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NANOTECHNOLOGY NEWS FROM THE UNIVERSITY OF MINNESOTA

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NATIONAL NANOTECHNOLOGY INFRASTRUCTURE NETWORK FEATURED RESEARCH

The *BUMPS*, an Elegantly Simple Device to Quantify Finger Pad Touch Sensitivity

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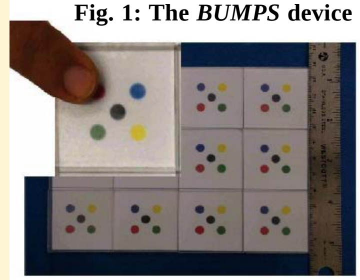
Touching and feeling with the fingers and hands is an important part of daily living. During waking hours we are continually touching and evaluating the size, contour, texture and compliance of objects to perform a wide variety of functions. Damage to nerves that innervate the fingers following trauma or peripheral neuropathy causes "numbness" and difficulty performing these every day tasks. Unfortunately, existing methods to quantify touch deficiency are time consuming and the results are difficult to reproduce. Consequently, they are rarely used in clinical situations.

The Kennedy lab (KLAB) devised an elegantly simple method to rapidly test tactile sensitivity on the finger pads. They call it the "*Bumps*". During the *Bumps* test a person rubs one finger across a smooth surface to locate small bumps that are of different sizes.

Fig. 1: The *BUMPS* device



The *Bumps* device is a smooth, flat surface divided into 12 squares (Fig. 1). Each square contains 5 circles, each a different color. One of the 5 circles contains a bump. Bumps are made by photolithography in the Nanofabrication Center. Bumps are 550 µm diameter and coin-shaped, but each has a different height (thickness) ranging from 2.5 µm to 26 µm. Subjects rub the circles with a finger pad to locate the circle that contains the bump. The touch threshold is the smallest size bump felt twice consecutively. Normal subjects usually locate all bumps, most even feel the 2.5 µm bump. The results clearly separate normal subjects from people with neuropathy. Bumps are 'felt' by exciting touch receptors called Meissner's corpuscles (MCs) in finger pads. Figure 2 shows two MCs on either side of the fingerprint ridges (see the wavy blue top). When "bumped" the MCs discharge impulses that travel to inform the brain of being touched.

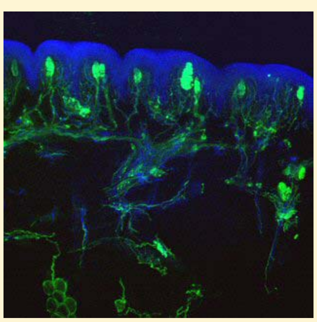


Fig. 2: Meissner's corpuscles

The *Bumps* device is used to detect the first signs of nerve pathology in cancer patients receiving chemotherapy at the M.D. Anderson cancer hospital, Houston. It is equally useful for diabetic neuropathy. The KLAB has developed two other devices; one to measure the rate and volume of water produced by single sweat glands, another to biopsy and quantify nerves in skin without causing a scar; both are for use in nerve disorders, as mentioned above.

Continued cooperation between Engineering and Medical faculty will accelerate the development of innovative medical devices to diagnose, track and ameliorate disease.

Reminder: If your work uses the Nanofabrication Center please add the following in the acknowledgements section of any publication: "Parts of this work were carried out in the University of Minnesota Nanofabrication Center which receives partial support from NSF through the NNIN program."

