Nanostructures Require Nanomeasurements

Stephen W. Carmichael[1], Mayo Clinic

Nanofabrication is upon us. But engineers require measurements of physical properties of their materials in order to use them appropriately. Because the size of the object is in the nanometer scale, tiny measuring devices are required. Furthermore, there is the problem of reading these tiny devices. Zhong Lin Wang, Philippe Poncharal, and Walter de Heer at Georgia Tech have solved this problem by using the transmission electron microscope (TEM) to read off the measurements[2].

A special device was designed to fit inside the TEM, allowing for simultaneous visualization and manipulation of a nanostructure. The nanostructure that Wang *et al.* used was the carbon nanotube which could be clearly visualized by the TEM and has a well-defined structure. Specifically, they used multiwalled nanotubes with diameters of 5 to 50 nm and lengths of 1 to 20 μm. The device they designed for *in situ* microscopy was a modified specimen holder that allowed carbon nanotubes to be mounted in a conducting medium and positioned across from a counter electrode, which was a droplet of mercury or gold/platinum balls. A specific nanotube could be visualized and an electric potential was applied between the nanotube and the counter electrode to carry out a variety of measurements. Thereby measurements could be done on a specific nanotube whose microstructure could be determined by transmission electron imaging and diffraction. Thus, the atomic-scale structure of the object whose properties are being measured is known.

The TEM they used had a relatively low vacuum at the specimen stage so that mercury could exist in the liquid state. The 100 kV electron beam did not damage the carbon structure, so extensive observations could be carried out on a single nanotube. Also, a large angular tilting range allowed precise measurements of the length of the nanotube which was necessary for determining the precision of the measurement.

Wang *et al.* could examine mechanical strength of a nanotube by applying an external voltage that results in an electrostatic force that deflects the nanotube. The nanotube could be bent to 90° and still recover its original shape. Applying negative and positive voltages gave rise to cyclic loading of the nanotube and allowed a direct measurement of its elastic limit. Alternatively, resonance could be induced with an oscillating voltage and the frequency could be accurately measured. This allowed Wang *et al.* to calculate the bending modulus of the nanotube, which was as strong as a diamond!

Electrical conductance of a single carbon nanotube was also measured with the *in situ* microscopy device. Interestingly, quantum conductance was observed, which means that electrons pass along the nanotube without generating heat. This could be important for nanoelectronics. Wang *et al.* also studied the electrical field-induced field emission characteristics of a single nanotube. The emission of electrons at an applied voltage could be visualized as a dark contrast near the tips of the nanotube. A detailed analysis of this phenomenon is underway using electron holography.

Perhaps the most fascinating experiment reported by Wang *et al.* resulted in their discovery of a "nanobalance," the most sensitive and smallest balance ever made. Analogous to a spring balance, the mass of an object at the end of a spring can be determined if the vibration frequency is measured and the spring constant is calibrated. They attached a small particle to the end of a nanotube and observed that the resonance frequency dropped about 40%. The mass of the particle was calculated from the frequency to be 22 ± 6 femtograms (femto = 10^{-15}, one millionth of a nano!). It was suggested that this nanobalance could be used to weigh single virus particles, or other biological molecules.

These fascinating experiments point to a way of using TEM to making quantitative measurements at the nanometer scale. The key appears to be in getting a close enough look to read the instruments. This is a new application of the TEM and a critical step in nanotechnology. ■

1. The author gratefully acknowledges Dr. Z.L. Wang for reviewing this article.
2. Wang, Z.I., P. Ponchard, and W.A. de Heer, Nanomeasurements in transmission electronmicroscopy, Microsc. Microanal. 6:224-230, 2000.

