CCD Camera Improves TEM Image Collection

Images obtained by a modified transmission electron microscope (TEM) can reveal much greater detail according to researchers at Japan's National Research Institute for Metals.

In transmission electron microscopy, an electron beam irradiates a specimen and those electrons passing through the specimen are captured as an image on photographic film. However, the contrast is relatively low, making it difficult to precisely measure the diffraction intensities from film micrographs of a specimen because of its low dynamic range (ratio of maximum to minimum signal intensity) of detectable 10–100. Although the method using an imaging plate gives much higher accuracy in measuring electron diffraction intensities, because of its high dynamic range of 10^4, neither this method nor the film method allows one to perform on-line measurements of electron-diffraction intensities.

This problem, however, has been solved by an NRIM research team headed by Takayoshi Kimoto by converting the electrons which pass through the specimen into photons, capturing those photons with a highly sensitive charge-coupled device (CCD) camera, and then processing the resulting digital signals with an on-line computer, and carrying out precise measurements of the electron diffraction intensities.

Using this arrangement, it is possible to observe the arrangement of atoms in metals and other materials. Moreover, because the CCD camera can be linked directly to a computer, it is possible to process electron diffraction and image data in real time. The institute intends to use the TEM to study ordering in alloys or superconductors.

To convert the transmitted electrons into photons, the group uses a yttrium aluminum garnet (YAG) scintillator, which emits photons in proportion to the number of electrons. The light emitted by this scintillator is collected by a large bundle of optical fibers and passes to the CCD camera after x-rays are filtered out to cut down on background noise. The CCD camera, having a maximum dynamic range of 40,000–64,000, comprises a grid of 512 × 512 elements covering a square of 13.8 × 13.8 mm, or just smaller than the scintillator (20 mm in diameter). The CCD camera feeds its signals into a computer, which processes the data and displays the TEM image on a monitor.

The CCD camera system makes it possible to obtain information about small regions, which cannot be obtained using x-ray or neutron diffraction methods. The researchers have applied the technique to investigate ordering in crystalline alloys. A paper entitled "Development of CCD Camera System for On-Line and Precise Measurement of Electron Diffraction Intensities and Its Application to the Investigation of Ordering in Cu_3Au Alloy" was presented at the 13th International Congress on Electron Microscopy (ICEM-13) held on July 17–22, 1994, in Paris. Another paper, "Quantitative Examination of Radiation-Induced Disordering in Precipitates with a Cooled CCD Camera Attached to a TEM," appeared in the *Journal of Nuclear Materials* (**212–215** [1994] pp. 275–280) concerning research carried out using the new modi-

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fied TEM. In this research the main objective was to use the cooled CCD system to quantitatively examine the radiation-induced disordering in the γ' (Ni_3Ti) precipitates, which could affect void formation. The research also investigated experimentally the effects of γ' precipitates on void formation. The new CCD camera successfully detected electron diffraction intensity from γ' precipitates.

As another example, high-temperature superconductors have been observed to adopt a particular atomic arrangement related to their superconduction. The new TEM thus promises to be a powerful tool for detecting the ordering in high-T_c superconducting materials and elucidating the mechanism of superconductivity, according to the researchers.

F.S. Myers

Coating Research Results in Battery Improvements

The New York State Energy Research and Development Authority will provide $200,000 to continue development of products resulting from research done by Clarkson University's Center for Advanced Materials Processing (CAMP) and Advanced Refractory Technologies, Inc. (ART). ART will further develop the technologies for commercial use.

The joint collaboration between ART and Clarkson has led to the development of two products, one for increasing the efficiency of electric batteries and another for making stronger engine parts.

The first product, an aluminum nitride (AlN) separator plate for lithium-metal sulfide (LiMS) batteries, utilizes the research of Clarkson chemistry professor Richard E. Partch. Partch's research has resulted in a coating for the aluminum nitride powder used in making the plate. This coating process reduces breakdown of the plate and increases the flow of ions, which is critical for raising battery efficiency. Commercial applications for these batteries include electric vehicles and portable power packs. The U.S. Department of Energy is providing $600,000 in funding for this project.

