Nov/Dec 2015 • No. 233

ESA Newsletter

Electrostatics Society of America - The Friendly Society

President's Message

Desalination of seawater – affordable?

It is time for me to say good bye to Abu Dhabi where I spent a great year working at the Petroleum Institute during my sabbatical. I started thinking about writing something that relates both to electrostatics and my stay here in the UAE. There are a few things that come to mind; such as, sandstorms that raise dust particles to almost a kilometer high in air, electrostatics in oil-water separation, and the desalination process. Nearly all the water consumed in the UAE, and the rest of the arid Arabian Gulf region, is extracted from seawater, using energy-intensive desalination processes.

"Water, water everywhere, nor any drop to drink", a line from "The Rime of the Ancient Mariner", reminds me of the truth that we need freshwater for living. Building massive infrastructure for desalination of seawater became the number one priority in many countries in the Middle East. The Jebel Ali plant in the United Arab Emirates pumps out more than 2 billion liters of water a day from the sea, a sign of the sheer scale that is used for supplying water in the region. However, energy is a significant cost of the process of desalination. Although energy consumption using reverse osmosis is reasonably lower than that with thermal methods, the energy requirements are still considerably high. In its simple form, reverse osmosis is a process in which seawater is forced under pressure through a membrane that strips out the salt.

It is not just in the Middle East that desalination has been adopted on a large scale; countries like Australia, China and the United States of America have also been installing big plants. California State has the longest coastal line compared to other states in the USA, but access to fresh water is still a major issue. The state has been building a $1 billion desalination plant in Carlsbad, California, expected to be completed in 2016, to supply about 2 billion liters (500 million gallons) of freshwater per day.

Problems with water are expected to grow worse in the coming decades, with water scarcity occurring globally, even in regions currently considered water-rich. I hope some of the principles of electrostatics and use of advanced materials can be explored to purify water at lower cost and with less energy, while at the same time minimizing the impact on the environment. It should be noted here that the desalination process leaves behind a huge amount of salt that is currently being dumped into the sea; threatening aquatic life.

Researchers at MIT have developed something they call shock electrodialysis. "Seawater flows through a porous material made of tiny glass particles, sandwiched between electrodes. The current flows between the electrodes and causes the salty water to separate into regions where the salt concentration is either depleted or enriched. When the current is turned up, at a certain point it generates a shock wave between the two zones, dividing the streams and allowing the fresh and salty regions to be separated".

Alternatively, Asakawa's effect is what Prof. Stuart Hoenig has explored to remove ions from seawater. "Power applied to the mesh screen creates ions that charge the water molecules in the air and push them away from the liquid surface". Please see ESA Newsletter July/Oct. 2015 for Prof. Hoenig's contact information if you are interested in working with him on this fascinating subject.

(cont'd. p. 2)

President's Message (cont'd.)

Other related issues of importance include development of desalination technologies that can be powered by renewable energy and storage of freshwater in aquifers for later use.

While enjoying the holiday season, let us all think about alternatives to help improve the existing processes and/or develop new technologies.

On behalf of ESA, I take this opportunity to wish you and your families a very prosperous and productive 2016. Happy Holidays!

For the Friendly Society
Shesha Jayaram, *shesha.jayaram@uwaterloo.ca*
President, Electrostatics Society of America

Calendar

- 2016 Electrostatics Joint Conference, June 14-16, 2016, Purdue University, West Lafayette, IN, USA, *http://www.electrostatics.org/conferences.html* Contact: Raji Sundararajan, *rsundara@purdue.edu*
- IEEE 34th Electrical Insulation Conf (EIC), June 19-22, 2016, Montreal, Quebec, *http://sites.ieee.org/eic/* Contact: Bernard Noirhomme, *noirhomme.bernard@ireq.ca*
- 1st Int'l Conf. on Dielectrics (ICD), July 3-7, 2016, Montpellier, France, *http://www.ies.univ-montp2.fr/icd2016/* Contact: Jérôme Castellon, *chairman@icd-2016.org*
- XIV Int'l. Conf. on Electrostatic Precipitation (ICESP 2016), Sept. 19-23, 2016, Wroclaw, Poland, *http://www.icesp2016.pwr.edu.pl* Contact: Arkadiusz Świerczok, *icesp2016@pwr.edu.pl*

