement of Digital Communications Analyzer Plug-In Modules**, Hewlett-Packard Journal, Vol. 47, No. 6, pp. 37-40 (December 1996).

[See **OPTOELECTRONICS**.]

Reliability

Suehle, J.S., and Chaparala, P., **Characterization of Time-Dependent Dielectric Breakdown in Intrinsic Thin SiO_2**, Microelectronics Journal, Vol. 27, pp. 657-665 (1996).

Time-dependent dielectric breakdown data collected from 6.5, 9, 15, 20, and 22.5 nm thick SiO_2 films are presented. The failure distributions are of single mode with no apparent extrinsic population. The logarithm of the median-test-time-to-failure, $\log(t_{50})$, is described by a linear electric field dependence. Contrary to reports in earlier studies, the field acceleration parameter is observed to be insensitive to temperature and has a value of approximately 1.0 decade MV^{-1} cm^{-1} for the range of oxide thicknesses studied. Capacitance-voltage studies indicate that there is no strong correlation between oxide-trapped charges and time-to-failure under constant voltage stress conditions.
[Contact: John S. Suehle, (301) 975-2247]

SIGNAL ACQUISITION, PROCESSING, AND TRANSMISSION

DC and Low-Frequency Metrology

Chang, Y.M., **NIST Measurement Assurance Program for Capacitance Standards at 1 kHz**, NIST Technical Note 1417 (March 1996).

This document describes the capacitance Measurement Assurance Program (MAP) service at the National Institute of Standards and Technology. This service, which uses a commercial digital capacitance meter as the transport standard, provides calibration for capacitance standards at both the 1000 pF and 100 pF levels, at a frequency of 1 kHz. In contrast to the typical MAP where the transport standards are measured by the client laboratory, the capacitance MAP involves measurements performed on "dummy" standards by both the Meter (1 kHz digital capacitance meter used as the transport standard) and the laboratory capacitance measuring system. Measurement procedures and requirements for client laboratories are included. Also presented are error analysis, assigned values, and equations to estimate the combined uncertainties of the assigned values.
[Contact: Y. May Chang, (301) 975-4237]

Lipe, T.E., **A Reevaluation of the NIST Low-Frequency Standards for AC-DC Difference in the Voltage Range 0.6-100 V**, IEEE Transactions on Instrumentation and Measurement, Vol. 45, No. 6, pp. 913-917 (December 1996).

A reevaluation of the NIST standards of ac-dc difference was undertaken in an effort to reduce the calibration uncertainty offered by NIST for thermal voltage converters at frequencies below 100 Hz. This paper describes the measurements taken in support of this effort, as well as the devices used for the reevaluation process and the analysis of the uncertainty of the measurements. This reevaluation of the NIST low-frequency standards will permit a significant reduction in uncertainty for ac-dc difference calibrations at 10 Hz in the voltage range from 0.6 V to 100 V.
[Contact: Thomas E. Lipe, (301) 975-4151]

Stenbakken, G.N., and Dolev, A., **NIST High Accuracy Sampling Wattmeter**, NIST Technical Note 1420 (August 1996).

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 goal of this effort was to develop an instrument having a full scale measurement uncertainty over these frequencies of less than ± 50 μW/W. The prototype instrument that came out of the development was used to demonstrate the accuracy achievable with the digital sampling method. The new high-accuracy sampling wattmeter was built around a wideband instrument developed earlier at NIST. The new wattmeter uses 16-bit analog-to-digital (A/D) converters and includes a two-stage current transformer in one of the input modules. This wattmeter operates with asynchronous sampling as did the previous wattmeter. 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 μW/W, of full scale, over the 50 Hz to 1000 Hz frequency range at all power factors.
[Contact: Gerard N. Stenbakken, (301) 975-2440]

Waveform Metrology

Paulter, N.G., **Selecting a Short-Pulse Laser System for Photoconductive Generation of High-Speed Electrical Pulses**, Optical Engineering, Vol. 35, pp. 3296-3300 (November 1996).

The selection of a short-pulse laser is important in electrical pulse metrology applications where the electrical pulses are generated photoconductively. Not only is the duration of the generated electrical pulse important, but so is the peak amplitude of that pulse. Insufficient pulse amplitude may cause excessive uncertainty in measurement results. An approximation is presented that can provide guidelines to selecting the optimal short-pulse laser according to photoconductor, laser and measurement system characteristics.