The second product, silicon carbide whiskers coated with different materials, acts as reinforcements for ceramics, metals and plastics, adding extra strength. This process also utilizes coating research conducted at CAMP by Partch.

This research is expected to increase commercial opportunities for use of these advanced materials in aluminum systems for automotive components by enabling reductions in weight, improvement in dimensional tolerances, and significant reductions in hydrocarbon emissions.

AFM Used to Increase Storage Capacity of Phase-Change Optical Disk Material

Matsushita Electric Industrial Co., Ltd. of Japan has announced the development of an ultra-high-density data storage method which, in principle, increases the storage capacity of conventional phase-change optical disks by several thousand times. Instead of employing a laser to read and write, the sharp probe tip of an atomic force microscope (AFM) is used. Data is stored by sending a current through the AFM tip to cause switching phenomena. The resulting change in resistivity of the switched area can then be detected by measuring the current between the disk and the AFM probe tip (see Figure).

Both phase-change and magneto-optical disks are currently in wide use as storage media. However, to manage the constantly increasing volume of data, techniques that enable higher density data storage are needed. An optical disk's data-storage density can be increased by narrowing the laser beam, but, in theory, the beam can only be reduced to about the narrowness of its own wavelength.

The newly developed ultra-high-density storage method employs an AFM instead of a laser beam. The new system is based on germanium-antimony-tellurium (20 nm in thickness), which is already in commercial use as phase-change optical disks. By applying a voltage of 3 V to a gold-coated silicon nitride AFM probe which is touching the surface of the media, it is possible to reduce the resistance of an area 10 nm in diameter by more than one hundred times (10^{11} ohm to 10^9 ohm). The resistance change seems to occur because the small, contacted area has been locally crystallized by joule heating. By detecting the resistance change with a probe to which a voltage of 0.5 V has been applied, it is possible to obtain a high signal-to-noise ratio (*S/N*).

Because the storage media's smooth surface is maintained while writing with this technique, the probe will not vibrate during the reading process, making possible higher speed reading than the mechanical resonance frequency of the probe. In addition, data can be read at a high *S/N* as the resistance is reduced more than one hundred times by the writing operation. Also, the reliability of phase-change material is already well established. The development of this new storage technology contributes to the potential for the realization of terabit memory capable of storing several thousand times the information a conventional optical disk can accommodate.

The researchers believe that this development has confirmed a basic principle for both writing and reading data in large-capacity disk memories. This new technology may be applied to large-capacity storage devices for moving-picture data and still-pictures in the multimedia and healthcare fields.

F.S. Myers

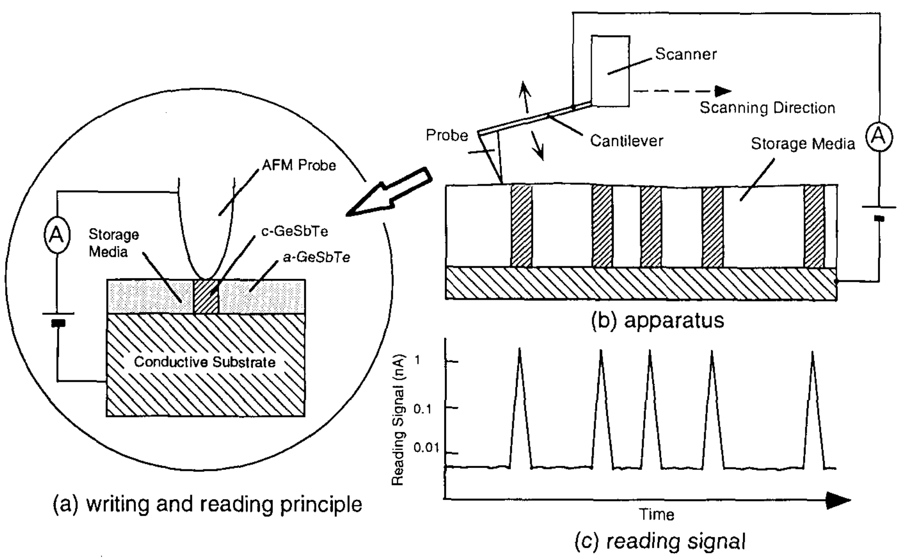

Figure. The writing and reading principle (a), atomic force microscope arrangement (b), and the electrical signal (c) for Matsushita's ultra-high-density data storage method.

