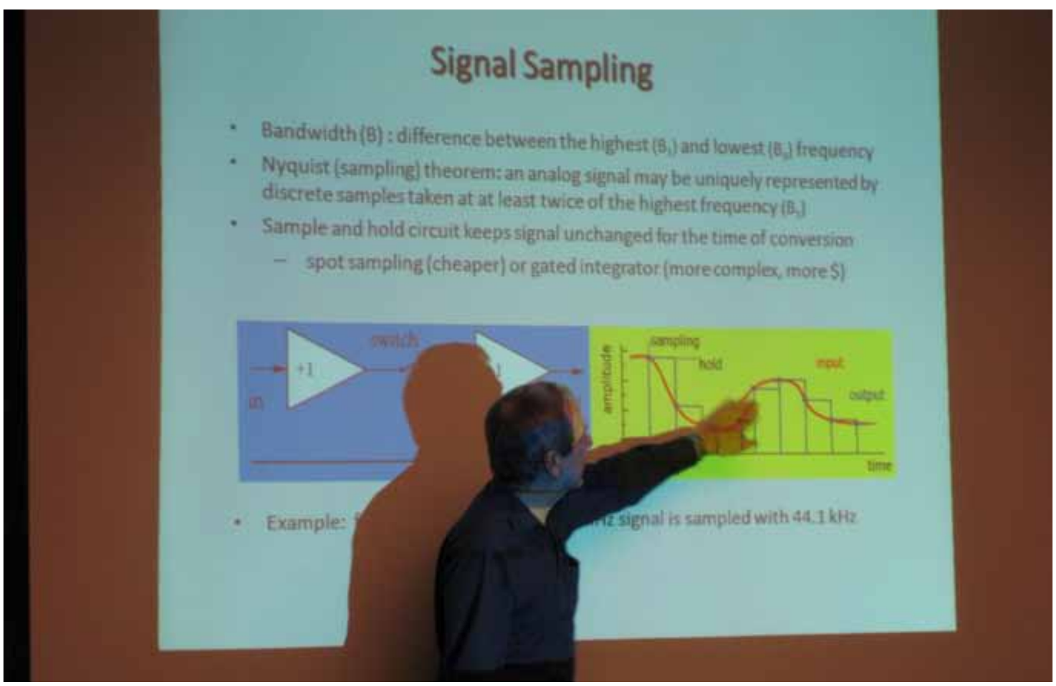
Science Afternoon at NIST with a Focus on Scanning Electron Microscopy
Wednesday, September 28, 2011

The afternoon began with the use of the Hitachi TM3000 Portable Scanning Electron Microscope designed to be simple enough to be used by school kids – and so certainly middle school teachers should be able to look at the objects they brought: butterfly wings, reptile skin, and a fly! Unlike the powerful and more precise SEMs used at NIST, this microscope requires no special setup and only a two-minute time to vacuum. Bob Gordon of Hitachi explains that the electrons are produced by a tungsten filament, just like in an incandescent light bulb, but since the sample is under a vacuum with almost all the air removed, the electrons can be focused to the sample and directed to produce an image.



Andras Vladar, an engineer in the Nanoscale Metrology Group explained how SEM works and how, after the sample is scanned row by row to form a complete image (a raster scan), the electronic signal is sampled at various points to produce something that is sensible to humans. “How the data is collected determines how much information you can get out of it,” Andras says. Few pixels versus many plus the impact of Signal/Noise (S/N) make a difference.

