NISTIR 5669

Electronics and Electrical Engineering Laboratory

J. M. Rohrbaugh
Compiler

Technical Publication Announcements

44

Covering Laboratory Programs,
January to March 1995
with 1995 EEEL Events Calendar

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

NIST

NISTIR 5669

Electronics and Electrical Engineering Laboratory

Technical Publication Announcements

Covering Laboratory Programs,
January to March 1995
with 1995 EEEL Events Calendar

J. M. Rohrbaugh
Compiler

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

June 1995

44

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

INTRODUCTION TO THE EEEL TECHNICAL PUBLICATION ANNOUNCEMENTS

This is the forty-fourth 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 first quarter of calendar year 1995.

Organization of Bulletin: This issue contains citations and abstracts for Laboratory publications published in the quarter. Entries are arranged by technical topic as identified in the Table of Contents and alphabetically by first author within each topic. Following each abstract is the name and telephone number of the individual to contact for more information on the topic (usually the first author). This issue also includes a calendar of Laboratory conferences and workshops planned for calendar year 1995 and a list of sponsors of the work.

Electronics and Electrical Engineering Laboratory: EEEL programs provide national reference standards, measurement methods, supporting theory and data, and traceability to national standards. The metrological products of these programs aid economic growth by promoting equity and efficiency in the marketplace, by removing metrological barriers to improved productivity and innovation, by increasing U.S. competitiveness in international markets through facilitation of compliance with international agreements, and by providing technical bases for the development of voluntary standards for domestic and international trade. These metrological products also aid in the development of rational regulatory policy and promote efficient functioning of technical programs of the Government.

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

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

Laboratory Sponsors: The Laboratory Programs are sponsored by the National Institute of Standards and Technology and a number of other organizations, in both the Federal and private sectors; these are identified on page 11.

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 10.

TABLE OF CONTENTS

TO LEARN MORE ABOUT THE LABORATORY....

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

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

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

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

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

EEEL 1994 Technical Accomplishments, Supporting Technology for U.S. Competitiveness in Electronics, NISTIR 5551 (December 1994).

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 1994 in the field of semiconductors, magnetics, superconductors, low-frequency microwaves, lasers, optical fiber communications and sensors, video, power, electromagnetic compatibility, electronic data exchange, and national electrical standards. Also included is a profile of EEEL's organization, its customers, and the Laboratory's long-term goals.

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

FUNDAMENTAL ELECTRICAL MEASUREMENTS

Richter, C.A., Seiler, D.G., and Pellegrino, J.G., **Mesoscopic Conductance Fluctuations in Large Devices**, Workbook of the 22nd International Conference on the Physics of Semiconductors, Vancouver, British Columbia, Canada, August 15-19, 1994, pp. 1967-1970.

[See Compound Materials.]

SEMICONDUCTOR MICROELECTRONICS

Silicon Materials

Albers, J., **An Exact Recursion Solution for the Steady-State Surface Temperature of a General Multilayer Structure**, IEEE Transactions on Components, Packaging and Manufacturing Technology-Part A, Vol. 18, No. 1, pp. 31-38 (1 March 1995).

[See Insulators and Interfaces.]

Compound Materials

McCallum, D.S., Cartwright, A.N., Smirl, A.L., Tseng, W.F., Pellegrino, J.G., and Comas, J., **Scaling of the Nonlinear Optical Cross Sections of GaAs-AlGaAs Multiple Quantum-Well Hetero n-i-p-i's**, IEEE Journal of Quantum Electronics, Vol. 30, No. 12, pp. 2790-2797 (December 1994).

We study the dependence of the Stark shift optical nonlinearity of GaAs-AlGaAs multiple quantum-well hetero n-i-p-i's on the number of quantum wells per intrinsic region in otherwise identical hetero n-i-p-i's. We determine that δ_{eh}, the nonlinear absorption cross section, is proportional to the number of quantum wells per intrinsic region. A study of the fluence dependence of δ_{eh} shows that the saturation carrier density is inversely proportional to the number of wells per intrinsic region. We find that the turn-on time of the nonlinear absorption change in our samples is independent of the number of quantum wells per intrinsic region. All of these results are consistent with the absence of retrapping of photogenerated carriers.
[Contact: Wen F. Tseng, (301) 975-5291]

Richter, C.A., Seiler, D.G., and Pellegrino, J.G., **Mesoscopic Conductance Fluctuations in Large Devices**, Workbook of the 22nd International Conference on the Physics of Semiconductors, Vancouver, British Columbia, Canada, August 15-19, 1994, pp. 1967-1970.

