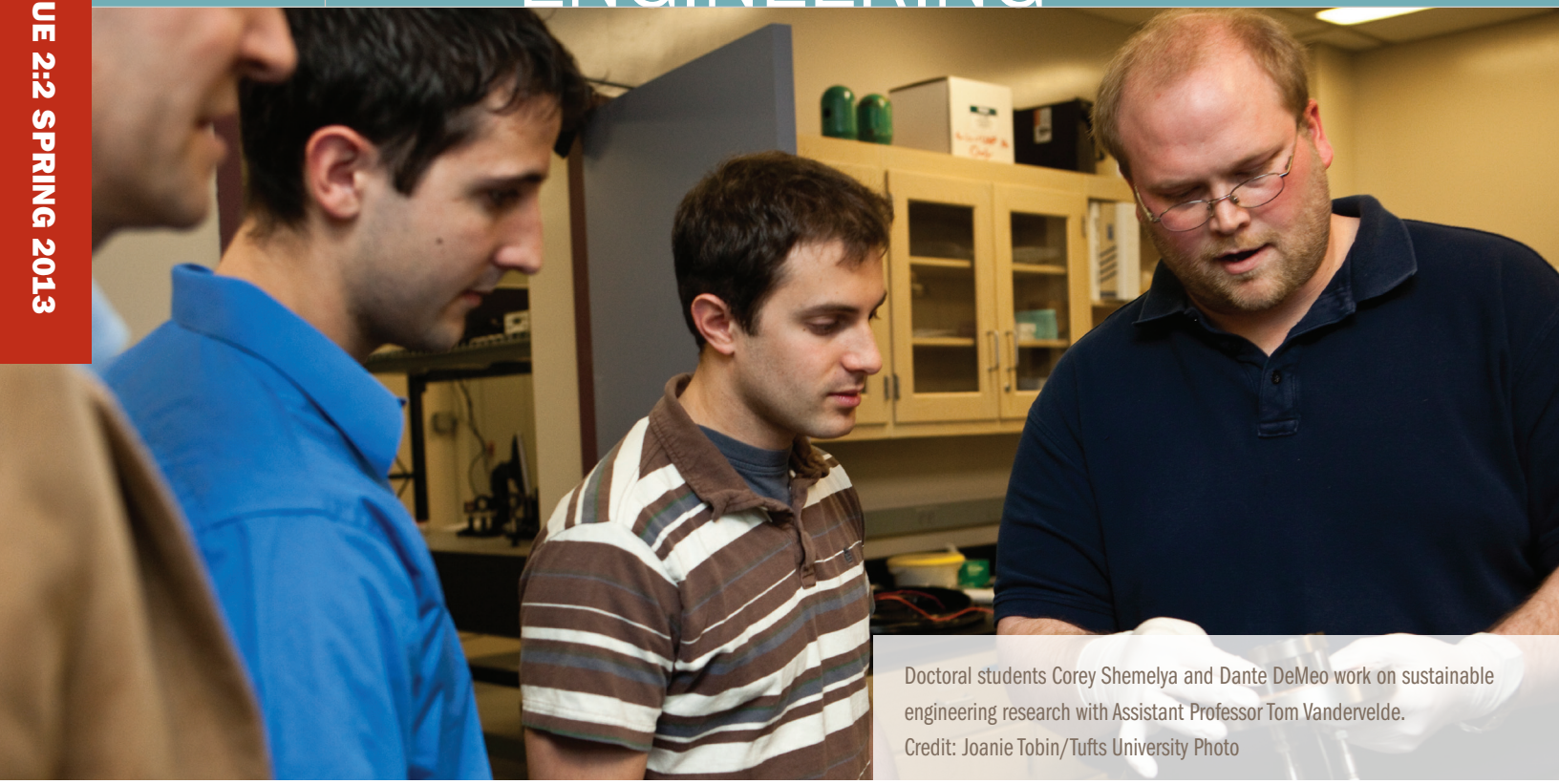
NEWSLETTER ISSUE 2:2 SPRING 2013

Tufts UNIVERSITY | School of Engineering

DEPARTMENT OF ELECTRICAL + COMPUTER ENGINEERING



Doctoral students Corey Shemelya and Dante DeMeo work on sustainable engineering research with Assistant Professor Tom Vandervelde.
Credit: Joanie Tobin/Tufts University Photo

CHALLENGING THE ENERGY CRISIS

EEs take top prize in Dow sustainability innovation challenge

Electrical engineering doctoral students Corey Shemelya and Dante DeMeo received Tufts' grand prize in the 2012 Dow Sustainability Innovation Student Challenge.

