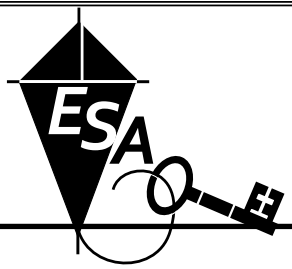
Mar/Apr 2009 • No. 196



ESA Newsletter

Electrostatics Society of America - The Friendly Society

President's Message

Electrostatics and Cancer

Dear All:

Understanding the molecular and cellular events involved in tumor formation, progression, metastasis, and drug binding is crucial to the development of innovative therapy for cancer patients. The human body could be considered as a composite conductor comprising a number of spatially distributed tissues/cells with differing electrical properties. Unlike metallic conductors, electrical conduction within biological cells is due to ions in which electrostatics also plays a major role in DNA's function, drug binding and cellular proliferation.

Electrostatic interactions are critical for protein structure and functions [1]. The electrostatic potential, governed by the Poisson-Boltzmann equation [2], is a function of all species of ions in the solution, including their charge and volume concentration, the dielectric permittivity of the solvent, and the ambient temperature. Recently, it was shown that by considering the dynamic solvent microstructure (especially the Debye polarization of water molecules), sophisticated effects at the protein-solvent interface could be revealed. Thus, cellular electrostatic interactions are also related to cancer and its treatment as dictated or directed by ribosomes [3-6].

Ribosomes are structures in our cells that are responsible for making proteins. They catalyze the assembly of amino acids into proteins using messenger RNA as a template. This process is called translation. Ribosomes are central to protein synthesis machinery and thus are target for several pharmaceuticals. The activity of ribosomes is dependent upon their appropriate three- dimensional conformation, influenced by electrostatic interactions between RNA and protein components. The functioning of ribosomes, and subsequent expression of distinct proteins, plays a major role in normal growth, development and disease pathogenesis. Thus, electrostatic interactions responsible for regulating ribosome efficiency can have a profound impact on diseases such as cancer, and its drug binding to DNA [3-5].

Ribosome systems have electrostatic properties which will provide information on translation and the rational design of novel antibiotics for cancer and other diseases. Several ribosomal proteins are activated in a variety of tumors [6]. Several tumour suppressors and proto-oncogenes have been found either to affect the formation of the mature ribosome or to regulate the activity of proteins known as translation factors. Disruption in one or more of the steps that control protein biosynthesis has been associated with alterations in the cell cycle and regulation of cell growth. Therefore, certain tumour suppressors and proto-oncogenes might regulate malignant progression by altering the protein synthesis machinery. Many studies have correlated deregulation of protein biosynthesis with cancer [4, 5]. Thus, the ability to determine the contribution of electrostatics to the forces and energies of biological systems should help better cure for cancer and the devise of better drugs with fewer side effects.

I hope we will see more papers in electrostatics and biological systems in the upcoming ESA 2009 meeting at Boston with 99 accepted abstracts. These abstracts are from almost all the continents, North and South Americas, Asia, Africa and Australia. I hope all the authors who submitted the abstracts also attend the conference and give either oral or poster presentations of their great work. The due date for registration is fast approaching.

(cont'd. on page 3)

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 LL
Past ESA President

ESA08 Conference Follow-up

ESA08 Presentations - Where are they?

ESA08 presentations are finally up on the web and can be viewed by going to *http://www.electrostatics.us* and clicking on the "ESA e-Proceedings" link at the far left of the page. For those who use a PC in a Windows environment step-by-step instructions (in MS-Word or pdf) can be found on that page to set up your Windows media player with a codec that will recognize presentations that are in an ogg format. For those who operate in the Mac, Linux, etc. environment as well as those in the Windows environment, instructions are also given to download and install the VLC media player which has a codec that recognizes the ogg format among many others. The ogg format was chosen so that the ESA presentations can be downloaded in a reasonable time and displayed with full screen clarity on your computer.

Only 35 of the 46 presentations (76%) are available for viewing. Those that are not downloadable are due to what can only be described as my lack of understanding of the details involved in setting-up, recording and post-processing the talks. For the most part these were due to problems on the first day of the conference.