"Universal" conductance fluctuations are reproducible, aperiodic fluctuations which are due to quantum interference of electron waves passing through an entire device. Here, we report experimental studies of these fluctuations in a variety of millimeter-size GaAs/AlGaAs modulation-doped heterostructure devices. It has generally been assumed that at finite temperatures, quantum interference effects cannot be observed in devices of this large size. We use an ac magnetic field modulation and lock-in amplifier technique to measure the conductance of the devices. This method allows changes in the resistance as a function of magnetic field to be measured with remarkable sensitivity. It is this enhanced measurement sensitivity which permits universal conductance fluctuations to be observed and studied in a new size-scale regime where devices have large areas.
[Contact: Curt A. Richter, (301) 975-2082]

Analysis and Characterization Techniques

Christensen, D.H., Hickernell, R.K., Schaafsma, D.T., Pellegrino, J.G., McCollum, M.J., Hill, J.R., and Rai, R.S., **Correlation of Optical, X-Ray, and Electron Microscopy Measurements on Semiconductor Multilayer Structures**, Proceedings of SPIE (The International Society for Optical Engineering, P.O. Box 10, Bellingham, Washington 98227-0010), Spectroscopic Characterization Techniques for Semiconductor Technology V, Vol. 2141, pp. 177-188 (1994).

Techniques based on optical, X-ray, and electron microscopy measurements are applied to characterize a wide variety of semiconductor multilayer structures. Bragg mirrors serve as valuable test structures for evaluating the epitaxial uniformity of crystal growth systems. Careful characterization of half-wave spaced single quantum wells provides a method for determining their complex refractive indices using reflectance spectroscopy. Comparison of cross-sectional microphotoluminescence to

surface-normal photoluminescence, combined with these characterization techniques, allows studies of spontaneous emission in microcavities and elucidates the difficulties with using surface-normal photoluminescence to determine the alloy composition of the mirror layers. The application of these characterization methods to visible-wavelength AlGaAs mirrors, 485 to 720 nm, enables the development of these mirrors for uses such as optically tailored substrates and visible surface-emitter of detector arrays.
[Contact: David H. Christensen, (303) 497-3354]

Schafft, H.A., Suehle, J.S., and Albers, J., **JEDEC "TCR" Interlaboratory Experiment - Lessons Learned**, Proceedings of the 1994 International Integrated Reliability Workshop Final Report, Lake Tahoe, California, October 16-19, 1994, pp. 12-19.

[See Reliability.]

Insulators and Interfaces

Albers, J., **An Exact Recursion Solution for the Steady-State Surface Temperature of a General Multilayer Structure**, IEEE Transactions on Components, Packaging and Manufacturing Technology-Part A, Vol. 18, No. 1, pp. 31-38 (1 March 1995).

A recursion relation technique has been used in the past to determine the surface potential from the multilayer electrical Laplace equation. This has provided for a vastly simplified evaluation of the electrical spreading resistance and four-probe resistance. The isomorphism of the multilayer Laplace equation and the multilayer steady-state heat flow equation suggests the possibility of developing a recursion relation applicable to the multilayer thermal problem. This recursive technique is developed and is shown to provide the surface temperature of the multilayer steady-state heat flow equation. For the three-layer case, the thermal recursion relation readily yields the surface results which are identical with those presented by Kokkas and the TXYZ thermal code. This recursive technique can be used with any number of layers while incurring only a small increase in computation time for each added layer. For the case of complete, uniform top surface coverage by a heat source, the technique gives rise to the generalized one-dimensional thermal resistance result. An example of the use of the new recursive method is provided by the preliminary calculations of the surface temperature of a buried oxide (SOI, SIMOX) structure containing several thicknesses of the surface silicon layers. This new technique should prove useful in the investigation and understanding of the steady-state thermal response of modern multilayer microelectronic structures.
[Contact: John Albers, (301) 975-2075]

Dimensional Metrology

Schafft, H.A., Mayo, S., Jones, S.N., and Suehle, J.S., **An Electrical Method for Determining the Thickness of Metal Films and the Cross-Sectional Area of Metal Lines**, Proceedings of the 1994 International Integrated Reliability Workshop, Lake Tahoe, California, October 16-19, 1994, pp. 5-11.

[See Integrated-Circuit Test Structures.]

Integrated-Circuit Test Structures

Linholm, L.W., Allen, R.A., and Cresswell, M.W., **Microelectronic Test Structures for Overlay Metrology**, to be published in Nikkei Microdevices (in Japanese). [An expanded version of this paper appeared as **Microelectronic Test Structures for Feature Placement and Electrical Linewidth Metrology**, in the Handbook of Critical Dimension Metrology and Process Control, Vol. CR52, K. M. Monahan, Ed. (SPIE, Bellingham, Washington 1994), pp. 91-118].

Control of image placement has been and is expected to remain one of the most important challenges required in the manufacturing of advanced microelectronic devices. By the year 2001, it is anticipated that level-to-level overlay requirements will be approximately 60 nm. The metrology to monitor and evaluate the performance of lithographic tools with those capabilities is lagging. Electrical test structures provide low-cost, post-patterning metrology for overlay that is routinely available during the advanced stages of process development and during manufacturing.
[Contact: Loren W. Linholm, (301) 975-2052]

Schafft, H.A., Mayo, S., Jones, S.N., and Suehle, J.S., **An Electrical Method for Determining the Thickness of Metal Films and the Cross-Sectional Area of Metal Lines**, Proceedings of the 1994 International Integrated Reliability Workshop, Lake Tahoe, California, October 16-19, 1994, pp. 5-11.