Since 2009, Tufts students have participated in the Dow Chemical Company's annual contest that rewards innovative thinking and sustainable practices that balance environmental, societal and economic decisions.

Shemelya and DeMeo won the top $10,000 prize for their research on thermophotovoltaic devices (TPVs), which directly convert heat into electricity. TPVs use the same physics as in solar panels, or photovoltaics, to capture light in a semiconductor material that excites electrons, which then can flow out of the devices as current. TPV devices can also convert infrared light; this is the portion of the electromagnetic spectrum that is felt as heat.

At the present time, TPVs require heat sources in excess of 1000°C. For example, the glass and steel industries with their large, hot furnaces are best suited to current TPV waste heat-harvesting technology.

If TPVs were made efficient enough at lower temperature operation, they could be used to harvest heat from electronic devices, car engines, or battery packs.

"Seventy-two percent of the power from your car's gasoline is lost in the form of heat. If we could harvest

"TPVs...could be used to harvest heat from electronic devices, car engines, or battery packs."

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IN THIS ISSUE

MESSAGE FROM THE CHAIR

As I write this letter in mid-January of 2013, I would like to start by wishing you all a Happy New Year from Medford where in the last week we have seen some wild weather from 60 degrees one Friday to snow the following Monday. Despite Boston's ever changing climate, the second semester is off to a great start building on what has been a very full year here in ECE. Certainly the highlights of 2012 begin with our students. We graduated a strong class last May with 19 earning their Bachelor degree in Electrical Engineering and another nine in Computer Engineering. Along with them we granted 15 Masters of Science and eight PhDs. We wish them all the very best and look forward to hearing about their accomplishments in the years to come.

The most significant accomplishment of 2012 was our successful re-accreditation by ABET. While the entire faculty and our Advisory Board contributed, we really have Hwa Chang, Jeff Hopwood, and Doug Preis to thank for their tireless efforts to ensure that the ABET visit went smoothly. The last year also marked a number of important transitions for the faculty in ECE. After serving on the faculty since 1985, Joe Noonan retired in May. In addition to a great party for him at Café Escadrille where Joe was feted by his family, colleagues and students, he was the recipient of the 2012 Simches Award for Excellence in Teaching and was granted the title of Emeritus. To fill the hole left by Joe in the area of communications and information theory, we have hired Mai Vu who has started with us this term as an Associate Professor. With a PhD from Stanford, postdoctoral work with Vahid Tarokh at Harvard, and three years on the faculty at McGill, we are thrilled to welcome Mai to Tufts.

ECE has also seen a change in leadership with Jeff Hopwood stepping down as Chair after five years of service. All of us owe Jeff a debt of gratitude. From revamping much of our undergraduate program and the expansion of the research enterprise to the six faculty hired by Jeff, the last five years have been transformational. It is with a deep sense of humility that I started as Chair in September 2012. For those whom I have not yet met, I have been at Tufts since 2007 after serving on the ECE faculty at Northeastern for about 13 years. I teach courses in probability theory and image processing. My research is focused on problems of tomographic image formation for biomedical and geophysical applications as well as image processing mostly for medically oriented problems.

In this edition of the newsletter, we highlight the work of three of the faculty: Tom Vandervelde, Jeff Hopwood, and Shuchin Aeron. The teaching, mentorship, and research done by these three are indicative of the depth of talent we have here in ECE. Should you be in the Boston area, please do stop by Halligan and see what is happening. Also, please look for ECE on-line either on our YouTube Channel, TuftsECE, or follow us on Twitter @TuftsECE. In the meantime, I hope to see you at the next Alumni and Student Awards Dinner on Sunday, May 5, 2013.

With best regards,
Eric Miller

Congratulations to Our Graduates

Undergraduate Awards

Victor Minden, Kevin Morrissey, Esha John, and **Lisa Pinals** were awarded Morris and Sid Heyman Prize scholarships. Victor also received the Class of 1947 Victor Prather Prize and the Ralph S. Kaye Memorial Prize. Esha also received a Benjamin G. Brown Scholarship.

