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News Briefs

General Developments

Inquiries about News Briefs, where no contact person is identified, should be referred to the Managing Editor, Journal of Research, National Institute of Standards and Technology, Administration Building, A635, Gaithersburg, MD 20899-0001; telephone: 301/975-3572.

AGENCIES TARGET HELP FOR POLLUTION PREVENTION

With generally limited financial and technical resources, small and mid-sized manufacturers are particularly vulnerable to the increased costs that accompany strict environmental rules. Therefore, the NIST Manufacturing Extension Partnership and the Environmental Protection Agency have established a joint pilot project to help these companies apply innovative pollution prevention tools and strategies. The pilot is part of a planned multi-year program where the two agencies will assist companies in the selection of currently available technologies and techniques to reduce or eliminate pollution sources in manufacturing. Also planned is the development of pollution-prevention assessment procedures suitable for small and mid-sized manufacturers. The field work will be done through the Great Lakes Manufacturing Technology Center in Cleveland, one of seven MTCs in the MEP. The pilot program will concentrate on screw machine, metal stamping, and electroplating facilities, which are in large numbers in the Great Lakes region. For more information, contact David Gold, B115 Polymer Building, NIST, Gaithersburg, MD 20899-0001, (301) 975-5020.

NIST, ALASKA EVALUATE IMPACT OF BURNING OIL SPILLS

To state of Alaska officials, "burning the midnight oil" may soon take on a whole new meaning. Using computer modeling, NIST is helping the Alaska Department of Environmental Conservation better understand the impacts of burning spilled oil. Two main questions need to be answered: "How much smoke will be produced?" and "How far will the smoke spread?" As part of a cooperative research and development agreement, a new version of a NIST-developed computer model called LES (Large-Eddy Simulation) will predict smoke concentrations up to 30 km downwind of a simulated oil spill fire. ADEC has devised likely oil-spill scenarios to use in the program and has provided two types of Alaskan crude oil for testing. In laboratory tests, NIST will burn the oil in 1.2 m pans to get data for LES, such as the smoke production rate and the size of particulates in the smoke. NIST researchers also may develop yet another version of LES to predict the effect that land features, such as mountains, might have on smoke movement. This 3 year project will help ADEC develop guidelines officials at an oil-spill site can use to evaluate the effects of burning.

NEW LAB FOCUSES ON NOVEL MACHINE-TOOL DESIGNS

A new NIST laboratory will study applications and control strategies for innovative forms of machine tools. Initial efforts will focus on a potentially revolutionary design featuring a Stewart platform (also the basis for the floating platform in mechanical flight simulators) suspended from an octahedral support frame. Several machine-tool makers are

pursuing variations of this concept because the combination of rigid frame and six-axis machining capability promises important advantages over conventional machine-tool designs, including lower cost, greater flexibility and reliability, and higher accuracy. For example, a private company has developed a spider-shaped prototype called an octahedral-hexapod machine. Last year, the company received an Advanced Technology Program grant to help it evaluate and refine its prototype. Through a competitive bidding process, NIST intends to purchase an octahedral-hexapod machine, built to its specifications, for the new Advanced Machine Tool Structures Laboratory. NIST research will focus on developing computer-control architectures that maximize machine-tool performance and versatility, and on factors influencing the dimensional accuracy of the machining process. For more information, contact E. Clayton Teague, A117 Metrology Building, Gaithersburg, MD 20899-0001, (301) 975-3490.

SOFTWARE DESIGNED TO SAVE ENERGY AND DOLLARS

NIST has developed a set of four computer programs that can help building designers, owners, and managers evaluate costs and savings of energy conservation projects and select projects with the lowest life-cycle cost. For example, the Building Life Cycle Cost, or BLCC, program can be used to determine the most economical level of attic insulation, select the most cost-effective heating and cooling system, or evaluate the cost effectiveness of a solar heating system. Another program called DISCOUNT can evaluate individual components of a life-cycle cost problem, such as the present value of annual energy savings over 20 years. A third program, ERATES, evaluates electricity costs based on time-of-use, block-rate, and demand-rate schedules. These programs are designed to run on most IBM-PC-compatible microcomputers. No special hardware or graphics capabilities are required. The programs are available from several vendors for a nominal cost. NIST building economists also offer life-cycle cost workshops and training videos. For a brochure with more information, call the NIST Office of Applied Economics at (301) 975-6132.

CERAMIC "CHEFS" FINE-TUNE RECIPES WITH NEW OVEN

All soufflé chefs know that if you open the oven door during baking, the dish is ruined. Ceramics developers have a similar problem. When sintering or firing ceramic powders at high temperatures, they typically must rely on trial and error to produce materials with the right properties. To overcome this drawback, NIST materials scientists have installed a unique furnace at the institute's Cold Neutron Research Facility that could help speed up research efforts. Paired with a small-angle neutron scattering instrument, the new furnace allows researchers to observe changes in the microstructure within ceramic materials in real time throughout the sintering process. Cold (slowed) neutrons are directed through a ceramic sample within the furnace, and the pattern of "scattering" produced as the neutrons re-emerge provides information about "grain sizes" and other structural features critical to the material's ultimate properties. For more information, contact Gabrielle Long, A163 Materials Building, NIST, Gaithersburg, MD 20899-0001, (301) 975-5975.

NO "SECOND GUESSING" WITH NIST TIME SERVICES GUIDE

Persons interested in time, timekeeping, and precise time and frequency measurements will want to get a new paper available from NIST. Titled Time and Frequency Services Offered by the National Institute of Standards and Technology, it describes in some detail shortwave radio stations WWV and WWVH, low-frequency radio station WWVB, satellite time services, and the Automated Computer Time Service. It also discusses two services for persons needing the most accurate time and frequency signals possible. Future trends in NIST services are discussed, including greater use of Global Positioning System satellites and optical communication technology. For a copy of this paper, contact Sarabeth Moynihan, Div. 104, NIST, Boulder, CO 80303-3328, (303) 497-3237. Ask for paper no. 37-93.

FEBRUARY MEETING TO FEATURE 1993 BALDRIGE WINNERS

"Quest for Excellence VI," Feb. 6–9, 1994, at the Washington Hilton and Towers in Washington, DC, will be the first conference to feature presentations by all of the 1993 recipients of the Malcolm Baldrige National Quality Award. The award recipients were announced in October. Chief executive officers and other team members from the winning companies will describe in detail their quality improvement strategies and results. The conference provides a unique networking opportu-

nity for people from across the country to exchange plans and ideas for quality and productivity improvements. It is being co-sponsored by NIST, the American Society for Quality Control, and the Association for Quality and Participation. For more information about "Quest for Excellence VI," call (301) 975-2036.

TWO COMPANIES RECEIVE 1993 BALDRIGE AWARD

The 18th and 19th winners of the Malcolm Baldrige National Quality Award were announced by President Clinton on Oct. 18, 1993. The companies are Eastman Chemical Co. (Kingsport, Tenn.) in the large manufacturing category and Ames Rubber Corp. (Hamburg, N.J.) in the small business category. Eastman Chemical, a division of Eastman Kodak Co., ranks as the 10th largest chemical company in the United States and 34th in the world. It manufactures and markets over 400 chemicals, fibers, and plastics for 7,000 worldwide customers—over 70 percent of whom rated Eastman their number one chemical supplier for the past 4 years. Founded in 1949, Ames Rubber produces rubber rollers for office machines and is the world's largest manufacturer of rollers for mid- to large-sized copiers. Quality improvements have saved the company and its customers more than $3 million, an average of $2,700 for each of its 445 employees in 1993. The two winners were honored for their world-class systems of management, employee involvement, and customer satisfaction at a ceremony in Washington, DC, in November.

NEW DENTAL MATERIAL CONTAINS NO MERCURY

A mercury-free, direct filling alternative for conventional dental amalgams is being developed at NIST in a collaborative effort between government and industry. The new restorative process uses metallic powders in a form easily applied to prepared tooth cavities with treatment procedures very similar to those in current dental practice. The National Institute of Dental Research is contributing support for the program through the American Dental Association Health Foundation's Center for Excellence. The ADAHF maintains the Paffenbarger Research Center at NIST. The restorative process, based on NIST electrochemical powder technology, was invented by a NIST scientist, and a guest scientist from Israel. The material involves the use of biocompatible metallic powders such as silver-coated tin. These pairs of metals undergo fast diffusion or combine to form an in-situ intermetallic compound at body temperature. According to the NIST scientist, the new restorative material could be in dental offices within 3 years.

TECHNOLOGY CENTERS TO HOST SBA EXPERTS

The Department of Commerce and the Small Business Administration have agreed to establish Small Business Development Center subcenters at the seven current Manufacturing Technology Centers sponsored by Commerce's NIST. Under the agreement, NIST intends to provide the MTCs with funding—up to $250,000 per center per year—to finance the subcenters for a 3-year trial period. SBDCs supply a wide range of financial and business planning services for small and mid-sized companies. The new subcenters will not only give MTC clients improved access to SBA programs but also will provide specialized services geared to needs of manufacturers. Specific details of each subcenter's operation will be decided by the associated MTC, working with the lead SBDC agency in that state. Following MTC practice, the SBDCs will be tailored to meet the specific needs of manufacturers in their service areas.

PANEL TO ADDRESS OPEN SYSTEMS COMPATIBILITY

Due to the incompatibility of two major computer networking protocol suites, NIST has named an interagency panel to review open systems network requirements and recommend policies on the use of networking standards by the federal government. The Panel on Federal Internetworking Requirements will consider the comparative strengths of the Internet Protocol Suite and Open Systems Interconnection specifications, two widely used, yet incompatible, protocol suites. The IPS and OSI specifications for computer communications provide many similar capabilities for interconnecting computers; local-area, wide-area, and other networks; and for routing information between computers. The panel will review the government's requirements for network features such as security, ease of use, national and international connectivity, and standards maintenance. Interoperability requirements, agency costs, and the role of protocols not in OSI or IPS specifications also will be considered. The panel is expected to issue a report in January 1994.

NEW STANDARD RANDOMLY CHOOSES COMPUTER PASSWORDS

For computer users who continue to rely on traceable passwords such as the name of a pet, a nickname or birthday, a new standard has been approved that may make their lives a bit easier. The Automated Password Generator, specified in NIST's Federal Information Processing Standards Publication 181, produces random passwords that are pronounceable, easily remembered, stored and entered into computer systems, yet are not readily susceptible to automated techniques that have been developed to search for and disclose passwords. Use of this algorithm adds an extra layer of security to protected computing resources. This standard complements the Password Usage Standard (FIPS 112), which specifies basic security criteria for the design, implementation, and use of passwords. Copies of FIPS PUB 181 will soon be available for purchase from the National Technical Information Service, Springfield, VA 22161, (703) 487-4650. For further information, contact Charles Dinkel, A216 Technology Building, NIST, Gaithersburg, MD 20899-0001, (301) 975-3367.