The electrical thickness of an aluminum-alloy metallization can be determined from resistance measurements of a van der Pauw cross structure at two temperatures, with corrections for the deviation from Matthiessen's rule and for thermal expansion. Thickness determinations made in this way agree with those made with a calibrated SEM to within the uncertainty of the instrument. The electrical cross-sectional area of metal lines can be determined by making resistance measurements at two temperatures.
[Contact: Harry A. Schafft, (301) 975-2234]

Packaging

Marks, R.B., and Williams, D.F., **Microwave Characterization of Printed Circuit Transmission Lines**, Proceedings of the National Electronic Packaging and Production Conference (NEPCON East '94), Boston, Massachusetts, June 13-16, 1994, pp. 520-527.

[See Microwave and Millimeter-Wave Metrology]

Photodetectors

Gifford, A.D., Humphreys, D.A., and Hale, P.D., **Comparison of Photodiode Frequency Response Measurements to 40 GHz Between NPL and NIST**, Electronics Letters, Vol. 31, No. 5, pp. 397-398 (2 March 1995).

The Letter presents a fourth-order delta-sigma modulator structure for switched-current implementation. By using 3.3-V switched-current and two-step switched-current memory cells that can be clocked at a frequency over 100 MHz, two modulators have been designed and implemented. Measurement results are also presented.
[Contact: Paul D. Hale, (303) 497-5367]

Reliability

Schafft, H.A., Suehle, J.S., and Albers, J., **JEDEC "TCR" Interlaboratory Experiment - Lessons Learned**, Proceedings of the 1994 International Integrated Reliability Workshop Final Report, Lake Tahoe, California, October 16-19, 1994, pp. 12-19.

Described are the results of an interlaboratory experiment involving wafer-level measurements intended to do the following: (1) to determine the precision and bias of both the JEDEC Standard Test Method (JESD33) for determining the temperature coefficient of resistance (TCR) and joule heating of a metal line and the ASTM standard (F 1261) for measuring the electrical width of a metal line; (2) to assess the reproducibility of measuring the temperature drop across the interface between the silicon substrate and the hot chuck; and (3) to obtain a temperature calibration of the hot chucks used by the participating laboratories.
[Contact: Harry A. Schafft, (301) 975-2234]

SIGNAL ACQUISITION, PROCESSING, AND TRANSMISSION

DC and Low-Frequency Metrology

Kinard, J.R., Huang, D.X., and Novotny, D.B., **Performance of Multilayer Thin-Film Multijunction Thermal Converters**, Proceedings of the Conference on Precision Electromagnetic Measurements, Boulder, Colorado, June 27—July 1, 1994, pp. 407-408.

New multilayer, thin-film multijunction thermal converters suitable as high-performance ac-dc transfer standards have been fabricated and studied at NIST. This paper describes their thermal and physical features and the materials chosen to improve performance. Performance data are given over a wide range of frequencies and conditions.
[Contact: Joseph R. Kinard, (301) 975-4250]

Antenna Metrology

Lewis, R.L., Muth, L.A., and Wittmann, R.C., **Polarimetric Calibration of Reciprocal-Antenna Radars**, NISTIR 5033 (March 1995).

We discuss how radar target depolarization enhances a radar's cross-polarization contamination, and we present a graphical study of radar

cross section (RCS) measurement error due to depolarization by an inclined dihedral reflector. Since error correction requires polarimetric RCS measurements, we recommend upgrading singly polarized radars to full polarimetric capability. We present a polarimetric calibration technique that is applicable to reciprocal antenna radars, saves calibration time by requiring a single calibration target, uses simple mathematical expressions, and smoothes measured calibration data to reduce the effects of clutter and noise.
[Contact: Richard L. Lewis, (303) 497-5196]

Muth, L.A., and Gary, J., **Accurate Computations of Radar Cross Sections of Simple Objects**, Proceedings of the 10th International Microwave Conference, Mikon - 94, Książ Castle, Poland, May 30—June 2, 1994, Vol. 1, pp. 298-302.

A comparison of two methods for the computation of the radar cross section is given. The first method is by Mei and the second by Keller and Givoli. Both direct methods solve a discrete version of the Helmholtz equation in a small domain containing the scatterer using absorbing outer boundary conditions. The solutions for a plane wave scattered from a two-dimensional infinite cylinder are better than 0.10 dB when compared to the analytic solutions.
[Contact: Lorant A. Muth, (303) 497-3603]

Wittmann, R.C., Francis, M.H., Muth, L.A., and Lewis, R.L., **Proposed Analysis of RCS Measurement Uncertainty**, Proceedings of the Antenna Measurement Techniques Association Symposium, Long Beach, California, October 3-7, 1994, pp. 51-57. [A similar paper, **Proposed Uncertainty Analysis for RCS Measurements**, appeared as NISTIR 5019 (January 1994)].