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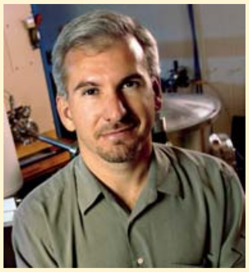
Characterization Facility News

CharFac Director's Message



CharFac Director,
Greg Haugstad

Recently the CharFac held two events in collaboration with instrument vendors: a Confocal Raman / Scanning Probe Microscopy user meeting and workshop on Oct. 14-15 (sponsor Witec), and a Surface and Thin Film Characterization workshop on Dec. 9-10 (sponsors J. A. Woollam Co., EBatco/Kyowa Interface Science, and Agilent Technologies). Principal organizer was staff member Dr. Jinping Dong. The schedule of each event included overview talks by experts, application talks by users, and demonstrations and sample analyses. Attendance was ~100 in each case (even in inclement weather), underscoring the value to our users and corporate partners.

In addition to education, these events help to market less-known capabilities to potential clients. Thus the emphasis tends to be on newer instrumentation, uncommonly available tools, and/or underutilized laboratories. Particularly in the second workshop – with a focus on the (complementary) techniques of spectroscopic ellipsometry, microscale contact angle measurements, special modes of atomic force microscopy, ion beam analysis and time-of-flight secondary ion mass spectrometry – we often heard comments such as "I didn't know the CharFac had this" or "I didn't know that

(continued, top right)

kind of information is obtainable with this technique". Clearly it remains incumbent on us to "re-advertise" some of these lesser known and underutilized techniques. The following is written with this in mind.

Spectroscopic Ellipsometry uses the change in light polarization under reflection and transmission, as a function of wavelength. It is sensitive to the properties of films ranging from 1 nm to 10 microns in thickness, providing information on film thickness and its uniformity and anisotropy; optical constants including variation with depth; surface conditions such as roughness or presence of contamination; and interfacial mixing.

The contact angle at which a liquid/vapor interface meets at a solid surface derives from interfacial tensions. Measuring the contact angle of a water droplet on a given surface is a quick and easy way to evaluate hydrophobicity and cleanliness. Other physical properties such as adhesion, wettability and repellency may be determined. Using droplets down to 20 μm in diameter and 10 picoliter in volume, the microscopic contact angle meter is especially useful on micro-devices and micro-regions of interest.

In atomic force microscopy (AFM), the interaction of a fine needle and sample surface is mapped across a sample with nanometer-scale resolution. In addition to the well-known image of surface topography, property-sensitive imaging can be simultaneously performed, and in controlled vapor or liquid environments. Sample temperature can be controlled, even programmatically ramped. AFM can probe surface energy/charge/potential, storage/loss modulus, hardness, friction & wear, crystallinity, polarizability, conductivity and magnetization.

Ion beam analysis (IBA) utilizes a high-energy, nondestructive helium ion beam to probe elemental composition (stoichiometry) as a function of depth to several microns, with a typical depth resolution of 100-200 Angstroms. Rutherford backscattering (RBS) is fast, nondestructive and standardless, and can be used to measure film thickness or porosity. Recoiling hydrogen can be detected to provide a quantitative depth profile of H. Characteristic X-ray emission can probe down to ppm concentrations. Nuclear reaction methods provide excellent sensitivity for light elements such as lithium.

Time-of-Flight Secondary Ion Mass Spectrometry (ToF-SIMS) uses a focused, pulsed gallium ion beam to dislodge chemical species from a material surface. Species include dissociated and molecular ions, including signature fragments of macromolecules. Mass analysis is resolved to micron-scale regions. Surface analysis or sputter-based depth profiling can be performed.

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Greg Haugstad, Director

NANOFABRICATION CENTER NEWS

NFC DIRECTOR'S MESSAGE

NFC Director,
Steve Campbell

Through the support of NNIN and the American Recovery and Reinvestment Act (ARRA), NFC received funding for the acquisition of "workhorse" tools. That is, systems that are used by many NFC users but are not sufficiently novel to be able to attract something like a Major Research instrumentation award. We have used these funds to buy three systems. The first is an Advanced Vacuum model 320 batch reactive ion etcher configured with fluorinated gasses for dielectric etching. This is similar to the existing STS etcher which is heavily used and no longer supported by the vendor. We expect a delivery in late March or early April. The system will go in Bay 3 near the current STS so we can share gas cylinders.