TWENTY-NINE GRANTS ANNOUNCED FOR ATP FOURTH ROUND

Commerce Secretary Ronald H. Brown announced on Nov. 4 the awarding of 29 grants for the fourth round of the Commerce Department's Advanced Technology Program. The NIST-administered grants are designed to accelerate the development and commercialization of promising, high-risk technologies with substantial potential for enhancing U.S. economic growth. These latest awards will help finance the multiyear R&D projects with a projected total cost of $118 million, of which some $60 million will be funded by the ATP. The new programs selected for funding included proposals in technology areas such as communications and information systems, biotechnology, electronics, manufacturing, and advanced materials. More than 50 companies, universities and research institutions —including more than 20 small businesses—will participate directly in work supported by these awards. Five grants went to joint ventures. Funding for the ATP program itself will rise from $68 million in fiscal year 1993 to nearly $200 million in FY 1994. The president's technology strategy calls for the program to grow to $750 million by FY 1997.

LASER LIGHT USED TO FOCUS ATOMS ON SURFACES

NIST physicists have successfully demonstrated a rapid new process for fabricating infinitesimally small metallic structures. The new process, known as "atom optics," manipulates chromium atoms into precise locations on a silicon surface using laser light. This technique of focusing chromium atoms opens new avenues for creating smaller and faster electronic devices. The physicists report their discovery in the Nov. 5 issue of Science. NIST physicists have patterned structures by channeling chromium atoms between the peaks in a light wave. As focused by laser light waves, the chromium atoms form tiny parallel rows on a silicon surface. Each row is approximately 65 nm wide, about one-thousandth the diameter of a human hair. These rows, visible with a scanning electron microscope, are about 34 nm high and 213 nm apart. Although other scientists have used light to focus sodium atoms, the NIST experiment marks the first time this technique has been used to create durable metallic structures. For more information, contact Jabez McClelland, B206 Metrology Building, NIST, Gaithersburg, MD 20899-0001, (301) 975-3721.

"ELECTROMAGNETIC BOTTLE" TRAPS IONS FOR STUDY

An exotic form of matter was recently created when NIST physicists stripped 46 electrons from a barium atom in the institute's new Electron Beam Ion Trap—or EBIT—Facility. The EBIT Facility holds the supercharged atoms with a force field that compresses them into a tiny column at the center of a vacuum chamber. In this 2 cm long and 60 μm wide (the width of a human hair) column, a powerful electron beam rips electrons from atoms injected into the trap. Superconducting magnets help hold the atoms, now missing most or all of their electrons, inside what could be considered an "electromagnetic bottle." As the electron beam excites these highly charged ions, they absorb and emit photons. NIST physicists use the energy spectra of these emitted photons to study quantum electrodynamics, the interaction of virtual matter/anti-matter particles with ions. The EBIT Facility also can help determine how ions behave in solar flares, black holes, and nuclear explosions. Possible industrial applications include the use of exotic ion beams in micromachining surfaces and nanofabri-

cation of electronic devices. NIST's EBIT was built by and operates under a collaboration between NIST and the Naval Research Laboratory, and follows pioneering work done by a group at the Lawrence Livermore National Laboratory.

1994 BALDRIGE CRITERIA FOCUS ON BUSINESS PLANNING

This year's criteria for the Malcolm Baldrige National Quality Award highlight the importance of integrating quality and operational aspects, such as manufacturing and service delivery strategies, into overall business planning. The seven criteria categories—leadership, information and analysis, strategic quality planning, human resource development, and management, management of process quality, quality and operational results, and customer focus and satisfaction—remain basically the same. Over one million copies of the award criteria, which double as quality improvement guidebooks, are in use worldwide. The criteria are accepted widely as the definition of what constitutes world-class quality. Individual copies of the 1994 award criteria, along with the 1994 application forms and instructions, are available from NIST by calling (301) 975-2036. Multiple copies in packets of 10 can be ordered for $29.95 plus postage and handling from the American Society for Quality Control, (800) 248-1946. ASQC's order number is T998. NIST manages the award program in conjunction with the private sector.

1994 NIUF MEETING DATES ANNOUNCED

Users and implementors interested in the Integrated Services Digital Network, which utilizes telephone lines to transmit voice, graphics and computer data simultaneously, are welcome to the 1994 meetings of the North American ISDN Users' Forum. The NIUF will meet first on Feb. 8–11, 1994, at the Hyatt Regency Tech Center in Denver, CO. Locations for the other meetings, June 20–24, 1994, and Oct. 3–7, 1994, have not been announced. The NIUF is a collaboration between NIST and industry partners who have a stake in using, implementing or providing service for ISDN. Previous meetings addressed the NIUF's participation in the National Information Infrastructure, impact on mass markets, and network interoperability. For more information, contact Dawn Hoffman, B364 Materials Building, NIST, Gaithersburg, MD 20899-0001, (301) 975-2937, fax: (301) 926-9675.

NEW DEVICE IMPROVES MAMMOGRAPHY IMAGING

A new NIST invention, an x-ray crystal diffraction spectrometer, can help radiologists improve image quality in mammography, one of medicine's most important breast cancer screening tools. The quality of a mammogram, an x-ray image of breast tissue, is determined in part by the electrical voltage that generates x rays in a mammographic unit. A radiologic technician sets the voltage on the unit based on the thickness and tissue density of the breast. The NIST spectrometer will be used as a calibration device. When placed in the x-ray beam, the device tells whether the actual voltage agrees with the indicated voltage. The x-ray crystal diffraction spectrometer, a metal box about 46 cm in length, measures the electrical voltage over the range used in mammography more accurately than any existing method. The research was reported in the November/December 1993 issue of Medical Physics.

SOFTWARE HELPS PREDICT, SOLVE MOISTURE PROBLEMS

Researchers at NIST and the Virginia Polytechnic Institute and State University have developed a user-friendly computer program called MOIST that predicts moisture accumulation in walls and ceilings. Too much moisture can cause nails to pop; paint to blister; wood beams to bow, shift or decay; insulation to thermally degrade; and indoor air to develop quality problems. For example, in 1992, a courthouse in Polk County, Fla., was closed for renovations costing $16 million—almost half of the original cost of the building. The problem: moisture trapped in the walls and ceilings allowed the growth of mold and mildew, causing a serious indoor air quality problem. With MOIST, users can define a wall, cathedral ceiling or low-slope roof construction, and then vary the type and placement of building materials. MOIST can determine whether a vapor retarder is needed and, if so, where it should be placed. It also can be used to evaluate the effect various paints, wall coverings, and climate have on moisture accumulation. Free copies of the MOIST software are available by writing to Doug Burch, B320 Building Research Building, NIST, Gaithersburg, MD 20899-0001.

NEW "ONE-STOP" INDUSTRY GUIDE TO NIST AVAILABLE

A new publication describing more than 250 different research projects, grants, and industry outreach programs at NIST is now available both in print and via electronic mail. The 116-page Guide to NIST includes sections on the Advanced Technology Program; the Manufacturing Extension Partnership; all major NIST programs (with contact names, addresses, phone numbers and e-mail addresses); electronic bulletin boards and information retrieval systems; research consortia; grants; publications; mechanisms for collaborative research; facilities; and a detailed subject index. For a free printed copy, send a self-addressed mailing label to the NIST Public Affairs Division, A903 Administration Building, NIST, Gaithersburg, MD 20899-0001; or fax requests to (301) 926-1630. Full text of the report is available electronically through the Internet Gopher system. From a remote log in, type "telnetgopher.nist.gov". At the log-in prompt, type "gopher". From a gopher client, use the gopher server as "gopherserver.nist.gov" with port 70. The electronic version of the guide allows for customized searches of topics of interest.

MEASURING ENERGY FLOWS IN A SUPER-COLD REFRIGERATOR

In the late 1980s, NIST developed a super-cold refrigerator with no moving parts in the cold end. Termed an orifice pulse tube refrigerator, or OPTR, it has a variety of potential uses in infrared sensor, vacuum pump, and medical technology. A recent NIST paper describes a technique allowing for the instantaneous measurements of mass flow rate, temperature, and pressure during the operation of an OPTR. The paper presents the values of enthalpy, entropy, and work fluxes at the cold end of the pulse tube evaluated from the measurements. These results will aid in improving input parameters to the analytical model developed at NIST, as well as verifying model predictions. The experimentally measured enthalpy flows and refrigeration powers within the pulse tube ranged from 60 percent to 85 percent of the ideal values from the NIST adiabatic model. For a copy of paper 40-93, contact Sarabeth Moynihan, Div. 104, NIST, Boulder, CO 80303-3328, (303) 497-3237.

NIUF GROUP STUDIES ISDN WIRING INSTALLATION

Professionals who own a small business or work in a home office may dream of the productivity possible with an advanced telecommunication service like the Integrated Services Digital Network. While such services are more commonly found in large businesses, a joint government-industry group is working to remove some barriers to general use of ISDN. The North American ISDN Users' Forum formed a Wiring and Powering Working Group to develop guidelines for those who install ISDN wiring for residential and small business customers. To date, most of the practical information for installing this high-technology equipment is incomplete and targeted primarily at large businesses. The working group is trying to make it easier for customers in all market segments—not just large business—to get hooked up. The effort is supported by several major industry players, including ISDN service providers, component vendors, installers, and communication planners. The NIUF, a collaboration between NIST and industry, helps users and manufacturers to concur on ISDN applications, standards, and conformance tests. For more information about the Wiring and Powering Working Group, contact Steve Halpern, NYNEX Science & Technology, 500 Westchester Ave., Room 2G19A, White Plains, NY 10604, (914) 644-2581, email: sjh@nynexst.com (via Internet).

EM MATERIALS MEASUREMENTS FOCUS OF NEW REPORT

In recent years, many industries have recognized a critical need for reliable data on electromagnetic properties of various materials. A new publication, NIST Measurement Service for Electro-magnetic Characterization of Materials (NISTIR 5006), presents an overview of special test and measurement services for characterizing dielectric and magnetic properties of materials at radio and microwave frequencies. For these services, NIST uses three automatic network analyzers that cover the frequency range from 100 kHz to 26.5 GHz. The publication describes measurements of permittivity and permeability using coaxial transmission line systems, waveguide systems, and several types of resonators.

The most widely used line system is the 7 mm coaxial airline with a frequency range from direct current (zero hertz) to about 18 GHz. The most widely used waveguide system uses X-band (WR-90) waveguide, which covers the frequency range from 8.2 GHz to 12.6 GHz. NIST's resonators are used for accurate measurements of loss tangents of low-loss materials. Also available is a software package for complex permittivity and permeability determination during transmission-line measurements. Copies of NISTIR 5006 are available from the National Technical Information Service, Springfield, VA 22161, (703) 487-4650. Order by PB 94-110186.

