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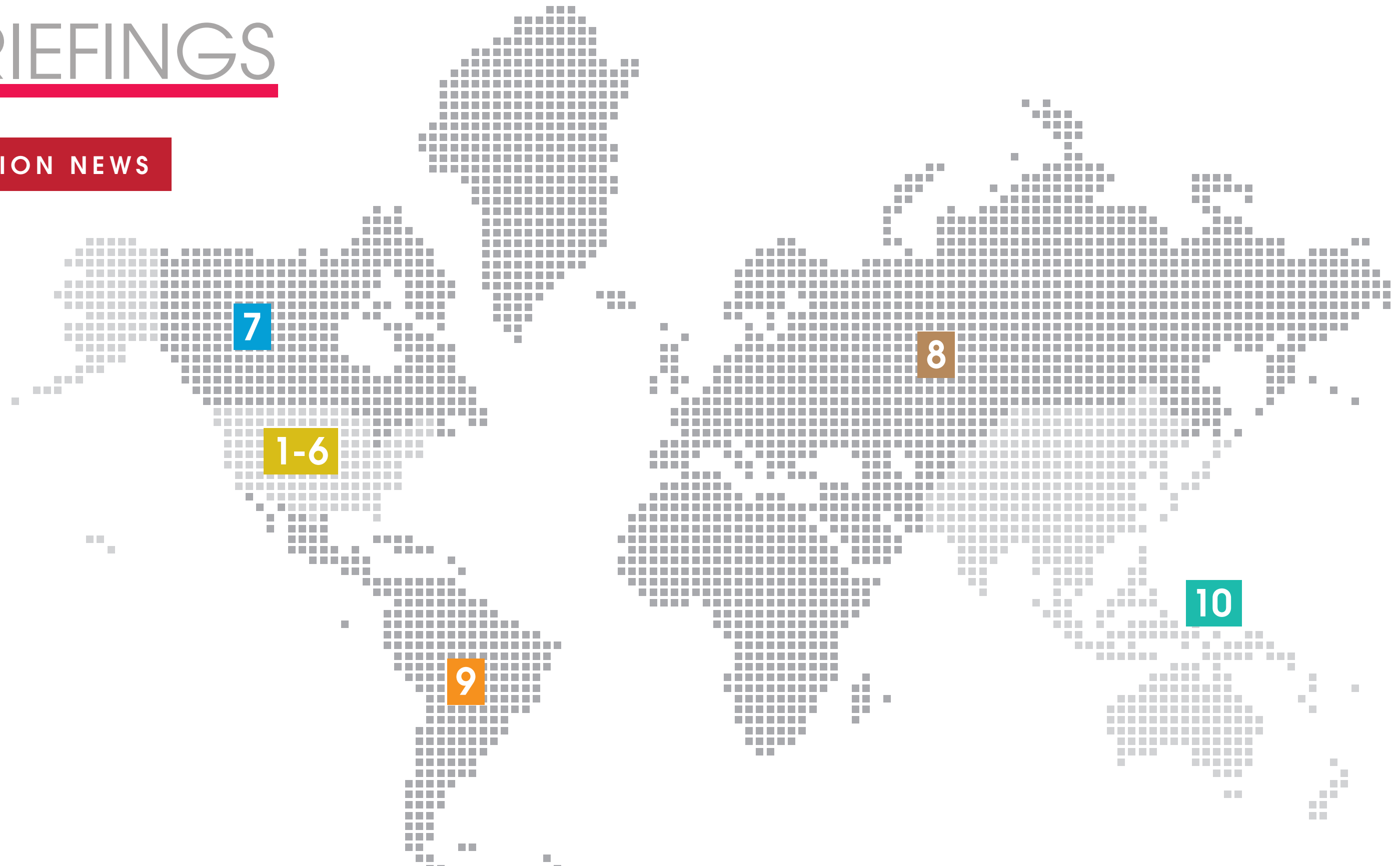
Nanotechnology

It's all around you

Members are leading the way in this growing field

IEEE

REGION NEWS



REGION 1 NORTHEASTERN UNITED STATES

■ **Long Island (N.Y.) Section** forms IEEE Photonics Society chapter.

■ Student branch formed at **Onondaga Community College, Syracuse, N.Y.**

REGION 6 WESTERN UNITED STATES

■ **Albuquerque Section** forms joint chapter of IEEE Power & Energy and IEEE Power Electronics societies.

■ **San Diego Section** forms Life Member affinity group.

REGION 7 CANADA

■ Student branch at **University of Ottawa** forms IEEE Photonics Society chapter.

REGION 8 EUROPE, MIDDLE EAST, AND AFRICA

■ Student branch formed at **Cambridge University.**

■ Student branch at **Universidade de Aveiro, Portugal,** forms Women in Engineering (WIE) affinity group.

■ Student branch formed at the **Polytechnic Institute of Leiria, Portugal.**

■ **United Arab Emirates Section** forms IEEE Microwave Theory and Techniques Society chapter.

REGION 9 LATIN AMERICA

■ **Argentina Section** forms IEEE Antennas and Propagation Society chapter.

■ **Bahia (Brazil) Section** forms IEEE Instrumentation and Measurement Society chapter.

■ **South Brazil Section** forms joint chapter of IEEE Circuits and Systems, IEEE Communications, and IEEE Instrumentation and Measurement societies.

■ Student branch formed at **Pontifical Catholic University of Rio de Janeiro.**

■ Student branch at the **University of Campinas, Brazil,** forms IEEE Computer Society chapter.

■ Student branch at **Universidad del Magdalena, Colombia,** forms IEEE Geoscience and Remote Sensing Society chapter.

■ Student branch at **Universidad Distrital Francisco José de Caldas, Bogotá,** forms IEEE Aerospace and Electronic Systems Society chapter.

■ Student branch at **Universidad Del Azuay, Cuenca, Ecuador,** forms WIE affinity group.

■ **Guadalajara (Mexico) Section** forms IEEE Computer Society chapter.

■ **Guanajuato (Mexico) Section** forms Graduates of the Last Decade affinity group.

■ **Nicaragua Section** forms IEEE Computer Society chapter.

■ **Peru Section** forms IEEE Antennas and Propagation Society chapter.

■ Student branch at **Universidad Ricardo Palma, Lima, Peru,** forms IEEE Industry Applications Society chapter.

■ Student branch at **Universidad Nacional Federico Villarreal, Lima,** forms IEEE Robotics and Automation Society chapter.

■ **Trinidad and Tobago Section** forms WIE affinity group.

■ **Uruguay Section** forms IEEE Broadcast Technology Society chapter.

REGION 10 ASIA AND PACIFIC

■ **Nanjing (China) Section** forms IEEE Microwave Theory and Techniques Society chapter.

■ Student branch formed at **Nanjing University of Aeronautics and Astronautics, China.**

■ Student branch at **Beijing Jiaotong University** forms IEEE Power & Energy Society chapter.

■ Student branch at **Hefei University of Technology, China,** forms IEEE Power Electronics Society chapter.

■ **Kerala (India) Section** forms IEEE Society on Social Implications of Technology chapter.

■ **Uttar Pradesh (India) Section** forms IEEE Computational Intelligence Society chapter.

■ Student branch at **Amrita Vishwa Vidyapeetham, Amritapuri, India,** forms IEEE Communications Society chapter.

■ Student branches formed in India at **Caymets Siddhant College of Engineering, Dr. Ambedkar Institute of Technology, Echelon Institute of Technology, Muslim Association College of Engineering, Selvam College of Technology,** and **VELS University.**

■ Student branch at **Federal Institute of Science and Technology, Angamaly, India,** forms IEEE Robotics and Automation Society chapter.

■ Student branch at **Jeppiaar Engineering College, Chennai, India,** forms IEEE Computer Society chapter.

■ Student branch at **KMEA Engineering College, Kochi, India,** forms IEEE Robotics and Automation Society chapter and WIE affinity group.

■ Student branch at **Pandit Deendayal Petroleum University, Gandhinagar, India,** forms IEEE Industry Applications Society chapter.

■ **Indonesia Section** forms IEEE Solid-State Circuits Society chapter.

■ Student branch formed at **Namal College, Punjab, Pakistan.**

■ Student branch at **Sri Lanka Institute of Information Technology, Malabe,** forms WIE affinity group.

■ **Thailand Section** forms IEEE Robotics and Automation Society chapter.

SEND US YOUR NEWS The Institute *publishes announcements of new groups once they've been approved by IEEE Member and Geographic Activities. To send us local news, like student branch events and competitions, WIE or preuniversity outreach efforts, or other IEEE group activities, use our form on the Region News page at http://theinstitute.ieee.org/region-news.*

CALENDAR

December

8 1993: The U.S. secretary of defense announces that the **Global Positioning System** is complete [top]. Later known as GPS, the satellite navigation system was accurate to within 100 meters.

9 1960: Sperry Rand Corp. unveils the **Univac 1107**, the first electronic computer to use thin-film memory.