[Contact: Nicholas G. Paulter, (301) 975-2405]

Cryoelectronic Metrology

Berkowitz, S.J., Hirahara, A.S., Char, K., and Grossman, E.N., **Low Noise High-Temperature Superconducting Bolometers for Infrared Imaging**, Applied Physics Letters, Vol. 69, No. 14, pp. 2125-2127 (30 September 1996).

High-temperature superconducting bolometric infrared detectors offer the promise of matching the sensitivity of HgCdTe detectors, but with an extended detection range to longer wavelengths ($\lambda > 15\ \mu m$). We fabricated high-temperature superconducting bolometers using an all-epitaxial micromachining technology based upon a $YBa_2Cu_3O_x$ thin film on a yttria-stabilized zirconia free standing $50 \times 50\ \mu m^2$ membrane supported on a $LaAlO_3$ substrate. This structure has simultaneously a low thermal conductance and a low heat capacity. Using this technology, we have made array-compatible pixels for infrared camera applications with optical noise equivalent powers as low as 6.3×10^{-13} W/$\sqrt{}$Hz at 32 Hz. Over more than 1 octave of frequency range, these bolometers are limited by fundamental (chiefly phonon) noise sources rather than excess film noise.
[Contact: Eric N. Grossman, (303) 497-5102]

Costantini, A., Chiarello, F., Carelli, P., Rotoli, G., Cirillo, M., and Kautz, R.L., **Thermally Activated Escape from the Zero-Voltage State in Long Josephson Junctions**, Physical Review B., Vol. 54, No. 21, pp. 15 417-15 428 (1 December 1996).

We have measured the rate of thermally induced escape from the zero-voltage state in long Josephson junctions of both overlap and in-line geometry as a function of applied magnetic field. The statistical distribution of switching currents is used to evaluate the escape rate and derive an activation energy ΔU for the process. Because long junctions correspond to the continuum limit of multidimensional systems, ΔU is in principle the difference in energy between stationary states in an infinite-dimensional potential. We obtain good agreement between calculated and measured activation energies for junctions with lengths a few times the Josephson penetration depth λ_J.
[Contact: Richard L. Kautz, (303) 497-3391]

Antenna Metrology

Guerrieri, J.R., MacReynolds, K., Canales, N., and Tamura, D.T., **Mismatch Errors in Insertion-Loss Measurements Using Harmonic Mixers**, Proceedings of the Eighteenth Annual Meeting and Symposium of the Antenna Measurement Techniques Association, Seattle, Washington, September 30—October 3, 1996, pp. 377-382.

[See Microwave and Millimeter-Wave Metrology.]

Stubenrauch, C.F., MacReynolds, K., Newell, A.C., Cormack, R.H., Will, J.E., and Norgard, J.D., **Phaseless Measurements of Antenna Near Fields Employing Holographic Phase Retrieval**, Proceedings of the Eighteenth Annual Meeting and Symposium of the Antenna Measurement Techniques Association, Seattle, Washington, September 30—October 3, 1996, pp. 20-24.

We describe a technique which employs amplitude-only measurements of an unknown antenna combined with a synthetic reference wave to produce a hologram of a near-field antenna distribution. The hologram, which may be recorded by amplitude-only receiving equipment, is digitally processed using an enhanced theory which allows complete removal of the spurious images normally encountered with optical hologram reconstruction. The recovered near-field data are then processed using standard algorithms to calculate antenna far-fields. We present the theoretical formulation and results of measurements obtained on an 1.2 m reflector antenna.
[Contact: Carl F. Stubenrauch, (303) 497-3927]

Wittmann, R.C., Alpert, B.K., and Francis, M.H., **Planar Near-Field Antenna Measurements Using Nonideal Measurement Locations**, Proceedings of the Eighteenth Annual Meeting and Symposium of the Antenna Measurement Techniques Association, Seattle, Washington, September 30—October 3, 1996, pp. 74-79.

The standard planar near-field to far-field transformation method requires data points on a plane-rectangular lattice. In this paper, we introduce a transformation algorithm in which measurements are neither required to lie on a regular grid nor are strictly confined to a plane.

Computational complexity is $O(N\log N)$, where N is number of data points. (Actual calculation times depend on the numerical precision specified and on the condition number of the problem.) This algorithm allows efficient processing of near-field data with known probe position errors. Also, the algorithm is applicable for other measurement approaches, such as plane-polar scanning, where data are collected on a nonrectangular grid.
[Contact: Ronald C. Wittmann, (303) 497-3326]

Wittman, R.C., and Black, D.N., **Antenna/RCS Range Evaluation Using a Spherical Synthetic-Aperture Radar**, Proceedings of the Eighteenth Annual Meeting and Symposium of the Antenna Measurement Techniques Association, Seattle, Washington, September 30—October 3, 1996, pp. 406-410.