ATOMIC CLOCK, WEAR-RESISTANT ALLOY RECEIVE HONOR

Popular Science magazine has selected two NIST technologies, the NIST-7 atomic clock and a biocompatible alloy that resists fracture and wear, as among its "Best of What's New in 1993." The list honors what the publication considers "the year's 100 most significant new products and achievements in science and technology." Both NIST winners are featured in a special section in the December 1993 issue of the magazine. Started up in April 1993, NIST-7 is the seventh generation of atomic clocks built by NIST's Time and Frequency Division in Boulder, CO. It neither gains nor loses a second in 1 million years. The development of the new alloy—a biocompatible mixture of zirconium, palladium, and ruthenium—was announced in January 1993 at NIST's Paffenbarger Research Center in Gaithersburg, MD. Tests show that under applied stress normally large enough to produce a change in shape, the alloy undergoes internal changes that actually increase its ability to resist further deformation and wear. It is being researched as a potential material for dental and medical devices, and holds significant promise as an industrial coating where high-performance materials are required for bearing surfaces and mechanical joints.

INTERAGENCY COMMITTEE ON STANDARDS POLICY ISO 9000 CLEARINGHOUSE

NIST has issued a fact sheet, entitled "Federal ISO 9000 Related Activities," which summarizes information received by NIST on ISO 9000-related activities in the Departments of Education, Commerce, Health and Human Services, Interior, Labor, and State, as well as the Federal Trade Commission, General Services Administration, U.S. International Trade Commission, Nuclear Regulatory Commission, Office of Management and Budget, and the U.S. Postal Service. The fact sheet also includes information on foreign government use of the ISO 9000 Standards and is the result of a recommendation by the newly formed Working Group on ISO 9000 of the Interagency Committee on Standards Policy (ICSP) that NIST should serve as the ICSP ISO 9000 clearinghouse for dissemination of information on federal agency activities related to the ISO 9000 Standard Series.

The fact sheet is available to federal agencies and others with an interest in such activities. Additional fact sheets on federal agency ISO 9000-related activities will be issued as new or revised information is received by the clearinghouse.

PATENT ISSUED ON SENSOR TO DETECT AND CLASSIFY SUBMICROMETER PARTICLES

NIST has received a patent on a solid-state sensor capable of detecting particles having dimensions down to 0.1 μm. The patent, number 5,218,211, was issued June 8. The target application is for the detection of particles in the ultra-clean environment required for the manufacture of integrated circuits. The sensor consists of a dime-sized "monolithic" array of individually addressable, photosensitive pixels connected to a hardware/software electronic subsystem. The array is activated by illumination with an electronically alterable spectrum of electromagnetic radiation. The device includes a screen patterned with apertures of different sizes and geometries designed to facilitate the extraction of particle-size distributions using neural network algorithms. To date, just over a dozen companies have made preliminary inquiries about the patent.

METHOD DEVELOPED FOR CHARACTERIZING PLANAR TRANSMISSION LINES FORMED ON LOSSY SUBSTRATES

Two NIST scientists have developed a method that should, for the first time, provide accurate determinations of the characteristic impedance of a microwave planar transmission line formed over a lossy or dispersive dielectric as substrate. Planar transmission lines are typically miniature structures and are essential components in applications such as monolithic microwave integrated circuits, printed-circuit boards, and special modules for high-performance computers. As the speed of advanced silicon digital circuits increases, microwave lines will be required for mainstream

silicon as well. The new method, known as the calibration comparison method, also determines the resistance, inductance, capacitance, and conductance per unit length of the line. That the conventional method used to estimate the characteristic impedance of lines fabricated on lossy dielectrics had problems was demonstrated by applying that method to a line formed over quartz, effectively a lossless substrate, for which the characteristic impedance can be determined as a function of frequency by other means. The plot of the real part of the characteristic impedance as a function of frequency showed values that agreed with the actual values at only a few points. The major problem in demonstrating the validity of the new method is that there is no other method to serve as a reference.

The scientists tested their method two ways. In the first test they used their method to determine the characteristic impedance of a line formed over quartz and showed good agreement with the actual values. In the second test, they fabricated four transmission lines with as near identical geometries as possible, one over gallium arsenide (effectively lossless) and the other three over silicon having differing conductivities. On applying their method, they found that the resistance and product of frequency and inductance for all four lines as a function of frequency was in good agreement, indicating that the method is consistent in determining them and that, as expected, these properties are independent of the substrate.

NIST IMAGES MAGNETIC RECORDING HEAD WITH NEW MAGNETIC-FORCE MICROSCOPE

Three NIST scientists have applied a new form of magnetic-force microscope having a non-vibrating sensing tip to image a thin-film recording head. This variation of magnetic-force microscopy, known as DC magnetic-force microscopy, provides direct correlation of magnetic fields to the pole pieces, as it simultaneously provides an atomic-force microscope image of the surface topography with the magnetic image. The magnetic force is calculated as the product of the spring constant of the cantilever probe and the deflection of the tip. The field gradient can then be determined. Since control of the separation of the probe tip from the scanned specimen is not dependent on the magnetic-force signal, the separation can be varied and, in particular, can match the flying height of a head above its magnetic media in a drive.

NIST-LED IEEE WORKING GROUP RECOGNIZED FOR DEVELOPMENT OF SURGE VOLTAGE DOCUMENT

Recently, the Power Engineering Society of the Institute of Electrical and Electronics Engineers recognized its Working Group on Surge Characterization in Low-Voltage Circuits for the development of IEEE Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits, C62.41-1991. This activity was led by a NIST scientist, who was both a major contributor to the over-100-page practice and coordinator for the efforts of the 28 member group.

Almost all who use computers have experienced a problem resulting from a power-line surge, whether the cause was a failure of equipment in a building distribution system or a close lightning strike from a summer thunderstorm. The practice addresses needs on the part of designers of equipment (such as computers) to provide an appropriate degree of surge-withstand capability in their products, on the part of users to specify appropriate surge-withstand capabilities, and on the part of test instrument suppliers and test laboratories for a limited set of well-defined test waveforms. The NIST scientist was the chief architect of the successful effort to simplify an extremely complex database on surges into the desired limited set of representative surge waveforms. The practice provides a basis for determining and designing voltage and current tests to be applied to equipment connected to power lines and discusses a variety of topics, including the origin of surge voltages, rates of occurrence and voltage levels that can be experienced in unprotected circuits, waveshapes of representative surge voltages, and the energy that surges can contain. The practice defines three categories of equipment location based on the relative position of the equipment with respect to the building service entrance. For each category, the practice provides two recommended "standard waveforms" and three suggested "additional waveforms" for surge voltage and surge current.

NIST'S LIGHT SCATTERING TAXONOMY HIGHLIGHTED IN *APPLIED OPTICS JOURNAL*

The July 1 issue of Applied Optics featured a collection of articles from the Optical Society's topical meeting on Surface Roughness and Scattering held in 1992. The issue's cover shows illustrative highlights from the conference and includes a taxonomy of light-scattering properties from rough surfaces

developed by NIST researchers for their article, "Regimes of Surface Roughness Measurable with Light Scattering," based on their presentation at the conference. The NIST taxonomy shows how different statistical properties of rough surfaces may be derived from light scattering depending on the ratio of the rms roughness to the wavelength of the incident light. The article also presents rules of thumb for distinguishing between the various regimes. This scheme represents a summary of previous experiments of the NIST researchers along with the work of many others in the field. Light scattering is an important technique for measuring the surface quality for a wide range of industrial components including optical elements and mechanical parts.

NIST CMM TEST DEVICE COMMERCIALIZED

The CMM interim testing standard invented at NIST has been commercialized by a major manufacturer of coordinate measuring machines (CMMs) and dimensional metrology equipment. Designed and developed by NIST scientists and engineers, the CMM interim testing standard was a joint effort between NIST, DOD, and private industry. The interim testing standard, a device employing kinematically mounted calibrated ball bars, is designed to detect faulty CMMs so that they can be removed from service before a significant problem develops. Fast and efficient, the interim testing standard can conduct a CMM system evaluation in typically 15 min. Early prototypes were field tested in quality conscious corporations through a cooperative research and development agreement with NIST.

ULTRATHIN FILM SnO_2 GAS SENSORS

Tin oxide has been used in carbon monoxide and combustible-gas sensors for many years. In these devices, sensing is achieved by monitoring the change in surface conductance when an analyte gas chemically interacts with the oxide surface. In commercially available devices, the active oxide material is in a bulk, polycrystalline form. While sensing performance in these devices is adequate for some applications, their utility is limited by slow and non-reproducible response characteristics. A major cause for these irreproducibilities in surface conductance is diffusion of oxygen atoms from the bulk to the surface. Because bulk diffusion is a relatively slow process, an undesirable, slowly drifting baseline-conductance occurs.

Scientists at NIST have been investigating alternative sensing materials and structures that would simplify the transduction process and improve sensor response characteristics. These alternatives include highly ordered, epitaxial films to address the problem of baseline drift. They theorize that by fabricating sensors using ultrathin films, films with essentially no bulk, the problems of baseline drift would be alleviated. Recently they have succeeded in producing 1.5 nm to 8.0 nm thick epitaxial tin oxide films on single crystal sapphire substrates. Conductance measurements were made while exposing the films to pressure cycles of prototypical oxidizing and reducing gases, O_2 and H_2, in an ultrahigh vacuum chamber. All the films, even for thickness down to 1.5 nm, showed sensing responses to O_2 and H_2. This result is quite remarkable because it requires that the 1.5 nm thick film, only 5 or 6 atoms thick, be electrically continuous over the 1 mm length scale of the conductance measurement. Most significant, however, is the observation from the initial studies that the 1.5 nm thick films exhibit less drift than the thicker films. This supports the original conjectures concerning the source of the drifts and the proposed approach to reducing drifts. Current research is extending the sensor response studies to higher pressure regimes and investigating the sensing response to other analyte gases such as CO and methane. These studies are an important step in the development of conductometric gas sensors that are more quantitative and reliable.

NEW COLLISIONAL PROCESS RESPONSIBLE FOR RADIATION DAMAGE IN COMPOUNDS

A specific collisional process that is due to electron-transfer collisions has been identified by a NIST scientist and guest researchers working in collaboration with researchers at the Jagellonian University in Poland. The results, obtained from electron emission spectra of ion-bombarded ionic crystals, define a new class of inelastic collisions in solids that are basic to defect production and chemical modification. In these collisions, the electron-transfer step involves lattice ions that are displaced and are no longer chemically bound. Such collision-induced electron transfers thus can change the chemical state of stable compounds, can switch interaction potentials, and can induce free-atom migration in the solid. The electron-transfer reactions are a fundamental component of radiation damage mechanisms in compound materials.

This type of collision event, identified at NIST, is the basis for the first mechanism to describe how collisions in solids can initiate electronic processes responsible for materials modification. Applications of this electron-transfer mechanism are found in chemical sputtering and plasma-assisted etching in ion track formation, and in the long-term stability problem of nuclear waste-storage materials where internal collisions can alter the chemical integrity of the material.