Remember, you must install a codec for your media player to recognize the ogg format used in ESA presentations. Let me know what you think of the instructions and the mechanics of getting and viewing the presentations, and feel free to send comments and complaints to me at *aseaver@electrostatics.us*

Al Seaver
Past ESA President

Calendar

- ISEHD2009. March 25-28, 2009, Universiti Malaysia Sarawak, Sarawak, Malaysia, Contact: ISEHD2009 Secretariat, Tel: 006-082-58-3326, *isehd2009@feng.unimas.my* or *aigit@feng.unimas.my* , website: *http://www.feng.unimas.my/ISEHD2009/* (abstracts due Oct. 31, 2008)
- 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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A Tribute to Chris Snelling

I am sorry to report the passing of longtime ESA member Chris Snelling this past November, 2008. His many significant contributions to electrostatics, in general, and xerography, in particular, are touched upon in the following tribute in 2006 honoring the occasion of Chris's 100th US patent.

WEBSTER, N.Y., April 14, 2006 -- Xerox Corporation will honor retired scientist Christopher Snelling for surpassing the 100-U.S. patent mark in a ceremony at the company's "Wall of Fame" in the Webster R&D campus on April 18th. Snelling joins a handful of scientists in the history of the company and the world to accomplish the prestigious milestone. Snelling, who joined Xerox (then the Haloid Company) in 1956, held the "pioneering patent" for image on image xerography. The invention is the basis for the Xerox iGen3™ Digital Production Press, a product that has revolutionized the business of colored printing.

"Individuals like Chris Snelling personify Xerox's dedication to innovation," said Sophie Vandebroek, president of Xerox's Innovation Group and the company's chief technology officer. "His work resulted in major technical achievements in areas of vital importance to the company."

Snelling, one of only 12 Xerox scientists to reach the 100-patent mark, currently holds 101 patents. He is recognized in the scientific community for his long-range foresight and creative thinking.

"Twenty years after winning the patent for image on image xerography we have a product like the iGen3," said Dale Mashtare, a research scientist who worked with Snelling. "It took literally armies of people to accomplish this, but at its root is this lone inventor of Xerox with vision."

Snelling retired from Xerox in 2000 as a research fellow and manager of a small Xerox laboratory called EXITE, which focused on exploratory xerographic process research. One of Snelling's achievements just before retirement was the invention of the acoustic transfer assist (ATA) process. This process, also used in the iGen3 family of products, enables xerographic printing onto textured paper surfaces.

→

President's Message (cont'd.)

I am very happy to tell you that I heard a very positive comment on our Jan/Feb Newsletter from one of our esteemed executive committee members. As usual, I look forward to hearing from many of you.

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

References:

[1] J. Dai, et al., New computational models for electrostatics of macromolecules in solvents, IEEE Trans. Magnetics, 43, 4, Apr. 2007.

[2] N. Baker, et. al., Electrostatics of Nanosystems: Application to microtubules and the ribosome, PNAS, Aug. 2001, 98, 18, 10037-41.

[3] S. Riahi et. al., A theoretical study on interactions between mitoxantrone as an anticancer drug and DNA: Application in drug design, Chem Boil Drug Des 2008; 71: 474-482.

[4] L. Montanaro, D. Trere, and M. Derenzini, Nucleolus, Ribosomes, and Cancer, Review, The American Journal of Pathology, 173, 2, Aug. 2008, p. 301-310.

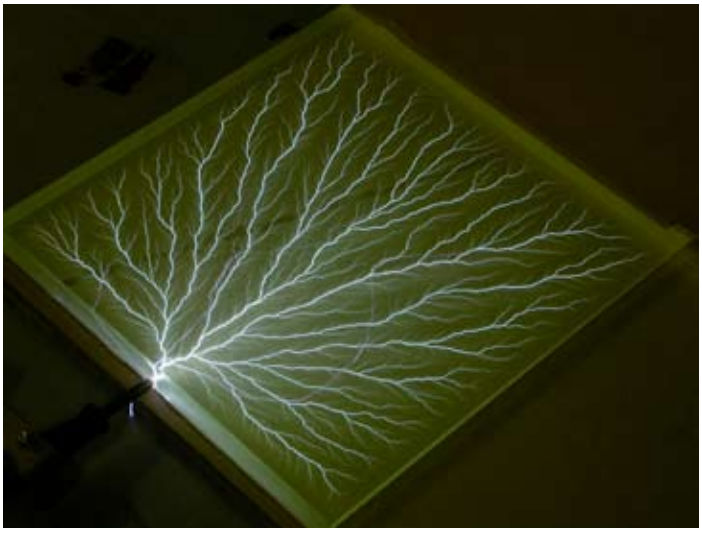
[5] A.V. Korennykh, C.C. Correll, and J.A. Piccirilli, Evidence for the importance of electrostatics in the function of two distinct families of ribosome inactivating toxins, RNA (2007), 13: 1391-1396.

