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SPM Laboratory courses gain exposure

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Nanoscience education is becoming increasingly important as new nanotechnology initiatives increase funding and awareness of this new field. Recent reports¹ estimate the number of nanotechnology workers needed internationally by the year 2015 will be close to 2 million. Such reports underscore the importance of exposing secondary school students and undergraduates to nanotechnology and nanoscience.

One way to give our future nanotechnologists hands-on exposure to this technology is through scanning probe microscopy laboratory courses and demonstrations. Many educators have already developed programs to teach chemistry and physics using atomic force and scanning tunneling microscopes. A recent issue of the *Journal of Chemical Education*² featured several articles about SPM laboratory experiments for undergraduates.

Kimberly Aumann, Karen J.C. Muyskens, and Kumar Sinniah³ at Calvin College in Grand Rapids, Michigan summarize a three week undergraduate introductory course on SPM. Samples such as DNA and filamentous actin adsorbed to mica, memory arrays in an EPROM chip, and self-assembled monolayer systems are used in the laboratory to familiarize students with the breadth of possible applications.

Biological applications of the AFM include imaging DNA in its relaxed, stretched and supercoiled states. An assessment of the use of AP-mica versus bare mica is made as well, and detailed descriptions of their preparation are given in the lab supplement. In addition, filamentous actin is immobilized on mica for AFM imaging. The students are able to measure branching angles, periodicity and heights of individual filaments.

Microelectronic applications are also investigated by disassembling EPROM memory chips and imaging the internal structure. Visualizing the complex pattern of layering in integrated circuits is an ideal application to demonstrate size reduction in the semiconductor industry. In addition, their low

cost and ease of preparation lends perfectly to such hands-on laboratories.

Self-assembled monolayers on graphite are an excellent application for scanning tunneling microscopy. In the work presented by the Calvin College group, 3 different 30-carbon hydrocarbons on graphite are imaged to observe the ways in which the functional group influences the appearance of the self-assembled monolayers.

Furthermore, atomic scale imaging is important for introducing students to nanoscience. Advantages range from the traditional sense of reinforcing theoretical ideas presented in the classroom to the basis behind nanoscience itself – understanding the atomic and molecular building blocks of our future products.

Chuan-Jian Zhong, Li Han, Mathew M Maye, Jin Luo, Nancy Kariuki, and Wayne Jones, Jr.⁴ at SUNY-Binghamton present a hands-on undergraduate SPM laboratory focused on atomic resolution. This lab gives a good background on the crystalline structure of 2 SPM standards – mica and HOPG. Detailed descriptions of the cleavage plane, interatomic spacing and bonding, and how these effect macroscopic characteristics is discussed. In addition, background on the imaging mechanisms in both AFM and STM are reviewed in the supplement.

The *Journal of Chemical Education* has previously featured papers⁵⁻⁸ on SPM education. The Feb 2003 issue, combined with the detailed supplements available online, has given its readers an exceptionally nice start to teaching with SPM.

¹ Government Nanotechnology Funding: An International Outlook, MC Roco, 30 April 2002

² *J. Chem. Educ.* **2003** 80

³ Aumann, Kimberly; Muyskens, K.; Sinniah, K. *J. Chem. Educ.* **2003** 80 187

⁴ Maye, M.; Luo, J.; Han, L.; Zhong, C. *J. Chem. Educ.* **2003** 80 194

⁵ Maye, M.; Luo, J.; Han, L.; Zhong, C. *J. Chem. Educ.* **2002** 79 207

⁶ Polar, Jordan C. *J. Chem. Educ.* **2000** 77 194

⁷ Giancarlo, L.C.; Fang, H.; Avila, L.; Fine, L.W.; Flynn, G.W. *J. Chem. Educ.* **2000** 77 66

⁸ Glausinger, W.S.; Ramakrishna, B.L.; Garcia, A.A.; Pizziconi, V. *J. Chem. Educ.* **1997** 74 310

Universität Basel

Uni Basel has created a virtual nanoscience program, *Nano-World*, bringing nanoscience applications and teaching tools to students through the internet.



Nano-World
The Computer Supported Cooperative Learning Environment on Nanophysics
a swiss virtual campus project

<http://www.nano-world.org>

The Nano-World program at Uni Basel is built around remote learning. Specialized software has been developed to interface with instruments as well as simulation programs to give secondary students access to the expensive resources housed at the University.

One instrument used in the Telelaboratory project is an easyScan AFM that has been modified with a remote controllable sample stage, remote

controllable acquisition software, and multiple-client access. Control of the system can be switched between users, and the data acquired on the system can be viewed via web browser, via PDA or via web-enabled mobile phone.

The demo site at nano-world.org has a very nice set of animations, an overview of the remote AFM, and a friction force simulator. The friction force simulator allows the students

to adjust parameters of an AFM in frictional force mode and view the resulting image in real-time. An animated user manual and stick-slip demonstration accompanies the simulator.