We describe an imaging technique which allows the isolation of sources of unwanted radiation on an antenna/RCS range. The necessary data may be collected by using a roll-over azimuth mount to scan a probe over a spherical measurement surface.
[Contact: Ronald C. Wittmann, (303) 497-3326]

Microwave and Millimeter-Wave Metrology

Guerrieri, J.R., MacReynolds, K., Canales, N., and Tamura, D.T., **Mismatch Errors in Insertion-Loss Measurements Using Harmonic Mixers**, Proceedings of the Eighteenth Annual Meeting and Symposium of the Antenna Measurement Techniques Association, Seattle, Washington, September 30—October 3, 1996, pp. 377-382.

In this paper, we discuss proper rf system design for performing insertion-loss measurements using a microwave receiver and harmonic mixers. Specifically, we deal with problems caused by changing reflection coefficients of the devices which feed the mixer. When broadband mixers and coaxial isolators are used, problems may be caused by the changing load seen by the local oscillator. This is due to local oscillator leakage through the mixer and isolator. We elaborate on this problem, noting its impact on the measurement and suggest a procedure to properly minimize its effect.
[Contact: Jeffrey R. Guerrieri, (303) 497-3863]

Milanović, V., Gaitan, M., Bowen, E.D., and Zaghloul, M.E., **Micromachined Coplanar Waveguides in CMOS Technology**, IEEE Microwave and Guided Wave Letters, Vol. 6, No. 10, pp. 380-382 (October 1996).

[See Microfabrication Technology.]

Milanović, V., Gaitan, M., Marshall, J.C., and Zaghloul, M.E., **CMOS Foundry Implementation of Schottky Diodes for RF Detection**, IEEE Transactions on Electron Devices, Vol. 43, No. 12, pp. 2210-2214 (December 1996).

[See Microfabrication Technology.]

Electromagnetic Properties

Baker-Jarvis, J.R., and Riddle, B.F., **Dielectric Measurements Using a Reentrant Cavity: Mode-Matching Analysis**, NIST Technical Note 1384 (November 1996).

The coaxial reentrant cavity dielectric measurement technique is examined. A full-mode model for the cavity is developed and solved numerically. Analytical expressions for wall losses are presented. The filing factor due to a partially-filled cavity is discussed. Dielectric results are presented and compare very closely to previous round-robin results.
[Contact: James R. Baker-Jarvis, (303) 497-5621]

Geyer, R.G., and Krupka, J., **Complex Permeability Measurements of Microwave Ferrites**, Proceedings of Materials Research Society Symposium, San Francisco, California, April 7-12, 1996, pp. 257-262.

A rigorous and accurate method for the experimental determination of the complex permeability of demagnetized ferrites at microwave frequencies is presented. The measurement uses low-loss dielectric ring resonators, is nondestructive, and allows complex permeability characterization of a *single* ferrite sample to be performed at frequencies from 2 GHz to 25 GHz. A wide variety of ceramic microwave ferrites having various compositions and differing saturation magnetizations was measured in the demagnetized state. Generally, at any frequency greater than gyromagnetic resonance, the real part of the

complex permeability increase as saturation magnetization increases. For the same frequency, magnetic losses increases as saturation magnetization increases. The real permeability results are compared with magnetostatic theoretical predictions. Measurement data show excellent agreement with theoretical predictions, but only when $2\pi\gamma\tau M_S/\omega$ <0.75, where γ is the gyromagnetic ratio, M_s is saturation magnetization, and ω is the radian rf frequency.
[Contact: Richard G. Geyer, (303) 497-5862]

Krupka, J., Geyer, R.G., Baker-Jarvis, J., and Ceremuga, J., **Measurements of the Complex Permittivity of Microwave Circuit Board Substrates Using Split Dielectric Resonator and Reentrant Cavity Techniques**, Proceedings of the Seventh International Conference on Dielectric Materials, Measurements, and Applications, University of Bath, United Kingdom, September 23-26, 1996 (unpaged).

