Nov/Dec 2011 • No. 210

ESA Newsletter

Electrostatics Society of America - The Friendly Society

President's Message

Dear ESA Colleagues,

Sometimes you can't predict what might result from participation in the ESA.

The second ESA meeting I attended was the 2008 meeting in Minneapolis. I met Dr. Rufus Akande, from the University of Botswana, at this meeting. I had known about Rufus's important contributions to triboelectric charging, dating back to the 1980's. I was particularly interested in Rufus's talk at the 2008 ESA meeting, in which he presented results that show that annealing a polymer material can change its propensity to triboelectrically charge. My group has been studying how material strain can affect triboelectric charging – this is closely related Rufus's work, in that annealing may alter the triboelectric charging by allowing localized strains in the polymer to relax.

Rufus and I had enjoyable discussions at the 2008 meeting. We talked about the possibility of his taking a sabbatical with me at Case Western Reserve University (CWRU). The sabbatical came to be, and Rufus spent the Spring 2011 semester collaborating with me and my colleague Mohan Sankaran at CWRU. The sabbatical worked out great.

But something else also came out of this interaction at the 2008 ESA meeting. In February 2010, I travelled to Botswana with Mohan and our former graduate student (and active ESA member) Keith Forward, to meet with Rufus to discuss the sabbatical possibility. We had never been to sub-Saharan Africa before, and didn't know what to expect. In addition to discussions with Rufus, we met with many others at the university, toured the campus and Gaborone (Botswana's capital and home to the university), and went on a safari the Kalahari Desert. We found the country to be beautiful, the people to be very friendly, and the university to be very modern and intellectually vibrant.

We realized that studying in Botswana would be an incredible experience for students from the United States, and we decided to start such programs. In November 2010, Mohan and I travelled back to Botswana, and we brought three undergraduates from CWRU. As part of their senior project, the students visited villages in Botswana off the electrical grid, and met with faculty at the University of Botswana and representatives from the Botswana Power Company to learn about solar energy initiatives in Africa. We also went on a safari. And again, it was a great experience.

Mohan and I developed two larger programs for U.S. students at the University of Botswana, offered for the first time in May/June 2011. First, we created a course for CWRU students to be taken at the University of Botswana; this course was a special offering of a core engineering course (in thermal science) required of all CWRU engineering students. Second, we instituted a research program for undergraduate students, funded by the U.S. National Science Foundation, focusing on sustainable energy processes relevant to sub-Saharan Africa. A key feature of both of these programs was that technical and cultural content were intertwined. Programs also included a 3-day safari excursion and visit to Victoria Falls, Zimbabwe. We had 21 CWRU students take our engineering course, and 5 students participate in the research program (we have funding for a larger research program in future years).

(cont'd. p.2)

President's Message (cont'd.)

These programs have been a big hit. For most participating students, their program was the highlight of their college career. The programs are generating a lot of excitement on our campus, and are being featured by the university in student recruitment brochures.

I joined the ESA to benefit my research efforts in triboelectric charging. I would never have foreseen that the ESA would lead me to develop educational programs in Africa!

Dan Lacks,
President, ESA
daniel.lacks@case.edu

ESA Officers

President:
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Executive Council
Sheryl Barringer, Ohio State Univ.
Kelly Robinson, Electrostatic Answers, LLC
Rajeswari Sundararajan, Purdue Univ.

Calendar

- 2nd ISNPEDADMSA (New electrical tech. for environment), Nov. 14-19, 2011, Noumea, New Caledonia, Contact: Gerard Touchard, *gerard.touchard@univ-poitiers.fr,* website: http://lea.sp2mi.univ-poitiers.fr/noumeameeting/
- ESA-2012, Joint ESA/IEJ/IAS/SFE Meeting, June 12-14, 2012, Univ. of Waterloo, Waterloo, Ontario, Canada, Contact: Shesha Jayaram, *jayaram@uwaterloo.ca,* website: http://www.electrostatics.org
- 8th Conf. of the French Society of Electrostatics (SFE), July 3-5, 2012, Cherbourg, France, Contact: Jean-Michel Reboul, Ph: (33) 2 33 01 42 04, *jean-michel.reboul@unicaen.fr,* website: http://www.chbg.unicaen.fr/sfe/?lang=en (titles due Jan. 15, abstracts due Feb. 13, 2012)
- ICAES-2012, 7th Int'l. Conf. on Applied Electrostatics, Sept. 17-19, 2012, Dalian Univ. of Tech., Dalian, China, Contact: Secretariat Office, Ph: +86 411 84708576-604, *ICAES2012@163.com,* website: http://www.icaes-2012.org/windows/index.htm (abstracts due Apr. 30, 2012)

