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ESA Newsletter

Electrostatics Society of America - The Friendly Society

President's Message

Dear Colleagues,

A recent 'phase change' led me to think about one of the roles of the ESA.

I went to my first ESA meeting in 2007, at Purdue University, and I brought an undergraduate and graduate student with me. The graduate student, Keith Forward, was my first graduate student on an electrostatics project; Keith had been working with me for almost two years at the time. Keith presented a talk on his experiments addressing electrostatic charging in fluidized beds. This was an exciting experience for Keith – it was his first talk at a scientific meeting, and the opportunity to interact with experts in the field was very motivational. And it was especially exhilarating when Keith won First Prize in the Student Paper Competition.

Keith's research went very well, and he graduated with his PhD in 2009. During his time in graduate school he also gave talks at the ESA meetings in Minneapolis (2008) and Boston (2009), and the International Conference on Electrostatics in Valencia, Spain (2009). Keith went on to a position as a postdoctoral associate at MIT, where he worked on the electrospinning of materials. He gave talks on his electrospinning work at the ESA meetings in Charlotte (2010) and Cleveland (2011), and also the International Conference on Electrostatics in Wales (2011). Keith moved beyond just giving talks, and he chaired sessions at several ESA meetings and was the Technical Program Chair for the 2011 ESA meeting.

This Fall, Keith started a position as an Assistant Professor in the Department of Chemical & Materials Engineering at Cal Poly Pomona. His research lab focuses on electrostatics, and he already has a group of students carrying out research with him. Keith recently wrote to me saying "I just finished up my first quarter. It was a great experience and I really enjoy working with the students."

I feel like I have moved into the 'next phase' of my career in electrostatics, in that I now have a former student doing independent work in the field.

This story emphasizes to me the importance of student participation in the ESA meetings, as the meetings played a key role in Keith's development as a scientist. We encourage student participation in our meetings by keeping the student registration fee low, and through the Student Paper Competition. We are very grateful for Sunless, Inc. (and its precursor companies), who have been sponsoring the Student Paper Competition for as long as I've been involved in the ESA.

I'm looking forward to the 2013 ESA Meeting, which will be held in Cocoa Beach, Florida, from June 11-13. Now is the time to start making your plans. I hope to see a lot of students there!

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

Current Events

Researcher directly measures the electrical charge of nanoparticles

Prof. Madhavi Krishnan, a biophysicist at the University of Zurich, has developed a new method that measures not only the size of the particles but also their electrostatic charge. Up until now it has not been possible to determine the charge of the particles directly. This unique method, which is the first of its kind in the world, is just as important for the manufacture of drugs as in basic research. The process has now been introduced for the first time in Nature Nanotechnology.

In order to observe the individual particles in a solution, Prof. Madhavi Krishnan and her co-workers "entice" each particle into an "electrostatic trap". It works like this: between two glass plates the size of a chip, the researchers create thousands of round energy holes. The trick is that these holes have just a weak electrostatic charge. The scientists than add a drop of the solution to the plates, whereupon each particle falls into an energy hole and remains trapped there. But the particles do not remain motionless in their trap. Instead, molecules in the solution collide with them continuously, causing the particles to move in a circular motion. "We measure these movements, and are then able to determine the charge of each individual particle," explains Prof. Madhavi Krishnan.

Put simply, particles with just a small charge make large circular movements in their traps, while those with a high charge move in small circles. This phenomenon can be compared to that of a light-weight ball which, when thrown, travels further than a heavy one. The U.S. physicist Robert A. Millikan used a similar method 100 years ago in his oil drop experiment to determine the velocity of electrically charged oil drops. In 1923, he received the Nobel Prize in physics in recognition of his achievements.

"But he examined the drops in a vacuum," Prof. Krishnan explains. "We on the other hand are examining nanoparticles in a solution which itself influences the properties of the particles".