Dielectric properties of microwave circuit-board materials are usually measured with stripline or microstripline resonator techniques. These techniques have two disadvantages. Firstly, it is difficult to measure dielectric loss tangent of low loss materials, because conductor losses in such resonators are large and are usually not known accurately. Secondly, it is difficult to measure particular tensor components of anisotropic materials. We propose a split dielectric resonator technique for measurements of the complex permittivity of isotropic materials and a combination of this method and the re-entrant cavity for characterization of the complex permittivity of anisotropic materials.
[Contact: Richard G. Geyer, (303) 497-5852]

OPTOELECTRONICS

Day, G.W., Franzen, D.L., and Williams, P.A., Eds., **Technical Digest, Symposium on Optical Fiber Measurements, 1996**, NIST Special Publication 905, Technical Digest—Symposium on Optical Fiber Measurements, Boulder, Colorado, October 1-3, 1996 (October 1996).

Measurements of polarization mode dispersion and nonlinear processes in optical fiber are two of the major topics in this Digest of Papers presented at the Ninth Symposium on Optical Fiber Measurements, held October 1-3, 1996, at the laboratories of the National Institute of Standards and Technology in Boulder, Colorado. Summaries of all of the papers presented at the Symposium–10 invited and 39 contributed–are included.
[Contact: Gordon W. Day, (303) 497-5204]

Deeter, M.N., and Bon, S., **Molecular Field Theory Analysis of Magneto-Optic Sensitivity of Gallium-Substituted Yttrium Iron Garnets**, Applied Physics Letters, Vol. 69, No. 5, pp. 702-704 (29 July 1996).

The temperature dependence of the magneto-optic sensitivity of gallium-substituted yttrium iron garnets was measured at 1.3 μm and compared with a model based on molecular field theory. The model incorporates results of measurements of both the saturation magnetization and saturation Faraday rotation versus temperature. These measurements were analyzed in the context of molecular field theory to extract the fundamental molecular field coefficients and the magneto-optical coefficients as functions of gallium content. The model and direct sensitivity measurements both indicate that the magneto-optic sensitivity of garnet compositions with gallium substitution levels near 0.8 should exhibit a vanishing first-order temperature sensitivity.
[Contact: Merritt N. Deeter, (303) 497-5400]

Hale, P.D., Wang, C.M., Park, R., and Lau, W.I., **A Transfer Standard for Measuring Photoreceiver Frequency Response**, Journal of Lightwave Technology, Vol. 14, No. 11, pp. 2457-2466 (November 1996).

We have developed a photoreceiver frequency response transfer standard which can be used to measure the optical modulation transfer function of a modulated optical source. It combines a photodiode with an rf power sensor or an amplified receiver with an rf power sensor. It is calibrated with an expanded uncertainty of 0.06 dB (coverage factor = 2) using a heterodyne technique at 1.319 μm. We present a theory which allows use of the transfer standard with arbitrary source modulation depth. The calibration is transferred to a SDH/SONET test equipment manufacturer, giving a

final uncertainty well below the 0.3 dB uncertainty specified by ITU-TS (formerly CCITT) recommendation G.957. The transfer standard may have other applications including calibration of CATV test equipment, lightwave component analyzers, and lightwave spectrum analyzers.
[Contact: Paul D. Hale, (303) 497-5367]

Leonhardt, R.W., **Low-Level Pulsed 1064 nm Laser Radiometer Transfer Standard**, Proceedings of the SPIE (The International Society for Optical Engineering, P.O. Box 10, Bellingham, Washington 98227-0010), Optical Radiation Measurements III, Vol. 2815, pp. 154-159 (1996).

The National Institute of Standards and Technology (NIST) has developed a low-level peak power and pulse energy radiometer (APD 900) transfer standard for collimated laser light at a wavelength of 1064 nm. The peak power irradiance measurement range is from 500 pW/cm^2 to 50 μW/cm^2 for laser pulse widths of 10 ns to 250 ns. The pulse energy measurement range is from 0.05 fJ/cm^2 to 50 pJ/cm^2. The instrument combines the functions of peak-power and pulse energy measurement into one unit, and improves the responsivity by two orders of magnitude greater than previous NIST designs calibrated at 1064 nm. The radiometer is based on an infrared-enhanced silicon avalanche photodiode with 100 mm diameter full aperture collecting optics. Selectable aperture sizes and a neutral density filter extend the measurement range of the instrument to higher levels, especially with large diameter beams. The output is a voltage waveform that can be measured with an oscilloscope. Calibration uncertainty for the APD 900 radiometer is typically less than ±8%. Improvements in the NIST calibration system will potentially lower the uncertainty to approximately ±5%.
[Contact: Rodney W. Leonhardt, (303) 497-5162]

Park, R., and Hale, P.D., **Frequency Response Measurement of Digital Communications Analyzer Plug-In Modules**, Hewlett-Packard Journal, Vol. 47, No. 6, pp. 37-40 (December 1996).

