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ESA Newsletter

Electrostatics Society of America - The Friendly Society

President's Message

Electrostatics in Nanotechnology

In the last two newsletters we saw how electrostatic effects are ubiquitous in bimolecular interactions. This message addresses some aspects of electrostatics and nanotechnology, which is also the theme of a few papers in our upcoming 2009 ESA Annual meeting. NASA had issued a Tech brief [1] about a simple, portable, automatic, robust apparatus for sample collection of selected biological or chemical species in harsh environments. Among other parts, it includes a sieve, consisting of a porous disk of silicon carbide on Si, supported by an electrically insulating ceramic ring. The sieve contains an array of nanopores formed by photo-electrochemical etching. The nanopores would be made to taper toward narrower openings on the capture-vessel side. For this year's Annual meeting we have a paper (ok, an extended abstract) on conical nanopores, by one of our esteemed authors, entitled, "Electrical manipulation of particles within a nanopore" [2], addressing the estimation of the estimation of electrical field conditions that exist within the constriction of a conical nanopore. The electric field intensity is calculated to be as high as 2.4 MV/m if the length of the constriction is 50nm, but correspondingly lower for longer constrictions. These results are for an applied voltage of 0.4V and for a pore resistance close to 70 MΩ. Various applications include collection of polarizable nanoparticles, such as viruses and some protein molecules, similar to those mentioned in the NASA tech brief.

In addition, electrostatic analyses of coaxial Schottky-Barrier nanotube field-effect transistors have been discussed in [3] as to how the work functions of the source, drain, and gate affect the potential barriers at the source/nanotube and drain/nanotube interfaces. The thickness and permittivity of the dielectric surrounding the nanotube also influence the potential barriers. The electrostatics of nanowire transistors is discussed in [4] as to how these can be quite different from conventional Si devices. Charge density on a nanowire depends critically on the electrostatic environment rather than the properties of the metal contacts. Reduction in both gate oxide thickness and contact size decreases the distance over which the source drain field penetrates into a nanowire channel and can, therefore, help suppress the short channel effects and improve the transistor performance.

Of the 90+ papers we have this year; there are a few papers on nanotechnology, including the invited talk by Dr. M. Zahn of MIT, addressing transformer oil-based nanofluids consisting of conductive nanoparticle suspensions that could enhance the cooling of power transformers [5], a very critical and timely energy efficiency issue.

(cont'd. on page 2)

2009 Electrostatics Joint Conference

2009 Electrostatics Joint Conference
June 16-18, 2009
Boston University, MA, USA

The Electrostatic Society of America (ESA), Institute of Electrostatic Japan (IEJ), International Electrostatic Assembly (IEA), Industry Applications Society (IEEE-IAS) Electrostatic Processes Committee, and La Societé Francaise d'Electrostatic (SFE) will hold our 2009 Electrostatics Joint Conference on the campus of Boston University. Please join us for possibly the largest, most diversified, international gathering on electrostatics in North America including technical papers, a student paper competition, poster sessions, informal discussions, and electrostatic demonstrations.

To review our Session Schedule, please visit our 2009 Electrostatics Joint Conference website: *http://www.electrostaticanswers.com/2009ESJC/2009ESJC.htm*

Kelly Robinson, PhD, Owner & President
Electrostatic Answers LLC
Past ESA President

Calendar

- 11th Int'l. Conf. of Electrostatics. May 27-29, 2009, Valencia, Spain, Contact: Dr. Pedro Segovia, Tel: (+34) 96 136 66 70, *pedro.llovera@ite.es*, website: http://electrostatics.ite.es (abstracts due Feb. 29, 2008)
- ESA-2009, June 16-18, 2009, Boston, MA Contact: Mark Horenstein, Tel: 617-353-5437, *mnh@bu.edu,* website: http://www.electrostatics.org
- ESA-2010, June, 2010, Charlotte, NC Contact: Maciej Noras, Tel: 704-687-3735, *mnoras@uncc.edu,* website: http://www.electrostatics.org

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President's Message (cont'd.)

I am looking forward to meeting many of you in Boston.

I am very happy to tell you that I have heard a very positive comment about our April Newsletter from one of our esteemed junior members. As usual, I look forward to hearing from many of you.

Thank you.

Have a pleasant & productive time.
Yours for the Friendly Society,
Raji Sundararajan,
ESA President

References:

[1] Electrostatic/electrodynamic nanoparticle-capture vessel, NASA Tech Briefs, Nov. 2002, *http://findarticles.com/p/articles/mi_qa3957/is_200211/ai_n9153442*

[2] W.M. Arnold, "Electrical manipulation of particles within a nanopore", ESA 2009, Boston.