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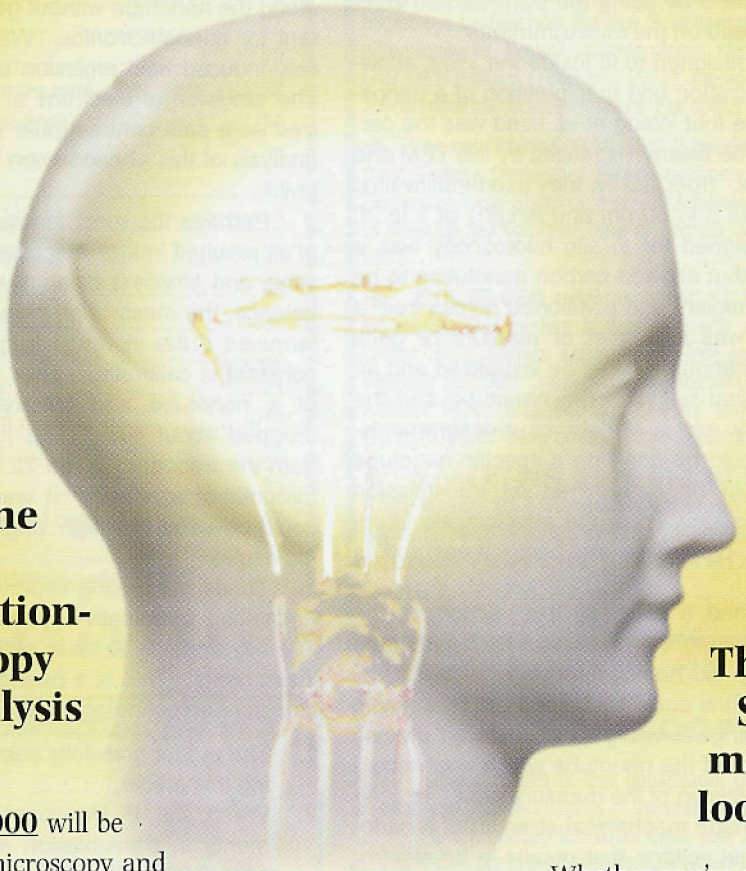

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National Society of Histotechnology

In May 2000 issue of Microscopy Today, in the article "A Comment on Formalin Safety", this society was incorrectly referred to as the National Society of Histochemistry. Thanks to Gayle Callis (Montana State University) for the correction.

Anyone interested in tissues can join other technicians; pathologists; lab assistants; research, hospital, animal, plant, human, and ASCP registered individuals; those just starting to study for the exam; old timers; newbies, U.S. citizens people from other countries,....in other words, all of us!

Membership in the society is only $40 a year. Not only do you get the NSH Newsletter (NSH in Action), but you also get the Journal of Histotechnology, many materials at a cheaper rate or free (great stuff for people studying for the ASCP exams or who are supervisors), cheaper rates for NSH Symposium, etc.

For additional information on the Society, visit their web site: http://www.nsh.org

✱ Noted British microscopist Brian Ford recently received the inaugural August Köhler medal from the State Microscopical Society of Illinois, as presented by Bill Mikuska of the Society, at INTER/MICRO-2000, sponsored by the McCrone Research Institute.

Brian was actually given the award three years ago, but the medal was not ready at that time. He was asked to give an illustrated autobiographical talk to mark the event, and whipped through 300 35 mm slides in thirty minutes.

Currently the Royal Literary Fellow at the Open University in England, Brian has been publishing microscopical research since the 1960s. His findings appear in the Encyclopaedia Britannica Yearbooks and many other encyclopedias. Some 100 editions of his books have been published worldwide.

✱ "GFP in Motion" is a free CD-ROM produced by Trends in Cell Biology and featauring more than 150 time-lapse movies of dynamic biological processes. In the two years since its production, the field of fluorescent proteins and their applications has advanced and expanded greatly. As a result, they have decided to produce a follow-up. Like it's predecessor, the new CD-ROM will be dedicated to applications of fluorescent proteins in the visualization of dynamic biological processes. The CD-ROM will feature examples from all areas of biological research and will be distributed at no charge.

