EES NOTES

ENGINEERING EXPERIMENT STATION • GEORGIA INSTITUTE OF TECHNOLOGY • ATLANTA, GEORGIA 30332

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In This Issue:

ANALYTICAL TECHNIQUES IN SURFACE PHYSICS

To obtain an exact understanding of surface phenomena, one must be able to characterize the surface as to the spatial arrangements of the individual surface atoms and the nature of impurity atoms.

Surface scientists, today, have at their disposal analytical techniques which are capable of giving this type of information under precisely controlled conditions. Two of these techniques have advanced the state-of-the-art, namely low-energy electron diffraction (LEED) and Auger-electron spectroscopy. Scientists in our Surface Science Section have played a very important role in developing these techniques and in their general acceptance as analytical tools.

Since both techniques use the same apparatus, with only electrical switching required to obtain one or the other type of data, complementary analyses can be made on the same surface and while in a given physical state.

With LEED, the primary electrons of a few hundred electron-volt energy interact elastically (no energy loss) with the first two or three layers of atoms in the surface. These electrons are diffracted back out from the surface at discrete angles and are made to fluoresce a screen which produces a visual display. The angular distribution of these diffracted electrons is indicative of the structural relationships of the atoms which gave rise to this diffraction.

When the primary-beam energy is increased to several thousand electron volts it can "knock out" electrons from the inner shells of the atom. The transition energy results either in the emission of a photon (characteristic X-ray) or the ejection of an electron from another shell (Auger electron). Like the X-rays, these ejected electrons have a characteristic energy which is related to the level and atom type, and thus can be separated in an electron spectrometer.

Because of the low energy of the ejected electrons, they are absorbed if they originate in other than the immediate surface layer of atoms, and thus cannot be detected by the spectrometer. So we have a technique which is suitable for identifying surface impurities in concentrations as low as one-hundredth of a monolayer of adatom coverage. The adatoms may be adsorbed or chemically bound to the surface.

New techniques are being developed in this laboratory so that we will not only be able to identify the foreign surface atoms, but also obtain a precise knowledge of their location in the area under investigation.

Rayond K. Hart
Physical Sciences Division

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THE SEISMIC OBSERVATORY

Since installation in June 1963, the Mineral Engineering Branch has managed the Atlanta (ATL) station of the Worldwide Standard Seismograph network. This network is coordinated by ESSA through the Coast and Geodetic Survey in Rockville, Maryland. The instrumentation and recording sensitivity of the Atlanta observatory are excellent, perhaps exceeded in the Southeast only by the large array of the Cumberland Plateau Observatory in Tennessee.

Six records of the motion of the ground at the ATL observatory caused by earthquakes and other events are obtained each day. These are the short period (0.1-5 sec.) and long period (8-50 sec.) recordings of the three independent directional components: vertical, north-south, and east-west. The periodicity of 5 to 8 seconds is avoided because the maximum background noise caused by storm centers in the Atlantic Ocean occurs in this interval.

Each day, holidays included, a student assistant travels the 27 miles south to the seismic observatory near Lovejoy, Georgia, to change the six records. An isolated location is required to avoid local traffic vibrations. Except for rare gaps caused by inaccessibility or power failure, the records are continuous. The continuity is important in the determination of earthquake risk and probabilities of occurrence (seismicity). Since large earth movements which would be generally noticed are very rare in the Southeast, seismologists must rely on small events to formulate statistics. In the observatory's seven years of existence, at least a half dozen "Georgia" earthquakes have been identified. Only two of these were sensed and reported by people.

In contrast, the Atlanta observatory records an average of about 60 teleseisms a month, a teleseism being an earthquake of which the focus (i.e., origin point) is more distant than 1,000 km. The waves recorded at ATL come from earthquakes with focuses in all the active areas of the earth's crust and upper mantle (no earthquake focus has been reported deeper than 700 km). Many teleseisms are just perceptible on the record and untold numbers of others go unrecorded because of their remoteness and small size. Occasionally a large event, disastrous in a populated area (as happened recently in Peru), occurs and the records show the disturbance for hours.

Since January 1970, the Atlanta observatory, in cooperation with the Atlanta Weather Bureau, has participated in an experimental program to transmit seismic data directly to the ESSA computers. In this manner, rapid publication of the machine computation of epicenter and magnitude is achieved with a minimum of data handling. After reading and processing here, the ATL seismograms are sent to

Rockville, Maryland, for microfilming and are made available to the scientific community.