14 1988: **TAT-8**, the world's first transatlantic system to use fiber optics [like the ones pictured above] begins service between Europe and North America.

17 1903: The **first manned, powered flight of a heavier-than-air airplane** takes place when Orville and Wilbur Wright test their machine near Kitty Hawk, N.C.

22 1968: Astronauts aboard NASA's *Apollo 8* spacecraft transmit the **first live telecast from outer space**.

January

1 1939: **Hewlett-Packard** is founded by IEEE Fellows Bill Hewlett and David Packard [above, left to right].

6 1838: In what would become an IEEE Milestone, Samuel Morse and Alfred Vail conduct the first public demonstration of their **telegraph system**, in Morristown, N.J.

13 1976: Raymond Kurzweil announces the **Kurzweil Reading Machine**, the first print-to-speech reading device for the blind.

15 2001: **Wikipedia** is launched. Supported by the Wikimedia Foundation and private donations, the free online encyclopedia now has more than 30 million articles in almost 300 languages.

19 1904: Thomas Edison receives a patent for an **electric automobile**.

February

10 1883: Birth date of computer pioneer **Edith Clarke**, the first woman to earn a degree in electrical engineering from MIT and the first female Fellow of the AIEE.

16 1884: Birth date of Alfred C. Gilbert, inventor of the **Erector Set** [below], a metal construction toy.

21 1858: Edwin T. Holmes installs the **first electromagnetic burglar alarm in the United States**, in Boston.

21–23 Region 2 Meeting in Galloway, N.J.

Historical events provided by the IEEE History Center. IEEE events indicated in red.

CLOCKWISE FROM TOP: NASA; JON BRENNEIS/TIME & LIFE PICTURES/GETTY IMAGES; AT&T; VECCHIO/THREE LIONS/GETTY IMAGES

NEWS

IEEE to Launch Eight Journals

EIGHT NEW publications are scheduled to debut in 2014.

IEEE Cloud Computing Magazine, a quarterly, will explore theories and applications related to the cloud, including software, security, standards, backup and recovery of data, interoperability, and energy consumption.

Another quarterly, *IEEE Transactions on Computational Social Systems*, will focus on such topics as modeling, simulation, analysis, and understanding of social systems from a quantitative and computational perspective.

The editors of the new quarterly *IEEE Transactions on Control of Network Systems* plan to publish research on the intersection of control systems and network science. The journal will address analysis, design, and implementation.

IEEE has partnered with the Chinese Association of Automation to publish the quarterly *Journal of Automatica Sinica*. It will cover topics related to control science and engineering, including automatic control, systems theory, pattern recognition, and intelligent systems.

The *IEEE Internet of Things Journal*, to be published six times a year, will tackle system architecture, networking protocols, services, and applications, as well the social implications of the IoT.

Articles in the quarterly *IEEE Power Electronics Magazine* will explore the effective use of electronic components, circuit design techniques, and analytical tools.

The *IEEE Transactions on Network Science and Engineering*, to be published twice a year, plans to address the theory and applications of network science and the interconnections among the elements in systems that form networks.

And look for the monthly open-access *IEEE Journal on Exploratory Solid-State Computational Devices and Circuits* to feature multidisciplinary research in solid-state materials and circuits beyond standard CMOS technology for novel energy-efficient computation.

The new journals will be available in the IEEE Xplore Digital Library.

—Amanda Davis

Member Benefits Roundup

IEEE HAS ROLLED out several benefits this year. They include:

- **IEEE MentorCentre**, a Web-based program that helps members in need of career guidance find mentors, based on such criteria as technical expertise and languages spoken.
- ***IEEE Access***, an open-access online megajournal that covers a range of disciplines, rather than a single field or topic.
- **GoogleApps@IEEE** gives members access to a range of features including Google's file-storage platform and social network.
- **Rosetta Stone** language-learning software, available at a discount.

- **Clements Worldwide** life insurance for members in IEEE Regions 8, 9, and 10.
- **IEEE Vacation Center** offers discounted vacation packages, including cruises and walking tours.
- **IEEE eLearning Library**, an online collection of short courses and workshops presented at IEEE conferences, will be adding about 60 courses next year.

To learn more or to renew your IEEE membership, visit http://www.ieee.org/membership_services/membership/renew.

—A.D.

CORRECTION

"Subtle Signals Could Help Forecast Earthquakes" [September, p. 7] incorrectly stated the date and location of an earthquake in New Zealand. It occurred on 4 September 2010 and struck about 40 kilometers west of Christchurch, close to the town of Darfield.

Online

Available 6 December at theinstitute.ieee.org

CAREER GUIDANCE
Find out how to break into the field of nanotechnology.

NANO GAME
Design strategies to destroy cancerous tumors using nanoparticles.

ISTOCKPHOTO

Big Applications for a Small Technology

Nanotechnology—1 nano, or nanometer, is one billionth of a meter—is sometimes referred to as a general-purpose technology because it's used in so many applications, including medicine and the automobile, cosmetics, and electronics industries. It's a multidisciplinary science that looks at how matter can be manipulated at the molecular and atomic levels to make things cheaper, cleaner, safer, stronger, or smarter.

You might be surprised to learn how many ordinary items already contain nanoparticles, such as food containers, toothpaste, and waterproof clothing [p. 8].

This special issue of The Institute *has been put together with assistance from the IEEE Nanotechnology Council [p. 14], which coordinates and advances IEEE's work in the area. You can see its handiwork in several featured products, standards, and conferences presented in the issue.*

The issue also highlights several projects that make use of nanomaterials, including one method for purifying water by filtering out salt and another that removes bacteria from water [this page].

"Sniffing for Cancer" [p. 7], describes how IEEE Member A.T. Charlie Johnson will help doctors detect skin cancer using an electronic "nose" he developed that employs nanosensors.

Also profiled in this issue is IEEE Member Alexandra Boltasseva [p. 16], whose work in nanophotonics—light manipulation at the nanoscale level—earned her two Young Investigator awards this year, from the IEEE Photonics Society and the Materials Research Society.

TECH TOPIC

Cleaner Water

Members are working on ways to make water potable BY **KATHY PRETZ**

ABOUT 1 OF every 6 people around the world has no adequate access to water, and more than twice that number lack basic sanitation, for which water is essential, according to the U.S. National Academy of Engineering. One of the Grand Challenges for Engineering set forth by the academy aims to develop technology that will make polluted water potable.

It's not that the world doesn't have enough water. Globally, water is abundant, but most of it is in the oceans, where it's unsuitable for drinking without expensive desalination.

Another problem for some developing countries is that contaminated drinking water contains bacteria and other pollutants. The application of nanotechnology to purify water is the focus of many papers presented at IEEE conferences and published in the IEEE Xplore Digital Library. Two are described here.

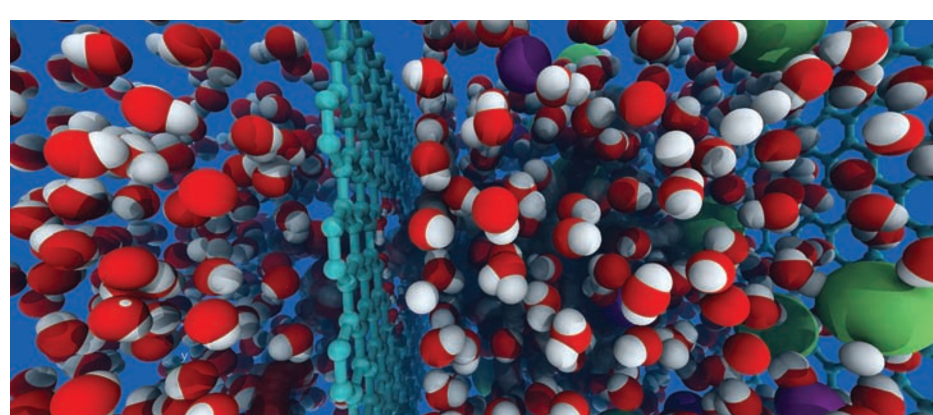
Jeffrey C. Grossman, MIT associate professor of power engineering, and his graduate students David Cohen-Tanugi and Shreya Dave are developing a filtration material made of a sheet of nanoporous graphene. The holes in the graphene—a one-atom-thick form of carbon—are small enough to block salt ions while letting water molecules through. *Smithsonian* magazine called this nanoporous form of carbon one of the top five surprising scientific milestones of 2012.

Cohen-Tanugi presented their paper, "Water Desalination Across Nanoporous Graphene," at the IEEE Conference on Technology for Sustainability, held in August, in Portland, Ore.

"It's essentially a single layer of carbon atoms shaped like a honeycomb," he explains. "Produced with holes in it, graphene is a much thinner, more porous, and efficient membrane than the polymers generally used for filtering water. It's extremely strong and has very interesting physical properties, but it is only now being looked at for water applications."