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Current Events

A charge that sticks

The widespread use in recent years of nets, insecticides and new drugs has helped to bring malaria under a measure of control—but evolution is constantly pushing back by generating resistant strains of both the parasite that causes the disease and the mosquito that spreads it. Even resistant mosquitoes, however, can take only so much chemical abuse, and Marit Farenhorst, a researcher at In2Care, a Dutch mosquito-control firm, and her colleagues think they have devised a way to dish out more of it.

Their method, as they report in the Proceedings of the National Academy of Sciences, is a version of the party trick of making a balloon stick to a wall by imbuing it with static electricity. Substituting mosquito nets and insecticide particles for walls and balloons, Dr Farenhorst believes, yields a way of delivering more, and more diverse, insecticides, and really making them stick where they are needed—on the cuticle of the target insect.

Current mosquito nets are woven from fibres impregnated throughout with an insecticide. This permits them to be washed and used for years without loss of potency. But it also means this potency is not as great as it could be, because the insecticide is released only slowly by the fibres. The impregnation, moreover, requires high temperatures, and only one class of insecticide, pyrethroids, can withstand these. In this case, therefore, natural selection has only one type of enemy to evolve around. Using static electricity, by contrast, means all of the insecticide is held on the surface of a net's fibres. Much larger doses can thus be transferred to an insect which blunders into the net. In addition, a wide range of insecticides—and even, possibly, the spores of a fungus harmless to people but lethal to mosquitoes—can be applied to the fibres.

To make her nets electrically attractive, Dr Farenhorst coats their fibres with a proprietary substance that maintains a positive charge. This induces an equal and opposite charge in particles of powdered insecticide, holding them in place if they are scattered over the net. The positively charged substance, crucially, stays put when a net is washed. And because the particles of insecticide themselves pick up an electrostatic charge, they are more likely to stick to a mosquito that dislodges them—as experiments using

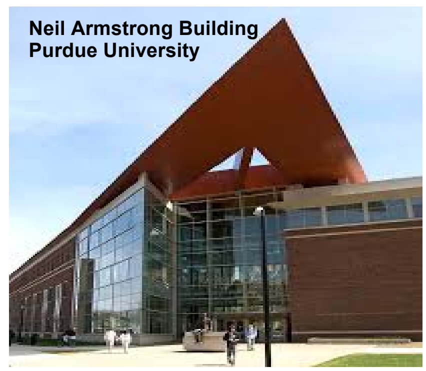
2016 Electrostatics Joint Conference

Purdue University
West Lafayette, Indiana, USA
June 14 - 16, 2016

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. The meeting will bring together experts across the diverse field to present the latest developments in electrostatics.

Anticipated Technical Session Topics

- Atmospheric and space applications
- Biological and medical applications
- Breakdown phenomena, safety and hazards
- Contact charging and triboelectric effects
- Electrically-induced flows and electrokinetics
- Flows, forces and fields
- Gas discharges and microplasmas
- Electrospinning and material processing
- Measurements and instrumentation
- Particle control and charging



Neil Armstrong Building
Purdue University

Conference information, including abstract submission, registration, student travel grants and lodging, will be updated and available at http://www.electrostatics.org

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

Important dates:
March 1, 2016 Abstract submission deadline (submit on-line at http://www.electrostatics.org)
March 17, 2016 Notification of paper acceptance
May 16, 2016 Final manuscripts due
June 13, 2016 Reception (6-9PM)
June 14, 2016 Conference begins (8AM)
June 16, 2016 Conference ends after evening banquet (7 PM – 10 PM)