From a study of several Radar Cross Section (RCS) measurement facilities, we identify significant sources of uncertainty and develop methods for estimating their effect. Our goal is to provide a reasonable and uniform formalism for evaluating RCS measurements which can be used on a variety of test ranges to produce comparable estimates of uncertainty.
[Contact: Ronald C. Wittmann, (303) 497-3326]

Microwave and Millimeter-Wave Metrology

Clague, F.R., and Splett, J.D., **Developing a NIST Coaxial Microwave Power Standard at 1 mW**, Proceedings of the National Conference of Standards Laboratories, Chicago, Illinois, July 31—August 4, 1994, pp. 291-298.

Some customers of the NIST microwave power calibration service report they are using their calibrated reference standard at a power of about 1 mW rather than 10 mW where the NIST measurement is made. Since the coaxial reference standards accepted by NIST for calibration are dual-element thermistor mounts, they are subject to a dual-element substitution error if not used at the calibration power level. The error differs for each mount. The error is not easily measured, nor is it possible to readily estimate an additional uncertainty for using the mount at a different power. Initial measurements indicate the error can be up to 50% of the quoted calibration uncertainty. If the calibration uncertainty does not increase too much, a reasonable solution is to extend the NIST calibration service to powers under 10 mW. This paper briefly describes the present standard and the approach being taken to add the 1-mW capability. Preliminary uncertainty estimates are included.
[Contact: Fred R. Clague, (303) 497-5778]

Hayden, L.A., Marks, R.B., and Rettig, J.B., **Accuracy and Repeatability in Time Domain Network Analysis**, Proceedings of the 44th Automatic Radio Frequency Techniques Group, Boulder, Colorado, December 1-2, 1994, pp. 39-46.

This paper examines the importance of measurement repeatability in time domain network analysis and includes an analysis of the limitations imposed on theoretical accuracy by measurement noise. A closed-loop correction algorithm implemented in a fast, equivalent-time sampling, time domain reflectometer improves source timing accuracy, the dominant cause of nonrepeatability. An example measurement of attenuation in a 3.5-mm coaxial air-line demonstrates performance approaching this theoretical noise limit and the limits imposed by connector repeatability.
[Contact: Leonard A. Hayden, (303) 497-3400]

Marks, R.B., Hayden, L.A., Jargon, J.A., and Williams, F., **Time Domain Network Analysis**

Using the Multiline TRL Calibration, Proceedings of the 44th Automatic Radio Frequency Techniques Group, Boulder, Colorado, December 1-2, 1994, pp. 47-55.

We apply the multiline thru-reflect-line (TRL) method to the calibration of a time domain network analyzer (TDNA). The calibration removes the effects of cables and connectors, nonideal source and sampler responses, source and sampler mismatch, and frequency-dependent characteristic impedance of the transmission lines. Multiline TRL is especially well suited to TDNA and provides not only a complete calibration, but also a full characterization of the transmission lines, information useful in the study of interconnections.
[Contact: Roger B. Marks, (303) 497-3037]

Marks, R.B., and Williams, D.F., **Microwave Characterization of Printed Circuit Transmission Lines**, Proceedings of the National Electronic Packaging and Production Conference (NEPCON East '94), Boston, Massachusetts, June 13-16, 1994, pp. 520-527.

This paper reviews the basic methodology for the microwave characterization of printed transmission lines in terms of scattering parameters, impedances, and frequency-dependent transmission line parameters. The focus is on a suite of methods developed at the National Institute of Standards and Technology for the characterization of high-performance electronic packaging and interconnections as well as monolithic microwave integrated circuits.
[Contact: Roger B. Marks, (303) 497-3037]

Williams, D.F., and Marks, R.B., **Compensation for Substrate Permittivity in Probe-Tip Calibration**, Proceedings of the 44th Automatic Radio Frequency Techniques Group, Boulder, Colorado, December 1-2, 1994, pp. 20-30.

We demonstrate a method of compensation for the effect of substrate permittivity on coplanar waveguide probe-tip scattering parameter calibrations, modeling the effect as a capacitance at the probe tip. Comparison to on-wafer multiline thru-reflect-line calibration verifies its accuracy. The method allows calibration to the probe tip using generic off-wafer standards with accuracy comparable to that of on-wafer calibration.
[Contact: Dylan F. Williams, (303) 497-3138]

Electromagnetic Properties

Hill, D.A., **Electromagnetic Shielding Characterization of Gaskets**, NISTIR 5032 (February 1995).

[See Radiated EMI.]

Optical Fiber Metrology

Young, M., **Standard Reference Materials for Optical Fibers and Connectors**, Proceedings of the 1995 Optical Fiber Communication Conference, San Diego, California, February 26—March 3, 1995, pp. 239-240.

This paper outlines the development of a standard of fiber cladding diameter and the three instruments, a micrometer, a scanning confocal microscope, and a white-light interference microscope, that were crucial to that development. An international round robin yielded agreement generally within 0.1 μm. Other artifact standards are in the planning stage.
[Contact: Matt Young, (303) 497-3223]

Optical Fiber/Waveguide Sensors

Deeter, M.N., **Domain Effects in Faraday Effect Sensors Based on Iron Garnets**, Applied Optics, Vol. 34, No. 4, pp. 655-658 (1 February 1995).