The Institute of Materials Presents 1994 Awards

The Institute of Materials in November presented 16 of the Institute's 1994 Awards for personal achievement and outstanding papers in the field of engineered materials. Through its awards, the Institute recognizes and encourages distinguished achievements among materials scientists and engineers in a wide range of disciplines within materials science, technology, and management. Many of the medals and prizes were given to those who had made an outstanding contribution to British industry and are acknowledged as international experts in their fields.

Among the recipients are D.V. Dunford and P.G. Partridge, who received the Cook Prize for their article "Effect of Joint Stiffness on Peel Strength of Diffusion Bonded Joints between Al-Li 8090 Alloy Sheet," which appeared in the December 1992 issue of *Materials Science and Technology*. A.P. Sutton, J.B. Pethica, H. Rafii-Tabar, and J.A. Nieminen received the Elegant Work Prize for "Mechanical Properties at the Nanometre Scale," published as Chapter 7 of the book *Electron Theory in Alloy Design*. A.P. Miodownik of the University of Surrey received the Hume-Rothery Prize for his research on phase transformation and the formation of metastable products. Over the past 30 years this research has resulted in publications on a wide variety of alloys ranging from candidate reactor materials to complex quaternary systems.

O.H.C. Messner, a metallurgist whose extended knowledge on industrial application of copper alloys is known throughout Europe, received the Prain Medal and Prize (sponsored by the Copper Development Association). He started the systematic development of new applications for the thermoconductivity of copper, thereby discovering the "heat shunt" principle of thermal transport through solid bodies.

AVS Announces 1994 Award Winners and Fellows

The American Vacuum Society (AVS) has selected 66 AVS members and graduate students to receive awards and honors for 1994. AVS established the annual awards program to encourage excellence in research and innovation in industrial applications in technical areas of interest to AVS.

Among the recipients are Majorie Olmstead from the University of Washington who received the Peter Mark Memorial Award for "elucidating the nature of semiconductor surfaces and the heteroepitaxial growth of insulating materials on these surfaces." This award recognizes outstanding theoretical or experimental work in a young scientist or engineer. David Hoffman, recently retired from Ford Motor Company, received the John A. Thorton Memorial Award for "basic contributions to the effects of magnetron sputtering on the stress and microstructure of thin films, gas dynamics, and resputtering." Outstanding research or technological innovation in thin films, plasma processing, and related topics is recognized by this award. John Yates, Jr., from the University of Pittsburgh, received the Medard W. Welch Award for "the development and use of modern measurement methods to provide insights into the behavior of chemisorbed species on metal and semiconductor surfaces." This award rec-

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ognizes and encourages outstanding research in the fields of interest to AVS. Robert Celotta and Daniel Pierce of NIST received the Gaede-Longmuir Award for their "innovative development of advanced, spin-polarized electron beam technology and their scientific contributions to atomic, surface, and microstructure physics." Outstanding discoveries and inventions in the science and technologies of interest to AVS are recognized and encouraged by this award.

Thomas Bramblett (University of Illinois), Qian Lu (University of North Carolina), and Britt Turkot (University of Illinois) received Graduate Research Awards.

Among the elected Fellows of the Society are Daniel Alpert, Ernst Bauer, Rointan Bunshah, Robert Celotta, John Coburn, Jerome Cuomo, Paolo della Porta, Francois d'Heurle, Charles Duke, Charles Fadley, Randall Feenstra, Maurice Francombe, Barbara Garrison, Richard Gottscho, John Grant, Marsbed Hablanian, Robert Hamers, Franz Himpsel, Paul Ho, Leslie Holland, Jack Houston, Harold Ibach, William Kaiser, Harold Kaufman, Eric Kay, Lawrence Kazmerski, Max Lagally, Charles Magee, Dennis Manos, Marjorie Olmstead, Daniel Pierce, Cedric Powell, Stephen Rossnagel, John Rowe, Donald Santeler, William Spicer, Michael Van Hove, John Vossen, Gottfried Wehner, H.H. Wieder, Jerry Woodall, David Woodruff, and John Yates, Jr.