EIGHTH NATIONAL SYNCHROTRON RADIATION INSTRUMENTATION CONFERENCE CONVENED AT NIST GAITHERSBURG CAMPUS

The biennial National Synchrotron Radiation Instrumentation Conference was first organized by and held at NIST in 1979 and has since been hosted by each of the U.S. national synchrotron radiation facilities. The cycle has taken 14 years for the conference to return to NIST, where it was held Aug. 23–26. Growth in the field of synchrotron radiation during this period is indicated by a tripling of the number of papers presented at the conference. At the eighth meeting, first reports were made of operations of three new U.S. facilities, and progress and planning reports were made concerning several more. There were more than 200 attendees at the meeting, and 20 industrial firms exhibited equipment.

Synchrotron radiation sources cover the entire electromagnetic spectrum. They are of particular interest as sources of x-ray radiation, where they provide the practical basis for a wide range of research in biology, materials science, chemistry, and physics. Most research on applications of x rays also utilizes synchrotron radiation, such as x-ray angiography, microscopy, and lithography. NIST maintains an in-house synchrotron radiation source, the SURF II Synchrotron Ultraviolet Radiation Facility, which is a national standard for absolute radiometry in the soft x-ray spectral region, and also supports measurement and research programs in atomic, molecular, and surface physics. Scientists from several NIST laboratories also make extensive use of the higher-energy radiation from other synchrotron facilities.

DEVELOPMENT OF TUNABLE, PULSED SOLID-STATE LASERS IN THE VISIBLE

Clusters of atoms, the amorphous transition state between the gaseous, liquid, and solid states of matter, are the latest challenge to the ancient science of spectroscopy. Of particular interest is the ability to prepare individual quantum states of a cluster and then to probe the dynamics of these precisely selected states in real time. One invaluable tool is a narrow-band, tunable infrared (IR) laser that produces pulses for pumping specific rovibrational states of the cluster. NIST scientists recently have developed such a method for generating Fourier-transform-limited (0.005 cm^{-1}), high-energy (5 mJ) pulses of tunable IR light by "seeding" an optical parametric oscillator (OPO) pumped at frequency ω_3 (from a pulsed, frequency-tripled Nd:YAG) with a single-mode, continuous-wave (cw), ring dye laser. The OPO cavity is locked onto the dye laser via polarization servo-loop schemes and generates intense, spectrally narrow pulsed output both at the dye laser frequency, ω_1, and the difference frequency, $\omega_2=\omega_3-\omega_1$. By replacing the "seed" dye laser with cw tunable, IR diode lasers, this difference-frequency scheme illustrates a novel method for generating tunable light pulses throughout the visible region, but based entirely on solid-state lasers.

CRADA WITH AISI FOR ON-LINE MAGNETIC MONITORING OF STEEL

To maintain quality control of coiled sheet steel, mechanical properties must be monitored throughout the entire length of the coil, with feedback to control the processing parameters. Because mechanical tests are costly and time consuming, a nondestructive method to continuously monitor the steel during production would increase product quality and reduce scrap. Toward this end, studies are being performed at NIST in cooperation with the Department of Energy, through a CRADA with the American Iron and Steel Institute (AISI). Researchers studied the effect of transducer configuration on Barkhausen signal characteristics, important for the constraints imposed by on-line measurements. They measured the mechanical and magnetic properties and the relationships between them for a set of low-carbon sheet steels, revealing good correlations between the mechanical yield strengths and the magnetic coercive fields. Cooperative work with the two steel companies is in progress to extend the relationships found and to determine their statistical validity.

MEASUREMENTS FOR CERAMIC POWDER PROCESSING

Fine powders are commonly used as starting materials for advanced ceramic components. These powders are often processed in suspensions for shape-forming prior to sintering. Measurements of key properties of suspensions have been recognized as one of the most important steps in the understanding and control of slurry-based processes for enhanced reproducibility of ceramics manufacturing. Researchers at NIST are developing electroacoustic techniques that show significant promise for slurry characterization.

The electroacoustic phenomena arise due to the reciprocal relationship between electric fields and sound waves in a suspension of charged particles. The electroacoustic analysis of suspensions constitutes the measurement of sound waves generated by the particles when an alternating electric field is applied to the suspension. The promise of electroacoustics is that the measurements can be carried out in concentrated suspensions that are inaccessible to optical techniques, and on stirred samples undergoing rapid sedimentation or exhibiting high viscosity.

The primary research focus has been on the development of measurement capabilities as applied to slurries of silicon nitride, an important structural ceramic. This research has been instrumental in improving understanding of the interfacial chemistry of silicon nitride and powder dispersion in slurries. Two industry-led workshops conducted on this topic at NIST in June 1992 and Feb. 1993 have led to a NIST/industry consortium to address issues relevant to powder processing.

COMBUSTION STUDY OF SILOXANE THROUGH CRADA WITH INDUSTRY

Siloxanes (silicon-oxygen based materials) are used as alternative transformer fluids, replacing PCBs. When most materials burn, the heat release rate increases significantly with an increase in external thermal radiant flux applied to the burning surface. This is true of wood and plastics. The burning behavior of siloxanes differs markedly from such carbon-based materials; the heat release rate for siloxanes (chain length >15 Si-O units) does not increase significantly with an increase in external thermal radiant flux. Whereas carbon-based materials form products of incomplete combustion such as soot and carbonaceous char, siloxanes form a minimum of char but produce substantial amounts of solid amorphous silica as a major product of combustion. It appears that this amorphous silica could play a significant role in mediating the burning behavior of siloxanes. A cooperative research and development agreement (CRADA) recently was signed between NIST and a private company to study why the above combustion behavior is observed for the combustion of siloxanes.

NIST RESEARCHERS LEAD EARTHQUAKE INVESTIGATION TO JAPAN

NIST researchers led a 12 member U.S. team investigating the damages resulting from a magnitude 7.8 earthquake, which struck northern Japan on July 12. The team consisted of structural/geotechnical, fire, and tsunami experts from NOAA, USGS, and the Earthquake Engineering Research Institute, who cooperated with researchers from counterpart agencies of the Japanese government, under the auspices of the 25-year-old U.S./Japan Panel on Wind and Seismic Effects. Direct structural damage to buildings was found to be light, with more widespread but still minor damage to roads, bridges, and rail lines, principally from soil displacements. A hotel located on the small island (Okushiri) hardest hit by the earthquake was buried by a landslide killing 10 people. A fire broke out on Okushiri eventually consuming half of the nearly 700 buildings in the village of Aonae. The most severe damage was the result of tsunami (tidal waves), which were determined by the team to have reached 31.5 m at one point on the island. Tsunami damaged nearly 1500 buildings. Total losses reported to date are 196 people dead (46 still missing) and property damage exceeding $600 million.

SMOKE YIELD MEASUREMENTS MADE DURING INTERNATIONAL OFFSHORE EXPERIMENT

NIST was one of 25 agencies participating in experiments 40 km offshore east of St. John's, Newfoundland to evaluate in-situ burning of oil spills as a response technology. Environment Canada organized the effort as part of the process for gaining acceptance for the technology through measurement of the effects on the water and air. These experiments were the first opportunity to measure the effects of burning oil spills on the ocean. NIST scientists used instrumentation developed in ongoing studies of oil spill fires. The instruments, hung below a tethered helium-filled blimp, sampled the smoke plume from the fire to measure the smoke yield (fraction of fuel mass converted to

particulate) and the particulate size distribution. In this experiment, the blimp was positioned in the smoke plume using a small boat positioned immediately downwind of the burning oil slick, which was contained in a fire resistant boom. The measured smoke yield of 15 percent in two tests was consistent with previous measurements made in meso-scale experiments conducted by NIST in Mobile, AL. The St. Johns experiments involved 210 people, 20 vessels, three full-size helicopters, two remote-controlled helicopters, two fixed-wiring aircraft, and the NIST blimp. Future experiments in U.S. waters are being discussed.

NEW PUBLICATION FOCUSES ON SECURITY ISSUES IN DATABASE LANGUAGE SQL

The Database Language SQL is a standard interface for accessing and manipulating relational databases. NIST Special Publication 800-8, Security Issues in the Database Language SQL, examines the security functionality that might be required of relational database management systems (DBMS) and compares these functions with the requirements and options of the SQL specifications. The document examines a variety of security policies that can be supported by SQL and discusses which types of functions are required by these security policies. The new publication will assist federal information technology managers in the selection of DBMSs with appropriate security functionality.

REPORT PRESENTS PROCEEDINGS OF WORKSHOP ON THE SECURITY OF NATIONAL COMPUTER NETWORKS

NISTIR 5232, Report of the NSF/NIST Workshop on NSFNET/NREN Security, July 6–7, 1992, describes the findings of a workshop co-sponsored by NIST and the National Science Foundation to address the need for improving the security of the National Science Foundation Network (NSFNET) and the National Research and Education Network (NREN). Workshop participants identified off-the-shelf security technology that could be implemented in the NSFNET, especially to control access to the supercomputers on the network.

NIST RELEASES SOFTWARE FOR ECONOMIC ANALYSIS

NIST has released version 4.0 of the Building Life-Cycle Cost (BLCC) computer program, the primary reference program for DOE's Federal Energy Management Program, and a related program, ERATES, for calculating electricity costs using complex rate schedules. BLCC provides comprehensive economic analysis of proposed capital investments that are expected to reduce long-term operating costs of buildings or building systems, especially those related to energy conservation and renewable resources. BLCC calculates the life-cycle costs of alternative buildings or building systems and calculates net savings, adjusted internal rate of return, savings-to-investment ratio, and payback for any project alternative. Version 4.0 has a number of new features, including special provisions for evaluating DOD projects and projects requiring OMB Circular A-94 guidelines (revised 1992), a Quick Input module for simplified analyses, and SI units.

ERATES (Electricity RATES) generates time-of-use, block-rate, and demand-rate schedules and uses these to calculate monthly and annual electricity costs for buildings or building systems. The block-rate and demand-rate schedules generated by ERATES can be imported into BLCC 4.0 to calculate life-cycle electricity costs. These programs run under MS-DOS with no special hardware or software requirements. User's guides are available for both programs. A brochure with more information regarding these programs is available from NIST.

WORKSHOP FOR INDUSTRY

On Aug. 2–6, NIST held the workshop "Experiment Design for Scientists and Engineers" in Santa Clara, CA. NIST instructors presented the latest statistical experiment design techniques for improving product and process quality to engineers from industry. These engineers had research and development responsibilities and represented such industries as biomedical, computer, electronic, polymers, and electrical utilities.

The workshop covered statistical designs for studying a single parameter in the presence of many nuisance parameters, screening the important parameters from a large set of parameters, and determining optimum settings of the important parameters. Students run a series of hands-on experiments to reinforce the underlying design concepts. In addition, each student designs an experiment for a project they are working on at their own company. On the last afternoon of class, the students gave presentations on their proposed experiments and received valuable feedback from the instructors and fellow classmates.

As part of NIST's continuing effort to work more closely with industry, students were informed of opportunities to collaborate directly with NIST and were given survey forms requesting information on the type of technical problems their company faces and on how NIST can help.