Sources and Sinks

Here is a request for information from an ESA member. If you have any input please email Garry Myers at *gnmyers@optonline.net.*

I have a wand the operates on 120VAC. It has a 6" wooden handle (shown on left below) and out of the handle is a 6" glass that turns 90° into a flat, round bulb (shown on right below). At the bottom of the handle is a knob, that, as it is turned, increases an electrostatic charge. At the max position, the stem and bulb have pink electrostatic ribbons and you can raise an arc from the glass bulb about ½" above the surface. I was wondering if you could direct me to a site, or group that might be able to identify the purpose of this device.

INTERNATIONAL ELECTROSTATIC ASSEMBLY (IEA)

2012 Electrostatics Joint Conference

Cambridge, Ontario, Canada, June 12 – 14, 2012

CALL FOR PAPERS

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'Electrostatique (SFE) invite papers in all scientific and technical areas involving electrostatics. The scope of the conference ranges from the fundamental physics underlying electrostatics to applications in industry, atmospheric and space sciences, medicine, energy, and other fields.

Technical sessions include:

I. Atmospheric and space applications
II. Biological and medical applications
III. Breakdown and discharge
IV. Flows, forces, and fields
V. Materials behavior and processing
VI. Measurement and instrumentation
VII. Particle control and charging
VIII. Safety and hazards

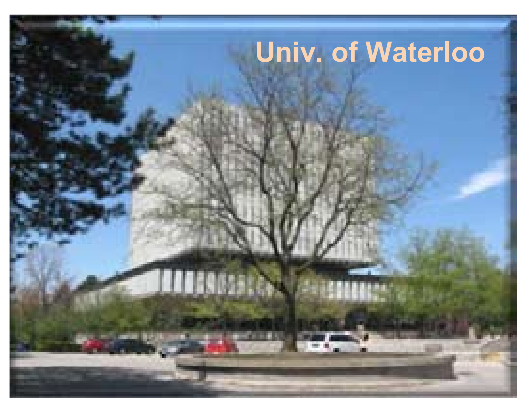
Abstract submission: Abstracts should be submitted online, at http://www.electrostatics.org

Student paper competition: Presentations by students (undergraduate and graduate) are eligible; please indicate participation when submitting abstract.

Registration and housing information: Will be posted online, at http://www.electrostatics.org

Important dates:

March 1, 2012 Abstract submission deadline
March 17, 2012 Notification of paper acceptance
May 15, 2012 Final manuscripts due
June 12, 2012 Conference begins (8 AM)
June 14, 2012 Conference ends after evening banquet
(Banquet: 7 PM – 10 PM)



Contact information:

For questions regarding the technical program and abstract submission, contact the Technical Chair:
Prof. Maciej A. Noras, University of North Carolina at Charlotte, mnoras@uncc.edu, (704) 687-3735
For all other questions, contact the General Chair:
Prof. Shesha Jayaram, University of Waterloo, jayaram@uwaterloo.ca, (519) 888-4567 ext.: 35337

Counterintuitive discovery boosts supercapacitor energy storage

Leo Williams

Flat is in the eye of the beholder. When you're talking about nanomaterials, however, that eye is pretty much useless unless it's looking through an electron microscope or at a computer visualization. Yet the pits and ridges on a seemingly flat surface—so small they are invisible without such tools—can give the material astonishing abilities. The trick for researchers interested in taking advantage of these abilities lies in understanding and, eventually, predicting how the microscopic topography of a surface can translate into transformative technologies.

Drexel University's Yury Gogotsi and colleagues recently needed an atom's-eye view of a promising supercapacitor material to sort out experimental results that were exciting but appeared illogical. That view was provided by a research team led by Oak Ridge National Laboratory (ORNL) computational chemists Bobby Sumpter and Jingsong Huang and computational physicist Vincent Meunier. Gogotsi's team discovered you can increase the energy stored in a carbon supercapacitor dramatically by shrinking pores in the material to a seemingly impossible size—seemingly impossible because the pores were smaller than the solvent-covered electric charge-carriers that were supposed to fit within them. The team published its findings in the journal Science.