Domain-induced diffraction effects produced by two iron-garnet thick films and two bulk crystals are compared. The thick films, characterized by a serpentine magnetic domain structure, produced nonlinear response functions; this is in qualitative agreement with a one-dimensional diffraction model. Bulk iron-garnet crystals, which exhibited a complex three-dimensional domain structure, produced qualitatively similar effects that diminished with increasing crystal length. Differential signal processing resulted in a linear signal for the thick films and a primarily sinusoidal response for the bulk crystals.
[Contact: Merritt N. Deeter, (303) 497-5400]

Rochford, K.B., Williams, P.A., Rose, A.H., Clarke, I.G., Hale, P.D., and Day, G.W., **Standard Polar-**

ization Components: Progress toward an Optical Retardance Standard, Proceedings of SPIE (The International Society for Optical Engineering, P.O. Box 10, Bellingham, Washington 98227-0010), Polarization Analysis and Measurement II, Vol. 2265, pp. 2-8 (1994).

NIST is developing a quarterwave linear retarder designed to have a retardance stable to within 0.1° over a variety of operational and environmental conditions. In this paper, we review several design strategies and early results of this effort. These have led to a promising prototype design consisting of a double rhomb total internal reflection retarder constructed from a low stress-optic glass. We also review several measurement methods that are used in our evaluations.
[Contact: Kenneth B. Rochford, (303) 497-5170]

Integrated Optics

Christensen, D.H., Hickernell, R.K., Schaafsma, D.T., Pellegrino, J.G., McCollum, M.J., Hill, J.R., and Rai, R.S., **Correlation of Optical, X-Ray, and Electron Microscopy Measurements on Semiconductor Multilayer Structures**, Proceedings of SPIE (The International Society for Optical Engineering, P.O. Box 10, Bellingham, Washington 98227-0010), Spectroscopic Characterization Techniques for Semiconductor Technology V, Vol. 2141, pp. 177-188 (1994).

[See Analysis and Characterization Techniques.]

Jino, M., Schlager, J.B., and Franzen, D.L., **Optical Sampling Using Nondegenerate Four-Wave Mixing in a Semiconductor Laser Amplifier**, Electronics Letters, Vol. 30, No. 18, pp. 1489-1490 (1 September 1994).

Picosecond optical sampling using nondegenerate four-wave mixing in a semiconductor laser amplifier (SLA) is demonstrated for the first time. High-peak-power pulses and electrical gating of the SLA produce an optical sampling signal with a high signal-to-noise ratio.
[Contact: John B. Schlager, (303) 497-3542]

Novak, S., Zavada, J.M., and Malone, K., **Using Secondary Ion Mass Spectroscopy (SIMS) to Characterize Optical Waveguide Materials**, Proceedings of the 28th Annual Microbeam Analysis Society Meeting, New Orleans, Louisiana, July 31—August 5, 1994, pp. 167-168.

Secondary Ion Mass Spectroscopy is used to analyze optical waveguides in $LiNbO_3$ and glass. Diffusion profiles are measured as well as cross-sectional images of waveguides.
[Contact: Kevin J. Malone, (303) 497-3289]

Patrick, H., Gilbert S.L., and Lidgard, A., **Decay of Bragg Gratings in Hydrogen-Loaded Optical Fibers**, Proceedings of the 1995 Optical Fiber Communication Technical Digest Series, San Diego, California, February 26—March 3, 1995, Vol. 8, pp. 179-180 (1995).

Bragg gratings written in hydrogen-loaded optical fibers showed a larger decrease in reflectivity than gratings in non-hydrogen-loaded fibers after 10 h at 110 °C and after 18 days at room temperature.
[Contact: Heather Patrick, (303) 497-6353]

Schlager, J.B., Jinno, M., and Franzen, D.L., **Millimeter-Resolution Optical Time-Domain Reflectometry Using a Four-Wave Mixing Sampling Gate**, IEEE Photonics Technology Letters, Vol. 7, No. 2, pp. 206-208 (February 1995).

We report an optical time-domain reflectometer that employs an ultrafast optical switch based on nondegenerate four-wave mixing in a semiconductor laser amplifier. Two-point spatial resolution on the order of 1 mm over 2 m is demonstrated: Fresnel reflections with optical return losses greater than 53 dB are detected. Submillimeter-resolution optical time-domain reflectometry over a 100-m range should be possible with modifications to the pulse sources.
[Contact: John B. Schlager, (303) 497-3542]

ELECTRICAL SYSTEMS

Magnetic Materials and Measurements

Kim, Y.K., and Sanders, S.C., **Magnetostriction and Giant Magnetoresistance in Annealed NiFe/Ag Multilayers**, Applied Physics Letters, Vol. 66, No. 8, pp. 1009-1011 (20 February 1995).