The next workshop will be given in Orlando, Fla., in April 1994.

SECOND-GENERATION NIST THIN-FILM MULTIJUNCTION THERMAL CONVERTERS DEMONSTRATE PRACTICALITY OF APPROACH

NIST scientists and a scientist from a private company which has a CRADA with NIST, have completed successfully a "production" run of thin-film multijunction thermal converter chips and tested them to show that they have accuracies approaching those of the best conventional standards, with very low dc reversal errors and small ac-dc differences in the audio-frequency range. Earlier problems appear to have been solved through the introduction of new chip designs and incorporation of new fabrication procedures. This achievement demonstrates the practicality of the approach: the yield of good chips from a wafer was very high, and the yield of working mounted chips only slightly less.

These thin-film converters result from applying modern semiconductor processing technology to the fabrication of carefully patterned heater/thermocouple structures and represent a substantive improvement over the electrical performance of the present standard wire thermal converters. It is estimated that they can be produced with a cost range of $100 to $200 each, depending on the electrical parameters, as opposed to a corresponding range of $150 to $2,500 for present standards.

The electronic instrumentation industry is interested in this development, which not only will provide a new generation of improved standards, but also is likely to make practical the incorporation of film converters in instruments such as precision multimeters, with the result that their ac performance should approach their dc performance. At present there are no intrinsic ac standards. For example, all ac voltage measurements derive from standards based on either digital synthesis or thermal voltage conversion. (NIST is pursuing both approaches.) At ultimate accuracy levels, root-mean-square measurements of ac signals—either current or voltage—are made in terms of dc standards using thermal transfer techniques where resistive heating of a properly designed standard is independent of frequency and can be detected precisely. Patents for the thin-film converter have been applied for; an associated patent for integrated micropotentiometers (which are similar structures) has been allowed.

DEVICE SIMULATIONS MADE POSSIBLE BY NIST MODELS SPEED UTILIZATION OF NEW POWER SEMICONDUCTOR DEVICES

A software developer and a major semiconductor manufacturer have signed a $3 million, 3 year agreement that will result in analog simulation models of a new device being available before devices are actually fabricated. This heralds a new approach to the design of semiconductor power devices and the systems in which they are incorporated and was made possible by the work of a NIST scientist.

Intelligent exploitation of the capabilities offered by a new semiconductor device in a practical circuit design requires that a model of the electrical behavior of the device exist. Before the NIST work, models customarily were not developed until long after the introduction of a new device. Furthermore, models did not take into account the thermal behavior of the device, a vital aspect of device performance. A device that has failed from overheating, no matter how good its electrical design and performance, is useless. Working in collaboration with the software company, the NIST scientist developed an electro-thermal model and applied it to his insulated-gate bipolar transistor (IGBT) model which the software company then incorporated into its commercial circuit simulator. As a result of the existence of the NIST models, the manufacturer was able last year to introduce a new IGBT ignition coil driver concurrently with the release by the software company of a model for the device in the simulator. The software company and the manufacturer now plan to carry the process one step further. When a customer submits a requirement for a power device, they will work together to develop a model for the device even before it has been manufactured. The customer then can carry out a preliminary design of the intended circuit based on the model and recommend changes in the design of the device to optimize it for the intended application.

COMMERCIAL SEMICONDUCTOR TEST EQUIPMENT BASED ON STANDARDS RESULTING FROM NIST WORK

Three private companies are now marketing hardware/software systems that depend on measurement procedures incorporated in formally adopted test-method standards based on research conducted at NIST. The availability of the procedures also results from NIST participation in the standardization process in both the American Society for Testing and Materials and the Electronic Industries Association/Joint Electron Device Engineering Council. Two important measurements relating to integrated-circuit reliability are electromigration characterization and time-dependent dielectric breakdown (TDDB). Electromigration is a failure mechanism which can occur as a result of high current densities in the thin-film metallization lines on an integrated-circuit microelectronic chip. Time-dependent dielectric breakdown measurements provide a means to characterize the reliability of the gate dielectric of devices fabricated in one of the most important semiconductor technologies, MOS (metal-oxide-semiconductor, used for example for semiconductor memory). All three companies market systems to evaluate both electromigration and TDDB.

NIST DEVELOPS ELECTRONIC POLICE RADAR CALIBRATOR

In order to support the possible use of cross-the-road radar for speed enforcement in the United States, the Office of Law Enforcement Standards has sponsored the development by NIST of an all-electronic Doppler radar calibrator. The calibrator operates at 24.1 GHz (K Band) and provides a radar signature that simulates accurately several types of vehicles passing through a radar beam aimed across the road. The simulated signature includes the effect of direction of vehicle travel. The capability of faithfully imitating the radar characteristics of a real vehicle is essential for interfacing with the sophisticated signal-processing circuitry in commercially available cross-the-road radar systems and for assessing the accuracy of speed measurement. The calibrator also can be used with conventional down-the-road radar speed-measuring systems that have been used widely by U.S. law enforcement agencies for some years. Since the NIST calibrator depends solely on electronics, without mechanical moving parts, it is expected to be a low-cost device in large-scale production, and the potential market is seen to be large. The principles underlying the calibrator also could be applied to calibrate a laser-based speed-measuring system.

MODEL DEVELOPED TO EVALUATE SHIELDING EFFECTIVENESS OF AIRCRAFT SKIN STRUCTURE

NIST scientists have developed a theoretical model that is intended to help aircraft manufacturers and the Federal Aviation Administration evaluate how well an aircraft skin and related structure provides electromagnetic shielding for instruments and components within the aircraft. The model takes into account both pulsed and continuous sources of electromagnetic energy incident on the skin. Serious safety concerns have been raised with respect to the effects of high-level sources such as high-power radars and even broadcast stations on aircraft electronics. The introduction of composite primary aircraft structure and composite skins, coupled with the trend to increasing reliance on electronics for direct control of engines (full-authority digital engine control) and control surfaces (fly-by-wire) exacerbates the situation. Concerns still apply to the "conventional" electronic functions, including radar, communications, navigation, monitoring of aircraft functions, and cockpit instrumentation. At least one modern aircraft has crashed as a result of electromagnetic interference. The regulatory response has been to require that electronic equipment authorized for installation in an aircraft (and the aircraft itself) withstand fields as high as 200 V/m, which takes little or no account of any mitigation of the fields inside the aircraft as a result of aircraft structure.

If the model is successful when applied to real-world conditions, it will provide a basis for determining the levels of fields that electronic equipment for aircraft must withstand without degradation in performance. Testing to excessively high field levels is very costly. To date, NIST has carried out laboratory experiments to test the predictions of the theory, with the result that over the frequency range 1 GHz to 18 GHz, the agreement is good and the theory is considered verified. NIST now plans to test how well the model predicts the shielding effectiveness of the skin structure of an actual aircraft.

RESULTS OF INDO-U.S. COLLABORATIVE PROGRAM ON INTEGRATED OPTICS DISSEMINATED THROUGH WORKSHOP

NIST recently co-sponsored and hosted a Workshop on Computer Modeling of Optical Waveguide Components to introduce selected results of the joint Indo-U.S. Collaborative Program on Integrated Optics to the U.S. technical community. Some 20 representatives from industry, academia, and government participated in the workshop, which incorporated a hands-on laboratory that allowed them to experiment with working computer code implementing four analysis tools developed over the last 5 years through the program. These tools and salient points about each are as follows: (1) the matrix method of analysis, which includes a convenient and highly accurate method of analyzing leaky structures; (2) Galerkins's method for arbitrary geometries, which provides a convenient and highly accurate prediction of waveguide characteristics, including absorption loss when the complex refractive index is known; (3) a perturbation method, useful in analyzing rectangular core waveguides and especially useful in treating odd shapes such as a rib or a channel waveguide; and (4) the use of modified Airy functions in a WKB-like analysis and the WKB method itself. (WKB refers to the initials of three independent workers—Wentzel, Kramers, and Brillouin—who first used the approximation procedure to solve the Schroedinger wave equation in one dimension.) Lecture material and examples on this last subject were taken from an NIST Monograph.

NIST WORKS WITH MACHINE TOOL BUILDER TO IMPROVE HIGH-SPEED LINEAR MOTION PERFORMANCE

Two NIST scientists in conjunction with the Massachusetts Institute of Technology and a private company, have developed a high-speed linear motion system using porous graphite air-bearing pads and replication assembly methods. An epoxy replicant was used to reduce the need for expensive precision components by potting the air-bearing pads into position. A "zero-clearance" assembly methodology was developed to simplify construction and minimize bearing gap. This yields the maximum bearing stiffness of 13 MN/m (75,000 lb/in) compared to 4.9 MN/m (28,000 lb/in) for a typical mechanical system. The system showed superior damping properties along with significant improvements in straightness of motion, bearing stiffness, and reducing sliding friction. The use of this system by the machine tool builder will result in a significant increase in reliability and reduction in manufacturing cost.

TOPOGRAPHY OF MULTILAYER X-RAY MIRROR

High-efficiency, totally reflective x-ray mirrors are critically dependent on the surface roughness of the mirrors. x-ray mirrors are utilized in such state-of-the-art technology applications as x-ray microscopes and telescopes, as well as soft x-ray projection lithography. Soft x-ray projection lithography might replace optical lithography for the production of integrated circuits with feature sizes below 0.2 μm. For a high-quality, near diffraction limited x-ray mirror, it is necessary to measure surface characteristics of the mirror with precision in the 0.1 nm range over spatial wavelengths from 0.1 nm to the full aperture of the mirror (about 0.1 m). NIST staff are developing measurement and calibration approaches that will span the requisite eight orders of magnitude in spatial wavelength.

The surface roughness of a multilayer mirror has recently been measured over more than four orders of magnitude of spatial wavelength using a long-range scanning tunneling microscope (STM) developed at NIST. Measurements were made over fields of view varying from 1 μm × 1 μm to 500 μm × 500 μm. The lateral and vertical displacement transducers were calibrated at each field of view. The data were used to compute the mirror's surface power spectral density (PSD) function over the spatial wavelengths from 10 nm to 320 μm. The resulting PSD curves, the first to bridge short-wavelength measurements made with traditional STMs and longer wavelength measurements made with phase measuring interferometric microscopes, agree with published data taken at the lower and upper regions of this bandwidth.

DEFECTS IDENTIFIED IN PROTOTYPE ADVANCED MEMORY CHIP

Data from NIST have revealed an unexpected form of defect in multilayer magnetic thin films used for magneto-resistive random access memory (MRAM) chips. In a collaborative effort between NIST and a private company, MRAM films were investigated by scanning tunneling microscopy and by depth-profile analysis with x-ray photoelectron spectroscopy. A typical MRAM film is a complex multilayer structure containing various alloys and other materials such as in the prototype devices Ta/CoFe/CuAg/CoFe/ NiFeCo/SiN/silicon wafer.