Electrostatic charge of "nano drug packages"

For all solutions manufactured industrially, the electrical charge of the nanoparticles contained therein is also of primary interest, because it is the electrical charge that allows a fluid solution to remain stable and not to develop a lumpy consistency.

"With our new method, we get a picture of the entire suspension along with all of the particles contained in it," emphasizes Prof. Madhavi Krishnan. A suspension is a fluid in which miniscule particles or drops are finely distributed, for example in milk, blood, various paints, cosmetics,

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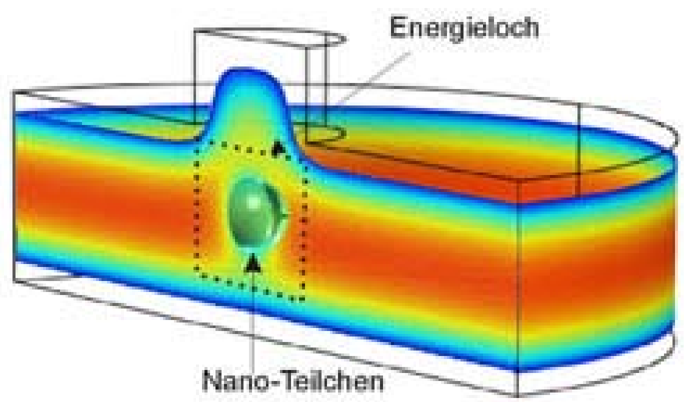
Calendar

- 12th Int'l. Conf. of Electrostatics, Electrostatics - 2013, April 2013, Budapest, Hungary, Contact: *info@electrostatics2013.org* website: http://www.electrostatics2013.org/
- ESA 2013, June 11-13, 2013, Cocoa Beach, Florida, USA, Contact: Charlie Buehler, *charles.r.buhler@gmail.com*
- EOS/ESD 35th Annual Symposium, Sept. 8-13, 2013, Las Vegas, Nevada, USA, Contact: Lisa Pimpinella, *info@esda.org,* website: http://www.esda.org/ *(abstract deadline Jan. 11, 2013)*
- ESA 2014, June 17-19, 2014, Univ. of Notre Dame, South Bend, Indiana, USA, Contact: David Go, *dgo@nd.edu*

Current Events (cont'd.)



Cross-section through two chip-sized glass plates in which a nanoparticle is trapped in an energy hole (or "potential well" to use the scientific term). The colored fields show the different charges in the electrostatic field. The red zone signifies a very low charge, while the blue edges have a strong charge. vaccines and numerous pharmaceuticals. "The charge of the particles plays a major role in this," the Zurich-based scientist tells us.

One example is the manufacture of medicines that have to be administered in precise doses over a longer period using drug-delivery systems. In this context, nanoparticles

2013 Annual Meeting of the Electrostatics Society of America
Cocoa Beach, FL, June 11-13, 2013

The Electrostatic Society of America (ESA) invites papers in all scientific and technical areas involving electrostatics for the 2013 Annual Meeting of the ESA. Contributions range from fundamental physics and new developments in electrostatics to applications in industry, atmospheric and space sciences, medicine, energy, and other fields.

Anticipated Technical Session Topics

- Breakdown phenomena and discharges
- Electrically-induced flows and electrokinetics
- Contact charging and triboelectric effects
- Gas discharges and microplasmas
- Atmospheric and space applications
- Biological and medical applications
- Materials synthesis, processing, and behavior
- Measurements and instrumentation
- Safety and hazards

Registration and Housing Information

The conference and housing will be located at
DoubleTree by Hilton Cocoa Beach Oceanfront
2080 N. Atlantic Ave. Cocoa Beach, FL 32931

Special Events

The conference will also include the annual banquet to be held at the DoubleTree by Hilton Cocoa Beach Oceanfront. There will be a special tour of NASA Kennedy Space Center given to members of the ESA.

Abstract Submission

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

Student Paper Competition

Presentations by undergraduate and graduate students are eligible for the Student Paper Competition; please indicate participation when submitting abstract.