Leland Timothy Long
Chemical Sciences and Materials Division

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GEORGIA TECH'S STATE TECHNICAL FIELD SERVICE

One of the major objectives of industrial development is to create jobs and thereby improve the economy of a community. Many people think of industrial development only in terms of the concentrated efforts to attract new industries and build new factories. This is the dramatic, much publicized side of industrial development.

Another side, however, much less publicized but equally important in creating jobs and upgrading a community's economy, is to strengthen existing business and industry. One method of doing this is to provide technical services and information to companies that do not have the advantages of large technical staffs or up-to-date technical and management libraries. To implement this method of industrial improvement, the Industrial Development Division (IDD) participates in a program to keep business and industry informed of the latest advances in management and technology and to assist in the application of this information.

This program, the Georgia State Technical Services Program, was created in 1965 and presently is supported entirely by state funds. Georgia Tech, the University of Georgia, and Georgia State University, as well as the Board of Regents of the University System of Georgia, all actively participate.

The Area Development Branch of IDD is responsible for the field services portion of this program. State technical field service professionals, operating from seven field offices strategically located throughout the state, contact industries in their areas and, by plant visits and interviews with key company personnel, try to determine how Georgia Tech can best assist them.

The field service representative has the responsibility of planning the company visits in his particular area. This plan sometimes includes visiting companies of certain sizes or certain industry groups; in some remote population centers, it could conceivably consist of visiting all industries in that area.

During the initial visit to a company, the field service man explains the various programs carried out by IDD and obtains pertinent information about the company. This information covers production equipment and capabilities, raw materials and waste (including potential air and water pollutants), sales and marketing, plant facilities and possible expansion plans. From this information, it is possible to determine what the company's technical information and assistance needs might be and how Georgia Tech might best assist in filling those needs.

Usually during this initial plant visit, the field service representative will have an opportunity to tour all of the manufacturing facilities. Often he is able to make on-the-spot recommendations for improvements. It sometimes is very difficult, however, to get company officials to expound on all the firm's problems and information needs. If the official is unable to effectively express or define his company's problems, the field service representative may be able to deduce from observations and conversations what the company's present and potential problems are and make the management aware of them.

A write-up of the interview, as well as the profile of the company, and any possible requests for information or assistance are sent to the field services headquarters in Atlanta. The information requests are screened and then either assigned to a researcher in the Industrial Development Division and his student assistants or directed to specialists on campus. Answers to these industrial questions can come either from reprints of pertinent articles, abstracts, and bibliographies or from visits by specialists.

In many instances, the field service representative will find that the information gathered by the research team at IDD in Atlanta, while very pertinent to the company's needs, is too technical for the level of sophistication or education of the company contact who will put it to use. In these cases, the field service representative must rely on his own technical background and knowledge of the company contact to interpret and explain the data. In some instances, even direct technical assistance in implementing the action plans stimulated by the proffered information is required.

The two prime measurements of the State Technical Field Service program's effectiveness are changes in company employment levels and changes in company profitability. Unfortunately, exact profitability figures are difficult to acquire, but many letters of appreciation from assisted companies attest to improvements in this area.

Employment change, however, is much more obvious, and its measurement has indicated that the State Technical Services program has been most effective. In a recent cost-benefit analysis conducted by a nationally known consulting firm, Arthur D. Little, Inc., six companies selected for evaluation out of more than 600 visited by Georgia Tech field service representatives indicated that the assistance provided by the State Technical Services program was instrumental in creating or saving over 300 jobs.

Ben E. James, Jr.
Industrial Development Division

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A NEW NUMERICALLY CONTROLLED MILLING MACHINE

The main machine shop of the Engineering Experiment Station recently acquired a new piece of equipment -- a two-axis numerically controlled milling machine with vertical spindle. This important new acquisition at Georgia Tech is located in the Electronics Building to take advantage of temperature-controlled space. It belongs to a class of automatically controlled machine tools developed during the last two decades, and it offers machining capabilities far beyond those of conventional manually controlled equipment.

The fundamental difference between numerically controlled and conventional machines is that the numerical control system can automatically direct all the elemental steps of even a complicated pre-programmed machining task without the direct intervention of the operator. Successive steps of a machining operation are performed according to a program on punched paper tape. For complicated programs, tape preparation can be done by direct computer output, while for simpler operations, the tape is more conveniently prepared with a manual punch device having a typewriter input. The prepared tape is then introduced into the control system by a reading mechanism, and the steps of the program are performed in sequence as they are read.

