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Center for Electronics and Electrical Engineering

Technical Publication Announcements

Covering Center Programs, April - June 1985 with 1986 CEEE Events Calendar

January 1986

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National Bureau of Standards
National Engineering Laboratory
Gaithersburg, Maryland 20899

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INTRODUCTION TO THE CEEE TECHNICAL PUBLICATION ANNOUNCEMENTS

This is the fifth 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 second 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 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 1986, an announcement of recently issued 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 9.

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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KEY CONTACTS IN CENTER, CENTER ORGANIZATION . . . . . back cover

SEMICONDUCTOR TECHNOLOGY PROGRAM

Analysis Techniques

Forman, R. A., and Mayo, S., **In Situ Alignment for X-Ray Topography**, J. Appl. Crystallography, Vol. 18, pp. 106-109 (1985).

A simple method for in situ alignment of samples in a double-crystal x-ray topography system is described. This method permits a specific crystallographic axis to be made coincident with the sample rotation axis used to set the Bragg angle. Surface reflections from approximately orthogonal crystallographic planes are required, and tables of such planes suitable for alignment of cubic crystals are given. This procedure allows rapid setup for the other accessible surface reflection or transmission topographs.
[Contact: (301) 921-3786]

Gallium Arsenide Materials

Imhoff, E.A., Bell, M.I., and Forman, R.A., **Hot Photoluminescence in Beryllium-Doped Gallium Arsenide,** Solid State Communications, Vol. 54, No. 10, pp. 845-848 (1985).

Hot photoluminecence in GaAs:Be is reported for the first time. The emission from a sample with $p = 6.5 \times 10^{16}$ cm^{-3} at 10 K consists of a shoulder at 1.803 ± 0.002 eV followed by a series of broad peaks at 1.781, 1.742, 1.704, 1.666, and 1.628 eV (all ±0.003 eV). Analysis of the results supports a decay model involving hot electron-acceptor recombination and implies an L-Γ splitting of 320 ± 4 meV in the conduction band at 0 K.
[Contact: Michael I. Bell, (301) 921-3786]

Power Devices

Blackburn, D.L., **Turn-Off Failure of Power MOSFETs**, Proceedings of the 1985 IEEE Power Electronic Specialists Conference, Toulouse, France, June 24-28, 1985, pp. 429-435.

Experimental results of the failure of power MOSFETs during turn-off are discussed. It is shown that the electrical characteristics of these devices during failure are identical to those of a bipolar transistor undergoing second breakdown. Other comparisons of the power MOSFET failure and bipolar second breakdown are made. A nondestructive measurement system is used allowing repeated measurements of the failure characteristics as a function of various parameters to be made on single devices. It is shown that practical, commercial power MOSFETs do not fail as a result of dV(DS)/dt currents. Drain voltage slew rates up to 22 V/ns were studied. Other measurements show that the drain voltage at which failure occurs increases with temperature, the critical current above which failure occurs decreases with temperature, and the magnitude of the load inductance has no effect on the failure. The results of this study are consistent with the theory that activation of the parasitic bipolar transistor initiates the power MOSFET failure.
[Contact: (301) 921-3621]

Integrated Circuit Test Structures

Roenker, K.P., Harner, B.L., and Linholm, L.W., **An NMOS Test Chip for Instruction in Semiconductor Parameter Measurements,** Proceedings of the Sixth Biennial University/Government/Industry Microelectronics Symposium, Auburn, AL, June 11-13, 1985, pp. 100-105.

This paper describes an NMOS test chip, NBS-40, designed for use in a graduate-level course in the measurement of semiconductor parameters using test structures. The rationale and objectives of a parameter measurements course are discussed and the organization and results of a course offered at the University of Cincinnati are described. The test chip layout and test structures are briefly described and parameter measurements using the test structures are

IC Test Structures, cont'd.

discussed. An NBS technical report describing the test chip has been prepared and is available as a student reference. Examples of recent measurement results obtained on chips fabricated through the MOSIS service are provided to demonstrate the functionality of the chip.
[Contact: Loren W. Linholm, (301) 921-3801]

Schafft, H.A., Grant, T.C., Saxena, A.N., and Kao, C.Y., **Electromigration and the Current-Density Dependence,** Proceedings of the International Reliability Physics Symposium, Orlando, FL, March 26, 1985, pp. 93-99.