Important Dates

March 1, 2013	*Abstract submission deadline*
March 15, 2013	*Notification of abstract acceptance*
May 10, 2013	*Early registration deadline*
May 17, 2013	*Final manuscript deadline*

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act as "packages" that transport the drugs to where they need to take effect. Very often, it is their electrical charge that allows them to pass through tissue and cell membranes in the body unobstructed and so to take effect. "That's why it is so important to be able to measure their charge. So far most of the results obtained have been imprecise," the researcher tells us. "The new method allows us to even measure in real-time a change in the charge of a single entity," adds Prof. Madhavi Krishnan. "This is particularly exciting for basic research and has never before been possible." This is because changes in charge play a role in all bodily reactions, whether in proteins, large molecules such as the DNA double helix, where genetic make-up is encoded, or cell organelles.

(*http://phys.org/news/2012-04-electric-fish-animal-behavior.html*)

Lightning Strike! Fragmentation Plant Tears Apart a Ton of Waste per Hour

Every year, several millions of tons of building rubble are produced. However, an efficient way of recycling concrete — the building material of the 20th and 21st century — does not yet exist. Researchers are working on new recycling methods and, with the aid of lightning bolts, they can break down the mixture of cement and aggregate into its components.

Whether the Pantheon in Rome or the German concrete canoe regatta, whether ultra-light or decorative: concrete is unbelievably versatile and is the world's most widely used material — next to water. It is made of cement, water and aggregate, a mixture of stone particles, such as gravel or limestone grit in various sizes. However, the CO_2 emissions, which are mainly the result of cement production, are problematic: the production of one ton of burned cement clinker of limestone and clay releases 650 to 700 kilograms of carbon dioxide. This means that, every year, eight to 15 percent of global CO_2 production is attributable to concrete manufacturing. And, when it comes to recycling waste concrete, there is no ideal solution for closing the materials loop. In Germany alone, the quantity of construction waste amounted to almost 130 million tons in 2010.

"This is an enormous material flow but, at the moment, there is no effective recycling method for concrete rubble" explains Volker Thome from the Fraunhofer Institute for Building Physics IBP from the Concrete Technology Group in Holzkirchen. The current method is to shred the concrete, which produces huge amounts of dust. At best, the stone fragments end up as sub-base for roads.

"This is downcycling," explains Thome, in other words, simply the reutilization of raw materials, the quality of which deteriorates from process to process. On the other hand, if it was possible to separate the stone particles from the cement stone, the gravel could easily be reused as an aggregate in new cement — a first decisive step in the direction of recycling waste concrete.

"The recovery of valuable aggregate from waste concrete would multiply the recycling rate by a factor of around 10 and, thereby, increase it to 80 percent," says Thome. If it also were possible to obtain a cement substitute from waste concrete, the cement industry's CO_2 emissions would be considerably reduced. To achieve these goals, Thome revived a method that Russian scientists already developed in the 1940s then put on ice: electrodynamic fragmentation. This method allows the concrete to be broken down into its individual components — aggregate and cement stone.

Recycling valuable components

Using this approach, the researchers in Holzkirchen are unleashing a veritable storm of lightning bolts. "Normally, lightening prefers to travel through air or water, not through solids," says Thomas. To ensure the bolt strikes and penetrates the concrete, the expert taps the Russian scientists' expertise. More than 70 years ago, they discovered that the dielectric strength, i.e. the resistance of every fluid or solid to an electrical impulse, is not a physical constant, but changes with the duration of the lightning.

"With an extremely short flash of lightning — less than 500 nanoseconds — water suddenly attains a greater dielectric strength than most solids," explains Thome. "In simple terms, this means that, if the concrete is under water and researchers generate a 150 nanosecond bolt of lightning, the discharge runs preferably through the solid and not through the water."