Emir Magen and **Daniel Rizzo** were awarded Amos Emerson Dolbear scholarships. Emir previously received a won a SPIE scholarship in Optics & Photonics for "prospect for long-term contribution that the granting of an award will make to the field of optics, photonics or related field."

Yunlin Huang received the Charles G. Bluhdorn Prize in Economics.

Erik Formella, Calvin Hopkins, and **Charles Powell** were awarded a Harry Poole Burden Prize in Electrical Engineering.

Doctoral Recipients

Alireza Aghasi: "Parametric Shape Based Methods for Inverse Problems"
Advisor: Dr. Eric Miller

Jian Guo: "Design and Implementation of a CMOS Digital Phase Imager for Time-Resolved Luminescence Imaging Application"
Advisor: Dr. Sameer Sonkusale

Fridrik Larusson: "Shape-Based Image Reconstruction Methods for Hyperspectral Diffuse Optical Tomography"
Advisors: Dr. Eric Miller and Dr. Sergio Fantini

Naoto Miura: "Design, Modeling, and Diagnostics of Microplasma Generation at Microwave Frequency"
Advisor: Dr. Jeffrey Hopwood

Premkumar Natarajan: "Stochastic Segment Modeling for Offline Handwriting Recognition"
Advisor: Dr. Joseph Noonan

Shahan Christian Nercessian: "Human Visual System-Based Multi-Scale Tools with Biomedical and Security Applications"
Advisor: Dr. Karen Panetta

Nahid Rahman: "Low-profile, Ultra-wideband, Cavity-backed Spiral Antennas"
Advisor: Dr. Mohammed Afsar

Oguz Semerci: "Image Formation Methods for Dual Energy and Multi-Energy Computed Tomography"
Advisor: Dr. Eric Miller

Jiong Xie: "Optimization of Parametric Discrete Orthogonal Transforms and Applications"
Advisor: Dr. Joseph Noonan

Ruida Yun: "Integrated CMOS Optical Sensing Architectures for Frequency-Domain Near-Infrared Spectroscopy"
Advisor: Dr. Valencia Joyner

Master of Science in Electrical Engineering

Syed Sabih Akber
Dianna E. Brown
Samit Kumar Chakraborty
John E. Chivers
Michael T. DiLiberto
Ruiling Gao
Ning Li
Debashree Mandal
Nick L. Marcoux
Nicholas John Matiasz
Susan Moira Murphy
Benazeer S. Noorani
Brian D. Nugent
Gerald Solimini
Junjun Xia

Bachelor of Science in Electrical Engineering

Yorman De Jesus Garcia
Yunlin Huang
Jason Huang
Esha John
Nicole Joyce Levasseur
Emir Salih Magden
Victor Lawrence Minden
Kevin John Morrissey
Christopher R. Mutzel
Andrew Thomas Pellegrini
Taylor H. Perkins
Lisa Michaela Pinals
Mathew Oren Richmond
Keegan Godshall Roth
Chandni Narshi Sanariya
Farhan Shaukat
Michael Arthur Siegel
Jesse Bowman Weeks
Weiyi Zheng

Bachelor of Science in Computer Engineering

Hershal Vyomesh Dave
Ian Michael Donovan
Erik Lee Formella
Calvin Michael Hopkins
Christopher David Kudlack
Charles Jeffrey Powell
Andrew Arthur Purcell
Daniel Brian Raisbeck
William Jessup Salisbury

Undergraduate Published Papers

Working with Assistant Professor Usman Khan, **Victor Minden**, E12, and master's student Clifford Youn's paper "A distributed self-clustering algorithm for autonomous multi-agent systems" was accepted at the *50th Annual Allerton Conference on Communication, Control and Computing* in Monticello, Ill. (October 2012)

Kevin Morrissey, E12, and **Gerald Solimini**, E12, co-authored a paper with professor Khan. The paper "Distributed control schemes for wind-farm power regulation" was accepted at the *44th North American Power Symposium* held in Champaign, Ill., (September 2012).

Last summer, NSF REU scholars **Nicholas Ferrentino**, **Thomas Cahill** and **Hassan Oukacha** worked in Associate Professor Sameer Sonkusale's Nanolab. Nicholas and Thomas' summer research was accepted for poster presentation at the 2012 Materials Research Society fall meeting. Nicholas worked on making plasmonic sensors using colloidal self assembly assisted lithography; Thomas worked on low cost prototyping of metamaterial based sensors.