This type of control is termed "numerical" because commands to the machine must be specified in numerical terms. For example, locations of steps to be performed are stated in terms of a horizontal coordinate system (x,y) relative to an adjustable origin. Typical operations which can be done automatically by Tech's new machine are milling, drilling, tapping, and boring. The operator provides precise vertical control as needed. The machine's milling ability is greatly enhanced by the control system's capability for linear and circular interpolation. These two functions involve milling between specified points: in linear interpolation, the machine automatically selects x and y feed rates so as to mill a straight line between specified points, while in circular interpolation, a circular arc with a given center is automatically milled between specified end points.

As an exercise in learning to use these capabilities, the machine was programmed to mill the words "Sensor Systems" in both block letters and script. Each of these programs required less than two hours to prepare and mirror images of the words were produced by flipping a switch on the machine rather than by reprogramming.

Once a job is programmed, it can be done rapidly and with great accuracy ($\pm$ 0.001 inch in 24 inches positioning accuracy in the x,y plane, with $\pm$ 0.0005-inch positioning repeatability). In earlier work with similar equipment, we have accurately machined parts as large as 12 by 3 feet with a machining table only 20 by 40 inches. The capabilities of the new machine will be augmented in midsummer by the addition of a numerically controlled rotary table accurate to 10 seconds of arc.

Such features as the linear and circular interpolation make easy some machining tasks that are not practical manually. Another useful feature of the machine is its ability to work directly from a tabulation of x and y coordinates; this ability is particularly valuable in constructing high-precision components, especially those defined only by computer-tabulated data rather than exact mathematical equations. Once programmed, the machine can make duplicate items efficiently. The machine also lends itself to the very simple and rapid production of templates for both fabrication and checking purposes, an application which should be helpful to the work of many groups at EES. Other important considerations are that shop layout work is eliminated, that machining time is usually much lower than would be possible manually, and that human error is minimized in the machining process.

The addition of this machine has enhanced the research potential of EES. Its extreme versatility makes it applicable to a wide variety of machining tasks, and Tech's staff members are encouraged to explore the role it can play in their particular work.

Those desiring to make use of the new machine should contact Dan Thomas, Shop Foreman, at extension 237. For programming, call the undersigned at extension 151.

Wayne A. Novak
Electronics Division

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KORAD K-15 LASER

Commercial lasers operate in either continuous or pulse modes. The majority of lasers are the so-called continuous wave lasers in which the light is continuous with time and at relatively low power levels. The less common type of laser is the pulsed laser in which the light is intermittent pulses of extremely high power levels. The power levels of pulsed lasers have reached hundreds of megawatts.

Recently the Nuclear and Biological Sciences Division acquired a KORAD K-15 pulsed laser. With a ruby rod the wavelength of the light pulses is 6943 A, and with a neodynium rod the wavelength is increased to 10.6 microns. The laser can produce light pulses of energies up to 22 joules and can be fired at a repetition rate up to 40 pulses per minute. In the normal operating mode, the pulse durations are of the order of one millisecond and the power levels are of the order of 20 kilowatts. In the Q-spoiled mode, the pulse durations are shortened to about 10 nanoseconds with power levels up to about 65 megawatts.

Support equipment with the laser includes a calorimeter for measuring pulse energies and a photodiode for measuring pulse durations, power levels, and energies.

In addition, we have a frequency doubler so that the wavelengths can be reduced to 3471 A and 5.3 microns. A focusing device also is available which reduces the 1/2-inch-diameter beam to about 0.001 inch. A focused pulse of 20-joule energy can burn a hole through a 1/16-inch-thick steel plate.

The NBSD is eager to cooperate with researchers who wish to use the pulsed laser and its support equipment. Interested persons should contact the undersigned at extension 5291.

James H. Rust
Nuclear and Biological Sciences Division

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CERAMIC FOAMS

Extensive research by High Temperature Materials Division personnel has led to the development of ceramic foams with interesting scientific properties and with possible commercial applications. Basically there are two ways to fabricate porous ceramic structures: by incorporating a burnout material into the ceramic structure or by entrainment of air bubbles. A multitude of organic materials which disintegrate at temperatures above $800^{\circ}F$ can be used effectively as burnout particles, but the use of these materials produces a non-uniform porous structure. In recent studies, organic foaming agents, usually pure detergents, have shown great promise in forming ceramic foams with uniform cellular cross sections. Lightweight ceramic foams have been fabricated using these foaming agents. A density relative to the solid of 50% is readily achieved, and foams with densities of less than 20% have been made.