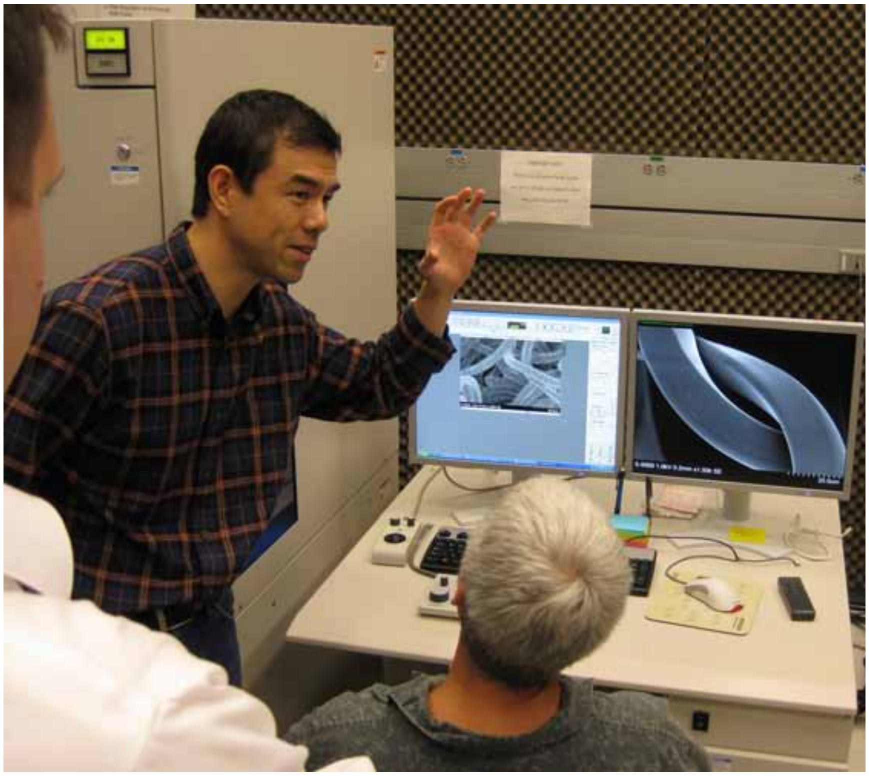
Teachers from middle schools in Montgomery and Frederick Counties listened intently as Andras explained how the images are manipulated to make them more useful to the viewer. Of course it's best to get the image right at the beginning but the scientist often has to manipulate the image for human perception. Image interpretation requires the human mind. Which image is best? Depends on the purpose. One caution: SEM images are not height maps – those seemingly 3D images can be deceptive!

Next Bob Gordon of Hitachi High Technologies America talked about the role of Hitachi in President Obama's program, "Change the Equation" and how Hitachi is working to improve science education in the United States.

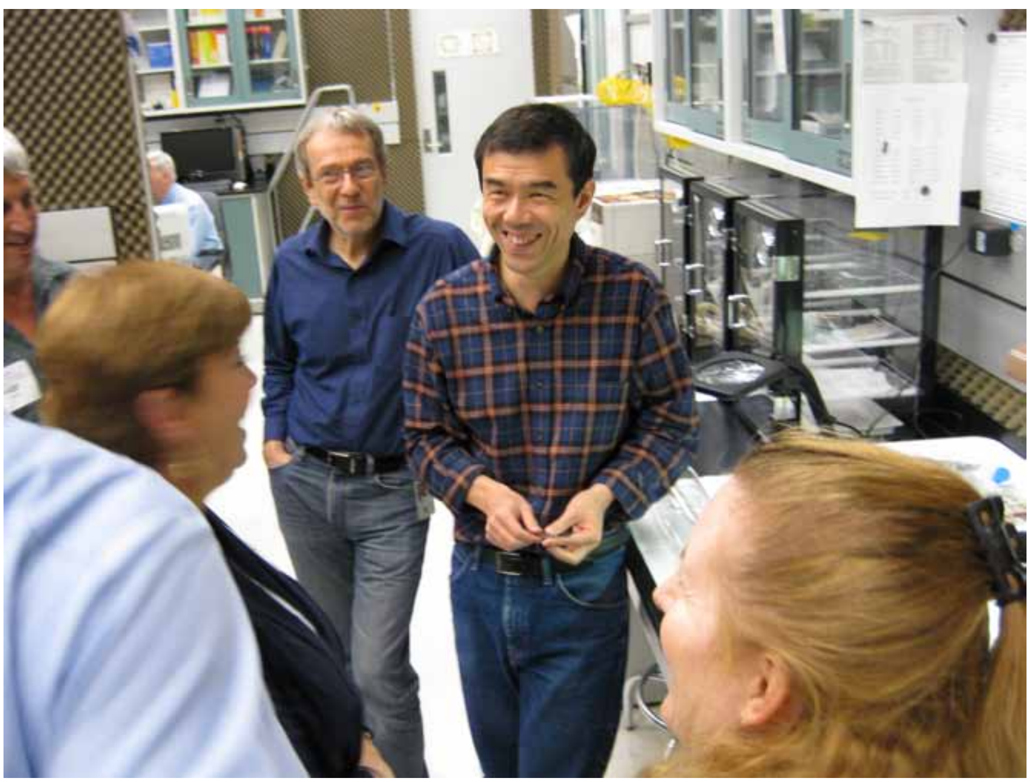
From the conference room with a microscope brought in just for this occasion and that fits on the tabletop to the lab with instruments that are protected from stray dust – that's what the transparent plastic is for – and require much more special care and handling. Why the difference in treatment? Increased resolution, pushing the limits of the measurements primarily on silicon wafers, or "chips," used by the semiconductor industry. With this instrument scientists have the accuracy to differentiate between groups of three silicon atoms! That's important in increasing and controlling computer memory.