The most efficient process today for desalination is reverse osmosis, which relies on semipermeable membranes to filter salt from water. But such systems demand high pressure to force water through the membranes, which are about a thousand times thicker than ones made of graphene. The process remains very energy-intensive and expensive, notes Cohen-Tanugi.

As an example, he points to a reverse-osmosis desalination plant providing fresh water in Almeria province, in southeastern Spain, that consumes about one-third of all the electric power in the region.



DAVID COHEN-TANUGI

When water molecules [red and white] and sodium and chlorine ions [green and purple] in saltwater encounter a sheet of graphene with holes of the right size [center], the water passes through from right to left, but the sodium and chlorine from the salt are blocked.

"That's a lot of energy," Cohen-Tanugi says. "And these are expensive plants to build, typically costing hundreds of millions of dollars, a price most developing countries can't afford. Also, the water ends up being too expensive for agriculture. It is suitable for drinking or high-value manufacturing, but you wouldn't dream of using it to irrigate a field.

"How the physical properties of graphene translate into a more energy-efficient process and cheaper water is still an open question," he continues. "Some assume that if you have a material like graphene that is 500 times more permeable, then you can reduce your energy costs by a factor of 500, but that's not correct and has been misinterpreted. But if we can, with nanotechnology, make the desalination process more efficient, affordable, and available to more people, we will have made a big contribution."

BACTERIA BE GONE

Developing cheaper water-treatment processes to remove pathogens from water supplies would be a huge step in reducing the number of deaths caused by drinking contaminated water. According to the NAE, nearly 5000 children worldwide die each day from diarrhea-related diseases.

IEEE Senior Member Jin-Woo Kim and his colleagues at the University of Arkansas, in Fayetteville, and the University of Arkansas for Medical Sciences, in Little Rock, say that using carbon nanotubes might be a lifesaver. Their paper, "Highly Effective Bacterial Removal System Using Carbon Nanotube Clusters," was presented at the 2009 IEEE International Conference on Nano/Micro Engineered and Molecular Systems.

What's more, the same process could be used

Jin-Woo Kim's system uses a magnet and clusters of multiwalled carbon nanotubes. The clusters capture bacteria such as E. coli, and as illustrated above, the rare earth element neodymium magnet attracts the nanotubes.

AMERICAN CHEMICAL SOCIETY

for other applications including sampling water for an environmental quality-control program, disinfecting medical instruments, and purifying human skin being used for skin grafts. Kim currently is exploring how to commercialize the system.

Conventional purification methods include chlorination, filtration, UV radiation, and the infusion of water with ozone gas. Those methods aren't that cheap, nor are they always practical for developing countries.

A professor of biological and agricultural engineering, Kim says his process is less expensive than the other methods because bacteria such as E. coli can be captured and killed on-site and the carbon nanotubes can be reused later, cutting down on the cost of materials.

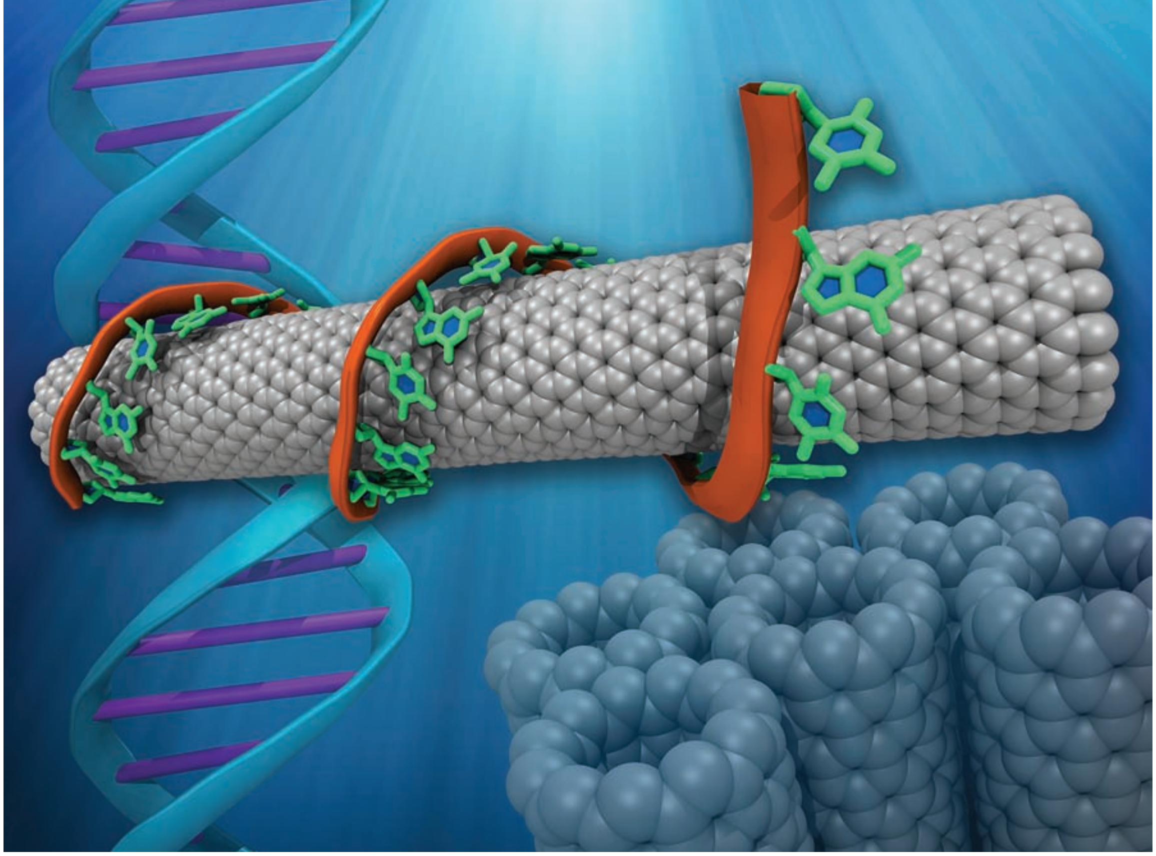
The carbon nanotubes, just nanometers wide, are essentially smooth pipes of water-repelling graphite. At the same time, they attract bacteria.

The researchers tested an approach using clusters of nanotubes in a vial of water to remove waterborne bacteria, which included both the gram-positive and gram-negative bacterial strains. Gram-positive bacteria are those that are stained dark blue or violet by gram staining. This is in contrast to gram-negative bacteria, which cannot retain the crystal violet stain, instead taking up the counterstain, appearing as red or pink. These two types were chosen because the properties of their surfaces could affect the interaction between the bacteria and the nanotubes.

The system consisted of large clusters of multiwalled carbon nanotubes (MWNTs) for capturing the bacteria and a magnet for attracting the nanotubes. The contaminated water is placed in the vial along with the MWNTs.

The magnet, a cube 2.54 centimeters on a side made of the rare earth element neodymium, was placed close to the vial's outer wall [see photo]. In less than five minutes, the MWNT clusters were completely separated from the bulk solution. No MWNT debris or bacteria were found in the residual water.

"The results clearly demonstrate the excellent potential of MWNT clusters as highly effective bacterial adsorbents of any type of bacteria," says Kim.



Researchers have developed a nanosensor [center] composed of a single strand of DNA attached to a carbon nanotube that can detect the odor of cancerous human skin cells.

TECH TOPIC

Sniffing for Cancer

Nanosensors can detect odors from melanoma

BY MONICA ROZENFELD

MELANOMA, the deadliest form of skin cancer, often causes subtle changes to the skin, such as discoloration or slightly enlarged moles. The usual detection method, a visual inspection of the skin, can overlook such signs. Instead of just looking for skin cancer, however, it might be better to sniff for it.

IEEE Member A.T. Charlie Johnson, a physics professor at the University of Pennsylvania, in Philadelphia, and his team have developed a DNA-coated nanosensor that can sense the odor from human skin cells that have turned cancerous. The team's so-called electronic nose is expected to reach clinical settings within the next two years. As with most cancers, the survival rate for melanoma depends on how early it is detected. According to the World Health Organization, more than 65 000 people die each year from the disease.

With collaborators at the Monell Center, a research laboratory in Philadelphia focused on the senses of smell and taste, Johnson's team was able to identify dimethyl sulfone, a volatile organic compound (VOC) specific to melanoma. The compound cannot be perceived by the human olfactory system.

"Our bodies make this compound, but we can't smell it," Johnson says. "In contrast, the sensor system we've developed using carbon nanotubes can detect dimethyl sulfone from melanoma down to concentrations of a few parts per billion."

ANIMAL SYSTEM

A growing body of research finds that odor can be used to detect several types of diseases, Johnson notes. The spur to such research has been the canine olfactory system, including well-documented research on dogs' ability to sense odor associated with lung cancer, he says.

Some breeds have a sense of smell estimated to be at least a million times more sensitive than that of humans. No wonder. The human nose has approximately 5 million scent receptors; a bloodhound's has about 300 million.

