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Center for Electronics and Electrical Engineering

Technical Publication Announcements

Covering Center Programs, January - March 1985 with 1985 CEEE Events Calendar

November 1985

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DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

INTRODUCTION TO THE CEEE TECHNICAL PUBLICATION ANNOUNCEMENTS

This is the fourth issue of a quarterly publication providing information on the technical work of the National Bureau of Standards Center for Electronics and Electrical Engineering. This issue of the CEEE Technical Publication Announcements covers the first quarter of calendar year 1985.

Organization of Bulletin: This issue contains citations and abstracts for Center papers published in the quarter. Entries are arranged by technical topic as identified in the table of contents and alphabetically by first author under each subheading within each topic. Following each abstract is the telephone number of the individual to contact for more information on the topic; unless otherwise noted, this person is the first author. This issue also includes a calendar of Center conferences and workshops now planned for calendar year 1985, an announcement of newly released standard reference materials, and a list of sponsors of the work.

Center for Electronics and Electrical Engineering: Center programs provide national reference standards, measurement methods, supporting theory and data, and traceability to national standards.

The metrological products of these programs aid economic growth by promoting equity and efficiency in the marketplace, by removing metrological barriers to improved productivity and innovation, by increasing U. S. competitiveness in international markets through facilitation of compliance with international agreements, and by providing technical bases for the development of voluntary standards for domestic and international trade. These metrological products also aid in the development of rational regulatory policy and promote efficient functioning of technical programs of the Government.

The work of the Center is divided into two major programs: the Semiconductor Technology Program, carried out by the Semiconductor Electronics Division (formerly the Semiconductor Materials and Processes and Semiconductor Devices and Circuits Divisions) in Gaithersburg, MD, and the Signals and Systems Metrology Program, carried out by the Electrosystems Division in Gaithersburg and the Electromagnetic Fields and Electromagnetic Technology Divisions in Boulder, CO. Key contacts in the Center are given on the back cover; readers are encouraged to contact any of these individuals for further information.

Center sponsors: The Center Programs are sponsored by the National Bureau of Standards and a number of other organizations, in both the Federal and private sectors; these are identified on page 8.

Note on Publication Lists: Guides to earlier as well as recent work are the publication lists covering the work of each division. These lists are revised and reissued on an approximately annual basis and are available from the originating division.

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SEMICONDUCTOR TECHNOLOGY PROGRAM

Silicon Materials

Baghdadi, A., **Comments on Precise Evaluation of Oxygen Measurements on Cz-Silicon Wafers,** Journal of the Electrochemical Society, 132, pp. 510 (February 1985).

This is a discussion of a paper by Graff, entitled "Precision Evaluation of Oxygen Measurements on Cz-Silicon Wafers" which was published in the Journal of the Electrochemical Society, Vol. 130, No. 6, p. 1378. The equations used by Graff in his paper do not adequately represent the physical situation. This discussion points out the inconsistencies in Graff's approach to the problem.
Contact: [(301) 921-3786]

Ehrstein, J.R., **Preparation and Certification of SRMs for Calibration of Spreading Resistance Probes,** NBS Special Publication 260-63 (January 1985).

This special publication describes the material selection, characterization, data analysis, and measurement process control procedures for four types of Standard Reference Materials (SRMs), available from the National Bureau of Standards, for calibration of spreading resistance measurements on semiconductor silicon. Each of the four comprises a single combination of silicon conductivity-type and crystallographic orientation and contains 16 rectangular silicon chips which are certified for resistivity value based on four-probe resistivity measurements on the slices from which they were cut. The resistivity values of the chips in each set range from about 0.001 Ω•cm to about 100 Ω•cm. The uncertainty of the certified resistivity, as it applies to any individual chip, depends both on the uniformity of the starting slice and on the inherent measurement process uncertainty. The procedure for determining this uncertainty, which is specifically evaluated and tabulated on the certificate for each SRM set, is described.
Contact: [(301) 921-3786]

Integrated Circuit Test Structures

Mazer, J.A., Linholm, L.W., and Saxena, A.N., **An Improved Test Structure and Kelvin-Measurement Method for the Determination of Integrated Circuit Front Contact Resistance,** J. Electrochem. Soc., 132, No. 2, pp. 440-443 (February 1985).