Then it's off to a couple of additional labs where NIST scientists have set up samples for teachers and view and also for teachers to "drive". Another instrument that is being used more and more is the Helium ion microscope that uses beams of Helium ions instead of electrons. The result? In some cases, a clearer image that provides complementary information to the SEM. This microscope can also perform nanomilling, or shaving off a few atoms of the sample at a time, SEMs can do similar work but with less of a fine touch: they shave off a much thicker layer. Why is this important? So you can see what's in the different layers and check for purity and just see what's there. Andras also explained how the helium ion microscope may someday be able to add materials instead of remove them, which would enable nanosculpting and potentially revolutionize the semiconductor industry!

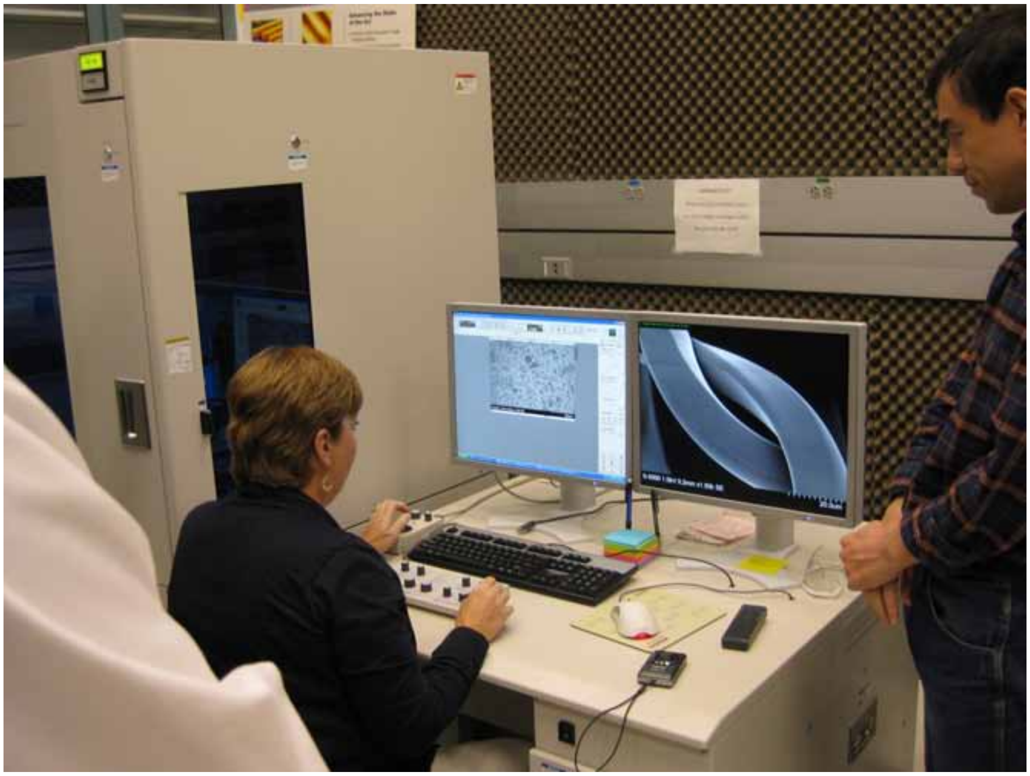
Bin Ming, a physicist in the Nanoscale Metrology Group, sets up Dan Goldman to use the HITACHI S-5500 High Resolution Field Emission Electron Microscope and investigate the three samples loaded all on the same probe: nylon pantyhose, yeast, and a wine cork.