Dog biology provided the blueprint for designing the electronic olfactory system, according to Johnson. His team's e-nose aims to replicate a dog's sense of smell with thousands of odor-detecting receptors built into the sensor. The receptors are made with single-strand DNA oligomers, or molecular complexes, coated onto a large array of carbon nanotube transistors. These transistors are then placed inside an instrument that captures the vapor released by skin, Johnson says. The vapor interacts with the DNA strands, leading to changes in the electrical characteristics of the nanotube transistors that can be used to identify a number of VOCs, not just dimethyl sulfone.

The e-nose aims to replicate a dog's sense of smell. This dog is being trained at the Penn Vet Working Dog Center, in Philadelphia, to sniff out the signature compound that indicates the presence of cancer.

The array output will contain information from the thousands of different DNA-based receptors, which will then be combined in a manner similar to how the olfactory cortex in the brain processes messages from the olfactory receptor neurons. In a real-world application, the device could draw vapor from a lesion on the skin suspected of being melanoma. Eventually, it might also be possible to detect cancer by sniffing the VOCs in a patient's blood, saliva, or urine, according to Johnson.

Adamant Technologies, a San Francisco company that produces chemical sensors for a range of medical applications, is working to bring the e-nose developed by Johnson's team to clinical settings.

It's important that the rate of false positives—a positive diagnosis of a patient who is free of disease—be very low, Johnson explains. "That's one of the difficulties of taking a new type of screening method to a mass scale," he says. "False results could cause more harm than good."

PERSONALIZED MEDICINE

With the new nanosensor, not only might it be possible to more easily detect early stage melanoma, but the cancer's progress or decline might also be monitored, and that information could affect how the disease is treated.

"Physicians won't just have one piece of information about the skin cancer but ideally several pieces of information from a compound that will provide a much more personalized look at treatment options," Johnson says.

Results from the screenings could lead to cancer therapies specific to individual patients, he says, adding: "Working with scientists in the biomedical field, learning from them, and helping them to understand the potential of nano-enabled devices is going to let our team do many things in the area of diagnosis of disease that we couldn't do before."

TOP: ROBERT R. JOHNSON; BOTTOM: MATT ROURKE/AP PHOTO

TECH TOPIC

Everyday Nanotechnology

Nanoparticles are found in many household products BY AMANDA DAVIS

IT HELPS KEEP YOUR FOOD fresher, your skin moisturized, your clothing stain-free, and your tennis balls bouncy. Nanotechnology is a relatively new science, and many consumers aren't aware that its applications can be found in many everyday items. According to Nano.gov, more than 800 commercial products incorporate nanomaterials. Here are just a few examples.

FRESHER, SAFER FOOD

It's likely that nanotechnology has protected you from food poisoning. For two decades, scientists have been working on ways to keep food fresh and safe for longer periods of time. Warding off foodborne pathogens is key. To that end, food manufacturers around the world are using plastic packaging made with polymer-based nanomaterials that can detect and in some cases eliminate salmonella, pesticides, and other contaminants found in meat and other foods before they hit store shelves.

The plastic storage bins used to transport food are often lined with silver nanoparticles that kill bacteria from the previously stored food. And some types of packaging contain nanoparticles that keep oxygen out so the food doesn't spoil as quickly.

Researchers at the Technical University of Munich recently developed a liquid mixed with carbon nanotube–based sensors that can be sprayed onto plastic packaging. The tiny sensors detect spoiled food based on small changes in the concentrations of gases it gives off, including ammonia, carbon dioxide, and nitrogen oxide. When the sensors are developed for sale, they will be linked to a wireless device that will alert store employees to discard the spoiled food, the researchers say.

Nanotechnology can also help keep carbonated beverages from going flat. Nanocomposites are embedded in plastic bottles to minimize carbon-dioxide leakage, extending the drinks' shelf life.

TOOTHPASTE AND COSMETICS

Nanotechnology has entered the world of dental care as well. Some brands of toothpaste contain nanoparticles of the calcium-based mineral found in bones to fill in microscopic cracks in dental enamel and help keep teeth cavity-free. And because silver atoms can slow down or eliminate the growth of bacteria, some toothpaste is made with silver nanoparticles to battle tooth decay.

Nanotechnology also abounds in pharmacies. According to the Centre for the Study of Environmental Change at Lancaster University, in England, the cosmetics industry holds the most patents for nanoparticles worldwide.

Several antiaging lotions and creams employ nanotechnology. Cosmetics giant L'Oréal, for example, says it has developed a polymeric nanocapsule that delivers active ingredients deep into layers of skin. L'Oréal and other manufacturers also use nanoparticles of titanium dioxide and zinc oxide to create vivid and metallic shades of lipstick and eye shadow. Similar nanoparticles are used in several brands of sunscreen.

RESILIENT FABRIC

The next time you spill red wine onto a stain-resistant carpet, you can thank nanotechnology for helping you avoid a permanent splotch. Carpets and clothing with stain-resistant finishes are made with nanotextiles that prevent the absorption of liquids. Coffee, wine, and other substances that might otherwise leave a permanent stain instead bead up so they can be wiped away.

Waterproof clothing is another example of nanotech's reach. Schoeller Technologies of Sevelen, Switzerland, has found a way to combine nano and nature to mimic the way plant leaves shed water.

Lotus leaves, for example, have a rough surface composed of tiny waxy spikes that cause moisture to bead up and slide off. Schoeller has developed a fabric treatment called NanoSphere that adds nanoparticles to the fabric surface, allowing clothing to shed water like a lotus leaf. Garments treated with NanoSphere have an uneven texture that leaves less surface area available for water absorption.

COMPETITIVE EDGE

Advances in nanotechnology have made sports equipment stronger, lighter, and more durable.

Tennis and badminton rackets are made with carbon nanotubes, which make them lighter and more powerful. Certain classes of nanomaterials have contributed to lighter golf clubs by lowering their centers of gravity, which can help golfers swing with more accuracy and propel the ball farther. Graphene oxide and "buckypaper" (sheets of carbon nanotubes) are incorporated into canoes and racing boats to improve their glide through water while making them stronger and lighter. And ultrahard nanoceramics are used to sharpen the edges of ice skates.

Nanomaterials can also make sports equipment last longer. Footballs and tennis balls are made with nanoclay to withstand impact and increase bounce. Fullerenes, a type of nanomaterial that helps prevent chipping and cracking, can be found on bowling balls and kayaks. And carbon nanoparticles are used in race-car tires to decrease rolling resistance and extend their useful life.

ISTOCKPHOTO (7)

OPINIONS

QUESTION OF THE MONTH

Are Nanotech Products Safe?

As part of the recipe for many everyday items, including toothpaste, cosmetics, and baked goods, nanomaterials are found in an incredible number of products [see p. 8]. Global revenue from their sales could reach US $2.8 trillion next year, according to a report by Charles R. McConachie, a consumer and health-care lawyer in Dallas.

The report cites concerns about environmental, health, and safety risks from such products, as well as their potential to add toxicity to water systems and landfills when discarded. A lot of money is being invested in nanotech research, but the report suggests not enough is being spent to regulate the products' safety before they reach the marketplace or to develop policies for disposing of them properly.

Do you feel comfortable using products made with nanomaterials?

Respond to this question by commenting online at http://theinstitute.ieee.org/opinions/question. A selection of responses will appear in the March issue of The Institute *and may be edited for space. Suggestions for questions can be sent to institute@ieee.org.*

RESPONSES TO "ASK THE EXPERT"

Rescue Robots and the Smart Grid

In an IEEE Roundup blog published online in September, we asked readers to submit questions to two IEEE experts—one a leader in rescue robots, the other in the smart grid—about how those technologies perform during natural disasters. Here are excerpts from their responses.

IEEE FELLOW ROBIN MURPHY

A pioneer in the field of rescue robots and human-robot interaction; director of Texas A&M University's Center for Robot-Assisted Search and Rescue, in College Station

Rescue robots can go where humans cannot. Can you tell us more about how they have been used?

Rescue robots have been deployed in more than 30 disasters worldwide since we first used them in 2001 after the attack on the World Trade Center. Most have been used to move through ruins of collapsed buildings and bridges to search for survivors. The robots that go into the rubble usually look like miniature tanks but are only about the size of a shoebox and have treads instead of wheels, for better traction.

As robots become more commonplace, they will be moved on-site more quickly to provide information to first responders as to whether the site is safe to enter. We are working with medical specialists in Texas on how they can use robots to help attend to injuries and communicate with trapped survivors. Other work has explored how robots can remove rubble.

IEEE MEMBER STEVE COLLIER

A leading technical expert on the smart grid; vice president of business development at Milsoft Utility Solutions, in Abilene, Texas

Much has been said about the benefits of the smart grid, but what are some of its pitfalls? Will it really solve the problem of power outages during an emergency? If so, why isn't it adopted in more parts of the world?