The empirical expression used to predict metallization resistance to electromigration failure involves the current density to a power of n. A value for n of 1.5 was obtained from stressing unpassivated Al-1% Si metallization test structures over a range of current densities of from 0.5 to 2.5 MA/cm^2. The steps taken to ensure an accurate estimate of the metallization stress conditions of temperature current density to obtain this value are described in detail.
[Contact: (301) 921-3801]

Process and Device Modeling

Bennett, H.S., **Band Structure and Density of States Changes for Doped Gallium Arsenide,** paper in NBS Special Publication 697, OM85, Basic Properties of Optical Materials, Summaries of Papers [given at the Topical Conference, Gaithersburg, MD, May 7-9, 1985], pp. 194-197 (April 1985).

Optical absorption measurements on doped GaAs are interpreted in terms of distorted band structures. Such data provide values for the many-body interactions which are essential in calculations on the operation of lasers and opto-electronic devices.
[Contact: (301) 921-3621]

Wilson, C.L., and Blue, J.L., **Semiconductor Measurement Technology: MOS1: A Program for Two-Dimensional Analysis of Si MOSFETs,** NBS Special Publication 400-77 (April 1985).

The MOS1 program is a portable FORTRAN 77 program suitable for analysis of currents and fields in VLSI devices. The program solves three coupled nonlinear elliptic partial differential semiconductor device equations in two dimensions. Historically, these equations have been solved using a special-purpose program and batch runs on a large, fast computer. We use a general-purpose program which runs on a large minicomputer or scientific workstation. This report discusses the physical formulation of the semiconductor equations and the methods used to select the solution strategy.
[Contact: (301) 921-3621]

Radiation Effects

Galloway, K.F., Wilson, C.L., and Witte, L.C., **MOSFET Electrical Parameter Extraction from Charge-Sheet Model Fitting,** Proceedings of the Sixth Biennial University/Government/Industry Microelectronics Symposium, Auburn, AL, June 11-13, 1985, pp. 77-81.

A method for extracting the flatband voltage and the channel mobility from the current-voltage (I-V) characteristics of long-channel MOSFETs is described. The one-dimensional charge-sheet model developed by Brews provides the basis for the I-V characteristics. The I-V characteristics given by this model are optimized with respect to a set of experimental data with the flatband voltage and the mobility the only free parameters. A computer program, CSFIT, has been developed for this purpose. The choice of parameters is usually appropriate for a device subjected to a stress condition (e.g., hot-carrier injection or ionizing radiation). To illustrate the application of this method and CSFIT, the flatband voltage and mobility for an n-channel enhancement-

Radiation Effects, cont'd.

mode device subjected to ionizing radiation are determined from the I-V curves and the changes of these parameters with radiation dose are tracked.
[Contact: (301) 921-3541]

FAST SIGNAL ACQUISITION, PROCESSING, AND TRANSMISSION

Cryoelectronic Metrology

Zimmerman, J.E., **Design of Cryocoolers for Microwatt Superconducting Devices,** Proceedings of the Third Cryocooler Conference, Boulder, CO, September 17-18, 1984, pp. 2-9, NBS Special Publication 698 (May 1985).

