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Center for Electronics and Electrical Engineering

Technical Publication Announcements

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National Engineering Laboratory
Gaithersburg, Maryland 20899

INTRODUCTION TO THE CEEE TECHNICAL PUBLICATION ANNOUNCEMENTS

This is the tenth 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 third quarter of calendar year 1986.

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 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 Center conferences and workshops planned for calendar year 1987, some preliminary events for 1988, 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 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. See the table of contents on the opposite page for identification of the topics covered by each program, as represented in this issue. 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 15.

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. The current set is identified in the Additional Information section, page 11.

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SEMICONDUCTOR TECHNOLOGY

Analysis Techniques

Bullis, W.M., Watanabe, M., Baghdadi, A., Yue-zhen, L., Scace, R.I., Series, R.W., and Stallhofer, P., **Calibration of Infrared Absorption Measurements of Interstitial Oxygen Concentration in Silicon**, Proceedings of the Silicon Symposium, Boston, Massachusetts, May 4-9, 1986, p. 196.

Many calibration factors for infrared absorption measurements of oxygen in silicon have been reported in the literature and adopted as standard during the past three decades. Reasons for this variability are examined and a new international experiment to establish a universally acceptable value and the reliability to which it can be found are described.
[Contact: Aslan Baghdadi, (301) 975-2062]

Wachnik, R.A., **The Use of Charge Pumping to Characterize Generation by Interface Traps**, IEEE Transactions on Electron Devices, Vol. ED-33, No. 7, pp. 1054-1061 (July 1986).

A small rectangular pulse technique for measuring the charge pumping current has been proposed as a method to characterize interface traps near mid-gap. It is shown theoretically and experimentally that the small rectangular pulse technique can be used to predict the surface generation current measured on a metal oxide-semiconductor field-effect transistor or a gated diode. This new technique has the advantage that the measured current is at least 10 to 100 times larger than the surface generation current.
[Contact: Gary P. Carver, (301) 975-2091]

Dimensional Metrology

Postek, M.T., **Electron Detection Modes and Their Relation to Linewidth Measurement in the Scanning Electron Microscope**, Proceedings of the 44th Annual Meeting of the Electron Microscopy Society of America, Albuquerque, New Mexico, August 10-15, 1986, pp. 646-649.

The basic premise underlying the use of the scanning electron microscope for linewidth measurement for semiconductor research and production applications is that the video image acquired, displayed, and ultimately measured reflects accurately the structure of interest. This paper demonstrates that depending upon the mode of electron detection (secondary, backscattered, or converted backscattered secondary electrons) and accelerating voltage used to image and measure the structure of interest, a variety of results can be obtained. The reasons for these differences are discussed relative to the coupling of this type of work with electron beam/sample interaction modeling to enable the acquisition of more precise linewidth measurements.
[Contact: Michael T. Postek, (301) 975-2299]

Integrated Circuit Test Structures

Cresswell, M.W., Pessall, N., Linholm, L.W., and Radack, D.J., **The Use of Artificial Intelligence and Microelectronic Test Structures for Evaluation and Yield Enhancement of Microelectronic Interconnect Systems**, Proceedings of the Third International IEEE Conference on VLSI Multilevel Interconnection, Santa Clara, California, June 9-11, 1986, pp. 331-340.

A major factor limiting the production and performance of high-density VLSI integrated circuits is the fabrication of reliable interconnect systems. Properly designed microelectronic test structures and appropriate test methods can be used to characterize the processes used to fabricate these systems. However, the computer-controlled testing of comprehensive process evaluation and

IC Test Structures (cont'd.)

of comprehensive process evaluation and diagnosis structures often results in large quantities of data which cannot be readily or effectively interpreted by the user. As a result, important features of the data are often overlooked or not considered in the evaluation of the fabrication processes. This paper describes an expert system for assisting the user to interpret test results associated with fabricating selected aspects of VLSI interconnect systems.
[Contact: Loren W. Linholm, (301) 975-2052]

Device Physics and Modeling

Bennett, H.S., **Band Structure and Density of States Changes in Heavily Doped Silicon**, Journal of Applied Physics, Vol. 59, No. 8, pp. 2837-2844 (April 15, 1986).

The Klauder self-energy method is applied to calculating the effects of one-body interactions among the dopant ions and the carriers in heavily doped silicon at 300 K. Many-body interactions of exchange energy for majority carriers and of correlation energy for minority carriers are estimated by interpretation of optical absorption measurements and by calculations based on degenerate theory. When densities exceed 5×10^{19} cm^{-3}, one-body and many-body terms become of the same order of magnitude and should be included in calculations of band-structure changes and of properties such as carrier transport which depend on the density of states.
[Contact: Herbert S. Bennett, (301) 975-2079]

Bennett, H.S., **Device Physics for Modeling GaAs Bipolar Transistors**, Proceedings of the Semiconductor Research Corporation Conference on Bipolar Technology, Tempe, Arizona, April 24-25, 1986, S. A. Abbas, Ed., Paper II.17.