Magnetostriction data are reported for NiFe/Ag multilayer thin films displaying giant magnetoresistance. Magnetostriction and magnetoresistance were measured as functions of annealing temperature for NiFe/Ag samples having different numbers of NiFe/Ag bilayers and Ag spacer thicknesses. They varied systematically with annealing temperature in a manner consistent with residual stress reduction and microstructural changes such as grain-boundary diffusion and grain growth. Zero magnetostriction concurrent with high-magnetoresistance ratio (5%) and field sensitivity [7.5% (dA/m) (0.6%/Oe)] was observed for an optimal multilayer configuration and annealing temperature. This combination of zero magnetostriction and high-magnetoresistive response makes the NiFe/Ag multilayer system an attractive candidate for high-performance magnetic recording read-head sensors.
[Contact: Steven D. Sanders, (303) 497-5096]

Superconductors

Aized, D., Haddad, J.W., Joshi, C.H., Goodrich, L.F., and Srivastava, A.N., **Comparing the Accuracy of Critical-Current Measurements Using the Voltage-Current Simulator**, IEEE Transactions on Magnetics, Vol. 30, No. 4, pp. 2014-2017 (July 1994).

A passive voltage-current (V-I) simulator developed by the National Institute of Standards and Technology is used to compare the accuracy of critical current measurements and the power-law behavior of high temperature superconductors. In this study, critical current measurements made from four data acquisition and analysis systems are compared with those carried out at NIST. This paper also discusses various measurement techniques, methods of calculating critical current, and n-values. The V-I simulator is believed to be an advancement towards defining the standards for critical current measurements and ensuring the traceability of results at different test facilities.
[Contact: Loren F. Goodrich, (303) 497-3143]

ELECTROMAGNETIC INTERFERENCE

Radiated EMI

Camell, D.G., and Ma, M.T., **Assessment of Particular Measurement Data by a Second-Order Transfer Function Technique**, NIST Technical Note 1372 (October 1994).

The newly developed theory for predicting the response of a linear system to an electromagnetic pulse, based only on the measured continuous-wave (cw) magnitude, is applied to a particular system as a case study. The problem being addressed is concerned with possible electromagnetic interfer-ences at a sensitive part of a torpedo. The measured magnitude representing the system's transfer function is deduced first from the measured response at this sensitive point to a known cw source, supplied by the Naval Surface Warfare Center. We then derive an analytic expression for the magnitude square of the transfer function to approximate the measured data, and obtain a system transfer function in terms of the complex frequency, from which we predict the system cw phase characteristics and its multiple solutions due to a given impulse source.
[Contact: Dennis G. Camell, (303) 497-3214]

Hill, D.A., **Electromagnetic Shielding Characterization of Gaskets**, NISTIR 5032 (February 1995).

Numerous measurement methods are used for determining the shielding performance of rf gaskets, but different methods give significantly different results for the same gasket. Various measurement methods and the reasons for the discrepancies are reviewed. Simple models and theories are used to explain the meaning of transfer impedance and shielding effectiveness for gaskets and to determine the frequency range of validity. Transfer impedance should be a valid characterization at low frequencies. The precise frequency limitations of these characterizations and current measurement methods are not well known, but a time-domain method is proposed for determining gasket properties over a broad frequency range.
[Contact: David A. Hill, (303) 497-3472]

LAW ENFORCEMENT STANDARDS

Worthey, J.A., and Lieberman, A.G., **Model Minimum Performance Specifications for Lidar Speed Measuring Devices**, DOT HS 808 214, U.S. Department of Transportation, National

Highway Traffic Safety Administration (February 1995).

This document establishes model minimum performance requirements and test methods for laser speed measuring devices (lidar devices) used by law enforcement agencies to enforce vehicle speed regulations. It applies to stationary laser-speed measuring devices that transmit coherent infrared light pulses, measure the time-of-flight for the pulses reflected from moving vehicles, then calculate and display the speed of the target vehicle. The specification addresses speed accuracy, beamwidths, pulse repetition rate variability, supply voltage tolerances, display requirements, susceptibility to electromagnetic interference and environmental extremes, and simulated and operational target vehicle speed tests.
[Contact: James A. Worthey, (301) 975-3396]

VIDEO TECHNOLOGY

Bennett, H.S., Fenimore, C., and Field, B.F., **Making Displays Deliver a Full Measure**, Information Display, Vol. 11, No. I, pp. 20-28 (January 1995).

High-resolution displays are essential for market acceptance of advanced video systems and for sophisticated exploitation of "the information age." Developing and manufacturing such displays will require advanced measurement capabilities. This is a subject that interests us greatly at the National Institute of Standards and Technology, where the development of measurement standards and their application to industrial competitiveness have long been a central part of our mission.
[Contact: Herbert S. Bennett, (301) 975-2079]

ADDITIONAL INFORMATION

List of Publications

Lyons, R.M., and Gibson, K.A., **A Bibliography of the NIST Electromagnetic Fields Division Publications**, NISTIR 5028 (September 1994).