Contact information:

For questions regarding the technical program and abstract submission, contact

Technical Chair: Dr. Keith Forward, California State Polytechnic University, Pomona, kmforward@cpp.edu, (909) 869-3621

For all other questions, contact

General Chair: Dr. Raji Sundararajan, Purdue University, raji@purdue.edu , (765) 494-6912

About Purdue University: The University is located at West Lafayette, 69 miles from Indianapolis and 144 miles from Chicago. With a student population of over 39,000, and alumni like Neil Armstrong, it is one of the best universities for Engineering and Sciences in the USA.

fluorescent particles show.

Further experiments demonstrated that the new nets do, indeed, have the desired effect. When the team tested them on mosquitoes resistant to a pyrethroid insecticide called deltamethrin, between 63% and 100% of the insects died within 24 hours of contact with a deltamethrin-dosed version of their invention. When they repeated the process using conventionally impregnated nets, only 10% died.

The new net does have one unfortunate constraint. Contact with human bodies reduces its potency, because the static-enhanced insecticide sticks to human skin as well as insect cuticle. It cannot, therefore, be used for making bed nets.

Beds, though, are not the only places where nets are useful. Window and door screens also play an important part in keeping mosquitoes at bay. Nor is there any reason why the coating could not be sprayed onto walls, making the deployment of insecticide on these favoured resting sites of mosquitoes more effective.

One inevitable side-effect of the new net's efficacy is that it needs regular resupplies of insecticide. But that is not a problem. In the field the researchers simply sealed a net and some powdered insecticide in a bucket and shook it up for 15 seconds. This was enough to recoat the net.

The upshot, then, is another useful weapon in the war on malaria. It will not win that war by itself. But it might bring victory closer.

(excerpted from *http://www.economist.com/news/science-and-technology/21663192-static-electricity-may-lead-better-mosquito-nets-charge-sticks*)

Printable electronics thanks to contactless liquid deposition

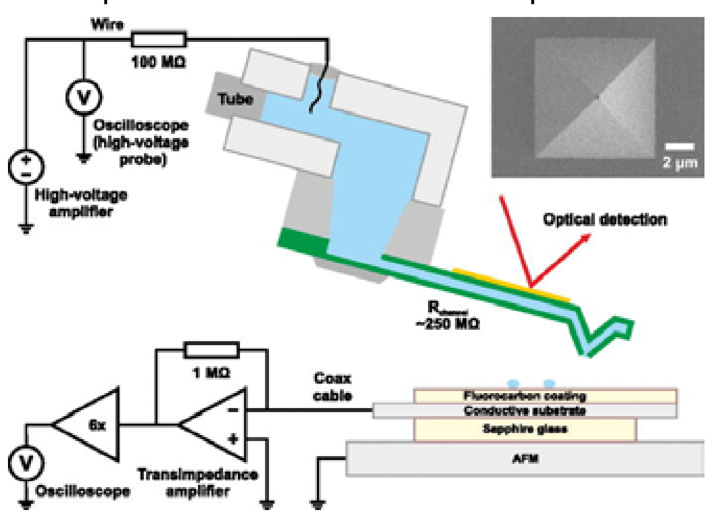
Jochem Vreeman

Scientists of research institute MESA+ of Twente University have developed a technology for contactless deposition of liquids at nanoscale. In doing so, they make use of an electric field. Their technology will lead to new 3D-applications and can be of great value to, for example, cell research, nano-lithography and printable electronics. The findings of the Twente-based Mesoscale Chemical Systems Department have recently been published in the academic journal Applied Physics Letters.

In conventional techniques for liquid deposition, pressure is exerted on liquids, or capillary forces are used. This is done with the aid of a so-called AFM (Atomic Force Microscopy) 'dip-pen' probe or a 'nano-fountain pen' probe. These probes have been equipped with a tip which permeates the liquid. A disadvantage of this method is that several elements, such as humidity and liquid or surface properties, can affect the deposition negatively.