The results indicated that these multilayer films were not the flat, well-ordered, layer-by-layer structures that had been envisioned. Instead, the films were highly granular with channels or crevices between grains. It was also found that some of the material from the upper layers of the multilayer stack was present in the deepest layers, indicating that the crevices allowed leakage of material downwards. The evidence for this leakage of material was verified by a NIST scientist using secondary ion mass spectrometry. Research is now under way to develop improved thin-film manufacturing techniques that will suppress the granularity and the associated channels or crevices.

FROBISHER IRON BLOOM STUDIED TO ESTABLISH PROVENANCE

Scientists at NIST have collaborated with a Smithsonian Institution summer intern in the study of a unique sample from the Smithsonian collection. The sample, labeled the Smithsonian Bloom, was donated to the Smithsonian in 1863 by Charles Hall who had explored the base camp (occupied 300 years earlier) of the 16th century English explorer Martin Frobisher, on the Kodlunarn Island in the Canadian Arctic. The sample was reputed to be connected to Frobisher's activities in mining and ironwork on this island. However, recent interpretations of the objects collected from the Frobisher site have identified a possible early Norse origin for some of these materials and an origin in northern Russia for others.

The goal of the project was to study the possibility that the lead isotopic signature for the artifact could be used in specifying its provenance. The work derives from a long-standing collaboration between the Smithsonian Institution and NIST in this field. Lead isotopic compositions vary considerably in nature, and these isotopic compositions can be measured very precisely by thermal ionization mass spectrometry. The analytical results showed useful levels of lead in the Smithsonian Bloom (2.5 parts per million) and the isotopic results were very different from catalogued lead compositions expected for samples of ore from England.

The information provided as a result of this study shows that the identification of the lead in the specimen is analytically viable and provides a means to relate the less than 20 existing blooms found in the arctic to one another in terms of provenance.

TWO NEW NIST PRECISION MEASUREMENT GRANTS AWARDED FOR FY 94

Two new $50,000 NIST Precision Measurement Grants have been awarded for fiscal year 1994. The recipients, Mark Kasevich of Stanford University, and Ronald Walsworth of the Smithsonian Astrophysical Observatory, Harvard-Smithsonian Center for Astrophysics, were selected from an initial group of 22 candidates. NIST sponsors these grants (administered by the Fundamental Constants Data Center) to promote fundamental research in measurement science in U.S. colleges and universities and to foster contacts between NIST scientists and researchers in the academic community actively engaged in such work.

The aim of Kasevich's project, "Development of an Atom Interferometer Gyroscope for Tests of General Relativity," is to develop significantly improved atom interferometers based on slowed and cooled cesium atomic beams and to use the interferometers to construct a high-precision rotation sensor. The motivation for the work is the possibility of achieving levels of sensitivity high enough to observe general relativistic effects. The goal for the 3 year time period of the NIST grant is to demonstrate a sensitivity to rotations of better than 10^{-11} (rad/s)/$Hz^{1/2}$.

Walsworth's project, "Development of a Dual Noble Gas Laser for Use in a Test of Time Reversal Invariance," involves building a newly conceived device, a dual noble-gas maser consisting of cohabitating ensembles of ^{3}He and ^{129}Xe atoms, each performing an active, steady-state maser oscillation. The device will be used for a 10-fold improvement test of time reversal invariance by searching for a permanent electric dipole moment (PEDM) of the ^{129}Xe atom. The ^{3}He maser will serve as a precision magnetometer to control the system's magnetic field, while the ^{129}Xe is used to search for a PEDM.

COUNTING SINGLE ATOMIC LAYERS DURING THE GROWTH OF THIN FILMS

Molecular beam epitaxy (MBE) is a method of materials growth used to produce artificial structures with abrupt interfaces at the single atomic layer level. MBE has had great success in producing complex multilayer semiconductor structures and recently has been extended to produce multilayer metallic structures, most notably in systems exhibiting novel magnetic properties. To obtain single-layer precision, the MBE technique requires the counting of the individual atomic layers during

growth. The most common technique to count these layers has relied on reflection-high-energy-electron-diffraction (RHEED) measurements, in which the reflected electron beam intensity is monitored in real time. One typically observes cyclic oscillations in the RHEED intensity, which are interpreted as corresponding to one atomic layer per cycle. To date, little has been known about the actual physical structure corresponding to the RHEED intensity behavior, or about the exact cause of the intensity oscillation themselves. Some of the questions plaguing scientists are: Is one oscillation really one layer? Do oscillations mean the material is growing one layer at a time?

Recently, scientists at NIST, using scanning tunneling microscopy, have obtained some of the first atomic real space images of the growing surfaces of iron crystals that correspond to various RHEED intensity oscillations. These experiments, which were reported in the June 7, 1993 issue of Physical Review Letters, found that one oscillation does correspond to one atomic layer, but only in special circumstances do oscillations imply that material is growing one layer at a time. These measurements show in detail how the mechanisms of surface diffusion, nucleation, and growth affect the quality of the resulting thin film. As a result of the NIST work, the RHEED measurements that are used widely by MBE researchers in the magnetics and semiconductor industries to monitor thin-film growth now can be used more knowledgeably to optimize growth processes in order to control film quality.

NIST ASSISTS MANUFACTURERS OF COLOR DISPLAYS

Recent measurements in the NIST Facility for Automated Spectroradiometric Calibrations (FASCAL) aided the U.S. color display technology industry. A manufacturer of single phosphor color monitors requested that three color displays be measured for spectral distribution. Based on the measurements, NIST also computed the chromaticity coordinates of the displays.

Basic calibrations of color tubes are performed at the manufacturer using spectroradiometers, but the methods of calibration are not standardized. The measurements performed in FASCAL will serve as the basis for the corrections of the readings from the manufacturer's spectroradiometers. The manufacturer is also a member of the Electronic Industries Association committee JT-31. This committee will set up a round-robin intercomparison of color tubes from several manufacturers of TVs. Again the measurements performed in FASCAL will serve as the base for the intercomparison. NIST is looking at this special test to be the first of many similar color tests, particularly since the manufacturers lack the facilities to perform these unique measurements.

POWERFUL OPTICALLY PUMPED FAR-INFRARED LASER LINE DISCOVERED

A 124 μm methanol laser line that is more than four times stronger than the previous "strongest" line (a 119 μm line also in methanol) was just discovered at NIST. The experiments were performed by guest researchers and a NIST scientist. The discovery is of special interest to plasma physicists who use far-infrared radiation to measure electron densities in plasmas. It is also of interest to spectroscopists because spectroscopic sensitivity is especially high at infrared frequencies.

The new line was found using other newly discovered (at NIST) lines of the 9 μm hot bands in the NIST ribbed-tube CO_2 laser. The radiation from one of these new CO_2 lines was used to pump methanol to produce the 124 μm radiation. Twenty-five additional far-infrared lines in methanol also were discovered using the new CO_2 lines.

FIRST INTERNATIONAL COMPARISON OF PHASE-NOISE-MEASUREMENT SYSTEMS

The first international comparisons of phase-noise measurements between the United States, France, and Switzerland have been completed successfully. NIST-developed systems were demonstrated at the Fifth European Frequency and Time Forum in Neuchκtel, Switzerland by a NIST scientist. He subsequently took these systems to laboratories in France and Switzerland for comparisons with their measurement systems. Phase noise is rising in importance in the specification of equipment for telecommunications, radar, and aerospace electronics.

Comparisons were made at carrier frequencies of 5 MHz, 10 MHz, and 100 MHz at Fourier frequencies extending up to 10 percent away from the carrier. Good agreement was found at 5 MHz and 10 MHz, but some errors on the order of 5 dB were found at 100 MHz. Because the NIST measurement method provides a complete internal capability for evaluating errors, it was easy enough to trace the problem to the commercial systems used in these European labs.

NIST ESTABLISHES TWO-WAY, TIME-COORDINATION LINK TO EUROPE

Three NIST scientists have completed construction and preliminary testing of a satellite Earth station that will provide for extremely accurate time and frequency comparisons between NIST and key national laboratories in Europe. The method promises an order of magnitude improvement in time-transfer accuracy, thereby providing better international time coordination. This is important in an era where atomic clock stability and accuracy is advancing rapidly. Improvements in international timekeeping should prove useful in international activities such as telecommunications and navigation.

The new NIST station can be used with both domestic and international communication satellites, and is expected to achieve a time comparison accuracy of 1 ns or better and stability of comparison in the 100 ps regime. There is substantial signal delay between the Earth station and the satellite, but proper handling of data exchanges broadcast through the satellite link in both directions results in a nearly perfect cancellation of the path-delay errors.

COLD NEUTRON REFLECTOMETER COMMISSIONED

Neutron reflectivity has emerged as a very powerful tool for the investigation of surface behavior of polymers, magnetic thin films, surfactant films, and other technologically relevant thin-film materials. NIST in cooperation with a private company and the University of Minnesota has built a new state-of-the-art neutron reflectometer in the neutron guide hall at the Cold Neutron Research Facility (CNRF) at NIST. The new reflectometer—which represents the state-of-the-art—gives NIST scientists, along with industrial and university collaborators, the opportunity to play an even greater role in technologically important research on surfaces and interfaces.

The instrument operates with the sample in the horizontal geometry allowing reflectivity measurements from the liquid-air interfaces. The reflectometer can be operated with extremely high resolution at small wavevector transfers and is also capable of routinely measuring reflectivities down to and below the 10^{-6} level. Very low background levels in the CNRF guide hall make it possible to use a linear-position-sensitive detector, which allows specular and off-specular reflection measurements simultaneously.

The new instrument has been fully operational since May 1993. A substantial improvement (by a factor of about 4) in the instrument is expected with the installation of new liquid hydrogen cold source in 1994. Demand for neutron reflectivity instrumentation time by U.S. industry and universities is rising rapidly, and the instrument is already oversubscribed by a large factor.

SOFTWARE EVALUATION AGREEMENT SIGNED

A private company and NIST signed an agreement to evaluate software developed at NIST that models processing of polymer matrix composites by resin transfer molding (RTM). The private company is interested in applying RTM processing technology to the manufacture of structural aerospace components. The agreement with the private company complements existing separate agreements between NIST and the Automotive Composites Consortium and two other private companies. All industrial partners seek to lower manufacturing costs while improving the reliability of large structural parts made from lightweight polymer composites.

RTM involves injection of liquid prepolymer into a mold that contains the reinforcement fibers (preform) arranged to meet design criteria for strength and stiffness. Mold design and optimal processing parameters depend on the resistance of the preform to resin flow. Availability of credible models that simulate flow of resin through the fiber preform are critical to implementation of RTM. Scientists at NIST are developing such software as well as measurement methods for input permeability data but need cooperation with industry so that computer programs can be tested with actual part manufacture. Under the agreement, NIST will provide one of the companies with the software and instruct its personnel on the methods for making permeability measurements. The company will provide NIST with results of the simulations and comparisons to actual processing data, which will be useful in refinement of the software.