An electric double-layer capacitor, or supercapacitor, represents an advance on the technology that allows for far greater energy density. While in traditional capacitors two metallic plates are separated by a nonconducting material known as a dielectric, in a supercapacitor an electrolyte is able to form an electric double layer with electrode materials that have very high surface areas. As such, supercapacitors are able to achieve the same effect within a single material, as properties of the material divide it into separate layers with a very thin, nonconducting boundary. Because they can both forgo a bulky dielectric layer and make use of the carbon's nanoscale pores, supercapacitors are able to store far more energy than their traditional counterparts in a given volume. This technology could help increase the value of energy sources that are clean, but sporadic, meting out stored energy during downtimes such as night for a solar cell or calm days for a wind turbine.

So Gogotsi's discovery was potentially ground breaking. The energy was stored in the form of ions within an electrolyte, with the ions surrounded by shells of solvent molecules and packed on the surfaces of nanoporous carbons. The researchers were able to control the size of pores in the carbon material, making them 0.7 to 2.7 nanometers. What they found was that the energy stored in the material shot up dramatically as the pores became smaller than a nanometer, even though the ions in their solvation shells could not fit into spaces that small.

Using ORNL's Jaguar and Eugene supercomputers, Sumpter and his team were able to take a nanoscale look at the interaction between ion and carbon surface. A computational technique known as density functional theory allowed them to show that the phenomenon observed by Gogotsi was far from impossible. In fact, they found that the ion fairly easily pops out of its solvation shell and fits into the nanoscale pore. "It goes in such a way that it desolvates in the bulk to get inside because there's electrostatic potential and van der Waals forces that pull it in," Sumpter explained. "There are a whole lot of different forces involved, but in fact it's very easy for it to get in." "In addition," Sumpter noted, "the microscopic bumps and divots on a carbon plate make a dramatic difference in the amount of energy that can be stored on or in it. When you get to the nanoscale, the surface area is huge, and the curvature, both concave and convex, can be very large. This makes a large difference in the capacitance. We derived a model that explained all the experimental data. You can back out the pieces of the model from the electronic structure calculations, and from that model you can predict capacitance for different types of curved shapes and pore sizes."

For example, he said, the calculations showed that the charge-carrying ions are stored not only by slipping into pores but also attaching to mounds in the material. "It's a positive curvature instead of a negative curvature," Sumpter said, "and they can store and release energy even faster. So you can store ions inside a hole or you can store ions outside." Using these and other insights gained through supercomputer simulation, the ORNL team partnered with colleagues at Rice University to develop a working supercapacitor that uses atom-thick sheets of carbon materials. "It uses graphene on a substrate and a polymer-gel electrolyte," Sumpter explained, "so that you produce a device that is fully transparent and flexible. You can wrap it around your finger, but it's still an energy storage device. So we've gone all the way from modeling electrons to making a functional device that you can hold in your hand."

(excerpted from *http://www.rdmag.com/News/2011/06/Materials-Electrical-Engineering-Counterintuitive-discovery-boosts-supercapacitor-energy-storage/*)

Laser, electric fields combined for new 'lab-

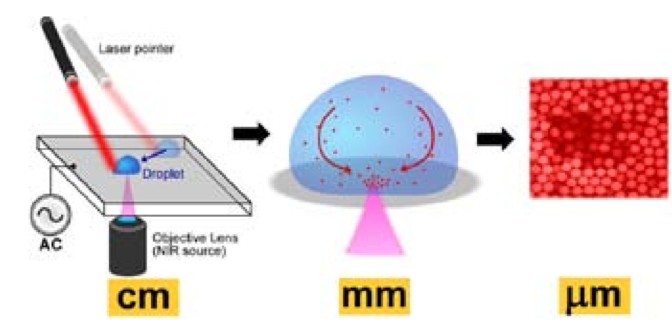
on-chip' technologies

Researchers are developing new technologies that combine a laser and electric fields to manipulate fluids and tiny particles such as bacteria, viruses and DNA for a range of potential applications, from drug manufacturing to food safety. The method, called "hybrid optoelectric manipulation in microfluidics," is a potential new tool for applications including medical diagnostics, testing food and water, crime-scene forensics, and pharmaceutical manufacturing.

The technology works by first using a red laser to position a droplet on a platform specially fabricated at Purdue. Next, a highly focused infrared laser is used to heat the droplets, and then electric fields cause the heated liquid to circulate in a "microfluidic vortex." This vortex is used to isolate specific types of particles in the circulating liquid, like a micro centrifuge. Particle concentrations replicate the size, location and shape of the infrared laser pattern. Systems using the hybrid optoelectric approach can be designed to precisely detect, manipulate and screen certain types of bacteria, including particular strains that render heavy metals less toxic.