It has been extremely difficult to characterize the SONET/SDH standard receiver with tolerances of ±0.3 dB. This paper describes a method for calibrating photoreceiver frequency response with the low inherent uncertainty of the U.S. National Institute of Standards and Technology Nd:YAG heterodyne system and transferring this calibration to a production test system while maintaining a low uncertainty.
[Contact: Paul D. Hale, (303) 497-5367]

Rochford, K.B., and Rose, A.H., **Simultaneous Laser Diode Emission and Detection for Optical Fiber Sensors**, Optics and Photonics News, Vol. 7, No. 12, pp. 35-36 (December 1996).

A summary is given of highlights of research published in 1996 in the area of laser diode emission and detection.
[Contact: Kenneth B. Rochford, (303) 497-5170]

Rochford, K.B., Rose, A.H., and Day, G.W., **Magneto-Optic Sensors Based on Iron Garnets**, IEEE Transactions on Magnetics, Vol. 32, No. 5, pp. 4113-4117 (September 1996).

The use of single-crystal bulk and film iron garnets in optical sensors is reviewed. Magneto-optic sensitivity and its stability are important parameters that depend on a variety of factors, including optical design. Polarimetric and diffractive sensor technologies are summarized, and several recent demonstrations of magnetic field, current, and rotation sensing using garnets are described. Garnets also find application as important nonsensing components in sensor systems.
[Contact: Kenneth B. Rochford, (303) 497-5170]

Rochford, K.B., and Wang, C.M., **Uncertainty in Null Polarimeter Measurements**, NISTIR 5055 (October 1996).

This internal report details the error analysis of a nulling polarimeter used for retardance measurements. We determined that the uncertainty arising from random effects is between 0.07° and 0.10° for measurements of several retarders with nominally 90° retardance. This instrument and two other methods were used to determine the retardance of a stable rhomb device proposed as a standard retarder. The measurement results were used to support certification of our retarder as a NIST Standard Reference Material.
[Contact: Kenneth B. Rochford, (303) 497-5170]

Rose, A.H., Ren, Z.B., and Day, G.W., **Twisting and Annealing Optical Fiber for Current Sensors**, Journal of Lightwave Technology, Vol. 14, No. 11, pp. 2492-2498 (November 1996).

We demonstrate that twisting a fiber a few turns per meter before it is annealed largely eliminates the residual linear birefringence. This dramatically improves the yield of annealed coils used for current sensing and makes it possible to use fibers that previously had large residual linear birefringence. Twisting the fiber is effective because the residual birefringence, associated with core ellipticity, is reduced to near zero by twisting. A theoretical model of the twisted and annealed fiber current sensor is compared to experimental data. We also show good temperature stability for a sensor made with this new technique.
[Contact: Allen H. Rose, (303) 497-5599]

Schlager, J.B., Mechels, S.E., and Franzen, D.L., **Determination of Zero-Dispersion Wavelength in Optical Fiber Using Four-Wave Mixing**, NIST Special Publication 905, Technical Digest-Symposium on Optical Fiber Measurements, Boulder, Colorado, October 1-3, 1996, pp. 121-124.

Wavelengths of measured maximum four-wave mixing efficiency in optical fiber are compared to zero-dispersion wavelengths measured with a highly accurate frequency-domain phase shift technique. The average absolute discrepancy between the two wavelengths determined on fifteen fibers is 0.19 nm; for an average pump-probe spacing of 5.9 nm, the average spectral width of the four-wave mixing efficiency curve is 0.45 nm.
[Contact: John B. Schlager, (303) 497-3542]

Vayshenker, I., Li, X., Keenan, D., and Scott, T.R., **Errors Due to Connectors in Optical Fiber Power Meters**, NIST Special Publication 905, Technical Digest—Symposium on Optical Fiber Measurements, Boulder, Colorado, October 1-3, 1996, pp. 101-104.