The accuracy and reliability of predictions from numerical simulations of advanced bipolar transistors depend on model input parameters. These parameters include the variations with doping and carrier concentrations in both n-type and p-type material of 1) the valence and conduction band edges, 2) the effective intrinsic carrier concentrations, 3) the minority carrier mobilities, and 4) the minority carrier lifetimes. This paper contains a summary of recent advances in device physics for modeling silicon bipolar transistors with submicrometer dimensions and high concentrations of dopant ions and carriers. It also contains preliminary results in device physics for modeling those regions of GaAs bipolar transistors which have high concentrations of either dopant ions or carriers. The latter results are based on lessons learned from modeling advanced silicon bipolar devices.
[Contact: Herbert S. Bennett, (301) 975-2079]

Bennett, H.S., Gaitan, M., Roitman, P., Russell, T.J., and Suehle, J.S., **Modeling MOS Capacitors to Extract Si-SiO_2 Interface Trap Densities in the Presence of Arbitrary Silicon Doping Profiles**, IEEE Transactions on Electron Devices, Vol. ED-33, No. 6, pp. 759-765 (June 1986).

The MOS capacitor model in SEDAN has been modified to include the effects of an energy-dependent Si-SiO_2 interface trap density and arbitrary silicon substrate doping profiles. These modifications have been used to calculate the quasi-static C-V characteristics of MOS capacitors and to compare them with those measured by the Kuhn technique for as-received and for gamma-irradiated p-well and n-type silicon MOS capacitors. The average substrate doping is obtained from high-frequency C-V curves. For the n-type substrate, the dopant redistribution was estimated with SUPREM II. Experimental and theoretical C-V curves were made to agree by varying the voltage offset due to fixed oxide charge and both the magnitude and the energy

Device Physics & Modeling (cont'd.)

distribution of interface trapped charge. The distributions of interface traps which gave the best fits between experiment and theory have peaks near mid gap for the p-well and n-type silicon MOS capacitors.
[Contact: Herbert S. Bennett, (301) 975-2079]

Berning, D.W., and Blackburn, D.L., **Power MOSFET Failure During Turn-Off: The Effect of Forward Biasing the Drain-Source Diode**, Conference Proceedings of the 1986 IEEE Industrial Applications Society Annual Meeting, Denver, Colorado, September 25-October 3, 1986, pp. 335-339.

The effects on the turn-off failure of power metal oxide-semiconductor field-effect transistors (MOSFETs) which result from forward biasing the intrinsic drain-source diode immediately prior to turn-off are discussed. A nondestructive test circuit is used to measure the turn-off characteristics of individual devices under a variety of conditions. It is shown that the drain voltage at which the device fails decreases as either the diode forward current or the reverse recovery current is increased. If the diode is forward biased, the voltage at failure can be less than one-half of the voltage at which the device fails if the diode has not been forward biased (and often less than one-half the manufacturer-rated voltage capability for the device). Also, if turn-off of the MOSFET is attempted with the diode conducting, the device loses its fast turn-off capability due to charge storage effects. A parallel resonant power converter circuit is employed to demonstrate how the intrinsic drain-source diode may and may not be used safely in practical applications.
[Contact: David W. Berning, (301) 975-2069]

Insulators and Interfaces

Candela, G.A., Chandler-Horowitz, D., Novotny, D.B., Vorburger, T., and Giauque, G.H., **Film Thickness and Refractive Index Standard Reference Material Calibrated by Ellipsometry and Profilometry**, Proc. SPIE - The International Society for Optical Engineering, Vol. 661, pp. 402-407, SPIE, P.O. Box 20, Bellingham, WA 98227 (1986) [conference Quebec, Canada, June 2-6, 1986].

A Standard Reference Material (SRM) has been designed and fabricated, and will be calibrated for thickness and refractive index using a highly accurate ellipsometer. The SRM consists of a three-inch diameter silicon wafer with a silicon dioxide film of uniform thickness. The design and preparation of the SRM is discussed and the ellipsometric measurement results and their comparisons with stylus profilometry are presented, along with an analysis of the precision of the measurements. The ellipsometric accuracy depends upon the wafer oxide film, the model that represents the film-interface-substrate system, and the methods used to make the measurements. Use of both correct sample preparation and correct model is important in order to obtain high accuracy for comparisons of optical thickness as determined by the ellipsometer and mechanical thickness as determined by the stylus profilometer. This SRM will be available initially in three nominal oxide film thicknesses of 50, 100, and 200 nm. The SRM can be used to calibrate many different optical and mechanical thickness monitoring instruments as well as the ellipsometer for which it was specifically designed.
[Contact: George A. Candela, (301) 975-2086]

Mazer, J.A., and Ehrstein, J.R., **Effect of Sintering on the Sheet Resistance Directly Under an Aluminum/Silicon Ohmic Contact**, Extended Abstracts of the Electrochemical Society 169th Meeting, Boston, Massachusetts, May 4-9, 1986, pp. 396-397.

Van der Pauw-type measurements with a

Insulators & Interfaces (cont'd.)

specially designed test structure and spreading resistance measurements indicate that the sheet resistance directly under a sintered 1% Si-Al/Si ohmic contact is lower than the sheet resistance of the diffused layer away from the contact. These results agree with transmission-line calculations made with measurements from six-terminal Kelvin test structures, and allow an improved calculation of the circuit-loading (or front-contact) resistance.
[Contact: James R. Ehrstein, (301) 975-2060]

Mountain, D.J., Russell, T.J., and Galloway, K.F., **Effect of Post-Oxidation Anneal on Electrical Characterization of Thin Oxides**, Extended Abstracts of the Electrochemical Society 169th Meeting, Boston, Massachusetts, May 4-9, 1986, pp. 382-383.