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 July 1993. Selected earlier publications from the Division's predecessor organizations are included.
[Contact: Kathryn A. Gibson, (303) 497-3132]

Meiselman, B., **Electrical and Electronic Metrology: A Bibliography of NIST Electricity Division's Publications, NIST List of Publications 94** (January 1994).

This bibliography covers publications of the Electricity Division, Electronics and Electrical Engineering, Laboratory, NIST, and of its predecessor sections for the period January 1968 to December 1993. A brief description of the Division's technical program is given in the introduction.
[Contact: Katherine H. Magruder, (301) 975-2401]

Smith, A.J., **Metrology for Electromagnetic Technology: A Bibliography of NIST Publications**, NISTIR 5029 (September 1994).

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.
[Contact: Annie Smith, (303) 497-3678]

Walters, E.J., **National Semiconductor Metrology Program, 1990-1994, NIST List of Publications 103** (March 1995).

This List of Publications includes all papers relevant to semiconductor technology published by NIST staff, including work of the National Semiconductor Metrology Program, the Semiconductor Electronics Division, and other parts of NIST having independent interests in semiconductor metrology. Bibliographic information is provided for publications from 1990 through 1994. 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]

1995 Calendar of Events

August 15-18, 1995 (Boulder, Colorado)

Laser Measurements Short Course. Sponsored by Colorado University and NIST, this course will provide training on laser measurement 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]

October 8-12, 1995 (Orlando, Florida)

Special Session on Model Validation, 1995 IEEE-IAS Annual Meeting. The Power Electronics Devices and Components Committee of the IEEE Industry Applications Society in cooperation with the NIST Working Group on Model Validation will hold a special session on model validation. This session is being introduced to reflect the growing needs and interest in establishing procedures for the comprehensive evaluation of circuit simulator models. Topics of interest include: characterization procedures that could be applied for evaluation of models, methods for identifying and implementing model validation procedures, and the application of validation procedures in comparing specific models.
[Contact: Allen R. Hefner, (301) 975-2071]

October 26, 1995 (Austin, Texas)

National Ion Implant Users Meeting. The Ion Implant Users Group (East Coast) and the Greater Silicon Valley Implant Users Group have joined together for the first meeting on a national level. This year's meeting on the needs, challenges, approaches, modeling, and results for low-energy implantation will be held in Austin, Texas, on October 26, 1995, in conjunction with SEMI's SEMICON/Southwest 95.

The meeting provides a forum for the informal exchange of information and ideas on ion-implant-related issues, future trends, and applications. Low-energy topics to be discussed range from practical semiconductor manufacturing issues to developmental doping techniques. These tie in directly with the SIA Roadmap for the fabrication of submicrometer structures envisioned in the next generation of computer CPUs and DRAMs. Presentations on other applications of low-energy implantation such as the treatment of space-age and medical materials for improved strength and corrosion resistance are also planned.
[Contact: John Albers, (301) 975-2075]

<u>EEEL Sponsors</u>

National Institute of Standards and Technology
Executive Office of the President
U.S. Air Force
  Hanscom Air Force Base; Newark Air Force Base; Patrick Air Force Base; CCG-Strategic Defense Command; CCG-Systems Command; Wright Patterson
U.S. Army
  Fort Belvoir; Redstone Arsenal; Combined Army/Navy/Air Force (CCG)
Department of Defense
  Advanced Research Projects Agency; Defense Nuclear Agency; National Security Agency
Department of Energy
  Building Energy R&D; Energy Systems Research; Fusion Energy; Basic Energy Sciences;
Department of Justice
  Law Enforcement Assistance Administration; Federal Bureau of Investigation
U.S. Navy
  CCG, Seal Beach; Office of Naval Research; Naval Surface Warfare Center; Naval Air Systems Command
National Aeronautics and Space Administration
  NASA Headquarters
Department of Transportation
  National Highway Traffic Safety Administration
 Central Intelligence AgencyMIMIC Consortium
Nuclear Regulatory Commission
Department of Health and Human Services
  National Institutes of Health
Various Federal Government Agencies

NIST SILICON RESISTIVITY SRMs

In response to needs of the semiconductor industry, NIST's Semiconductor Electronics Division provides silicon bulk resistivity Standard Reference Materials (SRMs) through the NIST Standard Reference Materials Program. A new class of resistivity SRMs is being introduced to respond better to users' requirements.

The first NIST (then NBS) resistivity SRMs were fabricated from crystal 50 mm (2 in) in diameter. These wafers represented various combinations of crystal growth process, crystallographic orientation, and doping, each combination chosen to give the best expected wafer uniformity for a given resistivity level. Each wafer in every set was individually measured and certified. Some of these sets are still available until the supply is exhausted (see table).

The Division is now certifying single-wafer resistivity standards at approximately the same resistivity values as were available in the earlier sets. These new SRMs are fabricated from crystal 100 mm in diameter, intended to provide improved compatibility with newer end-use instrumentation. In response to user comments, the new SRMs will be more uniform in both thickness and resistivity, will have reduced uncertainty of certified value due to use of an improved certification procedure using a four-point probe, and will be measured and certified at additional measurement sites for better characterization of wafer uniformity at its core. The additional measurements needed to qualify the improved SRMs will make them more expensive on a per-wafer basis than the earlier sets.