We discuss results of a major potential error source in the use of optical fiber power meters; outputs can vary dramatically when using various types of connectors or even connectors of the same type, but from different vendors. We investigate the magnitude of this connector-induced variation by calibrating several types of optical fiber power meters at three telecommunications wavelengths of 850, 1310, and 1550 nm. In these measurements, we vary the connector type and connector vendor, and observe the resulting offsets in calibration results. Observed variations of as much as 10% were found, due, presumably, to the different reflection properties of the detectors, windows, and connectors involved. A test meter user, therefore, can expect an error as large as 10% if the optical fiber power meter is used with a different connector (or vendor) than that used for calibration.
[Contact: Igor Vayshenker, (303) 497-3394]

Vayshenker, I., Yang, S., and Scott, T.R., **Nonlinearity of Optical Fiber Power Meters**, NIST Special Publication 905, Technical Digest—Symposium on Optical Fiber Measurements, Boulder, Colorado, October 1-3, 1996, pp. 101-104.

We have developed a system for measuring the nonlinearity of optical power meters over a dynamic range of more than 60 dB at three telecommunications wavelengths. This system uses optical fiber components and is designed to accommodate common optical powers; it is based on the triplet superposition method. This measurement system provides accurate determination of optical power meter nonlinearity through the use of correction factors.
[Contact: Igor Vayshenker, (303) 497-3394]

Williams, P.A., **Accuracy Issues in Comparisons of Time- and Frequency-Domain Polarization Mode Dispersion Measurements**, NIST Special Publication 905, Technical Digest—Symposium on Optical Fiber Measurements, Boulder, Colorado, October 1-3, 1996, pp. 125-130.

Systematic errors in Fourier transformed wavelength scanning and interferometric measurements limit comparisons between time and frequency domain polarization mode dispersion measurements. Several sources of systematic error in time domain measurements are discussed. Correction algorithms are described and applied to experimental comparison data.
[Contact: Paul A. Williams, (303) 497-3805]

ELECTRICAL SYSTEMS

Pulse Power Metrology

FitzPatrick, G.J., and Kelley, E.F., **Comparative High Voltage Impulse Measurement**, Journal of Research of the National Institute of Standards and Technology, Vol. 101, No. 5, pp. 639-658 (September—October 1996).

A facility has been developed for the determination of the ratio of pulse high voltage dividers over the range from 10 kV to 300 kV using comparative techniques with Kerr electro-optic voltage measurement systems and reference resistive voltage dividers. Pulse voltage ratios of test dividers can be determined with relative expanded uncertainties of 0.4% (coverage factor $k = 2$ and thus a two standard deviation estimate) or less using the complementary resistive divider/Kerr cell reference systems. This paper describes the facility and specialized procedures used at NIST for the determination of test voltage divider ratios through comparative techniques. The error sources and special considerations in the construction and use of reference voltage dividers to minimize errors are discussed, and estimates of the uncertainties are presented.
[Contact: Gerald J. FitzPatrick, (301) 975-2737]

ELECTROMAGNETIC INTERFERENCE

Radiated EMI

DeLyser, R.R., Holloway, C.L., Johnk, R.T., Ondrejka, A.R., and Kanda, M., **Figure of Merit for Low Frequency Anechoic Chambers Based on Absorber Reflection Coefficients**, IEEE Transactions on Electromagnetic Compatibility, Vol. 38, No. 4, pp. 576-584 (November 1996).

Return loss as a function of frequency and angle of incidence is studied to determine the effectiveness of the absorbing material used in an anechoic chamber. This alone is not enough to determine a figure of merit for an anechoic chamber or to compare the figure of merit for one anechoic chamber to that of another. While the information gained from return-loss calculations and measurements as a function of angle of incidence is valuable, an overall measure of anechoic chamber effectiveness is necessary in order to compare different designs. In this paper, a new chamber figure of merit which is based on the decay time of the chamber is introduced. This decay time is, in turn, based on the average power absorbed by the chamber walls. The resulting model is simple and does not require intensive numerical computation. Calculations of the figure of merit for anechoic chambers which contain different types of absorbing materials are shown, and calculated and measured values of decay time for a primary standards calibrations facility are compared.
[Contact: Robert T. Johnk, (303) 497-3737]

Johnk, R., and Randa, J., **Low-Frequency Representation of Radio-Frequency Absorbers**, Proceedings of the 1996 IEEE International Symposium on Electromagnetic Compatibility, Santa Clara, California, August 19-23, 1996, pp. 174-179.