The effect of pre- and post-oxidation treatments on thin oxide electrical characteristics was examined. Pre-oxidation clean and post-oxidation anneal (POA) times and ambients were varied. Three POA times and two gases (argon and nitrogen) were compared. Flatband voltages, oxide breakdown fields, and interface trap densities were measured for thin (20-nm) oxides. Interface trap densities were measured using the charge-pumping technique. Data indicate an optimum process can be designed. A sacrificial oxidation cleaning sequence and a long (120-min) POA in nitrogen gave the oxide with the best electrical characteristics.
[Contact: Thomas J. Russell, (301) 975-2073]

Other Semiconductor Topics

Dodge, M., **Refractive Index**, CRC Handbook of Laser Science and Technology, Vol. IV, Optical Materials: Part 2, M. J. Weber, Ed. (CRC Press, Boca Raton, Florida, 1986), pp. 21-47.

This section defines refractive index, gives the general form of the Cauchy, Sellmeier, and Hertzberger dispersion equations, and discusses the environmental factors that must be considered in the determination and use of refractive index values for a particular material. Tables are included that give the refractive index and the temperature coefficient of refractive index for crystals that are of particular interest for the fabrication of optical components to be used in laser systems.

Dispersion equations and equation parameters are also given for some of the materials.
[Contact: Marilyn Dodge, (301) 975-2386]

Ma, Y., Stern, E.A., and Bouldin, C.E., **The Structural Unit in Icosahedral MnAlSi and MnAl**, Physics Review Letters, Vol. 57, No. 13, pp. 1611-1614 (Sept. 29, 1986).

Extended x-ray-absorption fine-structure measurements were made on icosahedral MnAl and MnSiAl, and on the periodic standards α-phase of MnSiAl and orthorhombic phase of $MnAl_6$. Experimental evidence is presented that a cage of Mn atoms at the vertices of an icosahedron is the structural unit in the icosahedral MnSiAl and MnAl phases. The connections among these icosahedral units and between them and the Al atoms are different in the icosahedral phases and in the α-phase. As in the α-phase, the Mn icosahedra do not share vertices in the icosahedral phases; i.e., they are separated from one another. It is suggested that the i-phase grows by randomly nucleating together Mn icosahedra along their 20 threefold directions, as allowed by local steric constraints.
[Contact: Charles E. Bouldin, (301) 975-2046]

FAST SIGNAL ACQUISITION, PROCESSING, & TRANSMISSION

Cryoelectronic Metrology

Hamilton, C.A., Kautz, R.L., and Lloyd,

Cryoelectronic Metrology (cont'd.)

F.L., **The NBS Josephson Array voltage Standard**, CPEM 86 Digest, 1986 Conference on Precision Electromagnetic Measurements, Gaithersburg, Maryland, June 23-27, 1986, pp. 108-109.

It has been realized for many years that the accuracy of Josephson voltage standards can be substantially improved by using many junctions in series to generate a large voltage. A simple series extension of the single junction standard requires individual control of the bias current, for example, for each junction of 100 mV using 20 junctions. In 1977 Levinsen et al. suggested a method to avoid the multiple bias problem by using constant-voltage steps which cross the zero-current axis of the plot of junction current as a function of voltage (I-V curve). This allows a large array of junctions to share a common current bias at or near zero. With an array of 1000 or more junctions, a quantized voltage of 1 V is possible. After nearly ten years of effort, the problems of fabrication, stability, and radio-frequency energy distribution are largely solved and Josephson standards at the 1-V level are a reality. This paper reviews the design and operation of series array voltage standards and describes the efforts at NBS to engineer a versatile, reliable, and easily used voltage standard system.
[Contact: Clark A. Hamilton, (303) 497-3740]

Noise Metrology

Daywitt, W.C., **10-60 GHz G/T, Measurements Using the Sun as a Source -- A Preliminary Study,** NBSIR 86-3046 (April 1986).

Preliminary studies show that it may be possible 1) to determine the solar flux density incident on the earth's atmosphere using a simple algorithm with an uncertainty less than 8 percent, 2) to overcome a deteriorating accuracy in atmospheric loss calculations by using a "tipping curve" measurement, and 3) to reduce starshape correction factor uncertainty by using an equivalent solar diameter.
[Contact: William C. Daywitt, (303) 497-3720]

Optical Fiber Metrology

Day, G.W., and Etzel, S.M., **Annealing of Bend-Induced Birefringence in Fiber Current Sensors**, Technical Digest of the 5th International Conference on Integrated Optics and Optical Fiber Communication, Venice, Italy, October 1-4, 1985, pp. 871-874.

The bend-induced linear birefringence in coils of single-mode optical fiber has been greatly reduced by annealing. This should allow the construction of electric current sensors that are much more compact and potentially more sensitive than previously possible.
[Contact: Gordon W. Day, (303) 497-5204]

Yang, S., and Gallawa, R.L., **A Comparison of Three Bandwidth Measurement Techniques for Multimode Optical Fibers**, IEEE Transactions on Instrumentation and Measurement, Vol. IM-35, No. 2, pp. 187-194 (June 1986).

This paper presents the results of an experiment to compare three distinct methods of measuring the bandwidth of a telecommunication-grade, multimode optical fiber. The three methods are: 1) the time-domain method, 2) the frequency-domain method, and 3) the pulse spectrum analysis method. We find good agreement between the frequency- domain method and the pulse spectrum analysis method, but the time-domain method yields results that are lower than the other two for the cases we considered.
[Contact: Robert L. Gallawa, (303) 497-3761]

Electro-Optic Metrology

Young, M., **Low-Cost LCD Video Display for Optical Processing**, Applied Op-

Electro-Optic Metrology (cont'd.)

tics, Vol. 25, No. 7, pp. 1024-1026 (April 1, 1986).