The use of an improved microelectronic test structure and associated Kelvin measurement method for determining front contact resistance (circuit-loading resistance) of a metal/semiconductor ohmic contact is described. The values of front contact resistance for aluminum/silicon contacts are determined using this Kelvin cross structure and are compared with values determined by a two-terminal contact chain method and with values determined by a Kelvin voltage divider method. The values of front contact resistance using the Kelvin-cross structure and associated measurement method are shown to be less sensitive to photolithographic process variations and electrical measurement errors than those determined using the other two structures and measurement methods.
Contact: [(301) 921-3801]

Process and Device Modeling

Bennett, H.S., **Heavy Doping Effects on Bandgaps, Effective Intrinsic Carrier Concentrations, and Carrier Mobilities and Lifetimes,** Solid-State Electronics, 28, Nos. 1/2, pp. 193-200 (1985).

Conventional device physics in most computer models of transistors may not predict correctly the measured electrical performance for shallow, heavily doped transistors. This paper presents improved concepts for numerical simulations of solid-state devices with donor densities up to 3×10^{20} cm^{-3} and junction depths as small as 1 μm. These improved concepts pertain to bandgap

Process and Device Modeling, cont'd.

narrowing, effective intrinsic carrier concentrations, and carrier mobilities and lifetimes.
Contact: [(301) 921-3621]

Bennett, H.S., **Modeling GaAs/AlGaAs Devices: A Critical Review,** IEEE Circuits & Devices Magazine, 1, No. 2, pp. 35-42 (January 1985).

Device models for GaAs devices and GaAs/AlGaAs heterostructures are much less advanced than those for silicon devices. This paper critically reviews recent advances in the modeling of GaAs/AlGaAs devices. It is based on the examination of five selected device models which contain features common to the majority of device models for heterostructure bipolar and field effect transistors. Areas requiring improved measurement techniques on processed GaAs and improved physical concepts for GaAs/AlGaAs device models are identified.
Contact: [(301) 921-3621]

Lowney, J.R., **Band-Gap Narrowing in the Space-Charge Region of Heavily Doped Silicon Diodes,** Solid-State Electronics, 28, Nos. 1/2, pp. 187-191 (January/February 1985).

The densities of states of the valence and conduction bands have been calculated in the space-charge region of a heavily doped linearly graded p-n junction silicon diode. Both the donor and acceptor densities were chosen to be equal to 6.2×10^{18} cm^{-3}. The results showed the emergence of band tails which penetrated deeply into the energy gap and accounted for the band-gap narrowing observed in such a diode by analysis of capacitance vs. voltage measurements of the built-in voltage.
Contact: [(301) 921-3786]

Other Semiconductor Metrology Topics

Scace, R.I., **Materials Measurements: Present Abilities and Future Needs,** Solid State Technology, 28, No. 3, pp. 155-158 (March 1985).

Standard measurement methods and specifications for the semiconductor industry are reviewed and discussed with emphasis on applications to VLSI processes. The standards development process is an excellent way for material producers and users to develop good working relations and to solve their shared measurement problems; this process is described in some detail. Because the semiconductor industry is an international one, serious efforts have been made for a number of years to rationalize the technical differences between test method standards in Europe and the U.S. with considerable success. The present state of such cooperative activity with Japan, which is of more recent origin, is also reported.
Contact: [(301) 921-3357]

Walters, E. J., **Semiconductor Measurement Technology, NBS List of Publications 72** (March 1985).

This bibliography lists the publications of the Semiconductor Technology Program in the Center for Electronics and Electrical Engineering for the period from January 1962 to December 1984.
Contact: [(301) 921-3786]

FAST SIGNAL ACQUISITION, PROCESSING, AND TRANSMISSION

Waveform Metrology

Lawton, R.A., **An Efficient Antialiasing Filter**, Proceedings of the Conference on Precision Electromagnetic Measurements, Delft, Netherlands, August 20-24, 1984, pp. 104-105.

The application of a solid state reference filter as an efficient antialiasing filter is described. The analytical basis for the efficiency of this filter is described and a specific example of measuring a 1024-point waveform with an RC filter and the solid-state filter is given.
[(303) 497-3339]

Cryoelectronic Metrology

Kautz, R.L., and Monaco, R., **Survey of Chaos in the rf-biased Josephson Junction**, Journal of Applied Physics, 57, No. 3, pp. 875-889 (1 February 1985).

