EES NOTES

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In This Issue:

MAGNETICS LABORATORY

All materials are found to interact in some manner with magnetic fields. In most cases the magnitude of the interaction is quite small and fairly elaborate procedures are required for detection. However, certain classes of materials, such as the ferromagnets and ferrimagnets, exhibit exceptionally strong magnetic parameters which are vital to the operation of practically all modern machines. Measurements of the magnetic properties of both magnetically weak and strong materials are used extensively in research efforts concerned with such areas as electronic structure, phase transformations, and chemical reactions.

A primary effort of the Magnetics Group has been the study of the magnetic properties of thin films and, in some cases, multiple-layered structures. This work has included the study of thickness effects on the magnetization and Curie point, the detailed behavior of the magnetization in the neighborhood of the Curie point, and various studies of magnetic anisotropy. The Curie point is the temperature at which a ferromagnetic material becomes paramagnetic. The thin-film materials have included both the 3d transition metals and the 4f rare earth metals.

Magnetic studies also have been made on bulk materials. These investigations have included measurements of the magnetic anisotropy of nickel single crystals and studies of the magnetization and Curie point for certain transition metal alloys and the magnetization of ferrite samples. Magnetic susceptibility measurements also have been made on a few solid and liquid non-metals.

Planning in the development of the Magnetics Laboratory has taken into consideration the anticipated needs of research groups throughout the Institute as well as the interests of the Magnetics Group itself. It is found that workers in many areas of research encounter problems which require various magnetic property measurements even though the work area is not primarily magnetics. In addition, several research efforts within the Institute, both current and anticipated, are concerned primarily with magnetic materials studies using such techniques as neutron diffraction. The Magnetics Laboratory supports these programs by providing the necessary "conventional" magnetic property measurements.

The magnetics facilities are located in two adjacent rooms on the ground floor of the new Research Building. One houses a 12-inch Varian electromagnet mounted on a specially designed concrete slab. The other has been designed as a multiple-user facility to provide for campus-wide needs.

Most types of magnetic property measurements involve vibration-sensitive instrumentation and require careful alignment procedures. With this in mind, an elaborate arrangement was developed which allows a particularly convenient magnet to be shared between three vibration-free experimental stations with little or no loss of alignment. A slab of concrete 22 feet long by 7 feet wide is recessed in the floor of the laboratory, and the slab is suspended on a pneumatic isolation system. This system provides air suspension and automatic leveling when the magnet is rolled along steel tracks extending the length of the slab. An aluminum superstructure mounted on the slab provides support for experimental apparatus located at the three stations. A monorail hoist is mounted on the ceiling over the superstructure to permit convenient installation or removal of an experimental system as a unit. The magnet for this laboratory is scheduled for installation within a few months.

The measurement instrumentation for magnetic property determinations includes several automatic torque magnetometers, a vibrating sample magnetometer, and a susceptibility balance. Magnetic field intensity measurements are made with a Varian NMR gaussmeter and a Bell Hall-effect probe. Vacuum systems and cryostats allow magnetic property measurements at temperatures from $1^{o}K$ to above $800^{o}K$. Magnetic domain observations are made using the Kerr effect, Bitter techniques, and Lorentz microscopy.

Billy R. Livesay
Physical Sciences Division

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APPLIED NUCLEAR RADIATION EFFECTS STUDIES

The term "radiation effects" conveys to most technical people the image of "radiation damage" in which the physical, electrical, or optical properties of solids dependent upon regular lattice ordering are degraded. The forms of radiation effects which have been publicized do, indeed, tend to be in the degradation category: failure of solid-state electronics, embrittlement of metals, discoloration of optical materials, and transformations of organic solids ranging from viscous liquid to dry powder form.

Radiation effects studies within the Nuclear and Biological Sciences Division have been concerned with the damage aspects of radiation, but have emphasized as well the radiation-induced modifications in solids which can be used to achieve desired property changes. Gamma rays, neutrons, and accelerated charged particles provide a means of introducing regions throughout a solid in which the energy density exceeds the lattice energy or electron affinity within that localized region.