A smarter grid is not a cure-all, and power outages will still occur. A modern, intelligent grid can not only substantially reduce the likelihood of prolonged outages affecting large numbers of people, but it can also ensure a more rapid and orderly restoration of service. Through better monitoring and control, as well as distributed generation and storage, it will be able to anticipate, withstand, and recover from natural and man-made disasters and equipment failures.

There are indeed significant challenges, centered around such things as increased reliance on digital telecommunications, software applications, and information networks that increase exposure to cybersecurity threats. There is also a lack of interoperability among vendors.

The new hardware and software systems are expensive and can be complex to deploy and use. There will also be dramatic growth in consumer-owned generation and storage. All of these factors make it difficult to realize the full benefits of grid intelligence and control.

For more Q&A with our experts, visit http://theinstitute.ieee.org/askexpert0913.

CLOCKWISE FROM LEFT: WILSON CENTER'S PROJECT ON EMERGING TECHNOLOGIES; TEXAS A&M UNIVERSITY; STEVE COLLIER

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PRESIDENT'S COLUMN

No, Feynman Wasn't Joking

Our world, our knowledge, our responsibility

RICHARD FEYNMAN, the famous American theoretical physicist, said in a 1955 address to the U.S. National Academy of Sciences, "Scientific knowledge is an enabling power to do either good or bad—but it does not carry instructions on how to use it."

Markers of technology progress for over 60 years have shown exponential growth. This makes the responsible use of technology all the more important. There are countless instances in information and communications technology—the hacking of wireless medical devices being a perfect example—where the deficiencies of these advances are being exposed.

I believe that the IEEE community is uniquely qualified and positioned to aid in addressing these issues—and that two strategic priorities identified earlier this year by the IEEE Board of Directors can provide principles to guide us.

The first priority is to provide agile forums for discussion, development, and implementation of emerging technologies. The second priority is to call on the IEEE community to use its technology-related insight to provide society with innovative, practical guidance on technical issues. Together, they suggest a framework for assessing emerging technologies and the issues they raise and for responsibly communicating their positive and negative impacts.

You, as an IEEE member, can help write the instructions Professor Feynman said we lack. It is likely that you are already involved within your local section or with one or more societies or an IEEE affinity group. If so, your participation probably stemmed from your vocational interests and passion for technology. These communities are for you—make the most of them. But don't just discuss what's happening now. Discuss what might happen next.

Examine the technologies in your areas of interest that are emerging and/or converging. Form or join an agile forum and, with other members, foster the continued evolution of those technologies. Come together formally or informally, share your insights and ideas with colleagues within the global IEEE community, and map out the responsibilities and actions for those who take part in your agile forum. This "road-mapping" activity is the first step, I believe, in creating the professor's instructions.

As the population of our planet grows, however, emerging/converging technologies will—as they are developed and implemented—raise questions of responsibility and ethics. Answers to those questions, in turn, will shape guidelines and policies that define a second step in creating Feynman's instructions.

These two steps define our charge to make others aware of how best to evolve a "planet-friendly" technology path. As technologists, it is our responsibility to employ our expertise and assist others in making the decisions that will positively affect our lives—and the lives of future generations.

As I said earlier, IEEE is both well qualified and well positioned to engage in these efforts. We must remain impartial, however, relying on the sound fundamentals of our respective professional pursuits.

Leaders of the public, private, and academic worlds often hear competing voices shouting instructions about the choices to be made regarding a particular technology. Each voice carries its own views, shaped by its stake in the outcome. It is incumbent on all within the IEEE community to ensure that our voice, based on thoughtful consideration of the technical facts, remains clear and unbiased; only then will it stand out.

Scientific knowledge brings with it power, as Richard Feynman pointed out—which makes IEEE's global community quite formidable, indeed. Right now, in more than 160 countries, IEEE members are working on initiatives that may one day change the way in which human beings interact with one another and the world around them. For me it is a source of great pride and great humility to realize that our efforts today will help create a better tomorrow.

I do not have answers to all the questions that will accompany promising new technologies. I do not believe that any individual does. I do believe, though, that by working together and exchanging ideas, insights, and perspectives, we will find those answers.

Please feel free to share your comments and thoughts with me at president@ieee.org or through my blog at http://sites.ieee.org/pstaecker.

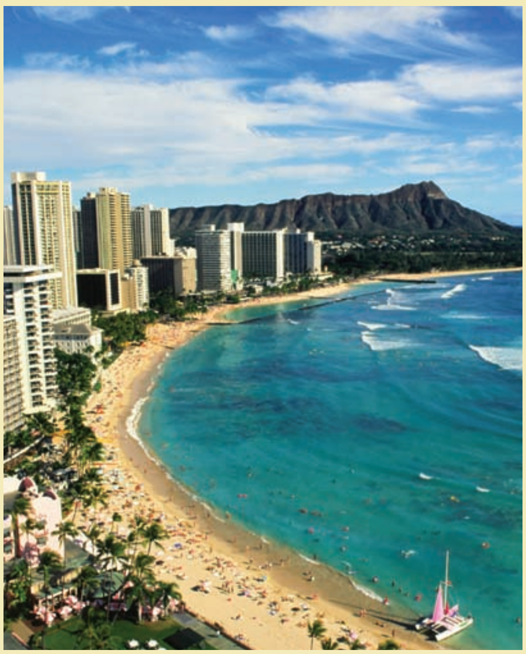
Peter Staecker
2013 IEEE President and CEO

BENEFITS

NANOTECHNOLOGY

CONFERENCES: FEBRUARY–AUGUST 2014

Upcoming IEEE events cover topics related to nanotechnology



IEEE International Conference on Nano/Micro Engineered and Molecular Systems

HONOLULU; 13–16 APRIL

TOPICS: Nanophotonics, nanomaterials, nanofabrication, nanobiology, labs-on-chips, micro- and nanosensors, carbon nanotube and graphene devices, molecular heat transfer and energy conversion, microrobotics, integration and application of microelectromechanical systems, flexible sensors and printed electronics, and nanotechnology safety and education.

SPONSOR: IEEE Nanotechnology Council
VISIT: http://www.ieee-nems.org/2014

IEEE Sensors Applications Symposium

QUEENSTOWN, NEW ZEALAND; 18–20 FEBRUARY

TOPICS: Microelectromechanical systems; nanosensors; virtual, optical, chemical, and smart sensors; sensor arrays and networks; and sensor applications in homeland security, agriculture, health management, monitoring, robotics and automation, and remote sensing.
SPONSOR: IEEE Instrumentation and Measurement Society
VISIT: http://sensorapps.org

IEEE Workshop on Microelectronics and Electron Devices

BOISE, IDAHO; 18 APRIL

TOPICS: Processing, integration, and reliability testing for micro- and nanoelectronic devices; semiconductor package characterization, including signal integrity and reliability; and microelectromechanical systems.
SPONSORS: IEEE Electron Devices Society and IEEE Boise Section
VISIT: http://www.ewh.ieee.org/r6/boise/wmed2014/WMED2014.html

International Conference on Electron, Ion, and Photon Beam Technology and Nanofabrication

WASHINGTON, D.C.; 27–30 MAY

TOPICS: Atomic and molecular manipulation, electron and ion-beam lithography, imaging methods, nanopatterning, soft lithography and embossing, extreme ultraviolet lithography, and nanoelectronics.
SPONSORS: IEEE Electron Devices Society, American Vacuum Society, and Optical Society of America
VISIT: http://eipbn.org

International Conference on Optical MEMS and Nanophotonics

GLASGOW; 17–21 AUGUST

TOPICS: Advances in microelectromechanical systems (MEMS)and nanophotonics, applications for micro-optical and nanophotonic devices and systems, and materials and processing technologies related to optical MEMS and nanophotonics.
SPONSOR: IEEE Photonics Society
VISIT: http://www.omn2014.org

IEEE International Conference on Nanotechnology

TORONTO; 18–21 AUGUST

TOPICS: Processes and components, including electronics, fabrication, robotics, metrology, circuits, sensors, actuators, photonics, communications, manufacturing materials, biomedicine, magnetics, fluidics, and networking.
SPONSOR: IEEE Nanotechnology Council
VISIT: http://ieeenano2014.org

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IEEE (2)

PRODUCTS AND SERVICES

Resources for a Tiny Technology

A website and several IEEE journals help demystify nanotech BY KATHY PRETZ

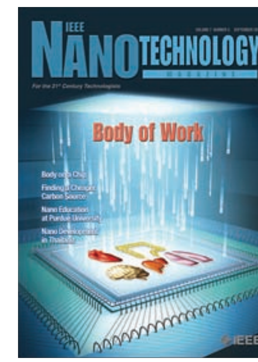
A NUMBER OF IEEE offerings not only explain the basics of nanotechnology but also cover the latest advances in the field.