The primary applications of the cryocoolers considered here are for cooling various Josephson devices such as SQUID magnetometers and amplifiers, voltage standards, and microwave mixers and detectors. The common feature of these devices is their extremely low inherent bias power requirement, of the order of 10^{-7} W (or sometimes much less) per junction. This provides the possibility, not yet fully exploited, of designing compact, low-power cryocoolers for these applications, the design criteria being totally different from those of any cryocoolers presently available. Several concepts have been explored and a number of laboratory model cryocoolers have been built. These include low-power non-magnetic regenerative machines of the Stirling or Gifford-McMahon type, three- or four-stage Joule-Thomson machines, liquid-helium dewars with integral small cryocoolers to reduce the evaporation rate, and liquid-helium dewars with integral continuously or intermittently operated small helium liquefiers to permit operation of cryogenic devices for indefinite time periods.
[Contact: Richard L. Harris, (303) 497-3901]

Antenna Metrology

Kanda, M., **Transients in a Resistively Loaded Loop Antenna,** Proceedings of the 1984 International Symposium on Electromagnetic Compatability [IEEE EMC Society], Tokyo, Japan, October 16-18, 1984, pp. 286-290.

Transient characteristics of a loop antenna loaded uniformly with a resistive material are analyzed. The current distribution of the antenna is obtained by the use of the Fourier series expansion technique. It is found that the distortion of the transient waveforms due to a resonance of a loop antenna can be reduced and the received transient waveforms can be tailored by resistive loading.
[Contact: (303) 497-5320]

Other Fast Signal Topics

Capobianco, T.E., and Fickett, F.R., **Precision Measurement of Eddy Current Coil Parameters,** Proc. Review of Progress in Quantitative NDE [paper given at Conference, University of California, San Diego, July 9-13, 1984] (Plenum Press, New York, 1985), pp. 491-498.

Precision measurements of impedance, phase angle, and dissipation factor of both commercial eddy current coils and specially prepared test coils by various techniques are described. Special emphasis is placed on use of the digital storage oscilloscope and commercial impedance (LCZ) meter. Detection of the effect on the coil parameters of shorted turns, deformation, and ferrite defects is described.
[Contact: (303) 497-3641]

Leedy, T.F., **An Approach to ATE Calibration Via Performance Verification at the System Interface,** Proceedings of the 1985 Measurement Science Conference, Sunnyvale, CA, January 17-18, 1985, pp. 198-201.

A method of verifying the performance of automatic test equipment (ATE) in its

Other Fast Signal Topics, cont'd.

normal operating environment and configuration is presented as the best approach to achieving an overall system calibration. The method consists of the transport of well-characterized signal sources to the ATE station and the application of these electrical stimuli directly to a well-defined electrical interface on the test station. Data are presented on typical accuracies that have been obtained on limited parameters and ranges during the testing process, using calibrated commercial equipment.
[Contact: (301) 921-2727]

Sorrells, J.R., Palla, J.C., Meiselman, B., and Oravec, B.A., **Electrical and Electronic Metrology: A Bibliography of NBS Electrosystems Division's Publications**, NBS List of Publications 94 (March 1985).

This bibliography lists the publications of the Electrosystems Division, Center for Electronics and Electrical Engineering, NBS, and of its predecessor sections for the period January 1968 to March 1984. A brief description of the Division's technical program is given in the introduction.
[Contact: (301) 921-2727]

ELECTRICAL SYSTEMS

Power Systems Metrology

Hebner, R.E., Kelley, E.F., Forster, E.O., and FitzPatrick, G.J., **Observation of Prebreakdown and Breakdown Phenomena in Liquid Hydrocarbons II. Non-Uniform Field Conditions**, IEEE Transactions on Electrical Insulation, Vol. EI-20, No. 2, pp. 281-292 (April 1985).

The prebreakdown and breakdown processes have been recorded in n-hexane toluene and Marcol 70, both in a pure state and with selected impurities. The study was carried out using a point-plane geometry. A low ionization potential additive had only a small effect on the breakdown voltage or the streamer propagation speed but did significantly alter the shape of the prebreakdown streamer when the needle was positive, i.e., an anode. For a negative needle (cathode), chemical impurities affected the breakdown voltage. The significance of these findings is discussed in detail.
[Contact: (301) 921-3121]

Van Brunt, R.J., **Production Rates for Oxyfluorides SOF_2, SO_2F_2, and SOF_4 in SF_6 Corona Discharges**, NBS Journal of Research, Vol. 90, No. 3, pp. 229-253 (May-June 1985).