The contactless deposition method with the AFM nano-fountain pen probe ensures a reliable and quick deposition of liquids on a 50 nanometre scale. This is thanks to the use of an electric field. By applying a voltage, the liquids inside the tip are charged. The difference with the charge of the surface causes the liquid to be pulled out of the probe. A relatively low voltage (60 Volt) can already be sufficient. As the pulse duration increases, the volume of the liquid deposition will grow too.

The research now published was carried out in collaboration with the company SmartTip. This spin-off of the University of Twente develops and produces smart probes with new functionalities. Researcher Joël Geerlings of the Mesoscale Chemical Systems Department expects that many new possible 3D-applications lie ahead with the development of the new deposition method. "Think of a 3D-printer with



Experimental setup with a pyramidal tip FluidFM probe. The inset shows a SEM image of the tip.

Citation: Appl. Phys. Lett. 107, 123109 (2015); *http://dx.doi.org/10.1063/1.4931354*

nanoscale resolution that produces a scaffold (construction) for cell research." Other applications are arrays of DNA or proteins, photonic crystals, microfluidic structures, printed electronics and MEMS structures (micro-electromechanical systems) for sensors, for example."

(from *http://phys.org/news/2015-10-printable-electronics-contactless-liquid-deposition.html*)

Measuring X-rays created by lightning strikes on an aircraft in-flight

Scientists have recorded measurements of X-rays of energies up to 10 MeV caused by electrons accelerated in the intense electric fields inside a thundercloud. The researchers, based at the Eindhoven University of Technology, The Netherlands, the National Aerospace Laboratory (NLR), The Netherlands, and Airbus France, report their findings Wednesday 30th September, in the Journal of Physics D: Applied Physics.

The researchers were able to mount equipment on an Airbus during test flights that took place in April 2014. These flights allowed an opportunity to further test the In-flight Lightning Strike Damage Assessment System (ILDAS) to which the researchers had previously contributed, in addition to mounting X-ray detectors within the cabin. The study reports on the findings of four lightning strikes on the aircraft, three initiated by the aircraft and one 'aircraft intercepted' strike. "These four lightning strikes represent all of the effects we were looking at, so they provided us with excellent data." Says Pavlo Kochkin, the first author on the paper.

The results show that most of the X-rays are synchronous with the initiating negative flow of charge within the cloud, as the moving electrons create X-rays via *bremsstrahlung* in bursts immediately preceding a current pulse of the lightning strike. The researchers estimate the highest radiation dose in their detector from one of these X-ray bursts to be in the order of 5 x 10-12 Gy. For comparison, the dose normally received due to long flights at altitude is approximately 8 million times higher. Some of the detected X-ray signals may also be associated with terrestrial gamma-ray flashes (TGF). Earth-bound TGF have previously been detected from space, but the relevance of these data to TGF requires further investigation.

"We were extremely lucky to be able to work with our collaborators and Airbus," explains Alex van Deursen, another author on the paper. "This data is very interesting – we've made other lightning physicists quite jealous by getting it first!" The researchers hope to continue to look for indications of terrestrial gamma-ray flow in the next batch of data from more recent flights.

(from *http://ioppublishing.org/newsDetails/2015/thunder-planes*)

Proposed Standards for Triboelectric Nanogenerators Could Facilitate Comparisons

More than 60 research groups worldwide are now developing variations of the triboelectric nanogenerator (TENG), which converts ambient mechanical energy into electricity for powering wearable electronics, sensor networks, implantable medical devices and other small systems. To provide a means for both comparing and selecting these energy-harvesting nanogenerators for specific applications, the Georgia Institute of Technology research group that pioneered the TENG technology has now proposed a set of standards for quantifying device performance. The proposal evaluates both the structural and materials performance of the four major types of TENG devices.