The Nano-World web site is located at www.nano-world.org. For information on the demos, see www.nanoworld.unibas.ch/nano/Lab/demo

The University of Wisconsin — Madison

UW's MRSEC Education and Outreach program offers a nanotechnology resource for people of all ages and educational background.

<http://mrsec.wisc.edu/EDETC/>

The Materials Research Science and Engineering Center on Nanostructured Materials and Interfaces (MRSEC) at the University of Wisconsin has established a comprehensive nano outreach program. Their web site, titled "*Exploring the Nanoworld*" offers the user a large number of modules, sample courses, and tutorials. The pages are organized by target audience: the general public, k-12 students, college students, k-12 teachers, college faculty, and MRSEC participants.

Science demonstration kits, models & booklets described on the site can

be purchased as well.

A video "lab manual" for nanoscale science shows experiments in action, so the teacher knows what to expect from the demonstration. It is also quite entertaining for those not in a lab to try them out.

One of the most unique parts of the site is "Exploring the Nanoworld with LEGO® Bricks." The 48-page manual offers an excellent tutorial on a variety of nanoscale structures as well as the devices used to image them. A review on atomic force microscopy is given as well, showing how

to assemble a large-scale version of an AFM with LEGO bricks. Color photographs and drawings accompany the text.

<http://mrsec.wisc.edu/EDETC/>



Nanosurf® easyScan STM

Atoms, easier than ever before!

The easyScan STM is an easy to use and affordable system that allows you to bring nanotechnology into your classroom or laboratory.

Schools around the world have implemented the easyScan STM into their curriculum. With a price under US\$8,000, multiple STMs can be purchased for a laboratory course.

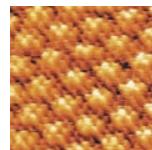
The easyScan STM system is fully computer controlled. On a normal table-top environment students can routinely obtain atomic resolution on samples such as graphite. Furthermore, we offer

a variety of samples to get you started with demonstrations and lab experiments.

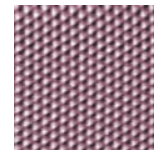
The STM software makes running the system easy and intuitive. Features of the software include online math functions, data export, customizable display, and STM spectroscopy.

Well written manuals give a good introduction to STM, and an optional teachers manual assists in using the STM in the classroom.

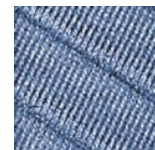
Find more information at www.nanoscience.com/products/easyScanSTM.html



Charged Density Waves on TaS₂, 5.4 nm scan size



Atomic resolution of HOPG, 4 nm scan size



Organic thin film 13 nm scan size, J. Francis Wolf, HU-Berlin



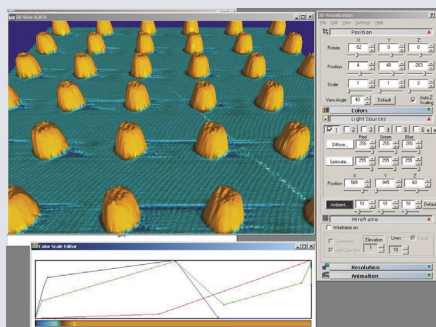
The easyScan system is compact and mobile

Presentation Tools

The Scanning Probe Image Processor

Ever wanted to spice up a presentation of SPM data? If you are using SPM images in a classroom or for presenting your research, nothing beats some multimedia to interest a crowd.

The Scanning Probe Image Processor (SPIP) software by Image Metrology now offers 3D animation to its already long list of data analysis and presentation tools. Rotate, pan, zoom, change lighting and coloring effects. Simple anchors to different views are recorded by the software



3D Visualization studio interface

and the animation is performed automatically between frames. Virtually all SPM formats are supported.

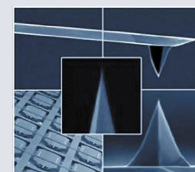
For a gallery of animations, see our web site at www.nanoscience.com/education/gallery.html

AFM Probes

Paying too much for tapping mode tips?

Finally, a low-cost, quality AFM probe with good consistency and reliability is available.

We provide tapping mode, tapping in liquids, force modulation, pulsed force mode and contact mode models. All tips have a sharp apex of better than 10 nm, and are perfect for both teaching and research environments. Information and prices can be found on our web site at: www.nanoscience.com/products/



The Nanoscience Education Newsletter

Spring 2003 Contents



- ▶ **SPM Student Laboratories reviewed**
Review of a recent Journal of Chemical Education issue that presents 2 student SPM lab courses
- ▶ **Overview of Nanoscience education programs**
Uni Basel and the University of Wisconsin have very active nanoscience education programs featuring public outreach and resources for teachers from the K-12 through university levels.
- ▶ **Tools for teaching nanoscience**
SPM related tools for education
 - The easyScan STM - a low cost, mobile and easy to use high resolution STM
 - SPIP software adds new 3D animation features to enhance any talk or demonstration
 - Tapping mode AFM probes that won't break your budget

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