Sproul is AVS 1995 President-Elect

William D. Sproul was elected as the 1995 President-Elect of the American Vacuum Society. The AVS Presidency is a three-year term, including one year as President-Elect, one year as President, and a final year as Immediate Past President.

Sproul has more than 21 years of experience in wear-resistant coatings. He currently manages the Vapor Deposition Group at BIRL—Northwestern University's industrial research laboratory in Evanston, Illinois—where he is working on the development and application of superhard polycrystalline superlattice and carbon nitride coatings and on the promotion of hard coatings for enhancing the life of commonly engineered components such as gears and bearings.

Prior to joining BIRL, Sproul was the senior research engineer at BorgWarner Corporation in Des Plaines, Illinois, and a research engineer at the American Can Company in Barrington, Illinois. Sproul received his PhD degree in materials science and engineering from Brown University in Providence, Rhode Island, after serving four years as an officer in the U.S. Navy.

Sproul has been an active member of AVS since 1975 and has served AVS at the local, divisional, national and international levels. Currently, he is the AVS Vacuum Metallurgy Division representative to the International Union for Vacuum Science, Technique and Applications (IUVSTA) and is the chair of the IUVSTA's Vacuum Metallurgy Division.

Recently Announced CRADAs

Lawrence Berkeley Laboratory (LBL) (Berkeley, California) received funding for four materials-related multi-year research collaborations with the following industries. **LBL** and **IBM Research Center** (San Jose, California) will study materials for high-density information storage using x-ray microscopy. LBL and the **Advanced Lithography Group** (Columbia, Maryland) will develop ion source/beam control technology for lithography. **Energy Research Corporation** (Danbury, Connecticut) will collaborate with LBL in the development of zinc/nickel oxide batteries for electric vehicles. **SI Diamond Technology, Inc.** (Houston, Texas) and LBL will study amorphous diamond for use in flat panel displays.

SBIR Update

Structured Materials Industries, Incorporated, (SMI) (Piscataway, New Jersey) has been awarded a Basslistic Missiles Defense Organization/IST contract for over $827,000. This two-year Phase II contract, administered by the U.S. Army Space and Strategic Defense Command, will address the development of silicon and germanium light emitting nanocrystals.

Kurt J. Lesker Company (Clairton, Pennsylvania) has been awarded a 24-month Phase II contract from the Air Force Material Command's Rome Laboratory (Hanscom Air Force Base, Massachusetts). The Company is to design, manufacture, and test an integrated, multichamber ultrahigh vacuum (UHV) system in which samples are transferred from the cluster tools of standard semiconductor processing equipment to advanced materials surface analysis environments.

Alfred Receives NSF Funds to Investigate Blue Light Lasers

Xingwu Wang, associate professor of electrical engineering at Alfred University and a principal investigator in several research projects through the New York State Center for Advanced Ceramic Technology at Alfred, received a $48,660 grant from the National Science Foundation for research contributing to the development of a blue laser.

Wang has developed a thin film coated with cadmium sulfide in a cubic, rather than the more stable hexagonal, crystalline form. The cubic shape, says Wang, enhances the ability of the CdS crystals to match cubic lattices of other semiconducting materials needed for blue light lasers.

Blue light lasers are sought because the shorter wavelength of blue light enables reading material stored on a denser optical disk, thus as much as quadrupling the storage capacity of compact disks to more than 2,600 MB of data.

Wang says that the CdS thin film also has potential as a semiconductor for photoconductors, piezoelectric transducers, solar cells, and optical devices.

Newnham Receives the John K. McMahon Memorial Award

Robert Newnham, Alcoa Professor of Solid State Science at The Pennsylvania State University Materials Research Laboratory, received the John F. McMahon Memorial Award presented at the annual John F. McMahon Memorial Lecture held at the New York State College of Ceramics at Alfred University. This award recognizes ceramic engineers or scientists who make significant contributions to the field; it is named after the former dean of NYS College of Ceramics.