COMPANY SIGNS CRADA INVESTIGATING FRACTURE IN ENGINEERING POLYMERS

A private company signed a cooperative research and development agreement to perform research with NIST on the incubation process for fracture of engineering thermoplastics. Lifetime and durability are important aspects of engineering material performance. As the use of polymers and polymer-based composites in structural applications expands, the understanding of the physics and chemistry that determine their reliability in use becomes increasingly important. Scientists from the private company will collaborate with NIST staff in studies using small-angle x-ray scattering and positron annihilation lifetime spectroscopy. The studies seek to establish the nanoscale mechanisms that result in incubation of fracture in engineering thermoplastics. Both techniques are sensitive to changes in the local environment, and it is anticipated that the way in which this evolves during mechanical deformation will provide insight into the molecular mechanisms that lead to deterioration of material performance.

NIST AND NCMS SIGN COOPERATIVE AGREEMENT TO DEVELOP LEAD-FREE SOLDERS

A new cooperative research program has been established between the National Center for Manufacturing Sciences (NCMS) and NIST to identify environmentally safe alternatives for lead-based solder alloys currently used for electrical/electronic interconnections. In response to congressional concerns on the use of lead in manufacturing, NCMS has formed a consortium for the design and evaluation of possible candidate lead-free solder alloys that meet the manufacturing and performance requirements currently met by lead-based solders. NIST has joined with Rensselaer Polytechnic Institute, Sandia National Laboratories, the Electronic Manufacturing Production Facility, and the NCMS industrial partners, in establishing the guidelines for development of these new solder alloys.

NEW TECHNIQUES USED FOR SITING SMOKE DETECTORS

NIST has applied computational fluid dynamics modeling to the analysis of smoke flow under complex ceilings. The technique provides a more detailed look than can be achieved through much more costly full-scale experiments. This new technique was used to examine the current siting guidelines for fire detectors and sprinklers and identified several areas where improved response could be achieved at lower cost. The technique has been verified against real-scale experimental data taken 10 years ago.

Both the fire detection and sprinkler industries are interested in the potential for this new methodology to address technical questions that have been extant for many years, in particular to reduce costs while improving life safety.

NEW FIRE SUPPRESSANTS RECOMMENDED FOR IN-FLIGHT PROTECTION OF AIRCRAFT

A NIST multilaboratory research team has identified a number of chemical compounds that can be used to replace halon 1301 (CF_3Br) for extinguishing aircraft fires while in flight. This chemical currently provides protection against fires in jet engine nacelles and other unoccupied spaces in nearly all commercial and military aircraft. Its manufacture will cease at the end of 1993 due to halon damage to stratospheric ozone. This makes the search for alternative suppressants urgent. As a result, the government agencies and the Federal Aviation Administration, through Wright-Patterson Air Force Base, have requested NIST to identify candidates that can be ready for use within 2 years.

Because of the unusual nature of the fires and the strict demands on the fire suppressant, the NIST team developed an array of new apparatus and procedures to understand the behavior of more than a dozen compounds in different aspects of the fire suppression process. Studies include thermodynamics of the chemicals in mixtures with nitrogen, dynamics of agent release, conditions leading to flame extinction, and byproducts of the suppression process. In addition, experiments were conducted to predict the long-term stability of the chemicals during storage and their compatibility with the metals and polymers used in storage containers. Environmental issues and the potential for human exposure also were investigated. The recommended chemicals, which are gaseous (at ambient conditions) halocarbons and halohydrocarbons, are to be tested in full-scale fixtures simulating portions of aircraft at Wright-Patterson Air Force Base. A final report documenting the NIST research and the rationale for the recommendations will be prepared by January 1994.

BACnet PRODUCES POSITIVE REACTION FROM INDUSTRY

NIST researchers have spent the last 5 years, in concert with industry, developing an open protocol for communication between computerized control systems for heating, ventilating, and air conditioning in buildings. While the BACnet protocol has not yet been released by the American Society of Heating, Refrigerating, and Air-Conditioning Engineers' (ASHRAE) Standards Project Committee 135 in its final version, it is in a form today that can be adopted by any manufacturer who chooses to write to it. A major air-conditioning company has just announced that they have chosen to implement BACnet at this time because industry use of an open standard is so important to building owners. Strong support from the company and others in the building automation industry is required to help deliver this needed standard to collective customers. All customers who join the company in implementing this early version of BACnet will be upgraded to the final version upon request and at no charge when it is accepted by ASHRAE.

COMPUTER SECURITY CONFERENCE ATTRACTS LARGE TURNOUT

On Sept. 20–23, NIST and the National Security Agency's National Computer Security Center (NCSC) co-sponsored the 16th National Computer Security Conference in Baltimore, MD The theme of the conference was "Information Systems Security: User Choices." The conference attracted about 1,800 attendees from government and industry.

Of special Interest was the conference session on the draft Federal Criteria for Information Technology Security and efforts toward international harmonization of criteria and evaluations for trusted products. Other sessions featured tutorials on viruses, trusted systems, networks, and system integration; research papers and recent technological developments by leading technical experts in information security; management topics such as contingency planning, risk management, and electronic crime; and recent accomplishments and lessons learned in the development and operation of systems and networks that provide security features. The closing plenary focused on "Information System Security Strategies for the Future."

RASTER GRAPHICS VALIDATION TEST SERVICE INITIATED

On Oct. 1, NIST initiated the NIST Raster Graphics Validation Test Service for a 1-year trial period. Conducted on a cost-reimbursable basis, the service tests raster files for conformance to Federal Information Processing Standard (FIPS) 150, Facsimile Coding Schemes and Coding Control Functions for Group 4 Facsimile Apparatus, and the DOD Military Specification MIL-R-28002, Requirements for Raster Graphics Representation in Binary Format. The test service analyzes implementations of ITU-T (formerly CCITT) Recommendation T.6 (Group 4) and Continuous Acquisition and Life-Cycle Support (CALS) Type I data files for conformance to the T.6 (Group 4) compression algorithm. A test report is produced, which summarizes the tests performed and describes any conformance deficiencies. Certificates issued for successful validations and registered test reports will be listed in the Validated Products List, which NIST updates and publishes quarterly. An information pack provides details of the test service and procedures for requesting validations.

NEW PUBLICATION FOCUSES ON INFORMATION RETRIEVAL TECHNIQUES

Information retrieval is the process of locating the data that best answer a user's query. Despite the growth of wide-area networks and the amount of potentially available information, many archives and information bases are not accessible to users who do not know site names and access methods. NISTIR 5243, Towards Flexible Distributed Information Retrieval, discusses a distributed information system being developed to make the best use of networked resources and to achieve flexible integration of existing information bases.

SECURITY OF ELECTRONIC DOCUMENTS SUBJECT OF NIST REPORT

NISTIR 5247, Workshop on Security Procedures for the Interchange of Electronic Documents: Selected Papers and Results, presents the findings of a workshop held at NIST Nov. 12–13, 1992. About 40 participants from government and industry attended the meeting. Co-sponsored by NIST and the Office of Management and Budget, the workshop focused on the need to devise rules for the use of security procedures in the electronic transmission of documents between organizations.

DIGITAL SIGNATURE CERTIFICATE MANAGEMENT WORKSHOP RESULTS PUBLISHED

NISTIR 5234, Report of the NIST Workshop on Digital Signature Certificate Management, Dec. 10–11, 1992, summarizes the presentations and discussions of about 40 invited participants representing the federal government, industry, standards organizations, and international interests. The workshop reviewed existing and required technologies for digital signature certification authorities and developed recommendations for certificate contents, formats, generation, distribution, and storage.

NIST CRITICAL STABILITY CONSTANTS OF METAL COMPLEXES DATABASE RELEASED

Standard Reference Database 46 provides comprehensive coverage of interactions for aqueous systems of organic and inorganic ligands with protons and various metal ions. Based on the six-volume Critical Stability Constants, the data have been thoroughly evaluated with correction of errors and addition of new material. Protonation constants under specified conditions of temperature and ionic strength, heats of protonation, entropies of protonation, stability constants and related equilibrium constants, thermodynamic constants, and a complete bibliography are included for nearly 4000 ligands. For an additional 1000 ligands, the metal ions studied and bibliographic citations are included. The database is available from the Standard Reference Data Program.

NIST FIRST-TIME MEASUREMENTS HELP MANUFACTURER DESIGN IMPROVED PORTABLE X-RAY UNITS

The production rates of gaseous byproducts that result from decomposition and oxidation of compressed sulfur hexafluoride (SF_6) during exposure to x rays were measured for the first time by NIST scientists as part of a cooperative research and development agreement with a private company. An outcome of the work is that the company, a manufacturer of portable x-ray units that use SF_6 as an insulating gas, will be able to design more reliable and longer-lived instruments. The company approached NIST because it had become interested in evaluating any possible effects of x rays on the SF_6 gas, including the formation of corrosive byproducts that could be harmful to the operation of the x-ray units.

In the collaborative experiments, the company supplied and operated the x-ray unit, and NIST scientists carried out analyses of decomposed SF_6 using the gas chromatograph-mass spectrometer method they had developed previously. They found that the SF_6 oxidation byproducts from the x-ray unit were the same as those formed by corona discharge in SF_6, including the very toxic gas S_2F_{10} and oxyfluorides of sulfur such as SOF_2, SO_2F_2, and SOF_4. The formation of these species is known to be accompanied by the formation of such highly corrosive byproducts as HF and free fluorine. The experimental results from this work are to be presented at the International Symposium on Gaseous Dielectrics next year.

LOCATING IMAGES PROJECTED BY INTEGRATED-CIRCUIT MANUFACTURING TOOLS TO NANOMETER-LEVEL ACCURACY

NIST researchers have devised a method to measure the relative location of projected images of features on a test mask when the images have been projected onto a "calibrated" substrate. This development responds to industry's needs for the rapid determination at nanometer scale of the placement of images of fiducial features on a mask as projected by a lithography tool on a substrate.

One specific application is low-cost evaluation of image placement by x-ray lithography masks. NIST researchers have shown that the image locations can be determined with an accuracy of 10 nm or better; a patent on the method has been applied for.

In one implementation, partially formed test structures are first fabricated on a substrate. Each structure serves as a local ruler, and the structure positions and scales are calibrated by means of NIST's linear-scale interferometry system. Next, images of fiducial marks on a mask are projected onto the substrate. These images, known as pointers, overlay the partially formed test structure local rulers to form completed test structures. The locations of the pointers within the respective test structures are then determined electrically. These measurements, combined with the calibration of the rulers, provide the location of the pointers on the substrate. The team is now developing a two-dimensional implementation intended to provide a low-cost metrology directly traceable to a two-dimensional metric of atomic spacings of single-crystal surfaces determined through molecular measuring machine.