Chaotic behavior in the rf-biased Josephson junction is studied through digital simulations of the Steward-McCumber model. Chaotic states are characterized by Poincare sections, Liapunov exponents, and power spectra. Models are presented which explain some features of the chaotic spectra. The parameter range over which chaotic behavior occurs is determined empirically for a broad range of dc bias, rf bias, and hysteresis parameters for a fixed rf frequency. It is shown that chaos does not occur if either the dc bias or the rf bias is very large. An attempt is made to explain the boundaries of the chaotic region in terms of simple models for chaotic behavior.
Contact: [(303) 497-3391]

Antenna Metrology

Stubenrauch, C.F., and Francis, M.H., **Comparison of Measured and Calculated Mutual Coupling in the Near Field Between Microwave Antennas**, Proceedings of the 1984 Antenna Applications Symposium, Urbana-Champaign, IL, September 19-21, 1984, pp. B1-B21.

Measurements of near-field mutual coupling were performed between two moderate sized microwave antennas and compared to coupling calculated using recently developed computer programs. Required input data for the programs are the complex far-field radiation patterns of the antennas and various geometrical factors describing the relative positions and orientations of the two antennas. Experimentally determined and calculated coupling as a function of both transverse displacement and separation agree closely except for a constant offset observed in some cases.
Contact: [(303) 497-3927]

Noise Metrology

Daywitt, W.C., **Design and Error Analysis for the WR10 Thermal Noise Standard**, Proceedings of the 1984 Antenna Applications Symposium, Urbana-Champaign, IL, September 19-21, 1984, pp. A1-A26.

This note describes the design and error analysis of a WR10 thermal noise power standard. The standard is designed to operate at the boiling point of liquid nitrogen with a noise temperature accurate to ±1 K.
Contact: [(303) 497-3720]

Laser Metrology

Johnson, E.G., Jr., **Using Optical Processing to Find the Beam Profile of a Laser Pulse (Theory)**, Proc. SPIE - The International Society for Optical Engineering, 499, pp. 75-88, SPIE, P.O. Box 10, Bellingham, WA 98227-0010 (1984) [paper given at Conference, San Diego, CA, August 21-22, 1984].

This paper looks at a particular form of optical processing, namely a form of cross-correlation, and demonstrates how the method measures certain beam profile features of a laser pulse. Beam profile is defined to mean a description of the electromagnetic field of a laser pulse in space and time. In this paper, I represent the laser pulse as a complete set of orthogonal modes and show that an appropriate spatial filter and a measurement system can provide information about the beam profile of the laser in terms of the individual eigenfunctions of this representation. First I trace what happens when a laser pulse is modified by the spatial filter. I then do a specific example which looks at the TEM_{00} laser beam pulse with beam tilt, beam curvature, beam width, and beam shift to show that these effects produce higher order Hermite modes in the measurement system. The spatial filter modifies the electric field distribution in the focal plane such that at known spatial locations, the magnitude of the intensity is proportional to the pulse power or energy in particular Hermite modes. Since the size of these loca-

Laser Metrology, cont'd.

tions is infinitesimal without getting errors from the electromagnetic fields from other modes, I demonstrate the effect and errors associated with using finite size detectors for measuring the magnitude of the intensity at these locations.
Contact: [(303) 497-3234]

Simpson, P.A., and Johnson, E.G., Jr., **A Calorimeter for Measuring 1-15 kJ Laser Pulses**, Proc. SPIE - The International Society for Optical Engineering, 499, pp. 121-124, SPIE, P.O. Box 10, Bellingham, WA 98227-0010 (1984) [paper given at Conference, San Diego, CA, August 21-22, 1984].

Two calorimeters for measuring high peak power laser pulses have been constructed by the NBS and delivered to the Newark Air Force Station, Newark, Ohio. These calorimeters are designed to measure pulses having intensities great enough to damage the volume absorbing material in normal calorimeters. In these new calorimeters the volume absorbing material is already fragmented and flowing dry N_2 gas is used to extract the temperature rise information. Pulse energy can be in the range 1 to 15 kJ. Wavelength range is from the ir to uv by employing various volume absorbing materials.
Contact: [(303) 497-3789]

Electro-Optic Metrology

Phelan, R.J., Jr., **Fast Detectors and Modulators**, Chapter 13 in book, Semiconductors and Semimetals, 21, Part D, Ed. J. I. Pankove, Academic Press, NY, pp. 249-259 (1985).