Challenging the Energy Crisis *Continued from page 1*

some of that lost heat and convert it back into energy to be used by the car we could double or triple a car's fuel mileage," said Tom Vandervelde, John A. and Dorothy M. Adams Faculty Development Professor, who advises Shemelya and DeMeo in his Renewable Energy and Applied Photonics (REAP) Laboratories.

"Even the human body could be used as a heat source, if our research is successful in allowing TPV devices to operate with temperatures as low as 37°C," said DeMeo. "If TPV devices could harvest heat from the body, there could be huge implications in bioengineering and medicine."

One of Shemelya and DeMeo's projects involves extending the operating range of TPV devices, giving them the ability to convert lower temperature heat sources, as well as converting the higher temperature sources more efficiently.

Traditionally, this is done using exotic alloys of different semiconductor materials; however, this approach can only go so far.

"We are presently working on using nanostructures, quantum effects, and novel device designs to push the technology boundaries," Shemelya said. Initial results are promising, showing electricity generation from thermal sources at 500°C and below.

FACULTY HIGHLIGHT

President Barack Obama greets awardees for the Presidential Awards for Excellence in Science, Mathematics and Engineering Mentoring recipients in the Oval Office. Credit: *Official White House Photo by Pete Souza*

Professor Karen Panetta was among nine individuals and eight organizations named a recipient of a 2011 Presidential Award for Excellence in Science, Mathematics, and Engineering Mentoring. The award recognizes the crucial role that mentoring plays in the academic and personal development of students studying science and engineering—particularly those who belong to groups that are underrepresented in these fields. Karen will also receive the 2013 IEEE Award for Distinguished Ethical Practices for exemplary contributions and leadership in developing ethics and social responsibility in students." She was also designated an IEEE Ambassador in 2012, one of only 40 IEEE Fellows given this distinct honor 2012. Prof. Karen Panetta won an APEX award for publication excellence as the Editor-In-Chief for the IEEE Women in Engineering Magazine 2012.

NEW FACES **MAI VU**

Mai Vu

Ph.D., Stanford University

Mai Vu (Ph.D., Stanford University) joined the ECE faculty as an Associate Professor this January. Vu came to Tufts School of Engineering from her position as an assistant professor in Electrical and Computer Engineering at McGill University. Before McGill, Vu was a lecturer and researcher at Harvard School of Engineering and Applied Sciences. Her research interests span the areas of wireless communications, information theory, signal processing and convex optimization. Currently, she conducts research in multi-user communications and cognitive wireless networks, studying fundamental performance limits and designing techniques for distributed communications.

RESEARCH HIGHLIGHTS

In July, Professor of the Practice **Ron Lasser** and collaborators filed a patent (# D663,856) for "Semi-Automated Device for Products and Methods for Single Parameter and Multiparameter Phenotyping of Cells"

Under the leadership of Associate Professor **Sameer Sonkusale**, Tufts ECE was part of a $2M National Science Foundation grant led by Harvard Medical School. Sonkusale's group will develop flexible sensors and electronics for sensor data acquisition and wireless telemetry. Sonkusale also secured a $0.5M Defense University Research Infrastructure Program (DURIP) award to fund instrumentation for terahertz science and technology.

Assistant Professor **Tom Vandervelde** was awarded the 2012 Intelligence Community Young Investigator's Award for his work on monovalent-barrier photodiodes with implications on photodetectors for infrared cameras and spectroscopic chemical identification systems. Moreover, TPV generators created from these devices could convert heat from sources as cold as 15°C and as hot as 6000°C (e.g. the Sun) into high-grade electricity. Because of their solid-state nature, these systems will be ultra-reliable, lasting decades.

Professor **Mohammed Afsar** is collaborating on projects with academic and industry research partners to characterize potential materials for advanced battery application, for thin-film integrated circuitry applications, and for meta-materialized higher power terahertz sources for energy generation. With Assistant Professor **Shuchin Aeron** and Professors Stephen Naber and Marc Homer of Tufts Medical Canter, Afsar is collaborating on a grant for "Fast Compressive Sensing and Millimeter Wave Breast Cancer Imaging." Afsar is collaborating on advanced battery technologies in partnership with Professor of the Practice Michael Zimmerman and Professor Anil Saigal in the Tufts Department of Mechanical Engineering. With Professor Nian Sun of Northeastern University, he is working on "Microwave Characterization of Thin-Film Ferrites." In partnership with Dr. John McCloy of Pacific Northwest National Laboratory (PNNL), Afsar is characterizing highly conductive fissile materials for energy application.