If you're looking for a primer, check out TryNano.org, a four-year-old website developed by the IEEE Nanotechnology Council and IEEE Educational Activities. Launched in conjunction with IBM and the New York Hall of Science, it's aimed at students, parents, teachers, school counselors, and anyone else wishing to get up to speed on the subject. The site provides a nanotechnology overview that spells out the related scientific disciplines. It also describes how the field evolved and where it's headed, as well as its implications for society. The site includes a glossary of more than 60 terms.

The downloadable lesson plans for preuniversity teachers on this site feature hands-on activities that explain just how small the nanoscale is. Each lesson provides background information, a list of materials needed, step-by-step instructions, and student worksheets.

For students wishing to pursue a degree, the site lists universities offering nanotechnology programs, including schools in Australia, Canada, India, Spain, Thailand, the United Kingdom, and the United States.

And to get an idea of what it's like to work in the field, there are interviews with nearly 30 leading experts as well as a list of organizations, like Drexel University, IBM Research, and the Industrial Technology Research Institute in Taiwan, that are, as noted on the website, at the forefront of nanoscale work.



PUBLICATIONS

IEEE Transactions on Nanotechnology publishes novel and important results in nanoscale engineering. Covering the physical basis and engineering applications of nanotech across all areas of science and engineering, the journal focuses on nanoscale devices, systems, materials, and applications and on their underlying science.

IEEE Transactions on NanoBioscience reports on original, innovative, and interdisciplinary work on molecular and cellular systems and tissues, including molecular electronics. Journal papers deal with engineering, physics, chemistry, and computer science, as well as biology and medicine.

IEEE Nanotechnology Magazine publishes articles aimed at a broad audience. It covers industry news, research, education, and policy, and it includes tutorials, surveys, opinion pieces, book reviews, and patent summaries.

A number of IEEE nanotechnology e-newsletters provide information on funding opportunities, events, developments in nanomaterials, nanoprocessing techniques, and nanotechnology products and applications.

For more information about the publications, visit the IEEE Xplore Digital Library.

IEEE GROUPS

IEEE Nanotechnology Council

This interdisciplinary group focuses on advancing the field BY KATHY PRETZ

THE IEEE Nanotechnology Council was formed more than a decade ago, and it has been nothing but busy ever since. After all, it was present at the creation of a nanotechnology industry that will top US $2.4 trillion by next year, according to the U.S. government's National Nanotechnology Initiative. The multidisciplinary council's purpose has been to coordinate and advance the work in nanotechnology being carried out throughout IEEE. It supports the theory, design, and development of nanotechnology and its scientific, engineering, and industrial applications.

An IEEE council usually has an interdisciplinary focus that spans multiple technical societies, and sometimes it is the precursor to the formation of a new society, but not in this case. Part of IEEE Division I–Circuits and Devices, the Nanotechnology Council's membership is comprised of representatives from its 21 sponsoring IEEE societies, including Aerospace and Electronic Systems; Components, Packaging, and Manufacturing Technology; Engineering in Medicine and Biology; Photonics; Systems, Man, and Cybernetics; and Ultrasonics, Ferroelectrics, and Frequency Control. Members join the council by first joining one of its member societies.

The council has 12 chapters around the world, including ones in Australia, China, Italy, Singapore, South Africa, and the United States. It also has two student chapters—one at the University of Texas, in Tyler, and another at Kuvempu University, in Shankaraghatta, India.

CONFERENCES

The council sponsors four annual conferences.

The IEEE International Conference on Nanotechnology (IEEE NANO) covers nanofabrication, nanomanufacturing, nanomaterials, nanobiomedicine, nanoenergy, nanoplasmonics, nanoelectronics, nanosensors and nanoactuators, and the characterization and modeling of structures and devices. The council's annual meeting takes place at IEEE NANO.

The IEEE Nanotechnology Materials and Devices Conference makes critical assessments of ongoing work and future directions in nanotechnology research, including nanomaterials and their fabrication, nanoelectronics, nanophotonics, devices, and integration.

The IEEE International Conference on Nano/Molecular Medicine and Engineering covers nano- and molecular technologies in medical diagnosis and therapy, drug delivery, biomedical imaging, biochips, cell mechanics, biological interfaces, and frontiers in nanobiotechnology.

The IEEE International Conference on Nano/Micro Engineered and Molecular Systems will bring together leading researchers to discuss topics dealing with microelectromechanical systems and nanotechnology.

See p. 12 for more upcoming conferences related to nanotech.

AWARDS

The council's awards program includes three annual prizes.

The Early Career Award in Nanotechnology goes to individuals whose contributions have had a major impact on nanotechnology within seven years after being granted their highest earned academic degree.

For those at least 10 years beyond their highest earned degree, there's the Pioneer Award in Nanotechnology. It recognizes those who, by virtue of initiating new areas of research, development, or engineering, have had a significant impact on nanotechnology.

And people who have performed outstanding service for the benefit and advancement of the council are recognized with the Distinguished Service Award. The service, which can be in such areas as conferences, meetings, and publications, is usually given to journal or magazine editors, administrative committee members, or chapter leaders.

For more information about the council, visit http://sites.ieee.org/nanotech.

STANDARDS

Nanotechnology Standards

Four focus on electrical applications of nanomaterials

BY MONICA ROZENFELD

THE IEEE NANOTECHNOLOGY Council has written four standards designed to help measure, report, test, and characterize nanomaterials for electrical and electronic products and systems.

IEEE 1650-2005
APPROVED DECEMBER 2005
The "Standard for Test Methods for Measurement of Electrical Properties of Carbon Nanotubes" recommends techniques and reporting practices for the electrical characterization of nanotubes. The standard was adopted in 2009 by the International Electrotechnical Commission as IEC/IEEE 62624.

IEEE 1620-2008
APPROVED SEPTEMBER 2008
The "Standard for Test Methods for the Characterization of Organic Transistors and Materials" defines a process for defining organic electronic devices, including measurement techniques, methods of reporting data, and test conditions. The standard was adopted this year by the IEC as IEC/IEEE 62860.

IEEE 1620.1-2006
APPROVED JUNE 2006
The "IEEE Standard for Test Methods for the Characterization of Organic Transistor-Based Ring Oscillators" recommends procedures and reporting practices for electrical classification of printed and organic oscillators. The standard was adopted this year by the IEC as IEC/IEEE 62860-1.

The following standard is under development in collaboration with IEC Technical Committee 113, a group that works on nanotechnology standardization for electrical and electronic products and systems. If approved by the IEEE Standards Association Standards Board, it will be released next year.

IEC/IEEE 62659
The "Standard for Large-Scale Manufacturing for Nanoelectronics" defines processes for incorporating nanomaterials in electronic products, enabling mass production of items such as nanostructured sensors and magnetic materials and devices.

For more information on these and other standards, visit https://standards.ieee.org.

ISTOCKPHOTO/LISE GAGNE

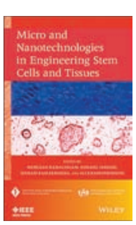
BOOKS OF INTEREST

Free E-Books Cover Nanotechnology Applications

HERE'S A SAMPLE of IEEE e-books that focus on nanotechnology. All are available free to members from the IEEE eBook Classics collection. To view the e-books, log in to IEEE Xplore using your IEEE member Web account. (Make sure to sign out of your institutional account first, if you're using one.) Click on Books in the left-hand navigation menu, then click on the Classics tab to browse the titles. Once you find a book you're interested in, click on the title to go to its home page, which has an abstract, a bibliography, the table of contents, and the cover image.

Micro and Nanotechnologies in Engineering Stem Cells and Tissue

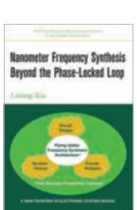
BY MURUGAN RAMALINGAM, ESMAIEL JABBARI, SEERAM RAMAKRISHNA, AND ALI KHADEMHOSSEINI (2013)



Covers the latest developments by top researchers in the field. Topics include advances in material systems, techniques for controlling stem-cell functions, technologies to engineer bone regeneration, and the application of stem cells in treating heart disease.

Nanometer Frequency Synthesis Beyond the Phase-Locked Loop

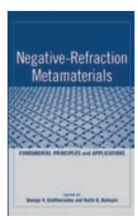
BY LIMING XIU (2012)



Introduces a novel way to look at frequency synthesis beyond the phase-locked loop, focusing on the clock signal in a time-based information-processing approach for nanochip design. Chapters cover the shortcomings of conventional techniques and present the concept of flying-adder frequency synthesis, a new technique for generating frequency. The book includes examples of using the concepts to build cheaper and faster systems.

Negative-Refraction Metamaterials: Fundamental Principles and Applications

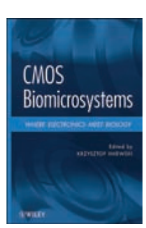
BY G.V. ELEFTHERIADES AND KEITH G. BALMAIN (2005)



Provides the fundamental principles and applications of artificial materials that support the electromagnetic property of negative refraction. Several classes of materials and their applications are presented, including lenses, antennas, and radar systems. One chapter is devoted to plasmonic nanowire metamaterials.