We present a simple model to characterize the behavior of radio-frequency absorbers at low frequency. The absorber is represented by a flat, homogeneous, isotropic slab of lossy material, with effective constitutive parameters. These parameters are determined by a fit to measured data. Excellent fits are obtained in the two applications considered. The model is intended for use in the characterization of absorber-lined chambers at low frequency. It could also be used to predict the low-frequency performance of partially loaded shielded enclosures.
[Contact: Robert T. Johnk, (303) 497-3737]

Tofani, S., Ossola, P., d'Amore, G., Anglesio, L., Kanda, M., and Novotny, D.R., **A Three-Loop Antenna System for Performing Near-Field Measurements of Electric and Magnetic Fields from Video Display Terminals**, IEEE Transactions on Electromagnetic Compatabilty, Vol. 38, No. 3, pp. 341-347 (August 1996).

This paper discusses the use of a three-loop antenna system (TLAS) for near-field measurement of electric and magnetic fields from video display terminals (VDTs). We calculated the electric and magnetic dipole moments to derive the electric and magnetic field patterns in the near field region. Electric and magnetic fields, emitted by several

different models of VDTs, were evaluated with the TLAS and were compared with those measured by conventional electric and magnetic field probes at different distances and directions from VDTs. A good correlation (±1.6 dB) between the two measurement techniques was found. This agreement is within the accuracy (±2 dB) of the conventional field probe measurements.
[Contact: Motohisa Kanda, (303) 497-5320]

VIDEO TECHNOLOGY

Boynton, P.A., and Kelley, E.F., **Measuring Contrast Ratio of Displays**, Information Display, Vol. 12, No. 11, pp. 24-27 (November 1996).

Conventional methods of measuring the contrast ratio of displays usually involve measuring the luminance of a black and white pattern on a screen using some type of light-measuring device. However, different methods can produce widely varying results which can be attributed to veiling glare. We showed possible methods for correcting for it.
[Contact: Paul A. Boynton, (301) 975-3014]

ADDITIONAL INFORMATION

Announcements

Yaney, D.S., and Settle-Raskin, A.D., **National Semiconductor Metrology Program, Project Portfolio, FY 1996**, NISTIR 5851 (June 1996).

The National Semiconductor Metrology Program (NSMP) is a NIST-wide effort designed to meet the highest priority measurement needs of the semiconductor industry as expressed by the *National Technology Roadmap for Semiconductors* and other authoritative industry sources. The NSMP was established in 1994 with a strong focus on mainstream silicon CMOS technology and an ultimate funding goal of $25 million annually. Current annual funding of approximately $11 million supports the 23 internal projects which are summarized in this Project Portfolio booklet.

The NSMP is operated by NIST's Office of Microelectronics Programs, which also manages NIST's relationships with the Semiconductor Industry Association (SIA), SEMATECH, and the Semiconductor Research Corporation. These include NIST's memberships on the SIA committees that develop the *Roadmap* and numerous SRC technical management committees. In addition, NIST is active in the semiconductor standards development activities of ASTM, Deutsches Institut für Normung, Electronic Industries Association, International Organization for Standardization, and Semiconductor Equipment and Materials International.
[Contact: Alice D. Settle-Raskin, (301) 975-4400]

Lists of Publications

Bradford, A.G., **Metrology for Electromagnetic Technology: A Bibliography of NIST Publications**, NISTIR 5051 (September 1996).

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 5052.
[Contact: Ann G. Bradford, (303) 497-3678]

Lyons, R.M., **A Bibliography of the NIST Electromagnetic Fields Division Publications**, NISTIR 5050 (August 1996).

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 1996. It supersedes NISTIR 5039 which listed the publications of the Electromagnetic Fields Division from January 1970 through July 1995. Selected earlier publications from the Division's predecessor organizations are included.
[Contact: Ruth Marie Lyons, (303) 497-3132]

Schmeit, R.A., **Electrical and Electronic Met-**

rology: A Bibliography of NIST Electricity Division's Publications, NIST List of Publication 94 (February 1996).

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 1995. A brief description of the Division's technical program is given in the introduction.
[Contact: Ruth A. Schmeit, (301) 975-2401]

Smith, A.J., **A Bibliography of Publications of the NIST Optoelectronics Division**, NISTIR 5052 (September 1996).

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, 1990-1996.** (March 1997).