(excerpted from

http://www.purdue.edu/newsroom/research/2011/110705WereleyHybrid.html)



This graphic illustrates a new technology that combines a laser and electric fields to manipulate fluids and tiny particles such as bacteria, viruses and DNA for a range of potential applications from drug manufacturing to food safety. The technologies could bring innovative sensors and analytical devices for "lab-on-a-chip" applications. (Stuart J. Williams, University of Louisville)

Sensor monitors exposure to airborne nanoparticles

Hutomo Suryo Wasisto, Andreas Waag, Erwin Peiner and Erik Uhde

Nanoparticles (NPs) are increasingly present in industrial and consumer products such as food packaging, cosmetics, pharmaceuticals, medical devices, odor-resistant textiles, and household appliances. Given their ubiquity, they could constitute a potential source of toxicity for human health and the environment. Thus, there is now a demand for sensors to detect airborne NPs, particularly for air-quality monitoring in the workplace.

Among other MEMS, micromachined cantilever sensors have recently become popular due to their simplicity, high sensitivity, portability, and low-cost batch fabrication. However, this method has limitations due to the high production costs of SOI wafers and the inability to change their thickness to modulate the sensor's performance.

To overcome these issues, we have developed a novel silicon cantilever sensor. Low-cost silicon was favored over SOI because of its high mechanical-quality factor, stability, and the degree of freedom it brings for cantilever design. This type of sensor reaches its standard resonance mode by means of a piezoactuator located at the base of the beam on a supporting frame, which works by expanding and bending the cantilever following application of a low voltage. The sensor detects NPs by determining changes in its resonance frequency that can be deduced from a change in resistance. Our method offers several advantages, including simplicity, large output signal of the order of the millivolts (obviating the need for a low-noise amplifier), low-power consumption, and high sensitivity.

We tested our sensor using a process that releases standardized NPs under controlled conditions, known as airborne NP sampling. We relied on dielectrophoresis (DEP) to detect NPs (see Figure 2). There, carbon NPs were subject to an electric force in a nonuniform electric field. A number of carbon NPs were thus trapped on the cantilever surface in a nonhomogeneous manner (see Figure 3). Most of them were deposited on the edges of the free end of the cantilever and agglomerated where the highest electrical field strengths and gradients occurred.

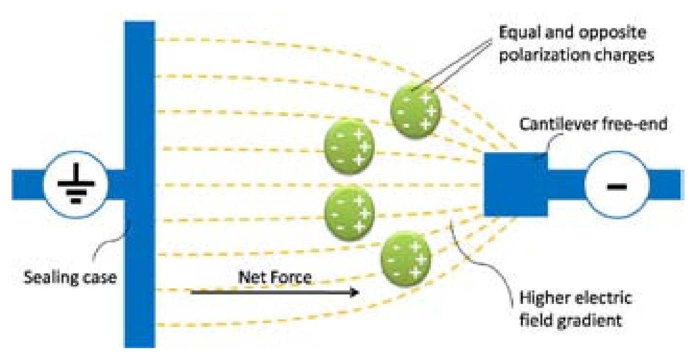


Figure 2. Principle of the dielectrophoresis mechanism for trapping nanoparticles (NPs).