Addressing Ceramic Engineering and Science students and guests at the lecture, Newnham talked about contributions ceramic engineers can make to society. For an example, water, he said, has always limited the growth of civilizations, but engineers may find ways to solve the distribution problems. Already in China, huge dams and a grand canal (constructed cement, a low-temperature ceramic) are being constructed to divert part of the Yangtze River to irrigate the arid plains of northern China. There is a proposed grand canal for North America, too, and Japan already has major works in progress, building bridges and tunnels to connect all its islands and South Korea. To accomplish that, he said, more work needs to be done in the areas of macro-defect free cement, and new cements that are more resistant to collapse and failure.

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Creating submicron-scale electronics are also important, said Newnham, who has devoted much of his research time to such projects. With the submicron-scale electronics he and his co-workers have been developing, for example, researchers are able to "communicate" with and track schools of fish.

Fullman Receives Acta Metallurgica J. Herbert Hollomon Award

The fifth annual Acta Metallurgica J. Herbert Hollomon Award has been awarded to Robert L. Fullman, retired from the General Electric Research and Development Center in Schenectady, New York.

Fullman was selected for the award in recognition of his leadership in fostering positive influences of materials science and technology on society during his service as Secretary/Treasurer of Acta Metallurgica, Inc., as well as for his technical and management contributions.

Fullman has served as Secretary/Treasurer of the Acta Metallurgica Board of Governors since 1966. Among his responsibilities, he manages the Board's finances and non-editorial correspondence for three international technical journals of materials science, lectureships, and Acta/Scripta Metallurgica Conferences.

Fullman received his undergraduate and graduate degrees in metallurgical engineering at Yale University and joined the General Electric Research Laboratory in 1948, where his research focused on how microstructural features evolve in metals and alloys.

His principal research contributions included the first measurements of the interfacial energy of twin boundaries, the discovery of the first rapid thermal process for preparation of dislocation-free crystals (iron "whiskers"); and the development of statistical relationships between the apparent sizes of microstructural features as observed two-dimensionally on polished surfaces and the actual sizes of the corresponding three-dimensional features. Fullman later performed research on ceramics technology for novel applications, stress corrosion cracking in nuclear reactors, "activated sintering" of metal powders, and nitriding of steels.

Fullman has been awarded nine patents. During his career he has served on numerous U.S. government advisory panels, including Materials Advisory Board studies of high pressure technology and of beryllium applications and technology needs, Department of Defense panels to study its continuing needs for materials technology, and as consultant to the Director of the National Bureau of Standards to review its programs and program management methods. He was made a Fellow of the American Society for Metals in 1971.

The award will be presented to Fullman on February 13, 1995 during the Annual Meeting of The Minerals, Metals and Materials Society in Las Vegas, Nevada. □

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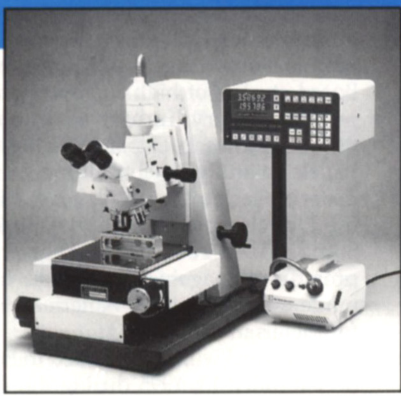

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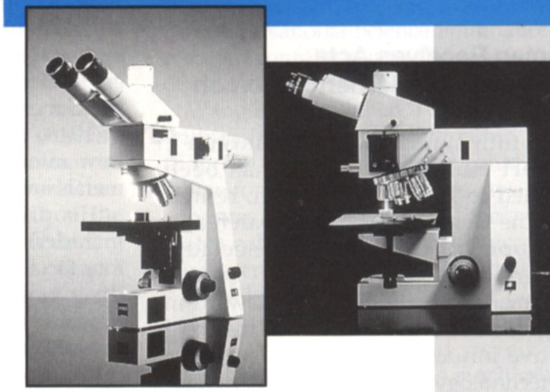

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