It is interesting to determine if hydrated amorphous silicon (a-Si:H) can be used to create useful electro-optic devices with picosecond response times. Although one normally does not associate fast devices with low mobility materials, subnanosecond optical detectors and modulators have been made using a-Si:H. Fast speeds are achieved by using very short lifetime materials or by making the structures sufficiently small that transit times are the limiting factor. A major factor favoring a-Si:H is the fact that it can be deposited on a wide variety of substrates allowing for the fabrication of structures that would otherwise be very difficult to construct.
Contact: [(303) 497-3696]

Phelan, R.J., Jr., Larson, D.R., Frederick, N.V., and Franzen, D.L., **Detectors for Picosecond Optical Power Measurements**, Proc. SPIE - The International Society for Optical Engineering, 499, pp. 34-37, SPIE, P.O. Box 10, Bellingham, WA 98227-0010 (1984) [paper given at Conference, San Diego, CA, August 21-22, 1984].

There are many features in addition to time resolution that are desirable for a picosecond optical power measurement system. An interdigitated-contact, Schottky barrier silicon photodiode coupled to an electro-optic sampler exhibits a rise time better than 22 picoseconds, a quantum efficiency greater than 30%, a uniform responsivity over its receiving aperture, and a usable spectral response to beyond 2 micrometers.
Contact: [(303) 497-3696]

ELECTRICAL SYSTEMS

Power Systems Metrology

Hebner, R.E., Jr., **Development of Power System Measurements -- Quarterly Report, April 1, 1984 to June 30, 1984**, NBSIR 85-3112 (March 1985).

This report documents the progress of three technical investigations sponsored by the Department of Energy and performed by or under a grant from the Electrosystems Division, the National Bureau of Standards. The work described covers the period April 1, 1984 to June 30, 1984. This report emphasizes the errors associated with measurements of

Power Systems Metrology, cont'd.

dc electric fields, the properties of corona in compressed SF_6 gas, and the measurement of voltage pulses on nanosecond time scales.
Contact: [(301) 921-3121]

Hebner, R.E., Jr., **Development of Power System Measurements -- Quarterly Report, July 1, 1984 to September 30, 1984**, NBSIR 85-3111 (March 1985).

This report documents the progress on four technical investigations sponsored by the Department of Energy and performed by or under a grant from the Electrosystems Division, the National Bureau of Standards. The work described covers the period from July 1, 1984 to September 30, 1984. The report emphasizes the errors associated with measurements of electric and magnetic fields, the properties of corona in compressed SF gas, the measurement of interfacial phenomena in transformer oil, and the measurement of dielectric properties on nanosecond time scales.
Contact: [(301) 921-3121]

ELECTROMAGNETIC INTERFERENCE

Adams, J.W., and Ondrejka, A.R., **Shielding Effectiveness (SE) Measurement Techniques**, Proceedings of the EMI/RFI Technical Conference, The Society of Plastic Engineers, Inc., Chicago, IL, June 18-20, 1984, pp. 19-26.

Five methods of measuring shielding effectiveness of the same lossy material were studied. Two of the methods were state-of-the-art involving time-domain techniques. Other methods include dual TEM cell, a variation of MIL-STD 285, and a coaxial holder. Comparative measurement data are shown, and insights are offered as to interpretation of results. Some methods give agreement; others do not. This is a preliminary analysis, not a definition work.
Contact: [(303) 497-3328]

Ma, M.T., **Error Analysis of Radiation Characteristics of an Unknown Interference Source Based on Power Measurements**, Proceedings of the 1984 International Symposium on Electromagnetic Compatibility [IEEE EMC Society], Tokyo, Japan, October 16-18, 1984, pp. 39-44.

Theoretical derivations for analyzing the uncertainties in the source parameters and radiation characteristics of an unknown electrically small interference source, extracted from the power measurements made inside a transverse electromagnetic (TEM) cell, are given. Numerical examples with assumed unbiased and biased measurement errors, and for the worst case, are also presented.
Contact: [(303) 497-3800]

Randa, J., and Kanda, M., **High-Frequency Errors of an Electric-Field-Meter in Complicated Environments,** to be published in the Proceedings of the IEEE Symposium on EMC, Wakefield, MA, August 20-22, 1985.

We report the results of a study of electric-field-meter (EFM) errors in complex electromagnetic environments. Two types of errors are considered - errors in the measured electric field for a common EFM design, and errors in the assumption of equal electric and magnetic energy densities in a multiple-plane-wave environment. Typical errors in both cases are around one-half to three dB, but in some circumstances they can exceed 10 dB.
Contact: [(303) 497-3150]

Wilson, P.F., and Ma, M.T., **Small Obstacle Loading in a TEM Cell**, Proceedings of the 1984 Symposium on Electromagnetic Compatibility [IEEE EMC Society], Tokyo, Japan, October 16-18, 1984, pp. 30-35.