[3] D.L. John, L.C. Castro, J. Clifford, and D.L. Pulfrey, "Electrosatics of coaxial Schottky-barrier nanotube field effect transistors", IEEE Trans. Nanotechnology, Vol. 2, No. 4, Sep. 2003, pp. 175-180.

[4] Electrostatics of nanowire transistors", IEEE Trans. Nanotechnology, Vol. 2, No. 4, Dec. 2003, pp. 329-334.

[5] J.G. Hwang, M. Zahn, et. al., "Electron scavenging by conductive nanoparticles in oil insulated power transformers", Invited paper, ESA 2009, Boston.

Current Events

New Technology to Trap Killer Sparks

Seema Singh
(excerpted from ...
http://www.spectrum.ieee.org/energy/the-grid/new-technology-to-trap-killer-sparks/1)

On the morning of 14 April 2006, an engineer was working on a 480-volt disconnect switch in the Relativistic Heavy Ion Collider at the Brookhaven National Laboratory, in New York, when a blinding flash of heat and light left him seriously burned. The cause, an electrical hazard called arc flash, rattled the lab and set off a chain of investigations. The engineer was lucky to escape with just first- and second-degree burns on his face, chest, arms, and hands. Arc flash is an explosion that happens when the electrical resistance of air breaks down, connecting conductors with an arc of hot plasma. The temperature of an arc can exceed four times the surface temperature of the sun, and a 10,000 ampere arc at 480 V packs the equivalent power of about eight sticks of dynamite.

At General Electric's John F. Welch Technology Centre (JFWTC) in Bangalore, India, a team of engineers has developed what it believes is the best way yet to prevent arc-flash hazards. It's a device called an arc-flash absorber. It uses ionized gas to transfer the open arc into a contained electrical system in less than 200 microseconds. In the process, it absorbs 20 percent of the electrical energy, thereby reducing the damage caused by the short-circuited current and lessening the overall stress to the electrical system. The GE engineers plan to report details of their work at the IEEE Petroleum and Chemical Industry Committee Technical Conference, in September, in Anaheim, Calif.

To combat arc flash today, power grids deploy either energy-limiter or energy-diverter systems. As the names suggest, the former cuts off the supply of electricity, taking about 10 milliseconds to react. The latter is more commonly used and diverts the arc by deliberately shorting the circuit, taking about 5ms to react. However, the diversion can stress an industrial plant's or distribution grid's entire electrical system. And the longer it takes for these circuits to react, the greater the damage to upstream equipment, such as the transformers. Since the total electrical energy is a function of voltage, current, and time, dramatically reducing the arc-transfer time from 5 to 10 ms to less than half a millisecond minimizes the damage significantly.

In the event of an arc fault, the GE device, which is connected in parallel to the electrical system, triggers a plasma gun that produces a current pulse 10- to 20-microseconds long and as large as 5000 A through the air inside the arc absorber. The plasma transfers the arc flash to a double-layered safe-containment vessel, allowing the electrical system to trip. The hot, ionized vapor produced during this operation evaporates a layer of ablative polymer, instantly cooling it, so the gas can be vented out safely.

The developers have tested the arc absorber for a short-circuit level of 65kiloamperes, that is, for low- (600) to medium-voltage (15,000V) electrical systems but say it can be scaled up to 100kA. Nelson believes that even the 65kA rating will handle the vast majority of electrical systems. "It would appear that the theory would work for practically any system, so there is a high probability that it could be developed for higher-rated equipment."

Simple device can ensure food gets to the store bacteria free

Brian Wallheimer
Purdue University News
(excerpted from ... http://news.uns.purdue.edu/x/2009a/090302KeenerBacteria.html

A Purdue University researcher has found a way to eliminate bacteria in packaged foods such as spinach and tomatoes, a process that could eliminate worries concerning some food-borne illnesses. Kevin Keener designed a device consisting of a set of high-voltage coils attached to a small transformer that generates a room-temperature plasma field inside a package, ionizing the gases inside. The process kills harmful bacteria such as E. coli and salmonella, which have caused major public health concerns. By placing two high-voltage, low-watt coils on the outside of a sealed food package, a plasma field is formed. In the plasma field, which is a charged cloud of gas, oxygen has been ionized and turned into ozone. Treatment times range from 30 seconds to about five minutes, Keener said.