The most abundant, long-lived stable gaseous species generated by corona discharges in SF_6 gas containing trace levels of O_2 and H_2O are the oxyfluorides SOF_2, SO_2F_2, and SOF_4. Absolute energy and charge rates-of-production of these and the minor products SO_2, OCS, and CO_2 have been measured at different total gas pressures from 100 kPa to 300 kPa and for discharges of different current, power, and polarity. Oxyfluoride yields for SF_6/O_2 mixtures containing up to 10% O_2 have also been measured. The results indicate that oxyfluoride production is not controlled by the concentrations of either O_2 or H_2O at levels below about 1%, and the rate controlling factor is the dissociation rate of SF_6 in the discharge. The discharge current and time dependence of the production rates are discussed in terms of gas-phase mechanisms that have been proposed to explain previous observations of electrical, thermal, and laser-induced decomposition of SF_6 and SF_6/O_2 mixtures. Upper limits on the total SF_6 decomposition rate in low-current discharges have been estimated. Details of the chemical analysis procedures are given, and application of the results to the design of chemical diagnostics for SF_6-insulated, high-voltage apparatus is discussed.
[Contact: (301) 921-3121]

Superconductors

Fickett, F.R., **Standards for Measure-**

Superconductors, cont'd.

ment of the Critical Fields of Superconductors, NBS Journal of Research, Vol. 90, No. 2, pp. 95-113 (March-April 1985).

The origins, definitions, and measurement of the various critical magnetic fields associated with superconductors are reviewed. The potential need for an ASTM-type standard for the measurement of these fields is discussed. Measurement techniques as practiced both in industry and in the national laboratories are reviewed. Extrapolation techniques commonly used to determine the upper critical fields of the newer materials are evaluated as to their suitability for various applications. Sources of error in the experimental determination of critical fields are assessed for the various common techniques. A comprehensive bibliography of the modern literature on critical field measurement and interpretation is included.
[Contact: (303) 497-3785]

Goldfarb, R.B., and Clark, A.F., **Hysteretic Losses in Nb-Ti Superconductors,** J. Appl. Phys., Vol. 57, No. 1, pp. 3809-3811 (15 April 1985).

When subjected to transient magnetic fields, superconductors exhibit losses. At low frequencies, most of the dissipation is hysteretic. Magnetization was measured in an axial field for eight multifilamentary Nb-Ti superconducting wires with different filament sizes and different ratios of copper to superconductor. The full-penetration field H_p was estimated from the high-field ends of the hysteresis loops. The estimate of H_p provides a method to assess the critical current density J_c. There was good agreement between measured losses and those predicted from H_p and the peak applied field.
[Contact: (303) 497-3650]

Goldfarb, R.B., and Clark, A.F., **Magnetic Hysteresis and Complex Susceptibility as Measures of AC Losses in a Multifilamentary NbTi Superconductor,** IEEE Transactions on Magnetics, Vol. MAG-21, No. 2, pp. 332-335 (March 1985).

Magnetization and ac susceptibility of a standard NbTi superconductor were measured as a function of longitudinal dc magnetic field. The ac-field-amplitude and frequency dependences of the complex susceptibility are examined. The magnetization is related to the susceptibility by means of a theoretical derivation based on the field dependence of the critical current density. Hysteresis losses, both obtained directly from dc hysteresis loops and derived theoretically from ac susceptibility and critical current density, were in reasonable agreement.
[Contact: (303) 497-3650]

Magnetic Materials and Measurements

Fickett, F.R., and Capobianco, T.E., **Magnetic Field Mapping with a SQUID Device,** Proc. Review of Progress in Quantitative NDE, Vol. 4A (Plenum Press, New York, 1985), pp. 401-410. [paper given at Conference, University of California, San Diego, July 9-13, 1984]

Results of tests applying a SQUID (superconducting quantum interference device) system to measurement of the magnetic near field of commercial eddy current coils are reported. The SQUID system offers some significant advantages over more conventional techniques in that very small coils can be used and the calibration of the system is tied to the quantum of flux.
[Contact: (303) 497-3785]

Goldfarb, R.B., Rao, K.V., and Chen, H.S., **Differences Between Spin Glasses and Ferroglasses: Pd-Fe-Si,** Solid State Communications, Vol. 54, No. 9, pp. 799-801 (1985).