This is an opportunity for you to make your movies and time-lapse sequences available to a broad audience. If you would like to have your contribution considered for inclusion, please send a message with a brief description of the materials you want to provide to <GFPin Motion@lis.ch> as soon as possible. You are encouraged to submit your completed contribution immediately for consideration. The deadline for the submission of completed contributions is 31 July 2000.

Author instructions: Provide 1-5 image sequences, each with a short self-explanatory legend, and a background text section including an introduction and a materils & methods section. Detailed instructions are available at:
ftp://ftp.eslo.co.uk/GiMll/Instructions/instructions.html

Last Call
Microscopy & Microanalysis 2000

✱ **M&M 2000 Exhibitor Demonstrations**

Once again, MSA's Education Committee is organizing mini-seminar or tutorial demonstrations known as "Exhibitor Demonstrations". These sessions are conducted by Exhibitors right in their own booth(s). Exhibitor demonstrations are the perfect way to make attendees more knowledgeable about products and services, at no charge, to the attendees. Admission is limited and controlled by tickets issued at the Education Committee Booth on the exhibit floor.

✱ **Microscopy & Microanalysis 2000 Annual Golf Tournament.**

The winter weather has broken and golfers once again fill their courses in the Northeast. Your M&M 2000 crew have selected a truly outstanding course for this year's traditional scramble event. Don't miss this opportunity for a memorable round with your colleagues and friends.

✱ **Late Breaking Poster Session at M&M 2000.**

Microscopy & Microanalysis 2000 will feature a poster session composed of presentations fo newly acquired data or analyses which were unavailable for submission by the February 15 deadline.

✱ **Just for Fun Micrograph Contest**

The concept of the contest is based upon composite images, made up of two or more images, at least one of which must be microscopical in nature. Contestants may enter up to two composite images and do not have to be present to win.

Entries will be displayed in our booth and conference attendees will be invited to vote on which they consider the most "creative and interesting". First prize will be $300, with $200 and $100 for second and third prizes, respectively.

Entries must be, of course, in hard copy. They may be either black and white or full color.

For further information on the above four events, refer to page 5 of the May 2000 issue of this publication.

FRONT COVER IMAGE

SEM Photograph of a Female Mosquito (Aedes aegypt)

Imaged on an ETEC SEM at 5 kV using the SEM wideband Multi-Detector Color Synthesizer (designed, built and patented by David Scharf). Then acquired digitally at 2,048 X 1,536 pixels directly into a Macintosh Power PC as a TIFF file, using Digital Micrograph software and Digiscan hardware. Then output to a CELCO film recorder, using Ektachrome 100+ film, to produce a 4 X 5 transpaency.

Photograph is Copyright© by David Scharf, 1994
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As one of a series, this image is available at 150X as a 18 1/2" X 19" high quality, lithographic print. To see the full series of 16 prints, and receive complete print descriptions and ordering information, visit the Microscopy Today web site at www.microscopy-today.com

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CALL FOR 2001 EAS Award Nominations

EAS is soliciting nominees for its 2001 Awards for Outstanding Achievement in:

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The deadline for receipt of nominations is June 30, 2000. These awards will be presented at the 2001 Eastern Analytical Symposium, to be held in Atlantic City, New Jersey.

A primary letter of recommendation should be submitted by someone familiar with the nominee's work and should be no more than six pages in length. It should include a discussion of his or her work's significance, a list of publications, presentations, and awards, and a statement of the nominee's willingness to present their work at an EAS Award Symposium. Each Award consists of an honorarium, plaque, travel expenses and the opportunity for the awardee to present his or her work to the attendees at an Award Symposium.