In this paper, I show that a liquid gate and low-pass filter are needed to use a new LCD video monitor effectively in a coherent-processing system, and I demonstrate the results of some simple spatial-filtering experiments.
[Contact: Matt Young, (303) 497-3223, -5342]

Other Fast Signal Topics

Cromar, M.W., Clark, A.F., and Fickett, F.R., **Flux Limit of Cosmic-Ray Magnetic Monopoles From a Multiply Discriminating Superconductive Detector**, Physical Review Letters, Vol. 56, No. 24, pp. 2561-2563 (June 16, 1986).

A multiply discriminating, three-loop superconducting monopole detector was operated for one year. During this period, 8523 hours of data were accumulated. The sensing area averaged over solid angle for trajectories passing through a loop was 178 cm^2. Including double coincidence events from trajectories passing through the shield but not through a loop, the total sensing area averaged over solid angle was 1195 cm^2. No candidate monopole events were observed, leading to an upper limit on the flux of cosmic ray magnetic monopoles of 5.0×10^{-12} cm^{-2} sr^{-1} s^{-1} with a 90% confidence level.
[Contact: Michael W. Cromar, (303) 497-5375]

Duffield, C.L., Moreland, J., and Fickett, F.R., **Problems with Cryogenic Operation of Piezoelectric Bending Elements**, Review of Scientific Instruments, Vol. 57, pp. 990-992 (May 1986).

Piezoelectric bimorphs constructed from lead titanate-zirconate (PZT) ceramic bonded to a brass sheet have been tested at cryogenic temperatures to determine their suitability for use in a low-temperature micropositioner. Experimental data are presented on bimorph sensitivity (displacement per volt) as a function of the number of temperature cycles. Results indicate that bimorphs of this type cannot be calibrated because of irreversible changes in the bending characteristics that occur while cycling from room temperature to 4 K.
[Contact: John Moreland, (303) 497-3641]

Young, M., **Scratch-and-Dig Standard Revisited**, Applied Optics, Vol. 25, No. 12, pp. 1922-1928 (June 15, 1986).

The scratch standard (MIL-O-13830A) is a cosmetic standard that is effected by a visual comparison with a set of secondary standards that are in turn evaluated by comparison with a set of master standards. Both manufacture and certification of the secondary standards are somewhat unreliable. This paper shows that they can be classified according to the relative power scattered at a relatively small angle and describes experiments with etched gratings that have the appearance of scratches but diffract light into a broad peak between 5 and 10 degrees off the axis of the incident beam. Some prototypes have been classified both by comparison with the master standards and by a photoelectric measurement; agreement between the two methods is good. Such gratings, used as the secondary standards, should display less intersample variation than scribed or other artifacts. The paper concludes by presenting evidence that the original primary standards have been stable over a long time.
[Contact: Matt Young, (303) 497-3223, -5342]

ELECTRICAL SYSTEMS

Power Systems Metrology

McKnight, R.H., **Discussion of Paper 85 WM 115-1, "A Fast Response Impulse Voltage Measuring System for Testing of Gas Insulated Substations Equipment,"**

Power Systems Metrology (cont'd.)

IEEE Transactions on Power Delivery, PWRD-1, No. 3, p. 47 (July 1986).

This is a discussion of a technical paper presented at the winter meeting of the Power Engineering Society, IEEE. It questions some of the author's assumptions and references further applications of the measurement method described.
[Contact: Ronald H. McKnight, (301) 975-2431]

Pulse Power Metrology

McKnight, R.H., Fenimore, C., and Lagnese, J., **The Use of Deconvolution Methods in Characterizing Electrical Sensors,** Proceedings of the Fifth IEEE Pulsed Power Conference, Crystal City, Virginia, June 10-12, 1985 (published by Institute of Electrical and Electronic Engineers, Inc., 345 East 47th Street, New York, NY 10017, May 1986), pp. 176-178.

Deconvolution methods have been applied to measurements made with different electrical sensors including resistive and capacitive dividers. Deconvolved and directly measured waveforms have been compared with good results.
[Contact: Ronald H. McKnight, (301) 975-3431]

Superconductors

Dube, W.P., and Goodrich, L.F., **Quench Detector Circuit for Superconductor Testing,** Review of Scientific Instruments, Vol. 57, No. 4, pp. 680-682 (April 1986).

A quench detector is a device that interrupts the flow of current through a superconductor in the event the superconductor reverts to the normal, resistive state. This new design has adjustable filtering and sensitivity. The input is well isolated from the output, eliminating any possible ground loop through the detector. It also has excellent noise immunity.
[Contact: Loren F. Goodrich, (303) 497-3143]

Fickett, F.R., **Research on Practical Superconductors at NBS,** ATB Metallurgie, Vol. 25, No. 4 (Proceedings of the Benelux Metallurgy Conference on Superconductors, Brussels, Belgium, May 8-9, 1985), pp. 265-271.

The National Bureau of Standards is engaged in a number of research programs which have as their goals the evaluation of various properties of practical superconductors related to their application in large-magnetic systems. The ability to have standard data, standard tests, and standard materials for evaluating the primary properties of superconductors and related measurement systems is essential if international commerce in these complicated conductors is to develop and grow. The NBS work has concentrated on measurement of critical current, critical field, ac losses, and properties of the copper normally used as a stabilizing material. Many parameters must be considered in these investigations. An overview of these research efforts and a selection of recent results are presented. Particular emphasis is given to work performed in cooperation with the International Copper Research Association (INCRA) on properties of oxygen-free copper.
[Contact: Frederick R. Fickett, (303) 497-3785]

Moreland, J., Ekin, J.W., and Goodrich, L.F., **Electron Tunneling into Superconducting Filaments: Depth Profiling the Energy Gap of NbTi Filaments in High-Field Magnet Wires,** Advances in Cryogenic Engineering Materials, Vol. 32, R. P. Reed and A. F. Clark, Eds. (Plenum Publishing Corporation, New York, NY, 1986), pp. 1101-1108.