Three basic radiation effects have been used: thermal neutron transmutation to change a small fraction of the host atoms into another element, fast neutron or gamma interactions to modify the lattice order, and gamma or charged particle irradiation to alter the charge balance within the solid. Transmutation effects are being studied for controlled introduction of desired elements into pure crystals and for activating thin films for composition, density, and thickness measurements. Cross-linking of organic polymers and introduction of desired energy levels into the band structure of semiconductor or optical materials are being accomplished by displacing structural atoms with energetic gamma rays or neutrons. "Pinning" or stabilizing of dislocations (structural defects) has been achieved in metals and ionic crystals.

Several developments in applying the charge production within a solid resulting from gamma interactions are now being investigated. For example, if this charge is produced within the charge-depleted region of a semiconductor junction, a nuclear "battery" is created by the diffusion potential of the junction and the current resulting from the charge collection. As the power requirements for metal-oxide-semiconductor devices now approach the microwatt range, the prospect of nuclear self-powered circuitry is being evaluated with interest. In contrast, a study of the effects of charge-balance alteration by irradiation for the production of ceramic structures, ceramic-metal interfaces, and whisker-reinforced fused silica will be initiated soon by the High Temperature Materials Division.

The constructive use of radiation interactions is potentially as varied as the number of materials to be studied. A list of available irradiation facilities is given below to encourage the Georgia Tech community to make greater use of them.

Irradiation Facilities

Georgia Tech Research Reactor: 1-Megawatt heavy-water moderated reactor, steady-state neutron flux to 2×10^{13} neutrons/cm^2 sec, gamma rates to 2×10^7 R/hr; special shield plugs for instrumented capsules, pneumatic and hydraulic sample transfer systems.

14-MeV Neutron Generator: Two TMC-Ellison machines, neutron output to greater than 10^{11} neutrons/sec.

12,000-Curie Cesium-137 Gamma Source: 622-keV gamma energy, rates to 1.5×10^6 R/hr for 1.5-inch diameter sample; experients may be instrumented.

Spent-Fuel Gamma Facility: GTRR spent fuel in storage pool; gamma energy average greater than 1 MeV, rates to 10^6 R/hr.

11-Curie Cobalt-60 Source: 1.173 and 1.332 MeV gamma energy, rates to 5000 R/hr; source in rod form for handling and use in hot cell.

X-ray Machines: Two, to 250-kv peak, to 25-ma beam current.

1-MeV Van de Graaff Positive Particle Accelerator with beam analysis unit to 250-kv peak.

David M. Walker
Nuclear and Biological Sciences Division

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APPLICATION OF ELECTROMAGNETIC AND ULTRASONIC ENERGY IN CANCER RESEARCH

For several years, research in cancer chemotherapy has emphasized the evaluation of anti-cancer drugs which in large amounts are very toxic at normal body temperature but which can be tolerated at reduced body temperatures (hypothermia). If a tumor is kept normothermic in the body of a hypothermic animal (differential hypothermia), the effects of such drugs injected into the blood are concentrated in the tumor because of the different metabolic rates between the tumor and the surrounding tissue. Briefly, the tumor treatment procedure consists of cooling the body of an animal to a low temperature of about 10°C, warming only the tumor to normal body temperature, 37°C, and then injecting an anti-cancer drug.

Until recently, application of the differential-hypothermia technique has been limited to the treatment of small surface tumors with the tumors heated by focused infrared light. Rays from an infrared source do not penetrate deeply into the tissue to heat a tumor uniformly; consequently, another technique is desirable for heating either thick surface tumors or small internal tumors.

During the past year, the Electronics Division has conducted preliminary research to determine the feasibility of using electronic techniques for accomplishing differential hypothermia. The use of both electromagnetic energy and ultrasonic energy has been investigated. This research was performed jointly by personnel from Georgia Tech and by scientists, under the direction of Dr. Vojin Popovic, in the Department of Physiology, Emory University. During the initial studies, a literature survey was made to obtain information on the electrical and thermal properties of biological materials and to examine existing theoretical and experimental techniques in the general area of microwave heating.