[6] D. Ruggero and P.P. Pandolfi, Does the ribosome translate cancer?, Nature Reviews Cancer 3, 179-192 (March 2003)

Acknowledgements:
Ignacio Camarillo, Biological Sciences Dep't., Purdue University, West Lafayette, IN 47907.

"The ATA process is another example of how Chris used obscure thinking to advance xerography," Mashtare said. "He is a creative, quiet inventor, but his ideas and excitement are quite contagious."

Snelling studied Electrical Engineering at Union College before receiving his masters in applied mathematics from the University of Rochester. From 1968 to 1972 he left Xerox to join Kayex Corporation, where he oversaw the design and construction of the Kayex's first czochralski silicon crystal growing furnace. These furnaces today are used around the world to process computer chips. Snelling returned to Xerox in 1972.



Space Charge-Driven Breakdown - a Curious Phenomenon

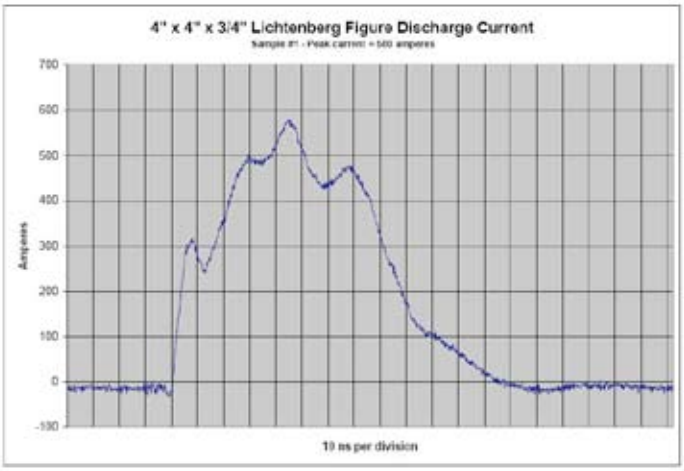
Bert Hickman, bert.hickman@aquila.net
Stoneridge Engineering, http://www.capturedlightning.com

Background: For many years we have been using commercial electron beam accelerators to make 2D and 3D Captured Lightning Lichtenberg figure sculptures within clear PMMA (Polymethyl methacrylate or acrylic). By injecting 3 to 5 MeV electrons to a depth of 0.25" to 0.5" below the irradiated surface, we develop a relatively narrow layer of dense space charge that remains temporarily trapped within the dielectric. After charging the specimen to just below self-breakdown (~1 μC/cm2), the potential of the internal charge plane may reach 1.5 – 2.5 MV versus outside specimen surfaces.

We create a small surface defect by poking a charged specimen with a sharp conductive point, releasing the trapped charge. The resulting high voltage discharge creates a bright flash and loud bang, leaving behind permanent chains of small fractures and tubules in a fractal, tree-like form. Because the propagating discharges are positively charged with respect to the negatively space charge, the result is a classic "positive" Lichtenberg figure. This process was initially discovered by electron beam pioneers Drs. Arno Brasch and Fritz Lange in the late 1940's, and was formally reported in the literature by Dr. Bernhard Gross in the 1950's.

The huge internal negative space charge attracts positive ions created as the electron beam passes through the air during irradiation. Positive ions accumulate on the surface of the specimens, partially neutralizing the internal field and forming a "plate-less" capacitor that is capable of storing significant electrostatic energy. A small 4" x 4" x ¾" specimen stores about 80 Joules, while a larger 12" x 12" x 1" specimen stores about 1 kJ. This helps to explain the significant mechanical damage that is associated with the formation of these Lichtenberg figures. Following is an image of a 12" square specimen being carefully discharged. A dark filter was used to prevent camera sensor saturation. The estimated discharge current for this specimen was between 2500 - 3500 amperes.