Near the multicritical point in the magnetic phase diagram, some alloys that

Magnetic Materials & Meas., cont'd.

appear to be simple spin glasses actually have an intermediate ferro-magnetic-like state between the high-temperature paramagnetic and low-temperature spin-glass states. The temperature dependences of the imaginary component of ac susceptibility and dc magnetization are presented to illustrate the subtle experimental differences between spin glasses and these ferroglasses.
[Contact: (303) 497-3650]

Other Electrical Systems Topics

Recently Published

Sorrells, J.R., Palla, J.C., Meiselman, B., and Oravec, B.A., **Electrical and Electronic Metrology: A Bibliography of NBS Electrosystems Division's Publications**, NBS List of Publications 94 (March 1985).

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[Contact: (301) 921-2727]

1986 CEEE CALENDAR

January 27-31 (San Jose, CA)

The Fourth International Symposium on Semiconductor Processing. This Symposium is presented by American Society for Testing and Materials Committee F-1 on Electronics, the National Bureau of Standards, the Semiconductor Equipment and Materials Institute, Stanford University Center for Integrated Systems, and the Components, Hybrids, and Manufacturing Technology Society of the American Institute of Electrical and Electronics Engineers. Technical areas to be covered include crystal growth and material preparation technology, fabrication processes, lithography and patterning, interconnects and silicides, material and process characterization, measurement and control of contaminants introduced during fabrication and particulates, equipment technology and automation, and manufacturing control systems to achieve improved product quality. Special in-depth sessions are also planned on the state of the art in dopant profiling techniques.
[Contact: Dinesh C. Gupta (Siliconix) (408) 988-8000]

February 17-18, 1986

IEEE VLSI Workshop on Test Structures. The IEEE Electron Devices Society is sponsoring a Workshop intended to bring together the designers and users of test chips to discuss new developments in microelectronic test chip/test structure research, implementation, and application. The Workshop will present papers covering such topics as: material and process characterization and diagnostics; device and circuit characterization; yield and reliability assessment; test structure utilization, data analysis, and data management; and advances in test equipment. Workshop proceedings will be published.
[Contact: Loren W. Linholm, (301) 921-3801]

March 5-7 (Gaithersburg, MD)

Workshop on Measurement of Electrical Quantities in Pulse Power Systems - 11. This Workshop is intended to disseminate information on modern measurement techniques, define the state of the art of measurement of electrical quantities in pulse power systems, and identify areas in which improvements in measurements are required. Papers are planned for the following three areas: (1) voltage, current, power, and energy measurements, including conventional and electro-optical techniques, beam and radiation methods, software corrections and modeling; (2) data acquisition and process-

1986 CEEE Calendar, cont'd.

ing, including signal transmission, electro-optical links, electromagnetic interference and noise suppression, data recording, and diagnostics for large systems; and (3) calibration methods for laboratory and machine use. The Workshop proceedings will be published. [Contact: John R. Sorrells, (301) 921-2727 or Ronald H. McKnight, (301) 921-3121]

April 22-23 (Gaithersburg, MD)

Workshop on Test Procedures for Precision Instrumentation and ATE Systems. This Workshop is intended to provide a forum for the exchange of information among researchers, users, manufacturers, testing companies, and calibration laboratories on the procedures used in testing the performance of precision instrumentation and automatic test equipment systems. Technical topics planned include first-article and acceptance testing, bid-sample testing, maintenance and calibration testing, developing and writing specifications and procedures, "minimum-use" specifications, test accuracy ratios, economic tradeoffs of testing, case histories of specific test programs, optimum calibration strategies, and recommended practices. The Workshop proceedings will be published by the Institute of Electrical and Electronics Engineers.
[Contact: John R. Sorrells, (301) 921-2727]