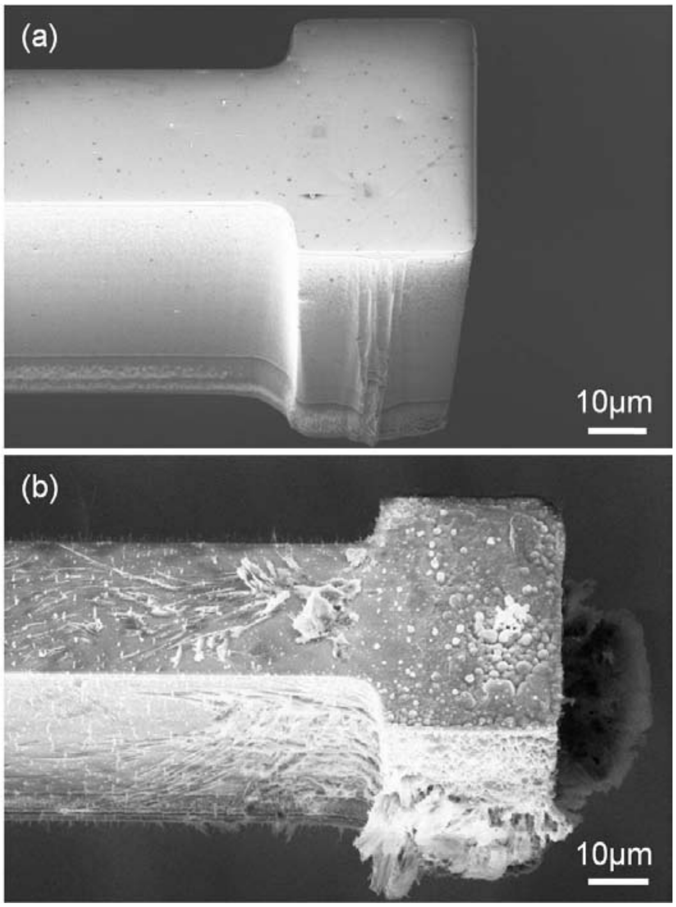


Figure 3. Magnified view of the free end of a cantilever sensor in the (a) unloaded state and (b) loaded state where airborne NPs are trapped on the edges.

Evaluation of sensor performance showed a mass sensitivity of 8.33Hz/nanogram with a frequency resolution of 0.04Hz, a mass resolution of 4.8pg, and a quality factor of 1230 in air. The mass sensitivity of these sensors can be improved by miniaturizing their geometry, i.e., by decreasing the effective mass—that of the cantilever without its supporting frame—and by increasing the frequency of the mechanical resonator.

(excerpted from *http://spie.org/x48770.xml?ArticleID=x48770*)

Physicists turn liquid into solid using an electric field

Physicists have predicted that under the influence of sufficiently high electric fields, liquid droplets of certain materials will undergo solidification, forming crystallites at temperature and pressure conditions that correspond to liquid droplets at field-free conditions. This electric-field-induced phase transformation is termed electrocrystallization. The study, performed by scientists at the Georgia Institute of Technology, appears online and is scheduled as a feature and cover article in the 42nd issue of Volume 115 of the Journal of Physical Chemistry C.

"We show that with a strong electric field, you can induce a phase transition without altering the thermodynamic parameters," said Uzi Landman, Regents' and Institute Professor in the School of Physics, F.E. Callaway Chair and director of the Center for Computational Materials Science (CCMS) at Georgia Tech.

In these simulations, Landman and Senior Research Scientists David Luedtke and Jianping Gao at the CCMS set out first to explore a phenomenon described by Sir Geoffrey Ingram Taylor in 1964 in the course of his study of the effect of lightning on raindrops, expressed as changes in the shape of liquid drops when passing through an electric field. While liquid drops under field-free conditions are spherical, they alter their shape in response to an applied electric field to become needle-like liquid drops. Instead of the water droplets used in the almost 50-year-old laboratory experiments of Taylor, the Georgia Tech researchers focused their theoretical study on a 10 nanometer (nm) diameter liquid droplet of formamide, which is a material made of small polar molecules each characterized by a dipole moment that is more than twice as large as that of a water molecule.

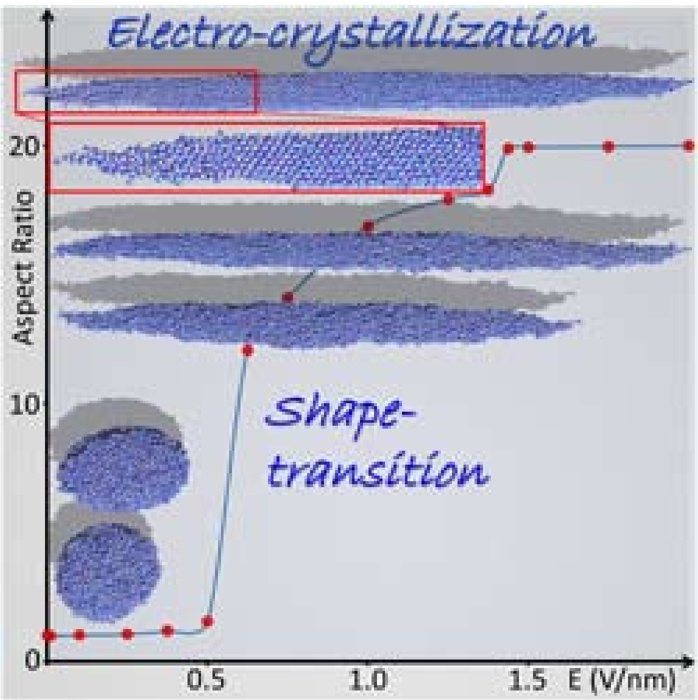
With the use of molecular dynamics simulations developed at the CCMS, which allow scientists to track the evolution of materials systems with ultra-high resolution in space and time, the physicists explored the response of the formamide nano-droplet to an applied electric field of variable strength. Influenced by a field of less than 0.5V/nm, the spherical droplet elongated only slightly. However, when the strength of the field was raised to a critical value close to 0.5 V/nm, the simulated droplet was found to undergo a shape transition resulting in a needle-like liquid droplet with its long axis – oriented along the direction of the applied field – measuring about 12 times larger than the perpendicular (cross-sectional) small axis of the needle-like droplet. The value of the critical field found in the simulations agrees well with the prediction obtained almost half a century ago by Taylor from general macroscopic considerations. Past the shape transition further increase of the applied electric field yielded a slow, gradual increase of the aspect ratio between the long and short axes of the needle-like droplet, with the formamide molecules exhibiting liquid diffusional motions.