Prof. **Alex Stankovic's** current projects include: Estimation and control in resilient energy systems, supported by the National Science Foundation Engineering Research Center program; Distributed control of energy systems with renewables, Stanford Global Climate and Energy Program; Large-scale optimization in energy systems with dynamic constraints from ARPA_E (via Charles River Associates)

Professor **Joe Noonan** received a graph from BBN Technologies for his project "Multilingual Automatic Document Classification, Analysis, and Translation."

Ricci Prize Winners

Undergraduate alumna **Esha John**, E12, was part of a team that won the inaugural Stephen and Geraldine Ricci Interdisciplinary Prize for development of a program that analyzes images of fat cells, or adipocytes, to identify new therapeutic targets to treat obesity.

The Stephen and Geraldine Ricci Interdisciplinary Prize promotes the advancement of research at Tufts through projects that assist in translation of research discoveries from the laboratory to applications that benefit society.

John and her chemical engineering colleagues **Brian Rohr**, E13, and **James Sims**, EG14, won $7500 for their research project "Automated Adipocyte Analysis: Quantification of Adipocyte Size, Lipid Droplet Distribution and Total Lipid Content for Evaluating Potenti al Anti-Obesity Therapeutics."

Professor and Chair Eric Miller and Associate Professor and Chair of Chemical and Biological Engineering Kyongbum Lee advised the Adipolyze team.

Watch a video about Adipolyze, a program developed by electrical and chemical engineering students, to target fat cells.

Notables...

Four students received National Science Foundation Graduate Research Fellowship Program (GRFP) awards: **Lisa Pinals**, E12, **Victor Minden**, E12, **Gregory Ely** (MSEE), and **Abigail Licht** (PhD in EE).

Abbey Licht was named a Tufts University Eco-Ambassador and took a position on the university's Sustainability Council.

Doctoral candidate **Dante DeMeo** received a Sima Xi Grant-in-Aid of Research (GIAR) award.

Leiny Garcia, E14, and **Yorman Garcia**, E12, were honored at the 2012 Latino Science & Engineering Awards Celebration for their work founding of a Tufts MAES chapter.

Tufts National Society of Black Engineers (NSBE) won the IEEE-USA Online Engineering Video Competition in the content and message category. Tufts NSBE received a $1500 scholarship for their video that highlighted the competition theme "How Engineers Make a Difference." Watch the video on Tufts YouTube!

QUICK HITS

Alan R Hoskinson and Jeffrey Hopwood's paper "A two-dimensional array of microplasmas generated using microwave resonators, " was featured as the cover article for the Institute of *Physics journal Plasma Sources Science and Technology* (October 2012).

Professor Emeritus Joe Noonan was awarded the 2012 Tufts' Seymour O. Simches Award for excellence in teaching.

Assistant Professor Tom Vandervelde gave an invited talk at the SPIE Optics+Photonics Conference in San Diego (August 2012).

Associate Professor Sameer Sonkusale was nominated and elected to serve as a vice chair of the 2011–2012 IEEE Biomedical Circuits and Systems Technical Committee.

Music and the Art of Engineering

What do plasma physics and music have in common? On the surface, almost nothing. But in Professor Jeff Hopwood's course "Music and the Art of Engineering," first-year students study the creation of music in order to develop a deeper understanding about the underlying principles of advanced engineering problems.

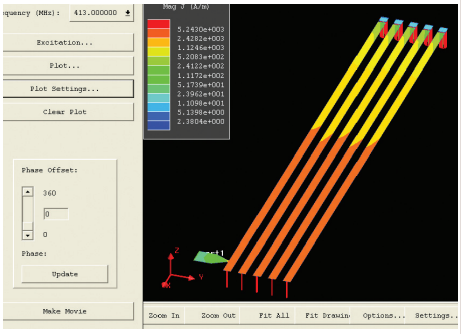
"I thought that introducing new students to the discipline through music might be a great way to engage their senses and to generate some excitement about the possibilities of studying ECE because we can't directly touch, feel, hear or see so many of the things that electrical engineers do," says Hopwood.