An S-band microwave system (2.5 GHz) was designed by Electronics Division personnel for heating the tumors, and experiments were performed at Emory to determine the feasibility and effectiveness of heating a surface tumor. In addition to the S-band system, an X-band microwave system (9.3 GHz) was designed to heat small surface tumors.

Preliminary results in the treatment of surface tumors on rats show that selective heating with S-band electromagnetic energy is feasible; however, the initial experiments did not provide conclusive results on the effectiveness of the treatment. Experiments using the S-band and X-band equipment are planned in the future.

The initial results of using ultrasonic heating techniques for surface tumors are encouraging. The ultrasonic system consists basically of an ultrasonic source operating at 1 MHz and a water-filled collar. The water collar is placed around the tumor and is used as a heat exchanger for removing surface heat.

The center hole of the collar is filled with a jell which also serves as a low-loss couplant between the ultrasonic transducer and the tumor. Typical results indicate that the temperature of the deepest part of a tumor in a hypothermic animal can be maintained at 37°C while the surface temperature is about 3°C higher. Tumors treated in rats ranged in size from 600 to 1,000 cubic millimeters, and with the ultrasonic technique, it was possible to keep the temperatures of the surface and the deepest parts of these tumors approximately the same.

Investigations also were made in the treatment of deep-seated tumors. No techniques seemed feasible to produce significant differential hypothermia without in some way altering the energy absorption of the diseased area. Addition to a deep tumor of a material which absorbs energy at ultrasonic or microwave frequencies offers a possible solution to accomplishing differential hypothermia associated with deep tumors. For the electromagnetic case, experiments were performed to determine whether differential heating could be achieved with ferrite powder as a doping agent. For the ultrasonic case, materials investigated included dimethyl sulfoxide, glycerol, paraffin, diacetin, and others. A considerable amount of investigation -- medical, electromagnetic, and ultrasonic -- needs to be performed before the applicability and effectiveness of these techniques can be established.

R. P. Zimmer
Electronics Division

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MOLECULAR SCIENCE IN SURFACE COATINGS

The relationships of atomic and molecular structure to the chemical and physical properties of materials are being developed by the author as a means for designing or selecting molecules to do specific jobs. Molecular architecture -- types of chemical bonds, spatial arrangements, size, etc. -- determines the nature and magnitude of the various forces between molecules. These forces, mechanical, gravitational, electrostatic, and electrokinetic, are the factors that determine the viscosities, solvent action, surface adhesiveness, and other properties of various materials. A preliminary article (W. H. Burrows, Journal of Paint Technology, February 1969) deals primarily with the materials and special problems of coating technology; however, much of the subject matter would be equally applicable to such fields as adhesives and lubricants.

Perhaps the most interesting topic discussed in the article is that of wetting and spreading. The old rule-of-thumb, "polar wets polar, and non-polar wets non-polar, but not vice-versa," has been shown not to be entirely true. Even the recent concept developed by Zisman, "Low energy liquids spread on high-energy surfaces, but not vice versa," has its limitations. The contributions of dispersion forces to surface free energies and to interactions between liquid and solid at the interface are defined, leading to Fowkes' expression for the spreading coefficient, which provides a criterion for predicting wetting and spreading. Even this relatively precise criterion has its exceptions. A low-energy ester that would be expected to wet a high-energy silica surface fails to do so because the silica catalyzes the hydrolysis of the ester, releasing a minute quantity of alcohol. The alcohol spreads as a mono-molecular film on the surface of the silica, presenting a hydrocarbon surface to the remainder of the ester, and thus the ester is unable to wet.

Applied molecular science is still in its infancy. We are keeping an active file of new contributions as they appear, but it will be years before paint technologists can use molecular science to bypass the established procedures of formulation, evaluation, reformulation, more evaluation, etc., to introduce new resins and related materials into successful practice. Still, it is a science that is well worth watching.