Lightweight ceramic foam structures are better thermal insulators than dense ceramics and therefore are useful for some high-temperature applications, such as furnaces. In addition, furnace walls can be formed in place at lower cost.

Fired ceramic foam articles have been coated to make their surfaces nonporous. Foams treated in this manner can be used as lightweight containers for liquids and in applications where a weatherproof surface is required.

With a novel single casting technique developed in the High Temperature Materials Division, composite structures of ceramic foams sandwiched between dense skins have been successfully fabricated. These composites show promise for use as electromagnetic windows in aerospace applications. The sandwich structure provides a low effective dielectric constant, and therefore, windows made of this construction can be used for applications requiring wide electromagnetic bandwidths.

Although a ceramic foam is not as strong as a dense structure of the same material, for some applications, the improved thermal and electrical properties and the lighter weight more than compensate for this difference. Our current research efforts are directed toward better fabrication techniques and stronger foams.

W. C. Miiller
High Temperature Materials Division

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THE GEORGIA TECH RESEARCH INSTITUTE

The Georgia Tech Research Institute (GTRI) is a nonprofit Georgia corporation established in 1937. It provides administrative support for the research programs of the Engineering Experiment Station, and it implements the use of EES staff and facilities by industry, by certain governmental agencies, and others. The Board of Trustees of GTRI is composed of representatives from the Georgia Tech faculty, from the Georgia Tech Foundation, from the Georgia Tech National Alumni Association, and from industry-at-large. In 1963 the Tech Administration established the Office of Research Administration to furnish centralized administrative support for research efforts conducted in areas other than EES. Harry L. Baker, Jr. heads the joint ORA/GTRI organization. Several other GTRI personnel also share appointments with ORA, and the joint operation occupies offices on the third floor of the Administration Building.

When a scientist has ideas, plans, or ongoing research programs for which he wishes to locate prospective sponsors, GTRI personnel may be of assistance in matching his program with that of such sponsors. Conversely, when a request for a proposal is received, a scientist with the desired capabilities is contacted through channels for possible preparation of a proposal. GTRI personnel who are conversant with the policies of both Georgia Tech and the sponsor will cooperate in the discussion of the material to be covered in the proposal. The scientist prepares the scientific program section and the draft of the budget estimate, while GTRI personnel supply the administrative and financial section as well as the letter of transmittal to inform the sponsor of the appropriate contact people on campus. After proper approvals are obtained and signatures are affixed, GTRI transmits the entire proposal to the sponsor. Deadlines for submission are carefully observed; consequently, scientists must allow sufficient lead time. Copies of all proposals are distributed on campus to the scientist and any staff who need to be kept informed of such activity. GTRI maintains complete records of each proposal submitted to a possible sponsor.

When a proposal is accepted by the sponsor, GTRI negotiates an agreement for the research project with acceptable terms and conditions. The analysis of the document received is based on knowledge of the sponsor's procurement procedures as well as the operating procedures of EES. Modifications to existing agreements also are negotiated as required to keep the document up to date with respect to changing situations.

Upon the acceptance and execution of an agreement for a research program, GTRI initiates the project, setting up and maintaining appropriate procedures and records to follow its progress and to assist the scientist in meeting all administrative requirements of the contract or grant document. As a matter of regular routine, the following steps are covered. Financial data are analyzed and invoices are rendered. Technical reports required by the agreement are transmitted and internal distribution is made on campus, with distribution records maintained as required. Invention and copyright checklists are processed, and the required patent reports are submitted. Records of Invention are processed and preliminary patentability searches are obtained. Advice of patent counsel is sought when needed, and assistance is provided to the inventor and counsel in preparing patent applications and in responding to subsequent U. S. Patent Office actions. GTRI negotiates license agreements and maintains liaison with the licensee to protect the interest of Georgia Tech and the inventor. Government property procedures are established and maintained by GTRI where title to the property remains with the sponsor. GTRI coordinates defense security matters for those situations which are subject to such regulations. The sponsor's approval is sought by GTRI when the scientist wishes to make changes in the conduct of the research program which are restricted by provisions of the agreement. When a research project is completed, the agreement is finally reviewed to assure that all terms and conditions are met, and then GTRI performs the necessary close-out actions.