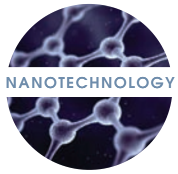
CMOS Biomicrosystems: Where Electronics Meet Biology

BY KRZYSZTOF INIEWSKI (2011)



Presents systems that integrate microelectronics with fluidics, photonics, and mechanics. Focuses on emerging applications of microelectronic integration for future technologies, including biomedical nanotechnologies. The book is geared toward electrical, mechanical, material science, micro, and nano engineers.

WILEY-IEEE PRESS (4)



PROFILE

Alexandra Boltasseva: A Rising Star

Creating new materials to manipulate light BY SUSAN KARLIN

AT THE NANOSCALE level, harnessing light is an exciting collision of worlds that combines theory-based experimentation with cutting-edge applications.

IEEE Member Alexandra Boltasseva's work in nanophotonics, or light manipulation at the nanoscale level, earned her two awards this year.

The IEEE Photonics Society honored Boltasseva in June with the 2013 Young Investigator Award, presented to an individual who has made outstanding technical contributions before his or her 35th birthday. In April, she received the Materials Research Society's 2013 Outstanding Young Investigator Award for pioneering research in advanced plasmonic, metamaterial, and optics devices. The awards came with a total prize of US $6000.

In college,"I had wanted to study elementary particle physics, like the Higgs boson, but then I realized that everything is so complex and expensive in high-energy physics that I might end up waiting decades for a result," says Boltasseva, who turned 35 in January. "Optics excited me because it's the technology of the future and touches all aspects of our lives."

She is an associate professor at Purdue University, in West Lafayette, Ind., at both the school of electrical and computer engineering and the Birck Nanotechnology Center. Her research focuses on plasmonic metamaterials, which are man-made composites of metals and insulators with optical properties not found in nature. She says she's hoping the new materials will lead to advanced optical technologies applicable to high-performance microscopes and computers, improved solar cells, and new devices for the emerging field of quantum information technology.

"One of our goals is to manipulate light effectively at the nanoscale level and to create novel optical nanodevices," she says. "My team is striving to bring materials research and engineering into the field of plasmonic metamaterials, an expertise that is largely missing."

NANO POSSIBILITIES

Optical transmission of data is faster than wire transmission and can carry information without degradation over long distances. But finding materials that allow cost-effective and efficient operation of nanoscale optical circuits has been tricky.

The wavelengths used for optical data transmission lie in the visible and near-infrared spectrum, 500 to 1550 nanometers, too large to interact with particles whose dimensions are in the neighborhood of 10 nm. This has hindered the development of chips containing nanoscale optics circuitry. Not only can shorter wavelengths—ultraviolet and X-rays—be harmful to human beings, but current methods of generating, transporting, and detecting them are too costly and complex. So Boltasseva's team is developing materials and metal-based nanodevices that attract and manage light waves at the nanoscale.

"The challenge is the large wavelength of light. Traditional approaches can't focus lasers on dimensions smaller than the order of the wavelength itself," she says. "This limits the sizes of optical integrated chips needed for the next generation of computers, because you can't shrink the dimensions of the conventional optical interconnects and components. So our goal is to focus, guide, and route the light at the nanoscale."

Metals at the nanoscale level support oscillations of free-floating electron clouds, which draw light to the metal nanoparticles that would otherwise pass around them. Optical nanophotonic circuits could then manipulate and control the routing of the harnessed light in devices much tinier than conventional lasers and fiber systems. The most efficient metals for that are gold and silver. But they are expensive, cannot be combined with materials used in conventional semiconductor devices, and absorb too much light.

Instead, Boltasseva and her team are developing cost-effective metamaterial devices for harnessing and controlling light that can also be integrated with today's semiconductor materials. "We're finding the right materials, tailoring and optimizing their properties, and making unit cells—or metamaterial 'atoms'—out of them," she says.

"There's no single answer to what the best plasmonic material is," she adds. "We've identified several classes of materials for specific applications, including nanoscale optical interconnects and high-sensitivity sensors, improved solar cells, and powerful microscopes capable of viewing things at nanoscale levels. Each requires different materials."

Boltasseva's group was able to get promising results with near-infrared wavelengths by pushing the limits of doping, a common semiconductor performance-enhancing technique in which electrons are added to a material to create additional charge and metallic properties.

Boltasseva found that adding aluminum or gallium to zinc oxide (used for display panels) donated enough free-floating electrons to create a metallic material in telecommunication wavelengths around 1500 nm. But shorter wavelengths require a different approach. That's where alternative plasmonic materials come in.

"There's a limit to how high you can dope semiconductors," she notes. "You can't get them to behave like a metal in the visible-light range, so we had to look at other materials, including metallic nitrides such as titanium nitride and zirconium nitride." She is also looking into how to tailor and fine-tune other materials to focus and route visible light.

THE EARLY YEARS

Born in Kanash, Russia, about 700 kilometers east of Moscow, to parents who were engineers, Boltasseva tinkered with resistors, transistors, and lightbulbs as a teen, and she earned national honors in Russia's Physics Olympics. She says it was her father and her high school physics teacher who motivated her to pursue physics and engineering.

Boltasseva graduated from the Moscow Institute of Physics and Technology, where she earned bachelor's and master's degrees in applied physics and mathematics in 1999 and 2000. She then earned her Ph.D. in electrical engineering in 2004 from the Technical University of Denmark (DTU), in Kongens Lyngby, just outside Copenhagen.

After brief stints as a research scientist for two start-up IT companies that manufactured optical components, she returned to DTU for a postdoctoral and faculty position. Purdue hired her in 2008 as an assistant professor of electrical and computer engineering. She was promoted this year to tenured associate professor.

Boltasseva's more than two dozen commendations for her work include the 2011 TR35 Award, *MIT Technology Review*'s annual listing of 35 innovators under 35 whose work, says the magazine, is changing the world.

VINCENT WALTER

ACHIEVEMENTS

IEEE MEMBER
Dennis Freeman

Freeman was appointed dean of undergraduate education at MIT.

A professor of electrical engineering at MIT since 1997, Freeman is a member of its Research Laboratory of Electronics, where he investigates cochlear micromechanics. He and his research group were the first to measure the sound-induced movement of cells and accessory structures in the inner ear.

He has served on a number of committees at MIT, including the committees on curricula and on global educational opportunities for MIT undergraduate students. Freeman has received several teaching awards from the school, including the Ruth and Joel Spira Award for Distinguished Teaching and the Irving M. London Teaching Award.

Freeman is a member of the IEEE Electron Devices Society.

IEEE FELLOW
David Plant

Plant was one of six researchers to receive a Killam Research Fellowship from the Canada Council for the Arts. Close to US $1 million will be shared among the recipients to support their research efforts.

Plant is a professor of electrical and computer engineering at McGill University, in Montreal. He specializes in broadband communications and is working to improve the bandwidth, speed, and power consumption of optical interconnects. Plant and his team pioneered the development of very-large-scale integrated circuit technology for optical interconnects.

He is the IEEE Photonics Society's vice president of conferences and was general chair of the 2013 IEEE Photonics Conference, held in September in Bellevue, Wash. Plant is a former associate editor of the society's newsletter and is also a member of the IEEE Communications Society.

IEEE MEMBER
Sossena Wood

Wood was elected chair of the U.S. National Society of Black Engineers. She is serving a one-year term and is working with the executive director to coordinate the society's operations. She was national vice chair of the NSBE from June 2012 until April.

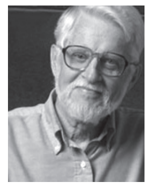
Wood is a graduate student researcher and Ph.D. candidate in bioengineering at the University of Pittsburgh, where she is helping to develop one of the first anatomically detailed electromagnetic simulations of a human head for ultrahigh-field magnetic resonance imaging.

ACHIEVEMENTS, FROM TOP: MIT; MCGILL UNIVERSITY; UNIVERSITY OF PITTSBURGH
IN MEMORIAM, FROM LEFT: MIT; WIKIMEDIA; NATIONAL ACADEMY OF ENGINEERS

IN MEMORIAM

Kenneth N. Stevens

ACOUSTICS PIONEER
Member Grade: **LIFE FELLOW**
Age: **89**; *Died:* **19 AUGUST**



Stevens was a pioneer of speech acoustics, including its production, perception, and processing.

For nearly six decades, he studied the connection between engineering and linguistics to grasp what creates the vocal sounds people produce and why many languages generally rely on similar patterns of sound. In 1972 he published his quantal theory, which suggests that humans naturally prefer speech sounds that are easier to produce, such as the vowels *a*, *i*, and *u* and the consonants *b*, *d*, and *g*. His research was helpful in the design of speech-recognition equipment.