NIST TRANSMISSION LINE MEASUREMENT METHOD DEMONSTRATED FOR HIGH-PERMITTIVITY MATERIALS

NIST scientists have developed and evaluated a method capable of measuring permittivity for materials having high permittivities; previous methods were not capable of these measurements. The method employs a coaxial air line system having the relatively large diameter of 77 mm. The principal advantage of the method is that the relative magnitude of the error resulting from the presence of an unavoidable small air gap between inner conductor and specimen material is reduced greatly compared to the air-gap errors present in the conventionally used line, which is 7 mm in diameter. Models have been developed and are used as a basis for compensating for the air gap, but the resulting correction is not perfect. Using the new method, the NIST team was able to characterize a high-permittivity commercial ceramic having a nominal value of the real part of the complex permittivity $\epsilon' = 270$ over the frequency range 50 MHz to 1000 MHz. The team's measured value was $\epsilon' = 275$, after air-gap correction. Meaningful measurements on this material using the conventional 7 mm diameter coaxial line would have been very difficult, even if possible, with large errors. Work is currently under way to extend the method to the low-frequency range of 0.1 MHz to 50 MHz.

NIST DEMONSTRATES CAPABILITY FOR HIGH-FREQUENCY SURFACE RESISTIVITY MEASUREMENTS OF HIGH-TEMPERATURE-SUPERCONDUCTOR FILMS

NIST has carried out a preliminary measurement of the microwave surface resistivity of high-temperature-superconductor films in collaboration with a researcher from the Warsaw University of Technology. Microwave surface resistivity is a key parameter for determining if a given high-temperature-superconductor material has potential for high-frequency applications. NIST scientists performed the measurements on yttrium-barium-copper oxide (YBCO) films grown at NIST. The measurements were made with a sapphire-rod resonator developed for NIST by the Polish researcher.

The resulting value for the microwave resistivity of 6 mΩ to 8 mΩ per square at 77 K compares well with values reported by others on YBCO films at the same frequency. The resonator rod is a small right circular cylinder that is excited at 25 GHz by microwave energy coupled into the resonator cavity through loops whose position can be moved to adjust the coupling. In operation, specimens of the material to be measured are brought into contact with the ends of the rod. For these first measurements, the cavity structure was submerged in a simple liquid-nitrogen bath; for planned future measurements on other YBCO specimens and on other high-temperature-superconductor films, a cryostat will be constructed to provide stable temperature control over the range 20 K to 120 K.

NEW METHOD TO DETECT HIGHLY EXCITED ATOMIC STATES

The creation and detection of very highly excited atomic states are important for precision spectroscopists and those studying the behavior of atoms in both strong and weak fields. A NIST scientist and a graduate student have demonstrated a new detection technique that uses an optical "dump" pulse from a visible dye laser to stimulate emission from the Rydberg state of interest to a lower valence level. Fluorescence from this lower level is then detected. This new technique has many advantages compared with earlier methods. It permits the selective interrogation of individual Rydberg states, and the ease of using optical light pulses. The Rydberg state being stimulated to the lower level is easily identified since the stimulated emission process is governed by the normal atomic selection rules and the wavelengths are well-known. The highest principal quantum number that can be unambiguously observed is limited by the "dump" laser's linewidth, not by the wavelength or energy resolution of the detection system. And while direct ionization of the Rydberg state occurs, this pathway is relatively limited in the new technique because of the strength of the stimulated emission transition. This technique has been first tested on Ca atom Rydberg states. Pulsed dye lasers were used to excite a series of ^{1}D states with principal quantum numbers $n = 11$ to 38 by a two-step process. States with $n = 12$ and 25–38 were detected with a third pulsed dye laser tuned to the "dump" transition $4snd\ ^1D_2 \rightarrow 4s5p\ ^1P_1$. Fluorescence from the ^{1}P state at 671 nm was observed through a monochromator. Work is in progress to use this new detection scheme for state-to-state collision studies of Rydberg states.

NIST RESEARCHERS DOCUMENT THERMAL AGING OF FOAM INSULATION

Two NIST scientists have completed a 1-year study of rigid polyisocyanurate foam thermal insulation co-blown with CCl_3F and CO_2, documenting the decrease in insulating capability and change in other important properties due to exposure to elevated temperature and humidity. Foam insulation has been used extensively throughout the building industry. However, recent changes in the laws protecting stratospheric ozone have forced manufacturers to develop new technology to minimize and eventually eliminate chlorofluorocarbons from their foam products. The "long-term" effectiveness of these new products is not known.

In this study, the researchers exposed samples to five different combinations of elevated temperature and/or humidity and measured changes in thermal conductivity, mass, volume, and density about every 50 days over the year. After 1 yr, the thermal conductivity increased about 40 percent and density decreased about 5 percent. They determined three regimes of aging by correlating the changes in thermal conductivity with changes in density. Results were compared to another foam blown with only CCl_3F and aged under similar exposures with good agreement. This technique could be used in an accelerated aging test to characterize a production lot of foam over its lifetime. By additionally using Fourier transform infrared spectroscopy and measurements under a scanning electron microscope, they determined the mechanisms of change occurring within the foam.

ISDN FEDERAL INFORMATION PROCESSING STANDARD (FIPS) APPROVED

The Secretary of Commerce recently approved FIPS 182, Integrated Services Digital Network (ISDN), for federal agency use. Effective April 15, 1994, the standard defines the generic protocols necessary to establish transparent ISDN connections among government networks and between government and conformant common carrier networks. Providing a minimal set of bearer services, FIPS 182 is based on national and international standards and on implementation agreements developed by the NIUF.

NEW REPORT FOCUSES ON EMERGING FEATURES FOR GEOGRAPHIC INFORMATION SYSTEMS (GIS) APPLICATIONS IN DATABASE LANGUAGE STRUCTURED QUERY LANGUAGE (SQL)

NISTIR 5258, Towards SQL Database Language Extensions for Geographic Information Systems, presents a collection of papers by the GIS/SQL Working Group of NIST's GIS Standards Laboratory. The goal of the laboratory is to facilitate joint efforts in adapting information technology standards for use by the GIS community.

A GIS extension to SQL will benefit users by providing a common database language to directly perform many of the functions and operations they require. For the GIS vendor software community, the integration of SQL into GIS software will result in less effort and maintenance by vendors. NIST will continue to participate in the development of a GIS extension to SQL as the work progresses in the national and international voluntary standards arenas.

NIST MAKES POSIX CONFORMANCE TEST SUITE AVAILABLE ELECTRONICALLY

On Oct. 15, FIPS 151-2, Portable Operating System for Computing Environments (POSIX), replaced FIPS 151-1 in its entirety. A new test suite has been developed, NIST-PCTS:151-2, to evaluate POSIX products for conformance to the revised FIPS. To be more responsive to the needs of the NIST POSIX testing community, NIST has arranged to sell the test suite directly via electronic mail. The electronic version of NIST-PCTS:151-2 will be delivered to the customer usually the same day that NIST receives the paperwork.

Standard Reference Materials

STANDARD REFERENCE MATERIAL 1746—SILVER FREEZING-POINT STANDARD

The International Temperature Scale of 1990 (ITS-90) was adopted by the International Committee of Weights and Measures in 1989, in accordance with the request embodied in Resolution 7 of the 18th General Conference of Weights and Measures of 1987. The ITS-90 supersedes the

International Practical Temperature Scale of 1968 (IPTS-68) and the 1976 Provisional 0.5 K to 30 K Temperature Scale (EPT-76). The ITS-90 was implemented at NIST on Jan. 1, 1990. The change in the temperature scale affects not only technical interests involved directly in thermometry but also those involved with other reference standards, such as electrical standards sensitive to temperature.

The Standard Reference Materials Program announces the availability of SRM 1746—Silver Freezing Point Standard. The SRM is intended for use as one of the defining fixed points of the ITS-90. The certified freezing point of (961.780 ± 0.002) °C is assigned to the freezing point of pure silver. The fixed point is realized as the plateau temperature (or liquidus point) of the freezing curve of slowly frozen high-purity silver. The metal is in the form of millimeter-size "shot." Each unit is 300 g and is packaged in an atmosphere of argon.

STANDARD REFERENCE MATERIAL 1978—PARTICLE SIZE DISTRIBUTION STANDARD

The measurement of the particle size and particle size distribution properties of solid materials in particulate form is an essential requirement in the manufacture of many different kinds of products, including food, catalysts, paints, pharmaceuticals, and office copier products. A variety of mechanical equipment and optical and electronic-sensing instrumentation are used routinely to provide particle classification data. Calibration of such equipment and instruments is accomplished by use of standard test methods that have been validated using certified particle size standards.

The Standard Reference Materials Program announces the availability of Standard Reference Material (SRM) 1978—Particle Size Distribution Standard for Gravity Sedimentation. SRM 1978, consisting of a granular zirconium oxide powder of irregularly shaped particles with a mean dimension of about 1 μm, is certified for cumulative size distribution. The data required to establish the certified values were generated by NIST and four outside laboratories participating in the NIST-directed interlaboratory study using SediGraph[R] Models 5000 and 5100. These instruments produce continuous size distribution plots, but for certification purposes only the values obtained at five representative cumulative percentiles (10, 25, 50, 75, and 90) are reported.

STANDARD REFERENCE MATERIALS 2590—2591 JOSEPHSON ARRAY VOLTAGE STANDARDS

The Josephson array device and the metrological system based on it are the realization of the quantum physics phenomenon that has been adopted as the basis of representations of the SI volt. This means that the Josephson array voltage standards, unlike most Standard Reference Materials (SRMs), are intrinsic standards.

The Standard Reference Materials Program announces the availability of two Josephson Array Voltage Standards, SRM 2590 (1 V) and SRM 2591 (10 V). These SRMs are superconductive integrated-circuit chips. They are certified to generate the quantum voltage levels on which the SI volt representation is based, when cooled to 4.2 K or less and irradiated with a millimeter wave input of approximately 5 mW and 15 mW, respectively, at 75 GHz. The precision of the voltages generated establishes the level of confidence that the Josephson standard is functioning correctly. Independent devices are found to generate voltages that agree to better than 2 parts in 10^{17} based on tests carried out in the same liquid helium bath; at room temperature, agreement is within a few parts in 10^{10}.

STANDARD REFERENCE MATERIAL 2137—BORON IMPLANT IN SILICON STANDARD FOR CALIBRATION OF CONCENTRATION IN A DEPTH PROFILE

Boron is an important dopant in the production of single-crystal silicon wafers for the semiconductor industry. The concentration depth profile of the implanted ion determines the electronic properties of the wafers so implanted. Secondary ion mass spectrometry (SIMS) is frequently used for determination of the depth profile. In the SIMS method, successive layers of the silicon wafer are removed by ion bombardment, and the sputtered ion species are monitored. Calibration of the instrument for SIMS measurement requires the availability of a standard with a known depth profile.

The Standard Reference Materials Program announces the availability of SRM 2137, Boron Implant in Silicon Standard, certified for the retained dose of ^{10}B atoms, determined by the neutron reaction method, neutron depth profiling. The SRM is intended for use as a SIMS calibration standard. It also can be used as a transfer standard for the calibration of working standards for ^{10}B in silicon.