Ozone kills bacteria such as E. coli and salmonella. The longer the gas in the package remains ionized, the more bacteria that are killed. Eventually, the ionized gas will revert back to its original composition. The process uses only 30-40 watts of electricity, less than most incandescent light bulbs. The outside of the container only increases a few degrees in temperature, so its contents are not cooked or otherwise altered.

Keener said testing has worked with glass containers, flexible plastic-like food-storage bags and rigid plastics, such as strawberry cartons and pill bottles. He said the technology also could work to ensure pharmaceuticals are free from bacteria.

Revealing the mechanism of chromosome separation in dividing cells

(excerpted from ...
http://www.rdmag.com/ShowPR.aspx?PUBCODE=014&ACCT=1400000101&ISSUE=0903&RELTYPE=LST&PRODCODE=00000000&PRODLETT=DK&CommonCount=0)

Univ. of Washington (UW) researchers are helping to write the operating manual for the nanoscale machine that separates chromosomes before cell division. The apparatus is called a spindle because it looks like a tiny wool-spinner with thin strands of microtubules or spindle fibers sticking out. The lengthening and shortening of microtubules is thought to help push and pull apart chromosome pairs. Understanding how this machine accurately and evenly divides genetic material is essential to learning why its parts sometimes fail. Certain cancers or birth defects, like Down syndrome or Trisomy 18, result from an uneven distribution of chromosomes.

In a study published March 6 in the journal Cell, a team led by UW scientists reports on the workings of a key component of this machine. Named a kinetochore, it is a site on each chromosome that mechanically couples to spindle fibers. "Kinetochores are also regulatory hubs," the researchers note. "They control chromosome movements through the lengthening and shortening of the attached microtubules. They sense and correct errors in attachment. They emit a "wait" signal until the microtubules properly attach." Careful control over microtubules, they added, is vital for accurate splitting of the chromosomes.

To understand how the kinetochore functions, the scientists sought to uncover the basis for its most fundamental behavior: attaching microtubules. The most puzzling aspect of this attachment, according to the researchers, is that the kinetochore has to be strong yet dynamic. It has to keep a grip on the microtubule filaments even as they add and remove their subunits. "This ability," the researchers say, "allows the kinetochore to harness microtubule shortening and lengthening to drive the movement of chromosomes."

The same coupling behavior is found in living things from yeast cells to humans, indicating that it was conserved during evolution as a good way of getting the job done. The question is how this mechanism works. Previous studies implicated a large, multiprotein complex, Ndc80, as a direct contact point between kinetochores and microtubules. However, researchers had only a static view of the complex. The UW researchers used special techniques to manipulate and track the activity of the complex in a laboratory set-up.

The researchers were able to show that the Ndc80 complex was indeed capable of forming dynamic, load-bearing attachments to the tips of the microtubules, probably by forming an array of individually weak microtubule binding elements that rapidly bind and unbind, but with a total energy large enough to hold on. The mechanism will produce a molecular friction that resists translocation of the microtubule through the attachment site. Other scientists have dubbed the mechanism a "slip clutch."

This kind of coupler, the researchers added, is able to remain continuously attached to the microtubule tip during both its assembly and disassembly phases. The coupler also can harness the energy released during disassembly to produce mechanical force. Coupling may depend on positively charged areas on the complex that interact with negatively charged hooks on the microtubules by electrostatic force. Based on their findings, the scientists propose arrays of Ndc80 complexes supply the combination of plasticity and strength that allows kinetechores to hold on loosely but not let go of the tips of the microtubules.

Shattering News: Electro-Pulse Technology Speeds Ice Removal

(excerpted from ...
http://www.scientificamerican.com/article.cfm?id=ice-tamers

Ever scraped ice from your car windows until your hands were stiff, cold and raw red? Or missed an appointment because it took so long for your window defroster to thaw through your ice-entombed windshield? Or had your lights, cable TV or telephone black out—and stay out for days—because an ice storm downed power lines?

Good news: a group of researchers has developed technology designed to electronically zap ice off surfaces within in seconds. Unlike conventional windshield defrosters that rely on gradual warming to liquefy snow and ice, the IceController—created by Ice Engineering, LLC, in Lebanon, N.H.—delivers a swift (less than a second in some cases) jolt of high-power electricity that immediately melts ice at its interface with an object's surface. Once the bond between the ice and surface is broken, the ice slides away, says Victor Petrenko, Ice Engineering's chief technology officer and a professor of engineering at Dartmouth College's Thayer School of Engineering, where he invented the "electro-thermal pulse de-icing" technology behind the IceController.