A typical transverse electromagnetic (TEM) cell measurement procedure involves calibrating an empty cell and introducing a test object. The loading effect due to the test object presence is normally assumed to be negligible.

Electromagnetic Interference, cont'd.

This paper examines the effect of the test object and the validity of the "non-perturbing" assumption. The analysis utilizes the small aperture theory, as applied to the dual problem of small obstacle scattering. The result is an equivalent T-network representation of the test loading which allows the overall transmission line circuit to be studied. In addition, evaluating the scattered modes gives the field perturbation due to the test object.
Contact: [(303) 497-3842]

Wilson, P.F., and Ma, M.T., **Some Problems Associated with Interpreting Shielding Effectiveness Measurement Results,** Proceedings of the EMI/RFI Technical Conference, The Society of Plastic Engineers, Inc., Chicago, IL, June 18-20, 1984, pp. 9-18.

Shielding effectiveness is usually measured in terms of insertion loss, that is, the reduction in the fields coupled between a transmitter and receiver achieved by introducing the shield material or case, etc. Although the insertion loss concept is simply stated, problems arise when one attempts to interpret specific insertion loss measurements. Insertion loss depends not only on the shield introduced but also on antenna types used and their positioning, the waveform incident on the shield, and contact resistance. Variations in these factors can yield almost any level of insertion loss for the same shield sample. These concepts will be discussed to emphasize both the difficulty in making even relative insertion loss comparisons and the importance of controlling and understanding insertion loss parameters.
Contact: [(303) 497-3842]

1985 CEEE CALENDAR

December 5 (Gaithersburg, MD)

1985 Power Semiconductor Devices Workshop. This Workshop is jointly sponsored by the IEEE Electron Devices Society and NBS and is held in conjunction with the IEEE Electron Devices Meeting in Washington, D.C., which it follows. Topic areas include: packaging, power integrated circuits, three-terminal devices, and modeling. The format of the Workshop calls for each topic area to be addressed by working groups of 15 to 30. Reports from the working groups will be developed and presented orally to all attendees in a concluding session. [Contact: Sandra B. Kelley (301) 921-3541]

NEW STANDARD REFERENCE MATERIALS

The first practical superconducting standard reference material (SRM) has been released by the Electromagnetic Technology Division to the NBS Office of Standard Reference Materials for sale to the public. The certified parameter of SRM 1457, Superconducting Critical Current -- NbTi Wire, is critical current at magnetic fields of 2,4,6, and 8 tesla at a temperature of 4.2 K and an electric field criterion of 0.2 μV/cm. Information is given to permit the user to determine critical current for temperatures in the range 3.90 to 4.24 K and electric field criteria from 0.05 to 0.2 μV/cm.

SRM 1457 consists of a 2.2-m length of a multifilimentary, niobium-titanium, copper-stabilized wire, wound in a single layer on a spool having a core diameter of 8.7 cm. The wire is evaluated for 34 parameters relating to current, voltage, magnetic field, temperature, strain, and physical specimen characteristics.

In conjunction with ASTM Standard Test Method B714-82, D-C Critical Current of Composite Superconductors, the new SRM is intended to provide means for calibrating apparatus used to measure key parameters of superconductor products

NEW SRMs (cont'd)

and thus should be useful to buyers and sellers of superconductors, users of superconducting equipment, and researchers in superconducting technology.

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Center for Electronics and Electrical Engineering

10. SUPPLEMENTARY NOTES

All technical information included in this document has been previously approved for publication.

☐ Document describes a computer program; SF-185, FIPS Software Summary, is attached.

11. ABSTRACT (A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here)

This is the fourth issue of a quarterly publication providing information on the work of the National Bureau of Standards Center for Electronics and Electrical Engineering. This issue of the Center for Electronics and Electrical Engineering Technical Publication Announcements covers the first quarter of calendar year 1985. Abstracts are provided by technical area for papers published this quarter.