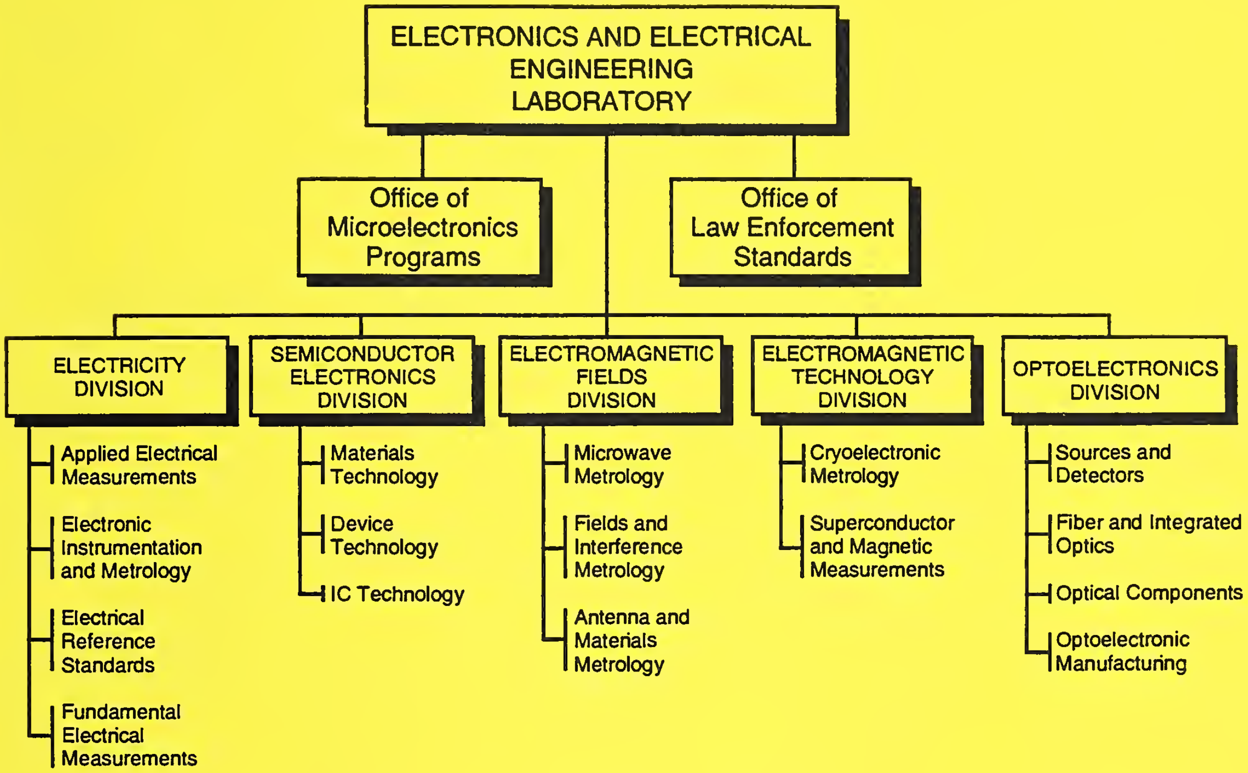
NIST SILICON BULK RESISTIVITY STANDARD REFERENCE MATERIALS

DATE UPDATED: 10 MARCH 1995

Note: Problems in producing and certifying new SRMs have resulted in substantial delays. The first to become available, for 10 and 180 ohm ·cm, are not likely to be ready until 1995.

NOMINAL RESISTIVITY (ohm · cm)	<u>OLD SRMs</u>	AVAILABILITY	<u>NEW SRMs</u>	ANTICIPATED AVAILABILITY
0.01	1523 (one of set of two wafers)	limited supply	2541	to be announced
0.1	1521 (one of set of two wafers)	limited supply	2542	to be announced
1	1523 (one of set of two wafers)	limited supply	2543	to be announced
10	1521 (one of set of two wafers)	limited supply	2541	to be announced
25	1522	set of three wafers are no longer available	2545	to be announced
75	1522		2546 (100)	to be announced
180	1522		2547 (200)	to be announced

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



KEY CONTACTS

Laboratory Headquarters (810)	Director, Judson C. French (301) 975-2220
	Deputy Director, Robert E. Hebner (301) 975-2220
	Associate Director, Alan H. Cookson (301) 975-2220
Office of Microelectronics Programs	Director, Robert I. Scace (301) 975-4400
Office of Law Enforcement Standards	Director, Kathleen M. Higgins (301) 975-2757
Electricity Division (811)	Acting Chief, William E. Anderson (301) 975-2400
Semiconductor Electronics Division (812)	Chief, Frank F. Oettinger (301) 975-2054
Electromagnetic Fields Division (813)	Chief, Allen C. Newell (303) 497-3131
Electromagnetic Technology Division (814)	Acting 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