Abstract concepts like the Fourier transform make a lot more sense when students can hear the difference in tonal quality (timbre) as harmonics are added or subtracted from an electronically synthesized sound. The goal is not to rigorously learn how to find a Fourier transform, but rather to develop an intuition for what spectra mean and how the time-frequency concept is useful in engineering. Seeing the frequency spectrum on an oscilloscope that displays a Fast Fourier Transform (FFT) function while listening to the sound quality provides a concrete context for understanding the mathematical subtleties in the junior-year courses.

Hopwood uses the same approach to introduce amplification, oscillators, filters, and signal mixing. These ideas are combined in a midterm design project in which students build a simple keyboard synthesizer using electronic parts, and then perform a song of their choice for the rest of the class. Later in the curriculum in the senior design course, ECE students design a system of optical sensors and highly-parallel embedded processors to create a low-latency interface between an acoustic piano and a digital synthesizer.

Striking the Right Chord

In addition to teaching, Hopwood is the director of Tufts' Plasma Engineering Laboratory. Most plasmas at atmospheric pressure are extremely hot and destructive—think lightning and arc welding. Hopwood's research interests focus on the new area of microplasmas in which hot electrons exist simultaneously with cold gas atoms and ions. "You can actually touch the microplasma without any sensation of heat," says Hopwood.

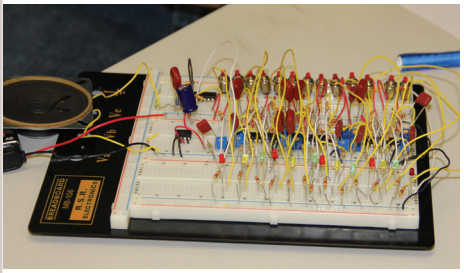


Model of electromagnetic resonators used to create microplasmas

The thumb piano

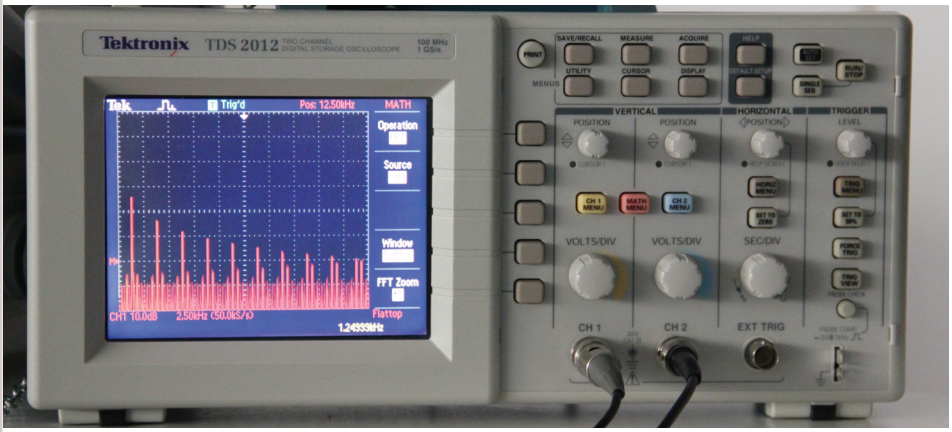
If you look closely at a plasma display, say a flat-screen TV with a plasma screen, the smallest pixel is a microplasma. "These huge plasma displays are quite impressive," he says, "but the real impact of microplasmas will be in low-cost manufacturing." Creating low-cost, low-temperature microplasmas that can be used at atmospheric pressure could also make it possible to treat skin conditions, generate reactive oxygen species for biodecontamination, and even coat exotic materials on inexpensive plastic substrates.

Tired of getting blank stares when describing this new microplasma technology, Hopwood said he drew on his experience with first-year students. The microplasmas require electrical energy to operate and this energy must be carefully controlled using microstrip transmission line resonators. The abstract electromagnetic problem has a close mechanical analogy, however. The thumb piano has metal strips that resonate to create sound when plucked. "The microplasma device works the same way, except the mechanical motion is replaced by electric fields," says Hopwood. "When people see the thumb piano, it's great to see the light of recognition."