"Here came the Eureka moment," said Landman. "When the field strength in the simulations was ramped up even further, reaching a value close to 1.5V/nm, the liquid needle underwent a solidification phase transition, exhibited by freezing of the diffusional motion, and culminating in the formation of a formamide single crystal characterized by a structure that differs from that of the x-ray crystallo-

Current Events (cont'd.)

graphic one determined years ago under zero-field conditions. Now, who ordered that?" he added.

Further analysis has shown that the crystallization transition involved arrangement of the molecules into a particular spatial ordered lattice, which optimizes the interactions between the positive and negative ends of the dipoles of neighboring molecules, resulting in minimization of the free energy of the resulting rigid crystalline needle. When the electric field applied to the droplet was subsequently decreased, the crystalline needle remelted and at zero-field the liquid droplet reverted to a spherical shape. The field reversal process was found to exhibit a hysteresis.



Analysis of the microscopic structural changes that underlie the response of the droplet to the applied field revealed that accompanying the shape transition at 0.5 V/nm is a sharp increase in the degree of reorientation of the molecular electric dipoles, which after the transition lie preferentially along the direction of the applied electric field and coincide with the long axis of the needle-like liquid droplet. The directional dipole reorientation, which is essentially complete subsequent to the higher field electrocrystallization transition, breaks the symmetry and transforms the droplet into a field-induced ferroelectric state where it possesses a large net electric dipole, in contrast to its unpolarized state at zero–field conditions.

Along with the large-scale atomistic computer simulations, researchers formulated and evaluated an analytical free-energy model, which describes the balance between the polarization, interfacial tension and dielectric saturation contributions. This model was shown to yield results in agreement with the computer simulation experiments, thus providing a theoretical framework for understanding the response of dielectric droplets to applied fields.

"This investigation unveiled fascinating properties of a large group of materials under the influence of applied fields," Landman said. "Here the field-induced shape and crystallization transitions occurred because formamide, like water and many other materials, is characterized by a relatively large electric dipole moment. The study demonstrated the ability to employ external fields to direct and control the shape, the aggregation phase (that is, solid or liquid) and the properties of certain materials."

(excerpted from *http://www.gatech.edu/newsroom/release.html?nid=71054*)

Sources and Sinks (cont'd.)

Here is a request for assistance from Matthew Rothfusz, a 3rd year student at the Univ. of Chicago. Please direct your responses to him at *rothfuszm@uchicago.edu*.

I am investigating the triboelectric charging of wind turbine blades and am hoping to connect with someone with expertise in electrostatics that can evaluate the concept.

I supposed that wind turbine blades are capacitors. As the wind flows by, it rubs against the blades, and so the blades are charged. I assume that the blade surface can be isolated from the rest of the machine such that it behaves like a capacitor. As the blades gather charge from the wind, they are adding energy to the wind turbine system beyond that which is predicted by the present model with betz limit.

Then, I imagined ways to have this charge increase or complement the power generator. One way might be to discharge the blade in a current between the tip of the blade and the tower. This current would be perpendicular to earth's magnetic field, and possibly create a magnetic force acting as torque in the direction of rotation, augmenting the torque from the lift force. Or, since the magnetic field in a generator is more than the earth's magnetic field, perhaps the turbine blade capacitors could assist the generator system directly. Or, other uses; I learned this evening from the book Electrostatics and its Applications A.D. Moore Editor p.149, for example, that electrostatics has its own electromechanical generator type. Maybe there's an ES generator type for wind turbines.

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