W. H. Burrows
Chemical Sciences and Materials Division

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MARKET RESEARCH

The Market Analysis Section of the Industrial Development Division (IDD) conducts professional, research-based studies identifying industries, products, and individual companies that are well suited to the resources and attractions of specific communities and areas in the state as well as to Georgia's total resource situation. To date the Market Analysis Section has published more than 100 feasibility studies of products and product complexes that can be profitably manufactured in Georgia. These range from wood products to metals and machinery, from textiles and apparel to paper and allied products, and from chemical products to mobile homes. Other activities include in-depth studies of industrial, wholesale, and retail markets in the Southeast, as well as short-term market surveys.

While the primary emphasis of the Section is on market analysis, the studies of manufacturing opportunities in the state cover all location factors which are determined to be critical to the products or industries involved. In fact, a continuing project of the Section is the identification of the location factors which apply to specific types of manufacturing operations. Staff members also conduct special studies and maintain close liaison with industrialists, businessmen, and associations for the purpose of identifying specific opportunities for developing satellite industries to supply raw materials, fabricate component parts, utilize by-products, or otherwise serve the needs of established manufacturing and business firms in the state.

The Market Analysis Section is composed of four full-time professionals, three of whom have senior status, plus support personnel assigned to the section as needed. The present professional staff represents a total of over 30 years' experience in economic and market analysis work. In addition, the Section not only has available the expertise of the entire IDD staff, but also enlists the support of other EES divisions and other units of Georgia Tech from time to time.

Marketing research services are provided to community and area development groups, state agencies, federal agencies, and foreign organizations. Assistance also is available to Georgia industrial firms and companies interested in a Georgia location in cases where IDD's services would not be competitive with those of private consulting firms. These services supplement the firm's knowledge of the industry with the special research skills, data-gathering facilities, and outside objectivity of the independent research organization.

As a major unit of IDD's Industrial Services Branch, the Market Analysis Section also participates in a comprehensive program of direct assistance to business and industry. This program emphasizes the expansion and diversification of existing manufacturing enterprises, as well as the establishment of sound new ventures which utilize the resources and manpower of Georgia and the Southeast. While much of the work of Market Analysis is basically research oriented, an increasing amount can be categorized as "problem solving." It is in this type of work that the applied business and industrial experience of the staff is especially valuable.

George D. Woodard, Jr.
Industrial Development Division

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OFFICE OF INDUSTRIAL ASSISTANCE

Georgia Tech, as a center for technological education and research, has always received inquiries from businessmen and industrialists with technical and management problems. In fact, the Engineering Experiment Station is specifically charged with a responsibility for research and service for the benefit of industry. In order to provide a focal point for these industrial liaison activities the Office of Industrial Assistance was established March 16. The new office will receive industrial inquiries and visitors who do not have previous contacts here, and will assist the inquirer in identifying his problem, obtaining technical information if required, or arranging for meetings with staff specialists. It may suggest handling of the inquiry under existing programs or recommend other appropriate action. Where sponsored research projects may be indicated, OIA will acquaint the caller with Tech's organization, capabilities, and procedures and will arrange for preproposal discussions with staff members. The office will be supervised by R. L. Yobs and will be located in Room 3065 in the new EES building, extension 5678.

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OPEN HOUSE AT HTMD

The High Temperature Materials Division, which until recently was located at the DeKalb-Peachtree Airport, is planning an open house to celebrate its return to the campus and to show off its new quarters in the Hinman Research Building, 8:00 A.M. to 5:00 P.M., June 1, 1970. You are cordially invited to tour the facilities and to meet the staff. On display will be such facilities and apparatus as a filament-winding machine for the development of high-temperature filament-wound structures, as well as the conventional fiber-glass systems; spray drier to process fine particles in ceramic precursors; arc-plasma and flame spraying equipment; a small H_2-O_2 rocket motor which is used in studies of thermal and erosion effects of high-temperature, high-velocity gases on materials; analytical instrumentation for determining the mechanical and physical properties of high-temperature materials; and high-temperature instrumentation which includes DTA (differential thermal analysis), TGA (thermal gravimetric analysis), and hot stage microscopes.