Stevens began his career in 1952 as a researcher at Bolt, Beranek, and Newman (now BBN Technologies, a subsidiary of Raytheon), in Cambridge, Mass. He left in 1954 to join MIT as an assistant professor of electrical engineering. He was promoted to associate professor in 1957 and full professor in 1963. He spent the rest of his career at MIT, retiring in 2007 at the age of 83.

He received the U.S. National Medal of Science in 1999 for "leadership and pioneering contributions to the theory of acoustics of speech production and perception."

He was honored with the 2004 IEEE James L. Flanagan Speech and Audio Processing Award for "fundamental contributions to the theory and practice of acoustic phonetics and speech perception."

Stevens, who received bachelor's and master's degrees in engineering physics in the 1940s from the University of Toronto, earned a Ph.D. in electrical engineering in 1952 from MIT.

Jan C. Willems

PROFESSOR EMERITUS
Member Grade: **LIFE FELLOW**
Age: **74**; *Died:* **31 AUGUST**

Willems was professor emeritus at the University of Groningen, in the Netherlands, where he specialized in control systems and theory.

Willems was an assistant professor in MIT's department of electrical engineering from 1968 to 1973. During that time, he studied optimal control and the algebraic, nonlinear Riccati equation, which arises in the context of infinite-horizon optimal control problems in continuous or discrete time. In 1973 he joined the University of Groningen as a mathematics professor. He was named professor emeritus in 2003.

He was a cofounder of the journal *Systems and Control Letters* (published by Elsevier), which debuted in 1981, and was its managing editor until 1994. He was editor in chief of the Society for Industrial and Applied Mathematics's *Journal on Control and Optimization* from 1989 to 1993.

Willems was president of the Dutch Mathematical Society from 1994 to 1996. In 1995 he cofounded the Dutch Network of Systems and Control (now the Dutch Institute of Systems and Control), a graduate school for students from the Netherlands' nine university departments active in systems and control theory and engineering.

A member of the IEEE Control Systems Society, Willems received the 1998 IEEE Control Systems Award for "seminal contributions to control theory and leadership in systems research."

After receiving a bachelor's degree in engineering from the University of Ghent, Belgium, he earned a master's degree in electrical engineering in 1965 from the University of Rhode Island, in Kingston, and a Ph.D. in the same subject in 1968 from MIT.

Frederick T. Andrews

FORMER IEEE COMMUNICATIONS SOCIETY PRESIDENT
Member Grade: **LIFE FELLOW**
Age: **86**; *Died:* **15 SEPTEMBER**

Andrews held a number of IEEE leadership positions, including 1986 president of the IEEE Communications Society.

During the 1970s he was chair of the society's Transmission Systems and Electronics Product committees. Andrews served as the first vice president of the IEEE Foundation, established in 1973. In 1992 he became director of IEEE Division III and chair of the IEEE Strategic Planning Committee.

Andrews began his career in 1948 as a researcher at Bell Telephone Laboratories. He was appointed laboratory director in 1962 and came to be involved with many of the company's pioneering innovations as phones moved from vacuum tube–based technologies to solid-state and digital transmission systems.

In 1979 he was promoted to executive director and was given the task of resolving the systems issues associated with the evolution of digital telephone networks. He pioneered a technique in the early 1980s to eliminate cross-talk interference from digital transmissions.

When the U.S. government ordered the breakup of Bell Labs in 1984, he became one of the founding corporate officers of Bellcore, a now-defunct subsidiary, in Livingston, N.J. He retired in 1990.

Andrews was honored with the 1998 IEEE Haraden Pratt Award for "sustained contributions and commitment to the institute, particularly for leadership in strategic planning and electronic product development."

He earned a bachelor's degree in electrical engineering in 1948 from Pennsylvania State University, in University Park.

PART-TIME PASSIONS

Anish Mohammed

Up in the Air

PASSION
Building and flying drones

OCCUPATION
Technology strategy consultant

HOMETOWN
Woking, England

SEVERAL YEARS into his hobby of building unmanned aerial vehicles (UAVs), IEEE Member Anish Mohammed earned some geek cred when he met William Premerlani, who'd written some of the initial open-source software that galvanized the do-it-yourself drone community. "He called me a true UAV addict!" Mohammed recalls, laughing.

Mohammed, an independent management consultant in information and data strategy in Woking, about 50 kilometers southwest of London, has degrees in medicine and information security. He has long maintained a side interest in robotics. Shortly after his 2002 move to the United Kingdom from his native India, he began tinkering with design kits from Vex Robotics and Lego Mindstorm. He went from building remote-controlled airplanes and helicopters to building drones. While traditional remote-controlled aircraft are controlled manually via a wireless network from the ground, drone models are programmed to fly themselves.

"I was looking for ways to reduce the number of crashes and found a software component that programs an autopilot takeover if the craft flies out of preprogrammed boundaries set with GPS," he says.

He began to collect the individual components for a quadcopter (four-rotor) drone and built one from scratch. That was in 2010. Since then, he has built 10 multicopters—aircraft with more than two rotors—including an octocopter made with eight rotors, as well as two fixed-wing aircraft. The rotors of his largest multicopters are more than a meter in diameter.

Mohammed flies multicopters both manually and autonomously.

"I was really interested in all the algorithms that help hold the multicopter in the air and fly and allow fixed-wings to fly along a programmed path," he says. "There's a whole bunch of challenging math and theory for doing that."

Mohammed says he spends 10 to 20 hours each week working on or testing his drones. He flies his copters with fellow enthusiasts in a nearby park.

"It's the configuration—making it stable—that takes the most time," he says.

The cost for DIY drones depends on "how geeky you want to get," he says. Both fixed-wing and copter drones can cost from US $300 to $3000, depending on their accessories. Higher-end models, for instance, might include a video camera that enables the flier on the ground to see where the aircraft is headed in real time.

Mohammed says it's exhilarating to build something and make it fly: "After all the long hours and wanting to give it a rest, the day I get a drone off the ground and into the air, it's like, 'Wow! I got it right!'"

— *Susan Karlin*

Richard Schwartz

Music Man

PASSION
Making flutes

OCCUPATION
Electrical engineer

HOMETOWN
Hawthorne, Calif.

IEEE MEMBER Richard Schwartz has spent a good half-century playing wind instruments: the recorder, which he picked up in college, the oboe after graduating, and the flute since his mid-50s (he's now 71).

So when he stopped by a favorite music store this year in Santa Monica, Calif., he couldn't help but notice some musically subpar models of simple flutes. "I thought I could do better than that," says Schwartz, an electrical engineering consultant since leaving the aerospace industry in the 1990s.

Home from the music store, he scoured the Internet to learn how to make his own plastic flutes, then tried his hand at making them from polyvinyl chloride pipe. PVC is relatively easy to cut, drill, and file, and it's readily available in hardware stores.

He once made a high-pitched piccolo out of PVC pipe to play in a local parade, but a flute is more difficult, he says, because pitch errors are more obvious in its lower frequency range. After his first dozen attempts foundered because the second-octave notes weren't on pitch, he decided to make 100 flutes in 3 months from standard half-inch (1.27-centimeter) outer diameter PVC pipes. "That's what I figured I had to do to teach myself," he says.

Schwartz uses Flutomat, a computer program that calculates the position and hole diameters. "For most wind instruments, each finger position can produce several notes, depending on the mouth position and blowing pressure," he notes. "But Flutomat does not calculate harmonic frequencies, and the high notes kept coming out flat. I had to find a way to correct that."

One problem with flutes of PVC pipe is that they are straight cylinders; actual flutes are barrel-shaped. "I put a half-inch pipe with a slightly smaller internal diameter on the head end, observed the result, and did some calculations to determine how much of the thicker-walled pipe was needed to get the flute perfectly in tune," he says.

Schwartz can produce a flute in about an hour. "The time-consuming part is tuning them," he says. "You have to adjust the size and position of each hole to get the right frequency." The flute also comes cheap: home-repair stores sell PVC pipe in 6-meter lengths for US $5.

As he gradually gives his batch of PVC flutes to friends, he is turning his attention to making PVC variations of piccolos that were popular in blues clubs during the late 1920s and early 1930s. "I'm trying to see how good I can make them," he says. "There are a lot of design compromises and trade-offs."

Schwartz has applied his engineering know-how to his hobby. "I figured out that the equations for a sound wave traveling through a pipe are the same as for an electromagnetic wave traveling through transmission lines," he says. "At first I thought I was brilliant. But after a Google search, I learned that someone discovered that same thing 50 years ago and wrote a paper on it. But the scholarly music community ignored him, and nothing came of it."

A perfect model would use computational fluid dynamics to figure out how the air flows through the flute, but then, he adds, "the computing really gets ugly."

For the time being, Schwartz is using a popular antenna and transmission-line finite-element model to solve the sound wave's differential equations and to study the best models for the features of the flute, such as the head cavity and tone hole.

—*S.K.*

PO-WAH YAU; KETUNG HSIAO

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