Measuring Discharge Current: During one experiment, we constructed a fixture that could hold a charged 4" x 4" x ¾" specimen. The fixture used isolated metal plates to make contact with the large surfaces of the specimen. A heavily insulated wire connected these plates to an insulated discharge point. The same wire also passed through an Ion Physics 50 kA wideband current transformer (CT), allowing us to measure and capture the discharge current waveform with a Tektronix 500 MHz digital storage oscilloscope. One of the discharge current waveforms is shown below.



In this experiment the peak discharge current reached almost 600 amperes, the duration of the main discharge was about 120 ns. The discharge is consistent with the estimated electrostatic energy initially stored within the specimen. This particular discharge consisted of four distinct current peaks - other specimens showed between three and seven peaks. This suggests that the discharge may have propagated in a series of advancing waves, or as several independent sections feeding (at various times) into the main current path. In either case, the captured waveforms suggest an average streamer velocity of 8.5 x 105 - 1.3 x 106 m/s. This is similar to the velocity of propagating positive streamers in air(!). Pauses between successive current surges suggest that peak streamer velocities may be considerably higher.

The Paradox: High velocity streamers within solids create a paradox. At over 800 times the speed of sound within PMMA, these streamers are propagating at veloci-

ties that are inconsistent with Griffith's theory of crack propagation. Normally, crack propagation is limited to the Rayleigh speed (~1.6 x 103 m/s for PMMA), and typical cracks propagate at significantly lower velocities. Our current waveforms imply that high-field space charge-driven breakdown within PMMA develops at velocities that are almost three orders of magnitude higher than allowed by crack propagation theory. Certain theories of solid dielectric breakdown rely on gas channel ionization and expansion behind propagating cracks for advancing propagation. This does not appear to be the driving mechanism for space charge-driven breakdown.

Instead, we suspect that intense internal electric fields at leading edges of propagating streamers may exceed 20 MV/cm, sufficient to trigger intrinsic ("electronic") breakdown within nearby PMMA. If field enhancement at streamer tips drives intrinsic breakdown, this may permit streamers to propagate at hypersonic velocity. This would be analogous to leader-streamer propagation within air. The process would culminate in a network of conducting filamentary streamers covering virtually the entire internal space charge plane. Intense Joule heating within streamers would be quickly followed by the formation of countless small, independent, cracks and tubules which are then expanded by gaseous breakdown products from the PMMA. We suspect that crack formation, expansion, and conduction occur as a consequence of prior intrinsic breakdown. This may be supported by microscopic examination of Lichtenberg figure discharge paths, which show that individual cracks are quite small, are virtually independent of each other, and often at right angles to the actual discharge path.

We have conducted a literature search but have thus far been unable to find reports of space charge-driven dielectric breakdown in solids at velocities as high as we have measured. We are very interested in getting feedback from the experts within ESA to help us better understand what is occurring or point us to prior research or researchers in this area.

Electroporation "Knife" for Cancer

Morgen E. Peck

Electroporation, a technique that microbiologists have long used experimentally to temporarily punch holes in cell membranes and ferry drugs or genes into them, may yield new benefits for cancer treatment, according to medical-device firm AngioDynamics, in Queensbury, N.Y. Last month, the company showed off an electroporation device that it claims can kill cancerous tumor cells with remarkable specificity while inflicting little or no damage on surrounding structures and causing no pain for the patient.

Such claims, if they hold up, would have a tremendous impact on a cancer surgery technique called tumor ablation, in which doctors rely on either chemical treatments or an array of techniques that heat up or cool down the tumor tissue until it succumbs. Because they kill with temperature, these therapies affect all tissue indiscriminately, wiping out blood vessels along with the cancer cells and potentially causing bleeding. Electroporation, on the other hand, does not produce enough heat to disrupt nearby tissue.

"Most procedures take a soft egg and boil it," says Stephen Kee, a radiologist at the University of California at Los Angeles Medical Center, who has been testing the device with guidance and funding from AngioDynamics. "To us, the real Achilles' heel of ablation techniques is the destruction of blood vessels."

When tumors abut especially large blood vessels, another problem arises for thermal ablation, says Kee. Radiologists call it the heat sink effect. The flow of blood provides convection to the area, cooling it substantially, and it becomes more difficult to maintain temperatures that thoroughly and consistently ablate the tissue. AngioDynamics' device, the NanoKnife, might circumvent this problem all together.