12. KEY WORDS (Six to twelve entries; alphabetical order; capitalize only proper names; and separate key words by semicolons)

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

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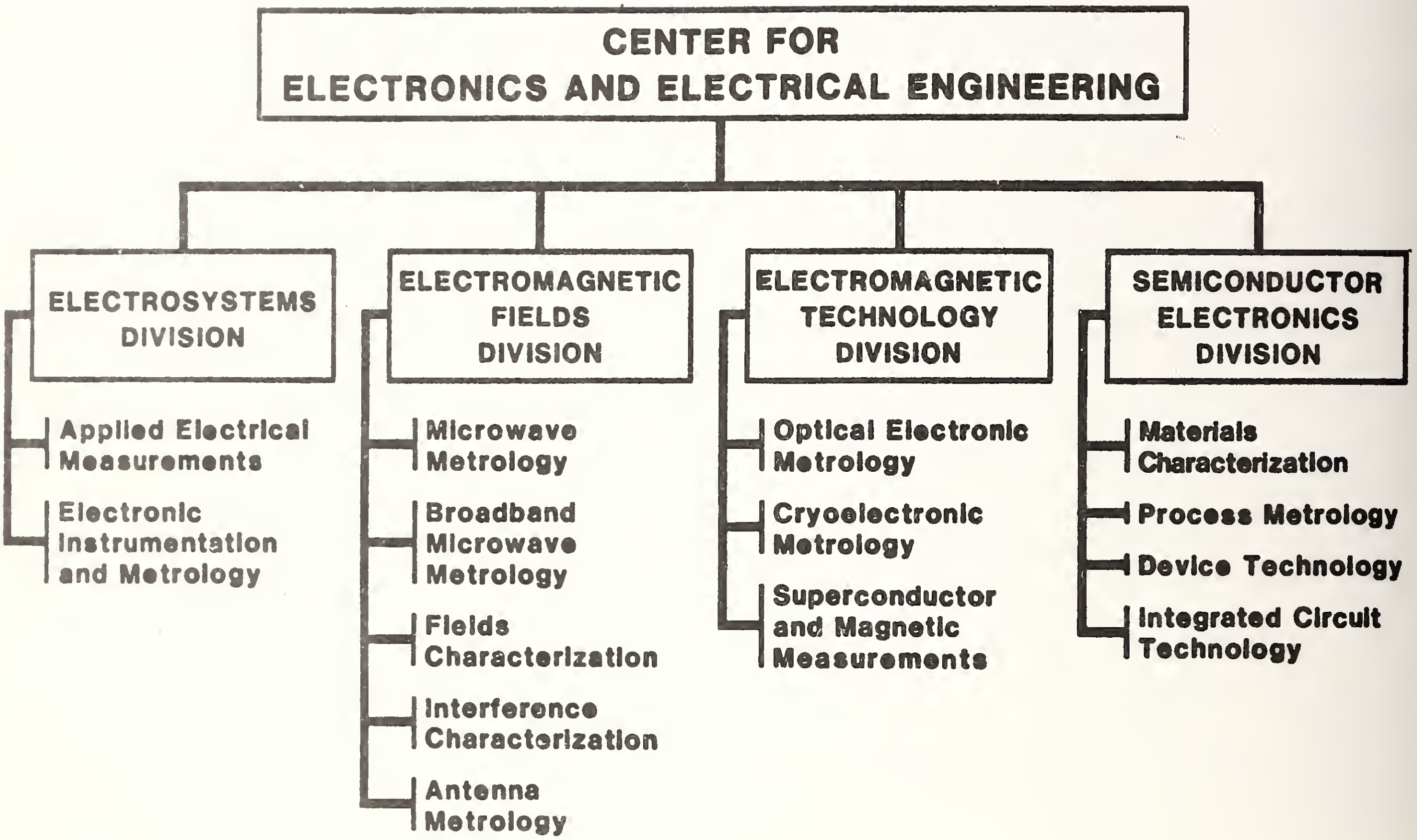

KEY CONTACTS:

Center Headquarters (720) — Director, Mr. Judson C. French (301) 921-3357
Deputy Director, Mr. Robert I. Scace (301) 921-3357

Electrosystems Division (722) — Chief, Dr. Oskars Petersons (301) 921-2328

Electromagnetic Fields Division (723) — Chief, Mr. Charles K.S. Miller (303) 497-3131

Electromagnetic Technology Division (724) — Chief, Dr. Robert A. Kamper (303) 497-3535

Semiconductor Electronics Division (727) — Chief, Dr. Kenneth F. Galloway (301) 921-3541

INFORMATION:

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

Center for Electronics and Electrical Engineering
National Bureau of Standards
Metrology Building, Room B-358
Gaithersburg, MD 20899

Telephone (301) 921-3357