The second new tool is a second AJA sputtering system. The system will have five gun positions and will be a sputter up tool – the guns will be on the bottom. The standard configuration for AJA systems, it allows us to apply substrate bias to improve step coverage. Higher substrate temperatures will also be possible. Guns will be interchangeable between the two systems, but because target change out will be more difficult, we are planning to keep the most heavily used targets in the new system. The existing system will be reserved for *(continued, top right)* less commonly used targets that can be swapped in and out. Installation is expected in the summer.

The third tool will be a new capability for NFC, a new JEOL-6610 SEM. This system has several very useful features including EDX, 12" sample capability, and low vacuum mode for soft samples. Perhaps most importantly, it has a fully automated electron gun (focus, brightness, stigmation, and contrast). Inexperienced or infrequent users can get crisp images in a "one-button" operation mode. Furthermore, one can save gun settings to facilitate measurement of similar samples within a research group. As such it complements the high resolution field emission SEMS at CharFac (~3nm vs. ~1nm). We are looking at reconfiguring some of the systems in areas 2 and 3 to accommodate this tool and expect it to be available next summer.

PROCESSING CAPABILITY IMPROVEMENTS: OPTICAL LITHOGRAPHY AND ALD UPDATE

Last summer we procured a Canon i3-2500 i-line stepper using National Nanotechnology Infrastructure Network (NNIN) funds. The system is set up for 100mm wafers, and is capable of defining 400 nm lines and spaces with overlay accuracy of about 150 nm. Furthermore, our current mask making system will be able to make the Canon reticles since the new system is a reduction stepper. We are now past some installation and startup hurdles, and process development and training have begun. This tool fills a gap in our lithography capabilities between contact lithography and electron beam lithography.

Atomic Layer Deposition (ALD) systems allow very well controlled growth of extremely thin films, even over highly nonplanar structures such as nanopores, nanowires, and nanoparticles. Typical films are metal oxides such as HfO_2 and Al_2O_3. The process involves the sequential exposure of the substrate to two gases. The gases are chosen such that at least one of them saturates the surface at one monolayer of coverage and the process conditions are such that neither gas, by itself, will decompose to form a solid. After exposure to the first gas, the system is flushed, but one monolayer of this gas remains on the substrate where it can react with the second gas to form a monolayer of the desired film. The process is repeated until the desired film is grown. NFC currently has source materials for the deposition of HfO_2, Al_2O_3, SiO_2, TiO_2, and ZnO. Please contact us if you have interests in this capability.

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Contact: Becky von Dissen at vondi001@umn.edu or 612-625-3069

Center for Nanostructure Applications

The primary mission of the Center for Nanostructure Applications is to seed interdisciplinary nano research projects that will go on to attract external support. Active nanostructures include applications of nano as diverse as energy conservation and production, large area displays and lighting, printed electronics, smart fabrics, electronic noses, drug delivery, cancer therapy, and new types of medical imaging.

These applications often require significant participation across traditional disciplines and the Center is designed to foster the cross-disciplinary research necessary to bolster the nano applications area at the University.

The Center also organizes workshops, speaker series, and short courses, as well as serving as a focal point for nano at the University.

For more information, visit http://www.nano.umn.edu/

The National Nanotechnology Infrastructure Network

The National Nanotechnology Infrastructure Network (NNIN) is an integrated networked partnership of user facilities, supported by the National Science Foundation, serving the needs of nanoscale science, engineering and technology. The mission of the NNIN is to enable rapid advancements at the nano-scale by efficient access to nanotechnology infrastructure. The NNIN supports the Nanofabrication Center at the University of Minnesota. As a node in NSF's National Nanotechnology Infrastructure Network (NNIN), the NFC provides access to advanced multi-user facilities to both industry and academic researchers, the latter at a subsidized rate.

For more information, visit www.nnin.org