The NanoKnife delivers quick bursts of energy through a set of electrodes inserted into and around the tumor. The pulses can last up to 100 microseconds and create an electrical field of up to 3000 volts per centimeter. A cell within range of the electric field will form pores in its fatty membrane, allowing ions to rush through. When electroporation is performed with a lower voltage than the NanoKnife delivers, and with single pulses instead of a train of pulses, the pores will eventually close as the electric potential of the cell stabilizes. Microbiologists have

(cont'd. on page 7)

Current Events (cont'd.)

A Surface-Tension-Driven Propulsion and Rotation Principle for Water-Floating Mini/Micro Robots

Sang Kug Chung, Kyungjoo Ryu, and Sung Kwon Cho
Univ. of Pittsburgh
(excerpted from ... http://www.pitt.edu/news2009/Cho.pdf)

This paper describes development and experimental verifications of a novel propulsion and rotation technique of water-floating objects. As opposed to mechanical paddling, this technique electrically controls surface tension forces acting on water-floating objects without any moving parts (so-called electrowetting-on-dielectric, EWOD), possibly providing a new simple and efficient method to propel and maneuver water-floating mini/micro robots and boats.

The present technique bio-mimics the propelling skill of some insects (e.g., Pyrrhalta larva). When the larva bends its back (Fig.1b), the symmetry of surface tension forces acting on its head and tail breaks, resulting in producing a net horizontal static force and thus generating static capillary thrust.

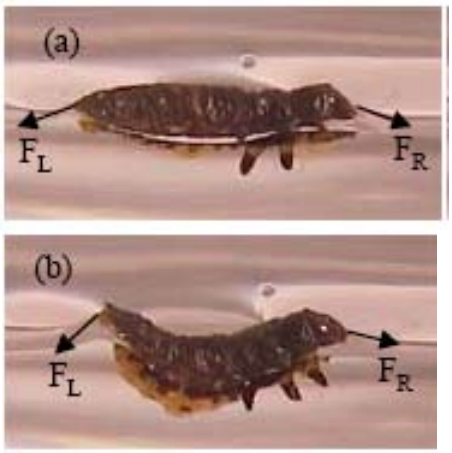


Figure 1. *The larva of Pyrrhalta is able to ascend the inclined meniscus. The larva deforms the water surface by arching its back, thus generate asymmetric forces between on its head and tail that generate the desired capillary thrust to move.*

Figure 2 illustrates the concept of bio-mimicked propulsion in a simplified rectangle mini-boat. Unlike the bending mechanism of the larva, the boat has an EWOD electrode on the left side to break force symmetry. Initially, the surface tension forces (FL and FR) on the boat are symmetric (Fig.2a): the boat is stationary. To generate asymmetric force configurations and thus horizontal net force, EWOD is applied to the left side of the boat (Fig.2b). Since the contact angle on the electrode is reduced by EWOD, FL becomes pointing downward while FR does not change significantly: the resultant of horizontal forces would direct right, and the boat would move right. →

Ready for a bolt from the blue

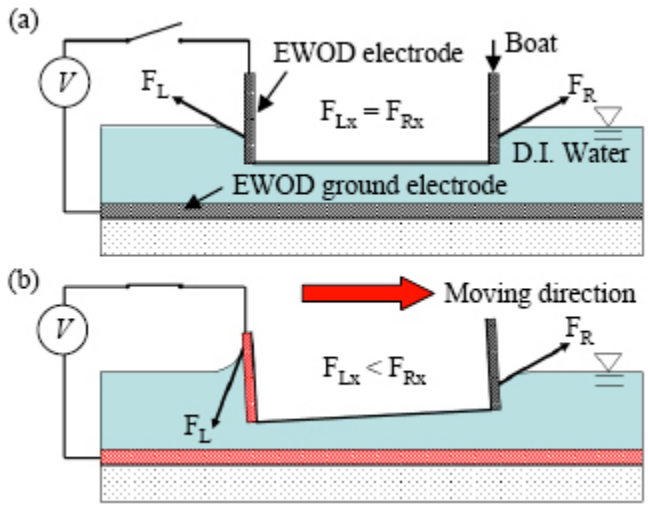
R&D Mag
(excerpted from ... http://www.rdmag.com/ShowPR.aspx?PUBCODE=014&ACCT=1400000101&ISSUE=0902&RELTYPE=TEST&PRODCODE=00000000&PRODLETT=CH&CommonCount=0)

Firing bolts of lightning at expensive electrical equipment is all in a day's work at NEETRAC—the National Electric Energy Testing Research and Applications Center. The goal for the lightning research and other testing done by the center is to improve reliability for the nation's electric energy transmission and distribution system.