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 1996. 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]

<u>1997-1998 Calendar of Events</u>

August 12-15, 1997 (Boulder, Colorado)

Laser Measurements Short Course. Co-sponsored by NIST and University of Colorado, the course will provide training on laser management theory and techniques. The course will emphasize the concepts, techniques, and apparatus used in measuring laser parameters and will include a visit to the NIST laser measurement laboratories.
[Contact: Thomas R. Scott, (303) 497-3651]

November 4-7, 1997 (Shanghai, China)

International Conference on Materials and Process Characterization for VLSI, 1997 (ICMPC'97). Co-sponsored by NIST and Institute of Microelectronics in Sinagore, this course will provide an international forum for the exchange of information on materials and process characterization for semiconductor and integrated circuit technology with emphasis on diagnostics and control of materials and processes, failure and reliability analysis, and new analytical methods. The Shanghai location will provide good opportunities to establish contacts with a large number of scientists and technologies from the Pacific Rim and China.
[Contact: David G. Seiler, (301) 975-2054]

March 23-27, 1998 (Gaithersburg, Maryland)

1998 International Conference on Characterization and Metrology for ULSI Technology. This workshop is to bring together scientists and engineers interested in all aspects of the technology and characterization techniques for semiconductor device research, development, manufacturing, and diagnostics: chemical and physical, electrical, optical, in-situ, and real-time control and monitoring.

The Workshop provides a forum to present and discuss critical issues; problems and limits; evolving requirements and analysis needs; future directions; and key measurement principles, capabilities, applications, and limitations. It will be comprised of formal invited presentation sessions and poster sessions for contributed papers. This Workshop is the second in a series. The first was held at NIST January 30 to February 2, 1995. Papers from that Workshop were published in *Semiconductor Characterization: Present Status and Future Needs* (AIP Press, New York, 1996), W. M. Bullis, D. G. Seiler, and A. C. Diebold, editors. This Workshop is sponsored by NIST, SEMATECH, Semiconductor Research Corporation, and American Vacuum

Society - Manufacturing Science and Technology Group.
[Contact: David G. Seiler, (301) 975-2074]

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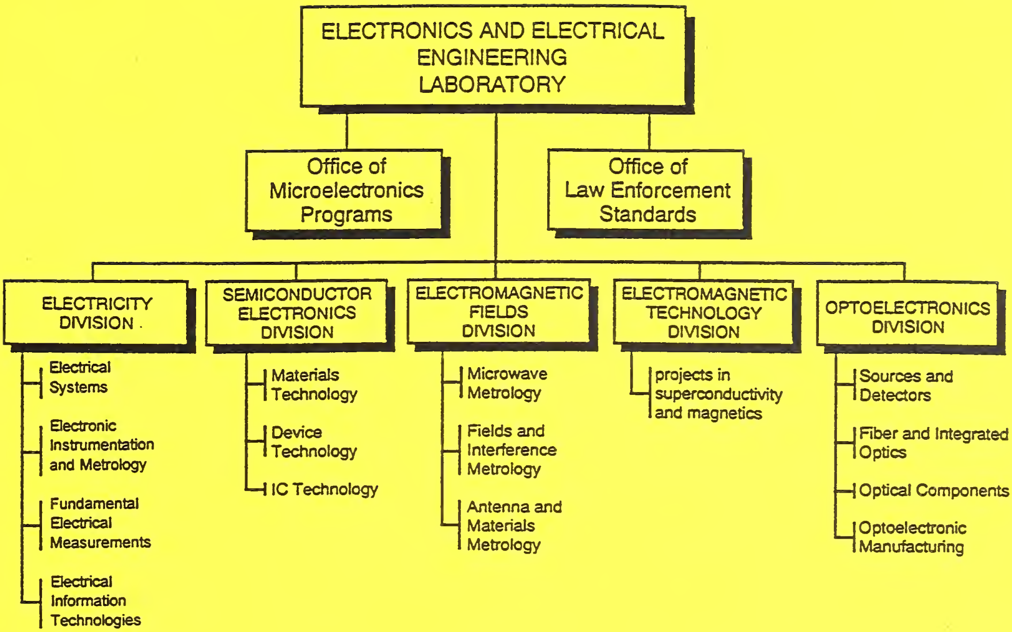

KEY CONTACTS

Laboratory Headquarters (810)	Director, Judson C. French (301) 975-2220
	Acting Deputy Director, Alan H. Cookson (301) 975-2220
	Acting Associate Director, Bruce F. Field (301) 975-2220
Office of Microelectronics Programs	Director, Robert I. Scace (301) 975-4400
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Electromagnetic Fields Division (813)	Chief, Allen C. Newell (303) 497-3131
Electromagnetic Technology Division (814)	Chief, Richard E. Harris (303) 497-3776
Optoelectronics Division (815)	Chief, Gordon W. Day (303) 497-5204

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