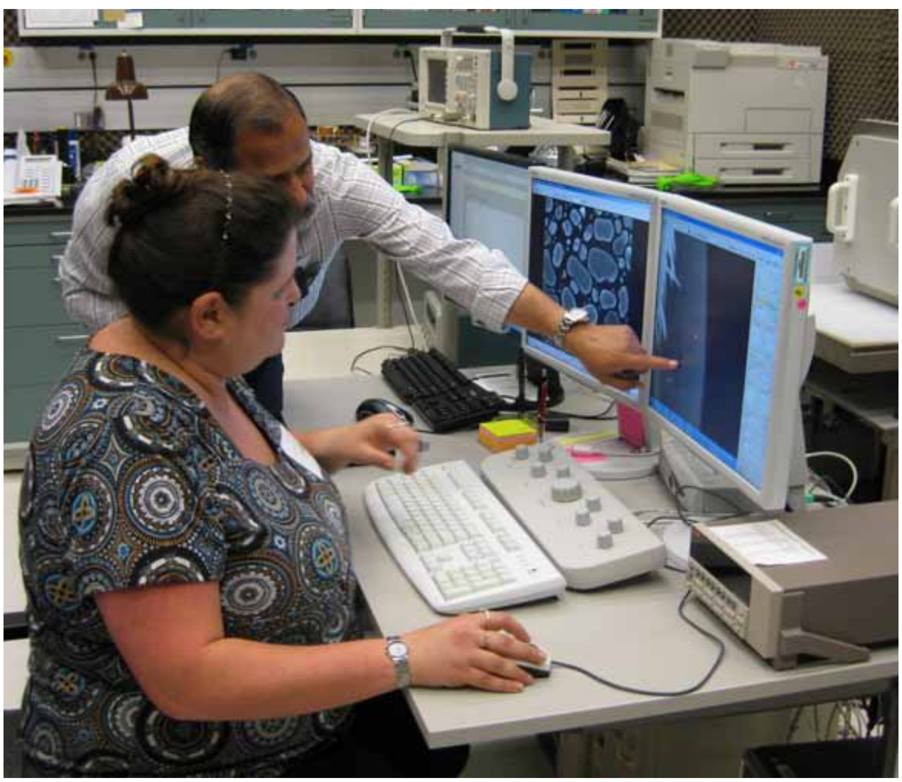
Bin explains how the instrument is used to investigate the sample – the strands of the nylon hose, in this case – shown in two different magnifications on the screens.



Not only are teachers learning about the latest microscopy technology, they're also enjoying interacting with the NIST scientists.



Jill Maisch prepares to investigate the yeast cell sample on her own. Turns out that the bakers yeast is compressed into columns or logs, each one composed of millions of dormant yeast cells. Add water and sugar and they begin to germinate – and produce CO_2 which makes our bread rise.