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NBSD GAINS ENVIRONMENTAL SCIENCE AND REACTOR UTILIZATION SPECIALIST

George W. Leddicotte has joined the staff of the Nuclear and Biological Sciences Division as a research professor of nuclear engineering. His major responsibilities will be to initiate research and development projects in the environmental nuclear and biological sciences fields and to stimulate R & D utilization of the Georgia Tech Research Reactor.

Dr. Leddicotte has had extensive experience in these areas. As vice-president and general manager of Atcor Laboratories, Inc., Columbia, Missouri, for the past year, he established and administered a laboratory concentrating on research and development in the environmental sciences and on the creation of practical products of nuclear and non-nuclear origin for use by medicine, agriculture, and industry. While at the University of Missouri (1965-1969), he was responsible for promoting the use of the University's Nuclear Science Center. He also originated programs to investigate the role of trace elements and substances in various natural and man-made materials; many of these investigations were directed to interests in environmental health, pollution, and environmental management.

Prior to joining the University of Missouri faculty, he was assistant manager, nuclear operations, of the Union Carbide Corporation Nuclear Research Center at Tuxedo, New York, where his duties included promoting the use of the Center's research reactor. He also was associated with the Oak Ridge National Laboratory for 16 years, during 12 of which he served as senior research chemist and nucleonics group leader. There he developed and promoted the USAEC-ORNL programs in activation analysis and the use of radioisotope methodology for analytical chemistry.

Dr. Leddicotte is a graduate of Lincoln Memorial University. The results of his work have been presented in over 140 technical publications. Dr. Leddicotte desires to assist persons having an interest in potential applications of radiation or radioisotopes to scientific or engineering problems.

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MEETING HELD TO REVIEW PROGRESS IN NEW AND INNOVATIVE SUBJECT AREAS

On April 3, project directors met to discuss their progress in a new program of research. These projects were selected for internal support last January as a result of an invitation by the EES Director for submission of proposals in new and innovative subject areas for which support was not otherwise available. This program, which will be a continuing one, is intended to stimulate creative new ideas which have potential for sponsorship and which have relevancy to the needs of Georgia. Persons with ideas for research which may fit these criteria are urged to contact R. L. Yobs, extension 5605.

Projects reviewed at the first meeting included the following:

Title	Principal Investigator(s)
Synthesis of Silicon Carbide Pigments	W. R. Tooke, Jr.
Generation of Uniform Particle Clouds	E. Y. Keng
Application of Laser Drilling to Millimeter Wave Material Fabrication	J. B. Langley, II
Electronic Aids for Public Roadways: A Wrong-Way Vehicle Warning Device	H. H. Jenkins
The Development of Coatings for the Protection of Structural Metals against the Erosive Effects of Sand	A. T. Sales
Development of Resin Reinforced Molds Materials	E. A. Welsh
Analysis of Georgia's Building Codes	F. S. Clarke
Proposal for the Establishment of a Mechanized Index to Reports Published by the Industrial Development Division	M. E. Anders
The Technological and Economical Impact of Low-Cost Nuclear Power by 1980	R. E. Van Geuns
The Role of Proteolytic Enzymes in the Initiation and Development of Dental Caries	R. D. Kimbrough, Jr.

Title (continued)	Principal Investigator(s)
Radiation-Induced Polymerization of Monomeric Impregnated Wood Shavings and Similar Materials	J. A. Knight, Jr. & M. W. Bowen
Studies of Heat Transfer Characteristics and Temperature Stability of Heat Pipe Quartz Resonator Ovens	A. L. Bennett
Completion of a Fiber Atlas	J. L. Hubbard

Reviews are held quarterly. The next review will be Wednesday, July 8, at 2:00 P.M. in the new EES auditorium. Meetings are open to all interested persons. Questions and comments from attendees will be welcomed.