"That is the essence of the method," says Thome. In the concrete, the lightning then runs along the path of least resistance, which is the boundaries between the components, i.e. between the gravel and the cement stone. The initially generated impulses, the pre-discharges, first weaken the material mechanically. "The pre-discharge, which reaches the counter-electrode in our fragmentation plant at first, then causes an electrical breakdown," explains Thome. At this instant, a plasma channel is formed in the concrete, which grows within a thousandth of a second, like a pressure wave from the inside outwards.

"The force of this pressure wave is comparable with a small explosion," says Thome. The concrete is torn apart and broken down into its basic components. With the laboratory fragmentation plant, the researchers can currently process one ton of concrete waste per hour. "To work efficiently, our goal is a throughput rate of at least 20 tons per hour," says Thome. In as little as two years' time, an appropriate installation could be ready for market-launch.

(http://www.scientificcomputing.com/news-DS-Lightning-Strike-Fragmentation-Plant-Tears-Apart-a-Ton-of-Waste-per-Hour-101512.aspx?et_cid=2899406&et_rid=41420904&linkid=http%3a%2f%2fwww.scientific-computing.com%2fnews-DS-Lightning-Strike-Fragmentation-Plant-Tears-Apart-a-Ton-of-Waste-per-Hour-101512.aspx)

Making 'nanospinning' practical

Nanofibers — strands of material only a couple hundred nanometers in diameter — have a huge range of possible applications: scaffolds for bioengineered organs, ultrafine air and water filters, and lightweight Kevlar body armor, to name just a few. But so far, the expense of producing them has consigned them to a few high-end, niche applications. Luis Velásquez-García, a principal research scientist at MIT's Microsystems Technology Laboratories, and his group hope to change that. At the International Workshop on Micro and Nanotechnology for Power Generation and Energy Conversion Applications in December, Velásquez-García, his student Philip Ponce de Leon, and Frances Hill, a postdoc in his group, will describe a new system for spinning nanofibers that should offer significant productivity increases while drastically reducing power consumption.

Using manufacturing techniques common in the microchip industry, the MTL researchers built a one-square-centimeter array of conical tips, which they immersed in a fluid containing a dissolved plastic. They then applied a voltage to the array, producing an electrostatic field that is strongest at the tips of the cones. In a technique known as electrospinning, the cones eject the dissolved plastic as a stream that solidifies into a fiber only 220 nanometers across. In their experiments, the researchers used a five-by-five array of cones, which already yields a sevenfold increase in productivity per square centimeter over even the best existing methods. But, Velásquez-García says, it should be relatively simple to pack more cones onto a chip, boosting productivity even more. Indeed, he says, in prior work on a similar technique called electrospray, his lab was able to cram almost a thousand emitters into a single square centimeter. And multiple arrays could be combined in a panel to further increase yields.

Surfaces, from scratch

Because the new paper was prepared for an energy conference, it focuses on energy applications. But nanofibers could be useful for any device that needs to maximize the ratio of surface area to volume, Velásquez-García says. Capacitors — circuit components that store electricity — are one example, because capacitance scales with surface area. The electrodes used in fuel cells are another, because the greater the electrodes' surface area, the more efficiently they catalyze the reactions that drive the cell. But almost any chemical process can benefit from increasing catalysts' surface area, and increasing the surface area of artificial-organ scaffolds gives cells more points at which to adhere.

A tiny array of silicon tips sandwiched between electrodes spins out "nanofibers" of plastic that could be useful for a host of applications.
Photo: Dominick Reuter

Another promising application of nanofibers is in meshes so fine that they allow only nanoscale particles to pass through. The example in the new paper again comes from energy research: the membranes that separate the halves of a fuel cell. But similar meshes could be used to filter water. Such applications, Velásquez-García says, depend crucially on consistency in the fiber diameter, another respect in which the new technique offers advantages over its predecessors.

Existing electrospinning techniques generally rely on tiny nozzles, through which the dissolved polymer is forced. Variations in operating conditions and in the shape of the nozzles can cause large variation in the fiber diameter, and the nozzles' hydraulics mean that they can't be packed as tightly together. A few manufacturers have developed fiber-spinning devices that use electrostatic fields, but their emitters are made using much cruder processes than the chip-manufacturing techniques that the MTL researchers exploited. As a consequence, not only are the arrays of tips much less dense, but the devices consume more power.