The 2.2 million-volt impulse generator needed to produce artificial lightning is just one part of the test gear used to evaluate utility industry equipment that ranges from wooden poles and aluminum transmission lines to transformers and switches. Part of Georgia Tech's School of Electrical and Computer Engineering, the center is supported by 32 equipment manufacturers and utility companies that provide nearly 60% of the electricity used in the United States. A major part of the work is ensuring reliability during the lightning storms that threaten utilities and their customers.

Thunderstorms can produce more than 100 million volts—compared to the 120 volts in household wall outlets and 240 volts that power large home appliances. To deal with those added millions of volts, utilities rely on a complex array of lightning arrestors, static lines and grounding systems.

Lightning arrestors, for instance, contain special materials that under normal conditions do not permit the flow of electrical current. But when they sense a sudden surge of electricity from a lightning strike, they change properties in a few microseconds, becoming conductors rather than



Current Events (cont'd.)

insulators. When strategically placed on the electric grid, the arrestors carry the lightning surges away to the ground—after which the arrestors return to their role as insulators. Without the arrestors, lightning could arc across the insulators that support power lines, causing interruptions and damaging other equipment. In severe cases, the damage could cause line circuit breakers to trip, resulting in power outages to businesses, hospitals and whole communities.

Helping the industry develop better equipment requires an understanding of lightning and how it works. For instance, though it's generally not visible to the human eye, most lightning strikes in the Southeast are made up of between three and five separate pulses between 30 and 120 milliseconds apart, each one containing potentially damaging electrical energy. In the Southeast, 90% of lightning has a negative charge. But positively-charged lightning also occurs, most often in the winter. Positive lightning ionizes the atmosphere more efficiently than negative lightning and can therefore travel longer distances.

"Positive lightning can travel 10 miles from the storm before striking an object on the ground, so the storm clouds may not even be visible when the lightning strikes," said Ray Hill, a research technologist with NEETRAC. "This is the source of what people call a 'bolt from the blue.' Because it tends to be a single pulse, positive lightning can be more dangerous since all of the energy is in a single stroke—and people aren't expecting it."

Though NEETRAC's lightning impulse generator can create explosive results, most testing at the center's facilities is less dramatic. For instance, salt fog chambers simulate long-term exposure in moist and corrosive environments to study how utility system components will withstand years of exposure to the elements. Strong ultraviolet lights and high temperatures test the ability of rubber seals to withstand summertime heat and strong sunlight while keeping moisture away from sensitive components. Computer simulations developed by Sakis Meliopoulos, a member of the Georgia Tech electric power faculty, help determine the most efficient way to ground the electric grid, which provides the only effective way to control damaging current.

(cont'd. from page 5)

used this kind of reversible electroporation, among many other things, to transport genetic material into stem cells. When exposed to higher voltages and longer pulse duration, however, the pores in the cell membrane remain open and cause the cell to initiate a programmed suicide, known as apoptosis.

The electroporator works with both unipolar and up to six bipolar electrodes. Proper placement largely determines how successful the ablation will be, especially with the bipolar electrodes, which must be spaced correctly in order to produce a spherical electrical field. Complicating things further is the fact that the conductivity of tissue varies from organ to organ.

The impact that irreversible electroporation has on blood vessels is still being researched. Studies show that they remain structurally intact, but it's not yet clear how much damage the blood vessels endure. A study published in 2007 in Technology in Cancer Research and Treatment found that the procedure killed a large proportion of vascular smooth muscle cells—cells that line the walls of blood vessels and cause them to contract—when directly applied to the carotid artery. But the study also found that the structures that connect these cells and form the basic architecture of the vessels remained intact.

(excerpted from ... http://www.spectrum.ieee.org/feb09/7687)

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