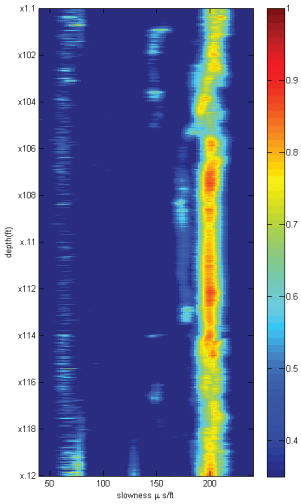
First-year design of a keyboard synthesizer

Senior Design project interfaces an acoustic piano to a digital synthesizer with low latency, funded by Steinway

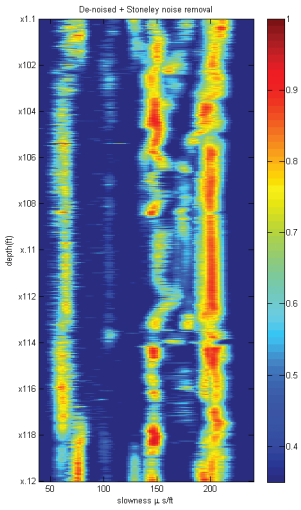


A frequency spectrum displaying a Fast Fourier Transform (FFT) function

SIGNAL PROCESSING SYNERGY



LWD log of sound velocity of different waves as a function of depth.



LWD log after removing noise and interference statistically.

Driving Signal Processing Innovation Through Cross-Cutting Research

Signals can be unpredictable for a variety of reasons—because of interference in a system or incomplete data. Modeling signals' statistical properties allows engineers to predict how signals will behave in the future.

Assistant Professor Shuchin Aeron's core expertise is statistical signal processing with an emphasis on information acquisition and processing for high-dimensional data. These concepts can be transformative to practices within disciplines outside of electrical engineering, such as geophysics and computational biology.

"Cutting across disciplines and identifying application areas is the driving factor behind my research efforts," said Aeron. "By doing so, my research group is always seeking new technical challenges for fundamental advancements within our core expertise."

For example, Aeron and his team of graduate students have applied their expertise to address critical problems affecting reliable and rapid petroleum exploration and production. When oil and gas company operators drill boreholes, they continuously probe the formation acoustically and record acoustic signals. Real time acquisition and processing of these signals is called Logging While Drilling (LWD) and can be quite challenging due to harsh operating conditions.

The concepts also have applications in locating gas trapped in geological formations such as sand and shale. These deeply buried gases can be harvested by introducing cracks or fractures in the rock, which, in turn, generate micro-seismic events, or acoustic noise. By monitoring the acoustic measurements in real-time, called Hydraulic Fracture Monitoring (HFM), drilling operators can redirect the fractures into pockets of trapped gases. Aeron's algorithms will increase the ability to localize these micro-seismic events in presence of heavy noise and interference. In an industry partnership with Schlumberger, Aeron's statistical signal processing research has already been implemented in current LWD and HFM systems.

Recently he has also applied these ideas to imaging spectrometry for geoscience and remote sensing applications. Spectral data can be used for remote sensing of mineral or gas deposits, monitoring temperature, detecting chemicals, or identifying objects in medical images. Using Computed Tomography Imaging Spectrometer (CTIS) systems, Aeron's algorithms can help dissect multiple frequencies, in Hyperspectral Imaging technologies.

Aeron has further diversified his research portfolio by venturing into computational biology. He is collaborating with Soha Hassoun, an associate professor in the Department of Computer Science, to come up with computationally efficient algorithms for analysis of large-scale metabolic networks, which are central to synthetic biology and related applications.

Of course, Aeron doesn't have to look far to discover technical challenges in electrical and computer engineering. He has also teamed up with Associate Professor Sameer Sonkusale to apply the theory and methods of compressive sensing for single chip design of direct analog to information converters for efficient sensing.

KNOW-HOW:

"In my courses, I stress the fundamental system design principles central to all information processing systems," says Aeron.

In Aeron's Courses, Learn How To:

- Sample music using Nyquist sampling criteria *Undergraduate: Linear Systems (EE 23)*
- Use entropic coding principles for data compression *Information Theory (EE 127)*
- Recover data from corrupted or limited measurements
- Remove noise and detect anomalies *Detection and Estimation Theory (EE 229)*

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Department of Electrical
and Computer Engineering
161 College Avenue
Halligan Hall
Medford, MA 02155

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Electrical Engineering Outreach

Students from Acera Massachusetts School of Science, Creativity and Leadership in Melrose visit Assistant Professor Tom Vandervelde's Renewable Energy and Applied Photonics Laboratories at the Science and Technology Center. Doctoral student John Chivers *(far right)* explains the use of sputter deposition to deposit a thin film of gold on materials used to engineer solar cells. (Kelvin Ma/Tufts University)