"The electrostatic field is enhanced if the tip diameter is smaller," Velásquez-García says. "If you have tips of, say, millimeter diameter, then if you apply enough voltage, you can trigger the ionization of the liquid and spin fibers. But if you can make them sharper, then you need a lot less voltage to achieve the same result."

Wicked wicker

The use of microfabrication technologies not only allowed the MTL researchers to pack their cones more tightly and sharpen their tips, but it also gave them much more precise control of the structure of the cones' surfaces. Indeed, the sides of the cones have a nubby texture that helps the cones wick up the fluid in which the polymer is dissolved. In ongoing experiments, the researchers have also covered the cones with what Velásquez-García describes as a "wool" of carbon nanotubes, which should work better with some types of materials.

Indeed, Velásquez-García says, his group's results depend not only on the design of the emitters themselves, but on a precise balance between the structure of the cones and their textured coating, the strength of the electrostatic field, and the composition of the fluid bath in which the cones are immersed.

"Fabricating exactly identical emitters in parallel with high precision and a lot of throughput — this is their main contribution, in my opinion," says Antonio Luque Estepa, an associate professor of electrical engineering at the University of Seville who specializes in electrospray deposition and electrospinning. "Fabricating one is easy. But 100 or 1,000 of them, that's not so easy. Many times there are problems with interactions between one output and the output next to it."

The microfabrication technique that Velásquez-García's group employs, Luque adds, "does not limit the number of outputs that they can integrate on one chip." Although the extent to which the group can increase emitter density remains to be seen, Luque says, he's confident that "they can make a tenfold increase over what is available right now."

(*http://web.mit.edu/newsoffice/2012/making-nanospinning-practical-1120.html*)

CSIRO explains the mystery of ball lightning

Sightings of ball lightning have been made for centuries around the world – usually the size of a grapefruit and lasting up to twenty seconds – but no explanation of how it occurs has been universally accepted by science. In a paper published in the Journal of Geophysical Research Atmospheres entitled 'The Birth of Ball Lightning' CSIRO and Australia National University scientists present a new mathematical theory which explains how and why it occurs.

Previous competing theories have cited microwave radiation from thunderclouds, oxidizing aerosols, nuclear energy, dark matter, antimatter, and even black holes as possible causes.

Led by CSIRO scientist John Lowke, the new theory focuses on how ball lightning occurs in houses and aeroplanes – and how it can pass through glass. His theory also proposes that ball lightning is caused when leftover ions (electric energy), which are very dense, are swept to the ground following a lightning strike. "A crucial proof of any theory of ball lightning would be if the theory could be used to make ball lightning. This is the first paper which gives a mathematical solution explaining the birth or initiation of ball lighting," says Lowke.

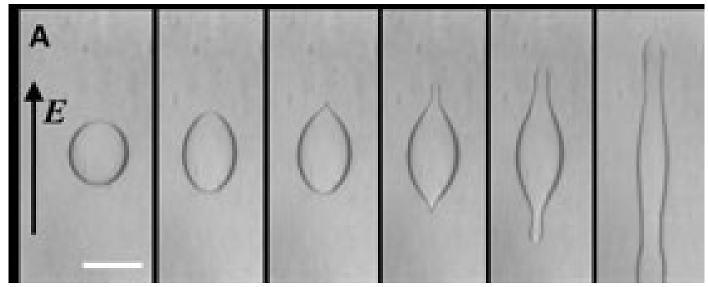
Lowke proposes that ball lightning occurs in houses and aeroplanes when a stream of ions accumulates on the outside of a glass window and the resulting electric field on the other side excites air molecules to form a ball discharge. The discharge requires a driving electric field of about a million volts. "Other theories have suggested ball lightning is created by slowly burning particles of silicon formed in a lightning strike, but this is flawed. One of the ball lightning observations cited in this paper occurred when there was no thunderstorm and was driven by ions from the aircraft radar operated at maximum power during a dense fog."