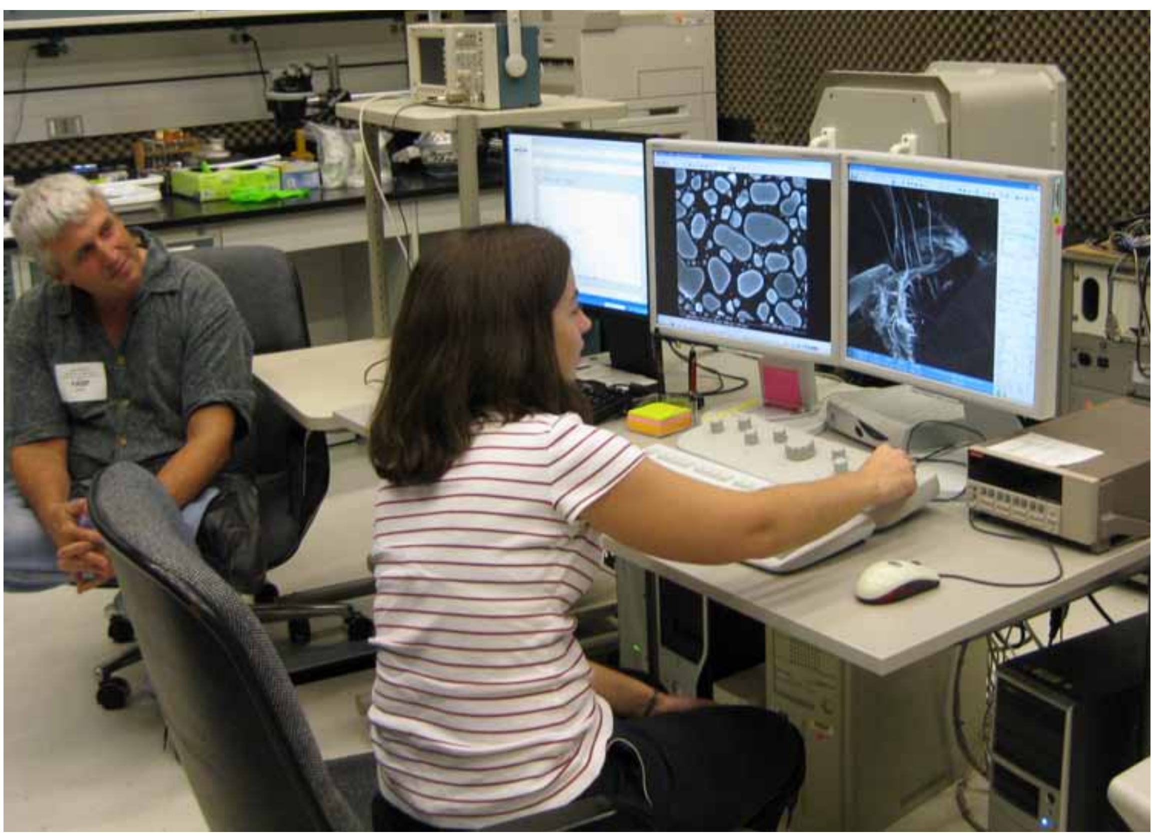


On yet another SEM, the FEI-Helios Dual Beam Focused Ion Beam (FIB), Dana Schneider begins to examine a cricket with the assistance of NIST engineer, Prem Kavuri .

Dana begins to get the hang of it …

…after figuring out that sometimes the image makes more sense if you hold your head a certain way.


Lisa Wheelock catches on quickly and moves the sample around to investigate interesting sections of the cricket. The cricket was coated with ~10 nm of gold to make it conductive so that it will show up when the beam of electrons hits it.


Mary Ellen Wolfinger discovers a hair-like structure on the cricket, while Dan looks on.

NIST Materials Research Engineer Kate Klein and teacher Carolyn Holcomb have a discussion about a complementary technique, Transmission Electron Microscopy, and the changes in the technology over the past thirty years.

Then it was back to the conference room for more work with the tabletop SEM and conversation with NIST scientists Andras Vladar, Brad Damazo, Mike Postek, Prem Kavuri, Bin Ming, and Kate Klein, plus Bob Gordon of Hitachi High Technologies America, Jenny Harms of the Hitachi Foundation, and Rei Tsuchiya of Hitachi, Ltd. What fun to actually be able to use the instrument that produce all those cool photos, plus learn about how they work and how NIST uses them!

And as an added bonus teachers were encouraged to consider attending the Scanning Microscopies Meeting at the SPIE conference on imaging and microscopy scheduled for April 23-27, 2012 in Baltimore. Scientists attend with a conference fee of ~$650 and teachers can attend for $25. For the first time there will be an educational session just for teachers and they'll be invited to go through the exhibits hall, which is certain to be an enlightening experience. Stay tuned for more information and the particular date chosen for the educational session.

Teachers are also reminded of the upcoming Maryland Association of Science Teachers Conference on October 21. The keynote speaker will be NIST's own Dr. Tim Foecke talking about his research on why the unsinkable Titanic sank. Turns out that the answer is more complicated than you've probably heard and is a combination of materials science, politics, and human error. For more information see http://www.emast.org/.

Pertinent web links from this Science Afternoon at NIST:
1. National Nanotechnology Infrastructure Network (NNIN): http://www.nnin.org/. See in particular the NNIN education portal: http://www.nnin.org/nnin_edu.html and Nanooze, a children's science magazine: http://www.nanooze.org/main/Nanooze/English.html.
2. A virtual microscope website funded by NASA that provides several microscopy tools including an explanation of how SEM works: http://virtual.itg.uiuc.edu/ (thanks to Dan Goldman for this one)
3. Science Buddies: http://www.sciencebuddies.org/, contains resources for teachers and parents on hands-on science investigations.
4. Here's a link to an optical microscope view of the cricket antennae we were looking at on the SEM: http://www.flickr.com/photos/solud/4328974537/in/photostream/lightbox/