Squeezable electron tunneling (SET) junctions consisting of superconducting NbTi filaments (extracted from magnet wires) and sputtered Nb thin-film counter electrodes were used to determine

Superconductors (cont'd.)

the energy gap at the surface of the filaments. The current versus voltage curves of junctions immersed in liquid helium at 4 K were measured for a series of filaments taken from the same wire. Each filament had been etched to remove a surface layer of varying thickness so that the energy gap could be determined as a function of depth into the surface of an average filament. It was found that some manufacturing processes yield filaments having surface layers with reduced energy gaps of 0.4 meV compared to measured interior bulk values ranging from 1.2 to 1.3 meV.
[Contact: John Moreland, (303) 497-3641]

Magnetic Materials and Measurements

Capobianco, T.E., Fickett, F.R., and Moulder, J.C., **Mapping of Eddy Current Probe Fields**, Review of Progress in Quantitative Nondestructive Evaluation, Vol. 5A, Chap. 3, Sec. A (Plenum Publishing Corp., New York, NY), pp. 705-711.

The magnetic fields produced by four different eddy current probes were mapped in the near field with very small (0.43-mm) diameter inductive magnetic field sensors. The four eddy current probes included two nominally identical, absolute, air-core probes; an absolute ferrite-core probe; a reflection probe with an air-core excitation coil; and two counterwound ferrite-core pickup coils. Measured fields for the air-core probes are compared with values calculated from the theory of Dodd and Deeds. All measurements were performed at 10 kHz; for the ferrite core probe, the field intensity was also measured from 1 kHz to 100 kHz using conventional methods.
[Contact: Thomas E. Capobianco, (303) 497-3141]

Heinrich, B., Cochran, J.F., Myrtle, K., Lonzarich, G., and Goldfarb, R.B., **Ferromagnetic Resonance at 9.55 and 23.9 GHz in the Weak Ferromagnet Ni_3Al**, Journal of Magnetism and Magnetic Materials, Vol. 54-57, pp. 1011-1012 (1986).

Ferromagnetic resonance (FMR) at microwave frequencies of 9.55 and 23.895 GHz has been measured in the archetypal weak itinerant ferromagnet Ni_3Al in the temperature range from 4 to 60 K. The observed FMR lines exhibited a strong Dysonian asymmetry and were well described over the whole temperature range by Maxwell's equations that included eddy currents, and by the Landau-Lifshitz (L-L) equation of motion including either Gilbert or L-L damping terms. At 4 K, the best fits were obtained using slightly angular dependent relaxation rates of 2.4×10^8 s^{-1} for saturation magnetization, M_s, along [111] and 2.0×10^8 s^{-1} for M_s along [100], and using a spectroscopic splitting factor g(Gilbert) = 2.2 ± 0.01 or g(L-L) = 2.14 ± 0.01.
[Contact: Ronald B. Goldfarb, (303) 497-3650]

ELECTROMAGNETIC INTERFERENCE

Radiated Electromagnetic Interference

Crawford, M.L., and Koepke, G.H., **Design, Evaluation, and Use of a Reverberation Chamber for Performing Electromagnetic Susceptibility/Vulnerability Measurements**, NBS Technical Note 1092 (April 1986).

This report presents the results of work at the National Bureau of Standards to evaluate, document, develop (when necessary) and describe the methodology for performing radiated susceptibility/vulnerability measurements using a reverberation chamber. The report describes the reverberation chamber theory of operation, construction, evaluation, functional operation, and use for performing immunity measurements. It includes an estimate of measurement uncertainties derived empirically from test results and from comparisons with anechoic chamber measurements. Finally, it

Radiated EMI (cont'd.)

discusses the limitations and advantages of the measurement technique to assist potential users in determining the applicability of this technique to their electromagnetic compatibility measurement needs.
[Contact: Myron L. Crawford, (303) 497-5497]

Crawford, M.L., and Koepke, G.H., **Electromagnetic Radiation Test Facilities - Evaluation of Reverberation Chambers Located at NSWC, Dahlgren, VA,** NBSIR 86-3051 (June 1986).

This report describes measurement procedures and results obtained from evaluating the reverberation chamber facilities located at the Naval Surface Weapons Center, Dahlgren, Virginia. Two chambers were tested referred to as 1) the half chamber, and 2) the full chamber. The facilities were developed by the NSWC for use in measuring and analyzing the electromagnetic susceptibility/vulnerability of weapon systems and the shielding effectiveness of enclosures and shielding materials. A brief description of each facility is given, including the instrumentation used for performing the evaluation and calibration of the facilities by the National Bureau of Standards. Measurements described include: 1) evaluation of the voltage standing wave ratios of the chamber's transmitting and receiving antennas; 2) measurement of the chamber's insertion loss or coupling efficiency versus frequency; 3) measurement of the effectiveness of the chamber tuners; 4) determination of the electric-field uniformity in the chamber's test zones versus frequency; 5) determination of the absolute amplitude calibration of the test electric fields in the chambers, based upon received power measurements of the reference antenna and calibrated dipole probe antenna measurements; and 6) comparison of the response of reference equipment under test to test fields established inside the NSWC reverberation chambers and the NBS reverberation chamber. These results can then be compared to anechoic chamber results. Conclusions given indicate that the NSWC chambers can be used at frequencies down to approximately 150 MHz. Estimates are given of the measurement uncertainties derived empirically from the test results.
[Contact: Myron L. Crawford, (303) 497-5497]

Crawford, M.L., and Koepke, G.H., **Performing EM Susceptibility/Vulnerability Measurements Using a Reverberation Chamber,** EMC EXPO 86, International Conference on Electromagnetic Compatibility, Washington, D.C., June 16-19, 1986, pp. T28.7-T28.13.