Another of GTRI's activities in support of EES personnel is financial assistance for business purposes under transactions called "petty cash." Travel advances are provided for EES personnel on EES-related business trips. Items of business expense and moving expenses which are not reimbursable through other channels are reimbursed when properly approved. Advance registration fees are paid for EES personnel attending seminars, short courses, etc., pending reimbursement as a travel expense after completion of the course.

The GTRI staff has specialists assigned to assist EES personnel in each of the functional areas noted above. As a follow-up to this article, it will prepare and distribute a directory of its main contact persons in each of these areas.

A. A. Camp
Georgia Tech Research Institute

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PROFESSIONAL ACTIVITIES

Papers and Speeches

J. L. Brown, PSD, presented an invited paper on "Applications of Transmission and Scanning Electron Microscopy to Materials Science" at a meeting of the Louisiana Society for Electron Microscopy in New Orleans on March 5.

On June 22, W. H. Burrows, CSMD, delivered an invited paper, "Molecular Science in Surface Coatings," at the "Organic Coatings Technology" session of the University of Utah 1970 Polymer Conference.

"Electron Sources - The State-of-the-Art" was the title of a paper presented by R. K. Hart, PSD, at the Spring Meeting of the Southeast Electron Microscopy Society, Gainesville, Florida, April 10. J. L. Hubbard, PSD, presented two papers: "A Comparison of TEM and SEM Fractography" and "Scanning Electron Microscopy of Fibers."

W. H. Hicklin, PSD, gave a paper on "Dynamic Temperature Behavior of Quartz Crystal Units" at the 24th Annual Frequency Control Symposium held in Atlantic City, New Jersey, April 27-29.

Another invited paper, "Fluorocarbon Resin Finishes for Wood Cutting Tools," was presented by Charles I. Poole, IDD, before the Mechanical Conversion Section at the Forest Products Research Society Annual Meeting in Miami Beach, Florida, on June 30.

G. W. Simmons, PSD, read a paper on "Auger Spectroscopy for Studies of the Aging Factors of Quartz Resonators" at the 24th Annual Frequency Control Symposium in Atlantic City on April 27. At the American Physical Society meeting in Washington, D. C., April 30, he presented a paper entitled "Characteristic Energy Loss Spectra of Titanium, Vanadium, and Chromium."

At the American Nuclear Society Conference, J. R. Williams, NBSD, presented three papers: "Radiant Heat Transfer Parameters of High-Temperature, High-Pressure Aerosols" (W. L. Partain and J. D. Clement, coauthors), "Refractory Particle Clouds for Thermal Radiation Shielding Against Nuclear Blasts" (N. R. Byrn, coauthor), and "Monte Carlo Radiant Heat Transfer Analysis of Gas Core Reactors" (W. R. Jacobs, N. R. Byrn, and J. D. Clement, coauthors). At the AIAA Thermophysics Conference, he read a paper entitled "Thermal Radiation Absorption by Particle-Seeded Gases" (A. S. Shenoy, W. L. Partain, and J. D. Clement, coauthors). Both conferences were held in Los Angeles June 28-July 2. Dr. Williams and S. V. Shelton wrote a paper on "Gas Core Reactors for MHD Space Power Systems" which was presented at the AIAA 6th Propulsion Joint Specialist Conference in San Diego June 15-18.

Publications

K. K. Brandes and R. J. Gerdes, PSD, "Formation and Electrolytic Dissociation of the Potassium Compounds of Monohydronaphthalene and Monohydroanthracene," Zeitschrift fur Naturforschung, 25b, 176 (1970).

R. J. Gerdes, PSD, "Scanning Electron Microscopy of Materials without Conductive Coatings," 3rd Annual Stereoscan Colloquium, in press.

R. J. Gerdes and C. E. Wagner, PSD, "Scanning Electron Microscopy of Oscillating Quartz Crystals," Proceedings of the 3rd Annual Scanning Electron Microscope Symposium, O. Johari, Ed. (Chicago, Ill.), p. 441 (1970).

Charles I. Poole, IDD, "Particleboard," Mobile Home/Recreational Vehicle Dealer, May 5, 1970, pp. 96-98, and "Air Systems," MH/RVD, June 5, 1970, pp. 94-95.

Honors

John H. Burson, CSMD, completed his term as president of the one-year-old Fine Particle Society by presiding at its First National Meeting, which was held in Chicago on June 17 at the Illinois Institute of Technology Research Institute. He is beginning a term on the Council of the Society, which now has approximately 350 members in 15 countries.

Charles I. Poole, IDD, has been elected a director of the Atlanta Chapter, AIIE.

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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