Triboelectric nanogenerators use a combination of the triboelectric effect and electrostatic induction to generate small amount of electrical power from mechanical motion such as rotation, sliding or vibration. The triboelectric effect takes advantage of the fact that certain materials become electrically charged after they come into moving contact with a surface made from a different material. The electricity generated by TENG devices could replace or supplement batteries for a broad range of potential applications. Developed over the past several years, the technology has advanced to the point where it can power small electronic devices, potentially enabling widespread sensing and infrastructure systems – as well as powering wearable consumer devices.

In their paper, Wang's team proposes a general figure of merit which can be used to quantify the potential energy output of the TENG devices. The general figure of merit is made up of information from two other sources: the capabilities of the specific TENG structure used, and the surface charge density provided by the specific materials chosen to construct the device. The output is compared to the mechanical energy inputs to provide an efficiency comparison.

These measurements are based on plots of the build-up of voltage and total transferred electrical charges from each device. The structural figures of merit are derived from theoretical calculations for each of the four major nanogenerator modes, plus experimental results produced by TENG devices placed into a circuit with a switch and an electrical load. The materials figure of merit depends on experimental measurements of the surface charge density done with an experimental set-up that uses liquid metal to collect the surface charge.

Variations in TENG structures allow a variety of applications depending on the source of mechanical energy. The four major groups include (1) vertical contact-separation mode, (2) lateral sliding mode, (3) single-electron mode, and (4) freestanding triboelectric-layer mode. There are also hybrid combinations of these major structural modes.

The contact-separation mode, for example, is powered by a periodic driving force that causes repeated contact, and then separation, between two dissimilar materials that have coated electrodes on the top and bottom surfaces. The lateral sliding model uses two surfaces that briefly slide together, then separate, generating a charge. "We can calculate for the four modes what are the best sizes and shapes, and the best power output you can expect for a specific structural figure of merit," Wang explained.

Material choices tested include fluorinated ethylene propylene, Kapton, polarized polyvinylidene fluoride, polyethylene, natural rubber and cellulose.

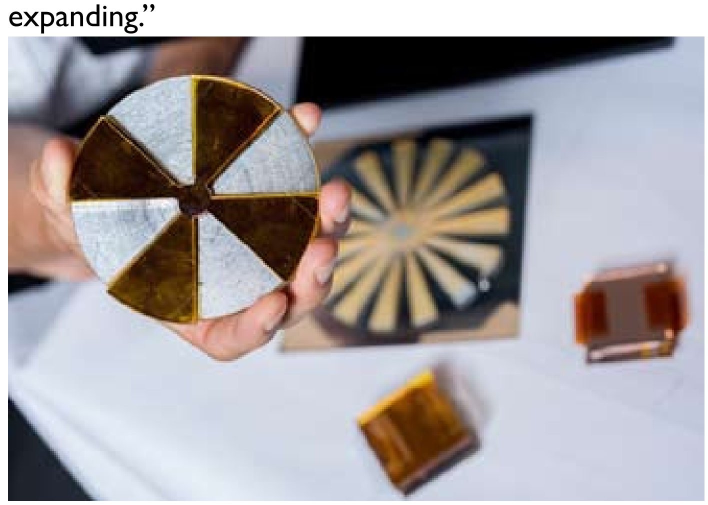
The measurement and theoretical techniques were developed by postdoctoral fellow Yunlong Zi and graduate student Simiao Niu, both members of Wang's research team. In developing their proposed standards, the researchers considered what had already been done in setting standards for heat engines and other technologies.

"For triboelectric generators, because the mechanical input is varied, you have different kinds of measurements to evaluate the performance," said Zi. "These figures of merit are considerably more complicated than would be needed for characterizing solar cell performance, for example."

Publishing the proposed standards is a first step in what Wang expects to be a long process of gaining acceptance. He plans to spend the next several months explaining the standards to other research groups developing TENG devices.

He estimates that there could be 60 research groups around the world working on TENG devices, and he expects that number to grow as the nanogenerators become more sophisticated and powerful.