This paper discusses the design, evaluation, and use of a reverberation chamber for performing electromagnetic susceptibility (EMS) measurements of electronic equipment. Included are brief descriptions of the test procedures, application advantages and limitations, some EMS test results, intrepretation of test results relative to free-space test methods, and an estimate of measurement uncertainties.
[Contact: Myron L. Crawford, (303) 497-5497]

Friday, D.S., **Methodology for Statistical Control of the Anechoic Chamber Field Generation System,** NBSIR 85-3033 (January 1986).

The microwave anechoic chamber in question is an NBS laboratory facility in which standard plane-wave electromagnetic fields are generated. This chamber enables specialized measurements and electromagnetic interference/electromagnetic compatibility tests to be conducted on antennas and other devices. This paper is concerned with methodology for assuring that the standard field patterns generated in the NBS and similar chambers are repeatable. Procedures are proposed for developing a data base from measurements obtained by placing the system, which generates the fields, in certain relevant reference configura-

Radiated EMI (cont'd.)

tions. Methodology is presented for developing statistical control charts to monitor both the location and the scale parameters of these data over time.
[Contact: Dennis S. Friday, (303) 497-5395]

Hill, D.A., **Out-of-Band Response of a Coax-to-Waveguide Adapter**, IEEE Transactions on Electromagnetic Compatibility, Vol. EMC-28, No. 3, pp. 156-158 (August 1986).

The input impedance and transmission coefficients of a coax-to-waveguide adapter are analyzed for out-of-band frequencies. Numerical results are shown for an S-band adapter for frequencies from 2 to 10 GHz. The above-band response is frequency sensitive because of the presence of higher-order propagating modes in the waveguide.
[Contact: David A. Hill, (303) 497-3472]

Hill, D.A., and Francis, M.H., **Out-of-Band Response of Antenna Arrays,** NBSIR 86-3047 (June 1986).

The response of antenna arrays to out-of-band frequencies has been analyzed using the effective aperture approach. An average value of effective aperture can be obtained by averaging out the incidence angle and the polarization of the incident field. Far-field patterns have also been calculated by treating the array element excitations as random variables. The randomness in the element excitations causes a decrease in directivity and an increase in sidelobe level. Out-of-band measurements of reflection coefficient and near-field response have been made on two large slotted-waveguide arrays for frequencies from 2 to 18 GHz. Both arrays are narrow band, attributable to the large impedance mismatch at out-of-band frequencies.
[Contact: David A. Hill, (303) 497-3472]

Wilson, P.F., and Ma, M.T., **Simple, Approximate Expressions for Higher-Order Modes and Resonances in TEM Cells**, IEEE Transactions on Electromagnetic Compatibility, Vol. EMC-28, No. 3, pp. 125-130 (August 1986).

Simple, approximate expressions for determining the cutoff frequencies of the first few higher-order modes and the associated resonances in transverse electromagnetic (TEM) cells are presented. Both symmetric and asymmetric cells are discussed with examples.
[Contact: Perry F. Wilson, (303) 497-3842]

Wilson, P.F., and Ma, M.T., **A Study of Techniques for Measuring the Electromagnetic Shielding Effectiveness of Materials,** NBS Technical Note 1095 (May 1986).

Shielding effectiveness relates to a material's ability to reduce the transmission of propagating fields in order electromagnetically to isolate one region from another. Because a complex material's shielding capability is difficult to predict, it often must be measured. A number of measurement approaches are studied including the use of a shielded room, coaxial transmission line holders, time-domain signals, the dual transverse electromagnetic (TEM) cell, and an apertured TEM cell in a reverberation chamber. In each case, we consider the system's frequency range, test sample requirements, test field types, dynamic range, time required, analytical background, and present data taken on a common set of materials.
[Contact: Perry F. Wilson, (303) 497-3842]

ADDITIONAL INFORMATION

Lists of Publications

Gibson, K.A., Page, J.M., and Miller, C.K.S., **A Bibliography of the NBS Electromagnetic Fields Division Publications**, NBSIR 85-3040 (February 1986).

This bibliography lists publications of

Lists of Publications (cont'd.)

the National Bureau of Standards' Electromagnetic Fields Division for the period from January 1984 through September 1985, with selected earlier publications from the Division's predecessor organizations.
[Contact: Kathryn A. Gibson, (303) 497-3132]

Kline, K.E., and DeWeese, M.E., **Metrology for Electromagnetic Technology: A Bibliography of NBS Publications**, NBSIR 86-3048 (June 1986).

This bibliography lists the publications of the personnel of the Electromagnetic Technology Division of NBS in the period from January 1970 through December 1985. A few earlier references that are directly related to the present work of the Division are included.
[Contact: Kathryn E. Kline, (303) 497-3678]

Palla, J.C., and Meiselman, B., **Electrical and Electronic Metrology: A Bibliography of NBS Electrosystems Division Publications, NBS List of Publications 94** (January 1987).