June 23-27 (Gaithersburg, MD)

1986 CPEM (Conference on Precision Electromagnetic Measurements). CPEM 86 is being sponsored by the U.S. National Bureau of Standards, the IEEE Instrumentation and Measurement Society, and the Union Radio Scientifique Internationale. The Conference will present papers covering the theory, design, performance, simulation, and application of electromagnetic standards, measurements, techniques, instruments, and systems. Sessions are tentatively planned to cover the following technical areas: electromagnetic-related fundamental constants and standards; direct current, low frequency, and radiofrequency; time, time interval, and frequency; antennas and fields; microwaves and millimeter waves; infrared, visible, and ultraviolet radiation; lasers; electro-optics and fiber optics; cryoelectronics; automated measurements; and technical calibration services. The Conference language will be English. [Contact: Sara Torrence, (301) 921-2721. (For technical information, contact John R. Sorrells, (301) 921-2727 or Norman B. Belecki, (301) 921-2715.)]

RECENTLY ISSUED 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 cali-

Recently Issued SRMs, cont'd.

brating apparatus used to measure key parameters of superconductor products and thus should be useful to buyers and sellers of superconductors, users of superconducting equipment, and researchers in superconducting technology.

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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 fifth 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 Center for Electronics and Electrical Engineering Technical Publication Announcements covers the second 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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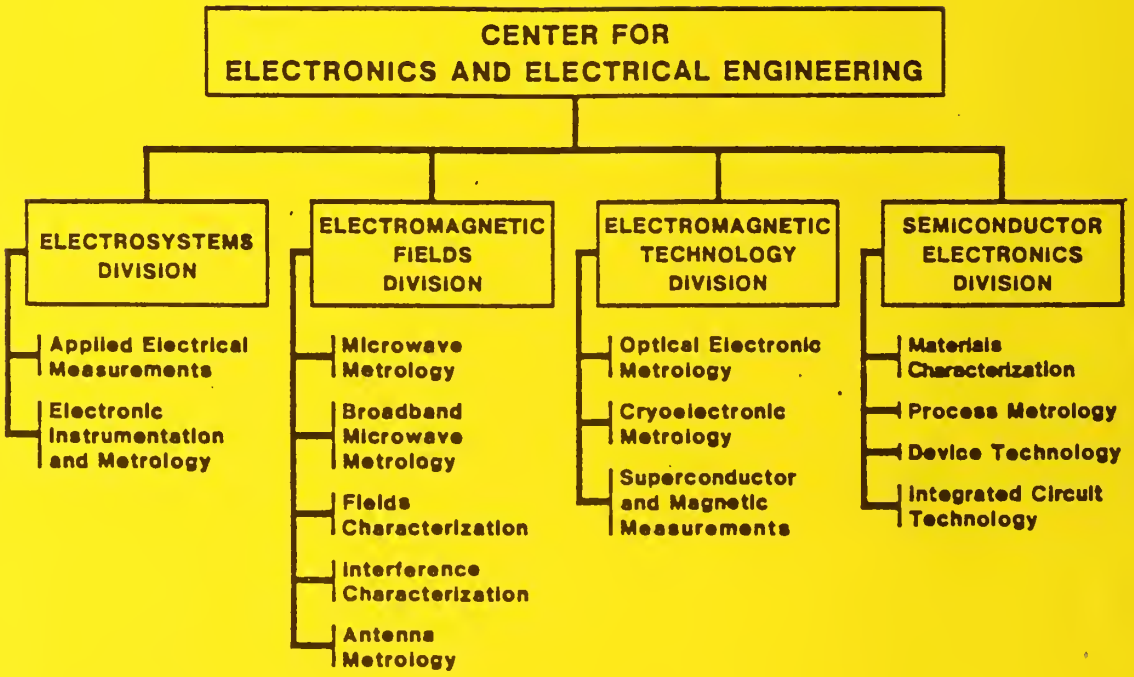

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