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PROFESSIONAL ACTIVITIES

Speeches

On March 11, R. M. Boyd, NSBD, spoke on "Environmental Considerations around Nuclear Reactors" to the Sandy Springs Chapter of the Georgia Society of Professional Engineers.

J. L. Brown, PSD, talked to a group of secondary school science teachers in Clarkesville, Georgia, February 14 on the subject of "Electron Microscopy." This was a CCSS program sponsored by NSF and administered by Oglethorpe College.

John Husted, CSMD, gave a talk on "Minerals of Dodge County" at the March 20 meeting of the Eastman, Georgia, Rotary Club.

G. W. Leddicotte, NBSD, spoke to the Missouri-Kansas Section of the American Nuclear Society on "The Commercial Atom: Activation Analysis for Pay" at a meeting held in Kansas City, Kansas, March 19-22.

At the Polytechnic Institute of Brooklyn Symposium on Submillimeter Waves held in New York City on March 30-April 2, two papers by Albert McSweeney, A. P. Sheppard, and K. H. Breeden, ED, were presented: "High Resolution Submillimeter Measurements of Atmospheric Water Vapor Absorption" and "Submillimeter Wave Material Properties and Techniques: Dielectric Constant, Loss Tangent, and Transmission Coefficients of Some Common Materials to 2000 GHz." Dr. Sheppard also was a symposium panel member.

I. E. Perlin, RECC, presented a lecture on "Frequency Management" at the March 16 meeting of the Atlanta Chapter, IEEE.

"Phonocardiography - Using Miniature Sensors" was the subject of a talk given by M. E. Sikorski, PSD, at the Georgia Tech Bioengineering Workshop on Instrumentation, February 12.

At a meeting of the American Crystallographic Association in New Orleans February 28-March 5, Kesavan Sudarsanan, PSD, read a paper, coauthored by R. A. Young, on "Crystal Structural Detail and Twinning Mechanism in Cadmium Chlorapatite."

R. A. Young, PSD, presented a paper on "Crystal Structural Evidence for CO_3 in Francolite" and served as vice-chairman of a session at the International Association for Dental Research meeting in New York City, March 15-18.

Publications

J. L. Brown, PSD, "Applications of the Stereoscan to Industrial Materials," Proceedings of the Engis Stereoscan Colloquium - 1969, Engis Equipment Company, Morton Grove, Illinois, 1969.

A. T. Chapman, R. J. Gerdes, and G. W. Clark, PSD, "Refractory Oxide-Metal Composites: Scanning Electron Microscope and X-ray Diffraction of Uranium Dioxide-Tungsten," Science, Vol. 167, No. 3920, February 1970, pp. 979-980.

D. M. Hall, J. L. Brown, et al., PSD, "An Electron Microscopy Study of Fibers and Starch," Proceedings of the 9th Annual Slashing Seminar, Auburn University, September 9-11, 1969, pp. 121-131.

Charles Poole, IDD, "Production Aids," Mobile Home/Recreational Vehicle Dealer, February 5, 1970, pp. 46, 48, and "Floor Systems," MH/RVD, March 5, 1970, pp. 42, 44.

Awards

Richard H. Wynn, graduate student in the College of Industrial Management and former expediter with EES Supply Services, has been awarded the Soldier's Medal, the Army's highest peacetime medal, for rescuing a 15-day-old baby from a burning apartment.

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SUBMISSION OF ARTICLES

Contributors in the divisions should submit their articles to the appropriate division coordinator listed below. Others may send their contributions via campus mail to Martha Ann Deadmore at the Industrial Development Division.

Division Coordinators

Chemical Sciences and Materials Division	Walter H. Burrows
Electronics Division	H. A. Corriher, Jr.
High Temperature Materials Division	Nick E. Poulos
Industrial Development Division	Martha Ann Deadmore
Nuclear and Biological Sciences Division	Geoffrey G. Eichholz
Physical Sciences Division	Robert L. Bullock
Rich Electronic Computer Center	John P. McGovern