This bibliography covers publications of the Electrosystems Division, Center for Electronics and Electrical Engineering, NBS, and of its predecessor sections for the period January 1963 to January 1987. A brief description of the Division's technical program is given in the introduction.
[Contact: Jenny C. Palla, (301) 975-2220]

Walters, E.J., **Semiconductor Measurement Technology: A Bibliography of NBS Publications for the Years 1962-1986**, NBSIR 87-3522 (February 1987).

This bibliography contains reports of work performed at the National Bureau of Standards in the field of Semiconductor Measurement Technology in the period from 1962 through December 1986. An index by topic area and a list of authors are provided.
[Contact: E. Jane Walters, (301) 975-2050]

1987 CEEE CALENDAR

July 28-30 (Vail, CO)

Short Course on Optical Fiber Measurements. This course is sponsored by the National Bureau of Standards and the University of Colorado with the cooperation of members of industry who serve as faculty together with staff from the Electromagnetic Technology and Electromagnetic Fields Divisions. The course is intended for scientists and engineers involved in optical fiber characterization and emphasizes concepts, techniques, and apparatus used in measuring engineering parameters of telecommunications-grade fibers.

The following major topic areas are addressed: optics for communications, emphasizing geometric optics concepts; fiber properties and parameters; index-profile measurements; fiber bandwidth measurements in the frequency and time domains; fiber attenuation measurements; connector and splice losses; optical time-domain reflectometry concepts and applications; single-mode fibers; statistics and error analyses, measurement uncertainties; and fibers for sensors.
[Contact: Office of Conference Services, University of Colorado (303) 492-8630; Robert L. Gallawa (303) 497-3761; or Matt Young (303) 497-3223]

September 14-16 (Research Triangle Park, NC)

VLSI and GaAs Packaging Workshop. This Workshop is co-sponsored by the Components, Hybrids, and Manufacturing Technology Society of IEEE and NBS; attendees are expected to be knowledgeable in the field and to participate in discussions. Topic areas include: VLSI and wafer scale package design (characterization and implementation, cost and performance driven solutions); package thermal design (characteristics, re-

CEEE Calendar (cont'd.)

sults, and issues); package interconnection options (wire bonding, TAB, flip chip, or optical); GaAs IC packaging (high speed packaging considerations); package electrical issues (reduction of parasitics and improvements in electrical performances); integrating package design (from die to system, including assembly and test issues); VLSI package materials advancements; die-attach solutions for large chips; new failure mechanisms in VLSI packaging. [Contact: George G. Harman, (301) 975-2097]

September 16-18 (Gaithersburg, MD)

Workshop on the Role of Optical Sensors in Power Systems' Voltage and Current Measurements. This Workshop is sponsored by NBS, the Bonneville Power Administration (BPA), the Electric Power Research Institute (EPRI), and the Empire State Electric Energy Research Corporation (ESEERC) and is intended for research and development engineers in utilities and in companies that supply equipment to the utility industry. The objective of this workshop is to identify anticipated opportunities for improved measurement techniques that should arise as power systems individually and collectively evolve to meet the needs of the 1990s. Presentations will stress the design and testing of optical systems for 60-Hz voltage or current measurement; the interfacing of electronic or optical components with existing metering and control systems; opportunities for new measurement hardware resulting from increased automated control of power systems and of the testing of power system components; and optical techniques for the measurement of electric and magnetic fields in power systems or system components. The results of an NBS study evaluating optical techniques for power-system electrical measurements and carried out in agreement with BPA, EPRI, and ESEERC will be presented as an invited keynote. [Contact: Raymond S. Turgel, (301) 975-2420 or Robert E. Hebner, (301) 975-2403]

September 22-25 (Boulder, CO)

Noise Measurement Seminar. This four-day course is presented and hosted by the Electromagnetic Fields Division in cooperation with representatives from industry and the NBS Time and Frequency Division. It is intended for practicing noise metrologists and technical managers responsible for systems in which accurate measurements of thermal and phase noise are important. Attendees will learn the most important precautions to take in making accurate noise measurements and will receive a set of notes that are suitable for use in solving precision noise measurement problems. Course topics include reference thermal noise sources; thermal noise measuring systems and techniques; phase noise; and the problems of measuring thermal noise in passive components, amplifiers, and communication systems.

The course design combines formal lectures on theory presented by NBS staff and industry experts with demonstrations in NBS laboratories and demonstrations of commercial equipment. A special feature of the Seminar is the opportunity each day for attendees to share their experiences in solving specific problems or their insights on practical noise measurement issues through short presentations to the assembled group. Time is scheduled for group discussions of these presentations and other topics raised by the Seminar. [Contact: Sunchana Perera (303) 497-3546]

October 26-28 (Boulder, CO)

Symposium on Optical Materials for High Power Lasers (Nineteenth Boulder Damage Symposium). This Symposium is cosponsored by the National Bureau of Standards, the American Society for Testing and Materials, the Air Force Office of Scientific Research, the Office of Naval Research, and the Defense Advanced Research Projects Agency and constitutes a principal forum for the exchange of information on the physics and technology of materials for high-

CEEE Calendar (cont'd.)

power lasers.