The IceController can be connected to any device or structure that can be coated with ice and uses electrodes or a thin film of stainless steel, copper or aluminum foil placed on the surface to deliver a jolt of electricity whenever it senses ice buildup. The frequency, intensity and duration of the jolts depend upon what the IceController is trying to de-ice—a windshield, airplane wing or bridge cable.

"The objective is to heat an interface in-between the ice and the surface from [the] ambient temperature to ice['s] melting point quickly and with a lot of power," says Petrenko, a former research lab director at the Russian Academy of Science's Institute of Solid State Physics and a physics professor at the Moscow Institute of Physics and Technology. "It happens so quickly that, unlike other de-icing methods, heat is not wasted warming up the [object's] surface or the ice. Once the ice is dislodged, gravity or air-drag force [such as on an airplane wing) do the rest."

Ice Engineering's two biggest installations are on the Uddevalla cable bridge in Sweden (where the technology has been in place since 2005, see slide show) and on the 107,639-square-foot (10,000-square-meter) glass dome of a mall being built in Moscow City. The Swedish government–owned bridge has two pylons taller than 489 feet (149 meters) and 120 cables, each more than 655 feet (200 meters) long and 10 inches (25.4 centimeters) in diameter. Each steel cable is covered by a thin polymer tube (wrapped in stainless steel foil) to prevent rusting. "We apply [an] electric pulse to either end of the cable for about one second," Petrenko says, "and all ice attached to it falls down."

More than one nanostring to their bow: Scientists moving closer to "artificial noses"

(excerpted from ... http://www.en.uni-muenchen.de/news/research/kotthaus.html

These days, chemical analysts are expected to track down even single molecules. To do this highly sensitive detective work, nano researchers have developed minute strings that resonate in characteristic fashion. If a molecule docks onto one of the strings, then it becomes heavier, and its oscillations become measurably slower. Until recently, however, such "nano-electromechanical systems", or NEMS, have been short of practical applications. Physicists at LMU Munich have now made a breakthrough in this field: They have constructed a system of nanostrings made of non-conducting material, where each string can be electrically excited separately. Thousands of these strings can be produced on a small chip. One of the devices that could be created with this system is a highly sensitive "artificial nose" that detects various molecules – pollutants for example – individually. These new NEMS could also be used in a multitude of other applications – acting as tiny pulse generators in mobile phone clocks, for example.

When a molecule docks onto a string, the string becomes heavier and its oscillation slows down a tiny bit. "By measuring the period of oscillation, we could therefore detect chemical substances with molecular precision," explains Quirin Unterreithmeier, first author of the study. "Ideally, you would have several thousand strings sitting on a chip the size of a fingernail, each one for highly specifically recognizing a single molecule – so you could build an extremely sensitive 'artificial nose', for example."

Until recently, however, getting such systems to work has proven technically difficult; one problem being to produce and measure the oscillations. While the nanostrings can be made to oscillate by magnetomechanical, piezoelectric or electrothermal excitement, this only works if the nanostrings are made of metal, or are at least metal-coated, which in turn greatly dampens the oscillations, preventing sensitive measurement. That hardly allows the detection of a single molecule. It also makes it harder to distinguish the different signals from differently oscillating strings.

The newly developed method now avoids these difficulties. Quirin Unterreithmeier, Dr. Eva Weig and Professor Jörg Kotthaus of the Center for NanoScience (CeNS), the Faculty of Physics of LMU Munich and the cluster of excellence "Nanosystems Initiative Munich (NIM)" have constructed an NEMS in which the nanostrings are excited individually by dielectric interaction – the same phenomenon that makes hair stand on end in winter. Following this physical principle, the nanostrings, which are made of electrically non-conducting silicon nitride, are excited to resonate when exposed to an oscillating inhomogeneous electric field, and their vibration then measured.

The alternating electric field required for this stimulation was produced between two gold electrodes right up close to the string. The oscillations were measured by two other electrodes. "We created this setup using etching techniques," reports Weig. "But this was easily done – even repeated ten thousand times on a chip. The only thing to do now is to make sure the strings can be individually addressed by a suitable circuit." All in all, this ought to be a technically easy exercise – but one that will allow a breakthrough in chemical analysis. Yet there are even more applications that can be seen beyond this "artificial nose". Among other things, the nanostrings could be employed as the pulse generators in mobile phone clocks, for example. These novel resonators could even be used as ultra-sharp electrical signal filters in metrological systems.

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