"As wearable electronics become more popular and fashionable, we will need a better way to power them," Wang said. "Triboelectric nanogenerators can play a large role in that. We have spent a lot of time improving the power efficiency, and the field is quickly expanding."



More than 60 research groups worldwide are now developing variations of the triboelectric nanogenerator (TENG). Shown in this image is a collection of the devices. (Credit: Rob Felt, Georgia Tech)

Ultimately, he said, the standards could also be modified for piezoelectric generators and other systems designed to produce electricity from mechanical motion.

(excerpted from *http://www.news.gatech.edu/2015/09/25/proposed-standards-triboelectric-nanogenerators-could-facilitate-comparisons?*)

Dielectric Film Has Refractive Index Close to Air for Photonics Applications

Chih-Hao Chang, Matt Shipman

Researchers from North Carolina State University have developed a dielectric film that has optical and electrical properties similar to air, but is strong enough to be incorporated into electronic and photonic devices – making them both more efficient and more mechanically stable.

At issue is something called refractive index, which measures how much light bends when it moves through a substance. Air, for example, has a refractive index of 1, while water has a refractive index of 1.33 – which is why a straw appears to bend when you put it in a glass of water.

Photonic devices require a high contrast between its component materials, with some components having a high refractive index and others have a low one. The higher the contrast between those materials, the more efficient the photonic device is – and the better it performs. Air has the lowest refractive index, but it isn't mechanically stable. And the lowest refractive index found in solid, naturally occurring materials is 1.39. But now researchers have developed a film made of aluminum oxide that has a refractive index as low as 1.025 but that is mechanically stiff.

"By manipulating the structure of the aluminum oxide, which is dielectric, we've improved both its optical and mechanical properties," says Chih-Hao Chang, corresponding author of a paper on the work and an assistant professor of mechanical and aerospace engineering at NC State. Dielectrics are insulator materials that are used in an enormous array of consumer products. For example, every handheld device has hundreds of capacitors, which are dielectric components that can store and manage electric charge.

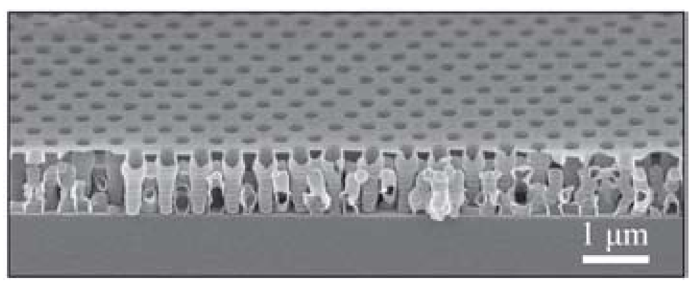
"The key to the film's performance is the highly-ordered spacing of the pores, which gives it a more mechanically robust structure without impairing the refractive index," says Xu Zhang, lead author of the paper and a Ph.D. student at NC State.

The researchers make the film by first using a nanolithography technique developed in Chang's lab to create highly-ordered pores in a polymer substrate. That porous polymer then serves as a template, which the researchers coats with a thin layer of aluminum oxide using atomic layer deposition. The polymer is then burned off, leaving behind a three-dimensional aluminum oxide coating.

"We are able to control the thickness of the aluminum oxide, creating a coating between two nanometers and 20 nanometers thick," Zhang says. "Using zinc oxide in the same process, we can create a thicker coating. And the thickness of the coating controls and allows us to design the refractive index of the film." Regardless of the how thick the coating is, the film itself is approximately one micrometer thick.

"The steps in the process are potentially scalable, and are compatible with existing chip manufacturing processes," Chang says. "Our next steps include integrating these materials into functional optical and electronic devices."

(excerpted from *https://news.ncsu.edu/2015/10/chang-refractive-2015/?*)



This image shows the structure of the dielectric film at the micrometer scale. Image credit: Chih-Hao Chang.

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