Topics to be discussed include new materials, bulk damage phenomena, surface and thin-film damage, design considerations for high-power systems, and fundamental mechanisms of laser-induced damage. Proceedings of the Symposium will be published (Note: The collection of Symposium proceedings contains information on optics for all aspects of high-power/high-energy lasers, including environmental degradation, durability, fabrication, material growth and deposition processes, and testing). [Contact: Susie A. Rivera (303) 497-5342]

December 10-11 (Gaithersburg, MD)

Power Semiconductor Devices Workshop. This Workshop, sponsored jointly by IEEE and NBS, is intended to bring together for interactive participation those actively working in the field of power semiconductor devices. It will be held in conjunction with the 1987 IEEE International Electron Devices Meeting in Washington, DC. Four specific topic areas have been selected, based on the response to a questionnaire sent to over 200 power device researchers worldwide. They are: power and high voltage integrated circuits, discrete devices, device modeling, and packaging. Attendees are expected to be prepared to contribute to the development of responses to specific questions that arise in the context of the particular topic areas; a final schedule identifying the topic areas should be available at the end of October. [Contact: David L. Blackburn, (301) 975-2053]

1988 CEEE Calendar

February 10-12 (San Diego, CA)

IEEE Semiconductor Thermal and Temperature Measurement Symposium. This fourth annual **SEMI-THERM** symposium is sponsored by the Components, Hybrids, and Manufacturing technology Society of IEEE in cooperation with NBS and constitutes an international forum for the presentation of new developments in, and applications relating to, generation and removal of heat within semiconductor devices and measurement of junction temperatures experienced in various applications and environments. Major SEMI-THERM topic areas include thermal measurements, thermal characterization, applications, and computation and software.

The program includes keynote speakers, technical presentations, tutorial sessions, workshops, and an exhibit. In addition, the Semiconductor Equipment and Materials Institute has scheduled in conjunction with SEMI-THERM a meeting of its Thermal Measurements Task Force, to which attendees are invited. [Contact: Frank F. Oettinger, (301) 975-2054]

May 11-13 (Los Angeles, CA)

Intersociety Conference on Thermal Phenomena in Fabrication and Operation of Electronic Components. This Conference is sponsored by the Components, Hybrids, and Manufacturing Technology Society of the IEEE, in cooperation with ASME Committee K-16 on Heat Transfer and NBS. It is intended to provide an interdisciplinary forum for exploring the progress made in understanding, analyzing, and modeling thermal transport processes and thermally induced failures in the fabrication, assembly, and use of logic, memory, and data-storage systems. Major topic areas covered are 1) processing and fabrication, including state-of-the-art semiconductor crystal growing techniques; thermal stress in wafers, chips, substrates, PC boards, and joints; and encapsulant behavior with respect to solidification, outgassing, mechanical properties, and water vapor diffusion and absorption; 2) packaging technology, including means for cooling components from cryogenic to high temperatures and reliability as affected by failure mechanisms such as dopant migration and intermetallic growth; and 3) peripheral

1988 CEEE Calendar (cont'd.)

equipment, including data storage in both magnetic and optical media and thermal issues in dot-matrix and thermal printer heads. The conference is being held in conjunction with the Electronics Components Conference (May 9-11) at the same site. [Contact: Frank F. Oettinger, (301) 975-2054]

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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)

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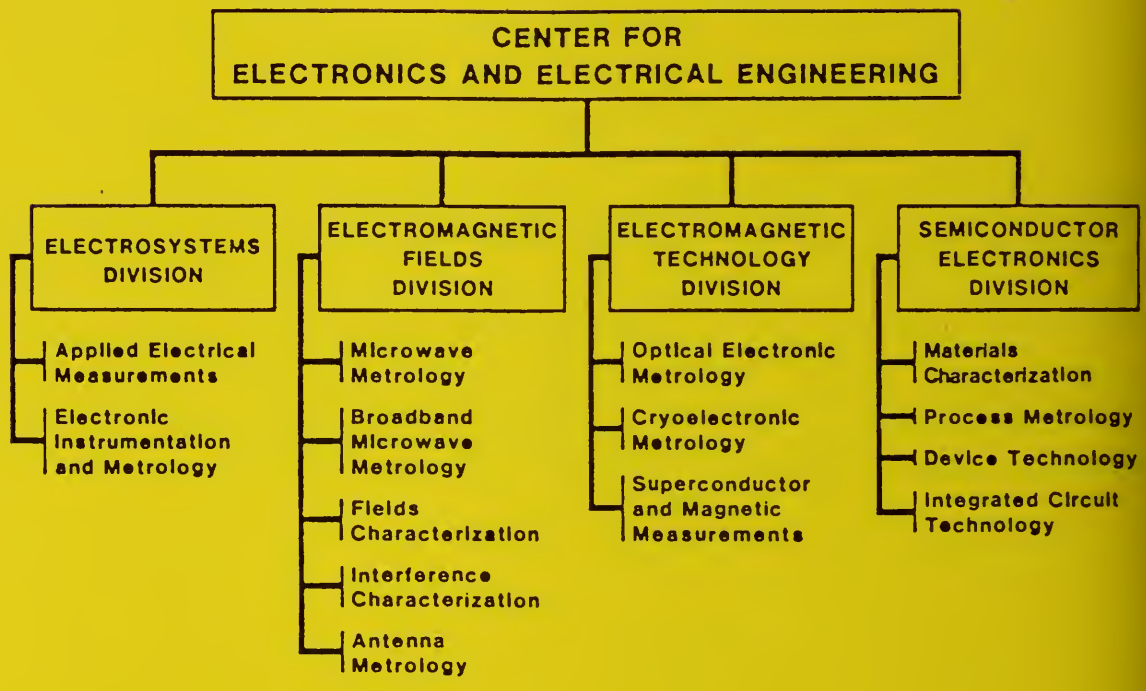

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