Lowke used eye-witness accounts of ball lightning by two former US Air Force pilots to verify the theory. Former US Air Force lieutenant Don Smith recalls: "After flying for about 15 minutes, there developed on the radome (radar cover) two horns of Saint Elmo's fire. It looked as if the airplane now had bull's horns...they were glowing with the blue of electricity."

Lowke's paper gives the first mathematical solution explaining the birth or initiation of ball lightning using standard equations for the motion of electrons and ions. He argues it is unique because it not only explains the birth of the ball but also how it can form on glass and appear to pass through glass resulting in globes of light in people's homes or in aeroplane cockpits.

(*http://www.csiro.au/en/Portals/Media/CSIRO-explains-the-mystery-of-ball-lightning.aspx*)

Droplet Response to Electric Voltage In Solids Exposed



For the first time, scientists have observed how droplets within solids deform and burst under high electric voltages. This is important, the Duke University engineers who made the observations said, because it explains a major reason why such materials as insulation for electrical power lines eventually fail and cause blackouts. This observation not only helps scientists develop better insulation materials, but could also lead to such positive developments as "tunable" lenses for eyes.

As the voltage increases, water droplets, or air bubbles, within polymers slowly change from their spherical shape to a more tubular shape, causing extremely large deformation within the material. Over time, this can lead to cracking and failure of the polymer, the researchers said. Polymers are a class of "soft" materials that can be found almost everywhere, most commonly as an insulator for electrical wires, cables and capacitors. Droplets or bubbles can be trapped in these polymers as defects during fabrication.

"The effects of electric voltage on droplets in air or in liquid have been studied over decades,' said Xuanhe Zhao, assistant professor of mechanical engineering and materials science at Duke's Pratt School of Engineering. "We take advantage of the understanding of these electrified drops in air or liquid every day, such as in the use of inkjet printers. "Conversely, no one has actually observed the effects of electric voltages on droplets in solids," Zhao said.

The results of Zhao's experiments were published online Oct. 23, 2012, in the journal Nature Communications. His work is supported by and the National Science Foundation's Research Triangle Materials Research Science and Engineering Center, National Science Foundation's Materials and Surface Engineering program and National Institutes of Health.

In air or liquid, droplets subjected to increased voltage tend to transform into a cone shape that eventually emits tiny droplets from the pointed end of the cone. This is the basic phenomenon that is taken advantage of in inkjet printers and similar technologies.

"Changes in electrified drops in solids have not been well studied, because it has been very difficult to observe the process as the solid would usually break down before droplet transformation could be captured," Zhao said. "This limitation has not only hampered our understanding of electrified droplets, but has hindered the development of high-energy-density polymer capacitors and other devices."

This knowledge becomes especially important, Zhao said, as scientists are developing new polymers designed to carry higher and higher loads of electricity.

Zhao's experiments involved droplets, or bubbles, encapsulated within different types of polymers. Using a special technique developed by Zhao group, the team observed and explained how increased voltage caused the droplet to form a sharp "tip" before evolving into the tubular shape.

"Our study suggests a new mechanism of failure of high-energy-density dielectric polymers," Zhao said. "This should help in the development of such applications as new capacitors for power grids or electric vehicles and muscle-like transducers for soft robots and energy harvesting."

The experiments also showed how polymers "deformed," or changed shapes, at different voltages before they failed. "It appears that it could be possible, just by varying voltages, to change the shape of a particular polymer," Zhao said. "One of the new areas we are now looking into is creating lenses that can be custom-shaped and used in ophthalmic settings." Other members of the team were Qiming Wang, Zhao's graduate student, and Zhigang Suo, Harvard University.

(excerpted from *http://www.mems.duke.edu/news/3770*)

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ESA-2013 Annual Meeting
June 11-13, 2013
Cocoa Beach, FL, USA