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COMING EVENTS

✓ June 26/30 '00: **Summer School on Computing in Electron Microscopy** (NCEM, Lawrence Berkeley National Lab) Berkeley, CA. (510)486-6036, http://ncem.lbl.gov/frames/workshops.htm#workshops

✓ July 2/5 '00: **International Kunming Symposium on Micdroscopy,** Kunming, China. http://www.iphy.ac.cn/microsc/IKSM.html

✓ July 3/8 '00: **Xith International Congress of Histochemistry and Cytochemistry.** (Royal Microscopical Society), York, U.K., www.med.ic.ac.uk/external/ichc_2000/

✓ July 9/14 '00: **2nd Meeting of the International Union of Microbeam Analysis Societies.** Kailua-Kona, Hawaii. www.microanalysis.org/iumas2000

✓ July 9/14 '00. **12th European Congress on Electron Microscopy.** Bruno, Czech Republic. http://www.eurem2000.isibrno.cz/

✓ July 17/19 '00: **Electron Microprobe Analysis by Wavelength Dispersive Spectroscopy.** (MIT) Cambridge, MA. E-probe-www@mit.edu, (617)253-1995.

✓ July 27/29 '00: **International Kunming Symposium on Microscopy** (Chinese Electron Microscopy Society) Kunming, P.R. China. IKSM Office: IKSM@aphy.iphy.ac.cn

✓ July 29/August 5 '00: **Biological Atomic Force Microscopy** (Johns Hopkins School of Medicine) Baltimore, MD. bioafm@jhmi.edu, fax: (410)614-3797

✓ August 13/17 '00: **Microscopy & Microanalysis '00:** (MSA) Philadelphia, PA. Annamarie Dowling / Mary Beth Rebedeau: (708)361-6045, rebgroup@earthlink.net

✓ August 17/19 '00: **Fundamentals of Light Microscopy**
August 21/23 '00: **Polarized Light Microscopy**
Wellesley College, Wellesley, MA. Mary McCann: (617)484-7865

✓ August 22/26 '00: **Scanning Probe Microscopy of Polymers.** (American Chemical Society) Washington, D.C. Vladimir V. Tsukruk: ((515)294-6904

✓ September 3/8 '00: **11th International Congress of Histochemistry** York, U.K., www.med.ic.ac.uk/external/ichc_2000

✓ September 10/15 '00: **CLEO/Europe-IQEC 2000**

✓ September 11/15 '00: **Advanced FTIR Microscopy** (McCrone Research Institute) Chicago, IL, Nancy Daerr, (312)842-7100, ndaerr@mcri.org

✓ October 8/13 '00: **3rd World Congress on Cellular and Molecular Biology.** Jena, Germany, www.uni-jena,de/wccmb

✓ October 11/19 '00: **Optical Microscopy & Imaging in the Biomedical Sciences.** (Marine Biological Laboratory), Woods Hole, MA. Carol Hamel: (508)289-7401, admissions@mbl.edu

✓ October 16/20 '00: **FLUORESCENCE 2000-Advanced Courses of Fluorescence Microscopy and Confocal Microscopy.** Lake of Garda, Italy. Dr. Annalisa Imberti: +390270646234, http://users.unimi.it/~fl2000/

✓ October 17/19 '00: **Fundamentals of Asbestos Analysis by Transmission Electron Microscopy** (MVA, Inc.) Norcross GA: (770) 662-8509

✓ November 12/16 '00: **International Symposium for Testing and Failure Analysis.** http://www.edfas.org/istfa

✓ November 13/17 '00, **8th Conference on Frontiers of Electron Microscopy in Materials Science** (National Research Instituite for Metals) Matsue, Japan. Http://femms2000.llnl,gov/

✓ November 13/17 '00: **Particle Isolation, Manipulation and Mounting for Additional Analysis** (McCrone Research Institute) Chicago, IL, Nancy Daerr, (312)842-7100, ndaerr@mcri.org

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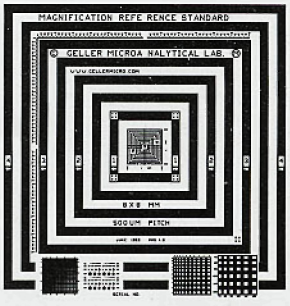

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